*****DRAFT*****

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Hazardous Fuels Reduction Treatments in the Northern Rockies: An Annotated Bibliography

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Table of Contents

Introduction

Those who manage forested lands in the Northern Rockies seek to reduce the fire hazard to communities, including our human, wildlife, and vegetative communities. While recognizing the historical role of fire in our various forest types, we also recognize that more than a century of fire exclusion and fire suppression has led to excessive fuel loads and ladder fuels, especially in our lower elevation forests. By reducing fuels through thinning and the use of prescribed fire, we hope to avoid stand-replacing fires that place our homes and old-growth forests in jeopardy.

We provide this annotated reading list to help land managers plan hazardous green fuel reduction projects that will minimize impacts on natural resources. It focuses on research studying the effects of thinning and prescribed fire treatments on various resources in the Northern Rockies. In recognition of the remote work locations of many land managers and the limited time available to conduct thorough literature reviews when faced with designing a project,

we went beyond a listing of papers to provide abstracts and additional notes. (We could also mention here that most are available online).

How we selected papers to include in this bibliography:

This annotated bibliography focuses on research studying the effects of hazardous green fuel reduction treatments on various resources in the Northern Rockies. The Northern Rockies is defined for this purpose as western Wyoming, western Montana, central and northern Idaho, northeastern Oregon, eastern Washington, far western Alberta, and eastern and central British Columbia. If a research study didn't occur in that area, we usually left if out of the bibliography, although some papers remain if we felt they were relevant to our cover types or provided information that no local studies provided.

We focused on the following cover types: ponderosa pine, western larch, Douglas-fir, lodgepole pine, and mixed conifer. Treatments include using prescription fire alone, using mechanical fuel treatments alone, and using a combination of prescription burning and mechanical treatments. Mechanical treatments might include some overstory removal with understory thinning, or might include just understory thinning.

Some recent research looks at treatments that were specifically designed as fuel reduction treatments or treatments designed to return forests to structures more similar to historical conditions. However, we also felt that other studies that looked at silvicultural treatments similar to what we would do for fuel reduction should also be included. So, we included the following treatments as listed in the papers: thinning, precommercial thinning (if there is ground fuel reduction after thinning), commercial thinning, shelterwood cutting, and individual tree selection (in ponderosa pine). Not included were: partial cut, clearcut, group selection cut, or even-age management. For the papers we did include, users will need to judge whether or not the treatments mimic what they would use on the ground.

We recognize that the "Rainbow Series" (e.g., *Wildland Fire in Ecosystems: Effects of Fire on Flora*) and the Fire Effects Information System do an excellent job of describing fire effects. Readers could use many of the papers cited in those publications to predict the effects of prescribed fire, however our focus was to find research that directly studied prescribed fire and/or mechanical treatments. However, the bibliography does include a number of literature syntheses, because of the small number of studies in the cover types and geographic area we cover. All literature reviews are given in the first section. We also didn't include studies that used modeling to predict effects, with the exception of economics studies, and a few others that used local data to develop models and the data were useful for looking at effects.

Abstracts

Where available, we used the abstracts provided with the paper, although we did some editing for consistency. Where you see "Additional notes," this shows where we provided our own summary of the paper, or added information from the paper when we felt the reader would benefit from additional descriptions, for example the types of treatments. We also added more specifics on results, especially when we wanted to emphasize results applicable to the purpose of this bibliography

Acknowledgments *(draft: depends on who else helps with reviews)*

We wish to thank Ward McCaughey, Tonja Opperman, Sarah Truman, and _____ for reviews and helpful comments. We thank the Bitterroot Ecosystem Management Research Project, Bitterroot National Forest, and Rocky Mountain Research Station for funding this project.

Metric vs. English Units

We chose to retain the original units of measurement used in the papers, rather than convert them or provide both types of units. We've included a conversion table for the user's convenience.

Conversion Table

To convert	Into	Multiply by	To convert	Into	Multiply by
Centimeters	Inches	0.394	Inches	Centimeters	2.54
	Feet	0.0328		Meters	0.0254
Meters	Inches	39.37	Feet	Centimeters	30.488
	Feet	3.281		Meters	0.305
	Yards	1.093	Yards	Meters	0.915
Kilometers	Feet	3281	Miles	Kilometers	1.609
	Miles	0.621		Meters	0.0006
Grams	Ounces	0.035	Ounces	Grams	28.35
	Pounds	0.0022	Pounds	Grams	453.59
Kilograms	Pounds	2.205		Kilograms	0.454
Liters	Cups	4.226	Cups	Liters	0.237
	Quarts	1.057	Quarts	Liters	0.946
Sq. Meters	Sq. Yards	1.195	Sq. Yards	Sq. Meters	0.837
	Sq. Feet	10.765	Sq. Feet	Sq. Meters	0.093
Sq. Kilometers	Sq. Miles	0.386	Sq. Miles	Sq. Kilometers	2.589
Cu. Meters	Cu. Yards	1.306	Cu. Yards	Cu. Meters	0.766
Hectares	Acres	2.47	Acres	Hectares	0.405

For Temperatures:
Centigrade = 5/9(F-32) Fahrenheit = (9C/5)32

Literature Reviews

There are 70 papers that are mostly literature reviews, with little original research. We have put all of them here, and refer to them in other appropriate sections. Our original intent was to leave out literature reviews, and we did leave out many more. However, the cumulative knowledge demonstrated by the reviewers, both through their review of literature and their own expertise, made these 70 papers of particular value. Where studies are lacking for a particular area or resource, these papers help bridge that gap until such time as original research is available. In addition, many of the studies covered in these reviews are from outside of the target area, but in many cases, the results may be interpreted to apply to the Northern Rockies, at least until such time as more studies can be conducted.

Agee, James K. 1996. Achieving conservation biology objectives with fire in the Pacific Northwest. Weed Technology. 10(2): 417-421.

Groups: soils; literature review.
Location: western U.S.

Abstract: Fire has been a part of natural ecosystems for many millennia. The species of those ecosystems have evolved through a series of "coarse filters," one of which is resistance or resilience to disturbance by fire. Plant adaptations to fire include the ability to sprout, seed bank adaptations in the soil or canopy, high dispersal ability for seeds, and thick bark. These adaptations are often to a particular fire regime, or combination of fire frequency, intensity, extent, and season. Fire can be used by managers to achieve species to ecosystem-level conservation biology objectives. Examples using prescribed fire include the grasslands of the Puget Trough of Washington state, maintenance of oak woodlands, and perpetuation of ponderosa pine/mixed-conifer forests.

Additional notes: In the discussion of using fire in ponderosa pine/mixed-conifer forests, the author points out that forest floors are generally much deeper than they were historically, and will tend to smolder for many hours. These long-duration fires can cause more damage than the flashy, short-lived fire events that historically occurred. The author also addresses thinning and some of the environmental trade-offs. This paper goes beyond ecology to a general discussion of important factors to consider when planning treatments.

URL: None at this time. Please check back for updates.
Keywords: conservation/environmental sciences/terrestrial ecology/field method/Pacific Northwest/prescribed burning/ponderosa pine/conservation biology/forest fire/fire regimes

Agee, James K.; Bahro, Berni; Finney, Mark A. and others. 2000. The use of fuelbreaks in landscape fire management. Forest Ecology and Management. 127 (1-3): 55-66.

Groups: fire behavior/fuel reduction; literature review.
Location: western U.S.

Abstract: None

Additional notes: There is renewed interest in fuelbreaks, defined as areas manipulated for the common purpose of reducing fuels to reduce the spread of wildland fires. This paper describes the various key components that characterize fuelbreaks, evaluates their use, and discusses alternatives to traditional fuelbreak approaches. In the conclusion, the authors state, “There is a clear theoretical basis for concluding that fuelbreaks will alter behavior in ways amenable to limiting both the sizes of wildland fires and reducing the severity of damage from them. It is also clear that physical effectiveness of fuelbreaks depends not only on their construction specifications but on the behavior of wildland fires approaching them, and the presence and level of fire control forces. Combining fuelbreaks with area-wide fuel treatments in adjacent areas can reduce the size and intensity of wildland fires.”

URL: http://www.qlg.org/pub/miscdoc/agee.htm
Keywords: landscape fire management/landscape management/prescribed fire/shaded fuelbreak/thinning

Alexander, Robert R. 1986. Silvicultural systems and cutting methods for old-growth lodgepole pine forests in the Central Rocky Mountains. General Technical Report RM-GTR-127. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 31 p.

Groups: hydrology; social/human dimensions/esthetics; wildlife; literature review.
Location: central Rocky Mountains.

Abstract: Guidelines are provided to help forest managers and silviculturists develop even-aged and uneven-aged cutting practices needed to convert pure and mixed old-growth lodgepole pine forests into managed stands. Guidelines consider stand conditions, succession, windfall risk, and insect and disease susceptibility. Cutting practices--clearcutting, shelterwood, and selection--are designed to integrate timber production with increased water yield, maintained water quality, improved wildlife habitat, and enhanced opportunities for recreation and scenic beauty.

Additional notes: This is a good reference on management of lodgepole pine forests.

URL: None at this time. Please check back for updates.
Keywords: lodgepole pine/ *Pinus contorta*/ shelterwood cut/ selection cutting/ clearcut

Bisson, Peter A.; Rieman, Bruce E.; Luce, Charlie and others. 2003. Fire and aquatic ecosystems of the western USA: current knowledge and key questions. Forest Ecology and Management. 171(1-2): 213-229.

Groups: fisheries; hydrology; literature review.
Location: western U.S.

Abstract: Understanding of the effects of wildland fire and fire management on aquatic and riparian ecosystems is an evolving field, with many questions still to be resolved. Limitations of current knowledge, and the certainty that fire management will continue, underscore the need to summarize available information. Integrating fire and fuels management with aquatic ecosystem conservation begins with recognizing that terrestrial and aquatic ecosystems are linked and dynamic, and that fire can play a critical role in maintaining aquatic ecological diversity. To protect aquatic ecosystems we argue that it will be important to: (1) accommodate fire-related and other ecological processes that maintain aquatic habitats and biodiversity, and not simply control fires or fuels; (2) prioritize projects according to risks and opportunities for fire control and the protection of aquatic ecosystems; and (3) develop new consistency in the management and regulatory process. Ultimately, all natural resource management is uncertain; the role of science is to apply experimental design and hypothesis testing to management applications that affect fire and aquatic ecosystems. Policy-makers and the public will benefit from an expanded appreciation of fire ecology that enables them to implement watershed management projects as experiments with hypothesized outcomes, adequate controls, and replication.

Additional notes: This is a literature review and policy paper.

URL: None at this time. Please check back for updates.
Keywords: wildfire/fire and fuels management/conservation/restoration/aquatic ecosystems/riparian ecosystems

Brennan, Leonard A. and Hermann, Sharon M. 1994. Prescribed fire and forest pests: solutions for today and tomorrow. Journal of Forestry. 92(11): 34-37.

Groups: insects/diseases; literature review.

Location: U.S.

Abstract: None

Additional notes: In the conclusion, the authors state, "It is clear from the literature that we have just begun to understand the relationships berween fire and forest pests. Forest managers need to talk to research scientists and participate in cooperative research programs. Managers and scientists must also talk to the public about the role of fire as an ecosystem process. It is vital that the public understand the time and research needed to unravel the ecological relationships among silviculture, prescribed fire, forest pests, and the ecological processes that dictate the amounts and kinds of products we are able to harvest from our forests."

URL: None at this time. Please check back for updates.
Keywords: prescribed fire/forest pests/bark beetles/pandora moth

Brown, Richard T.; Agee, James K.; and Franklin, Jerry F. 2004. Forest restoration and fire: principles in the context of place. Conservation Biology. 18(4): 903-912.

Groups: fire behavior/fuel reduction; literature review.
Location: western U.S.

Abstract: There is broad consensus that active management through thinning and fire is urgently needed in many forests of the western United States. This consensus stems from physically based models of fire behavior and substantial empirical evidence. But the types of thinning and fire and where they are applied are the subjects of much debate. We propose that low thinning is the most appropriate type of thinning practice. Treating surface fuels, reducing ladder fuels, and opening overstory canopies generally produce fire-safe forest conditions, but large, fire-resistant trees are also important components of fire-safe forests. The context of place is critical in assigning priority for the limited resources that will be available for restoration treatments. Historical low-severity fire regimes, because of their current high hazards and dominance by fire-resistant species, are the highest priority for treatment. Mixed-severity fire regimes are of intermediate priority, and high-severity fire regimes are of lowest priority. Classification systems based on potential vegetation will help identify these fire regimes at a local scale.

URL: http://www.blackwell-synergy.com/links/doi/10.1111/j.1523-1739.2004.521_1.x/full/
Keywords: thinning/prescribed burning/ponderosa pine/ladder fuels

Brown, James K. and Smith, Jane Kapler. 2000. Wildland fire in ecosystems: effects of fire on flora. General Technical Report RMRS-GTR-42 Vol. 2. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station. 257 p.

Groups: vegetative effects--trees; vegetative effects--understory; literature review.
Location: nationwide.

Abstract: None

Additional notes: This volume is a literature synthesis of wildland fire's effects on vegetation and fuels. The first opening chapter provides background on fire regimes. Chapter 2 discusses fire's effects on plants--how fire influences plant mortality, vegetative regeneration and regeneration by seed, and other aspects of plant growth and reproduction. Chapters 3 through 7 examine fire effects on plants in five major North American ecosystems with some discussion of prescribed fire and management suggestions. The eighth chapter focuses on climate change interactions with fire, and the final chapter examines the relationship between ecological principles and fire management. There are hundreds of references.

This literature review can be used to predict effects of prescribed fire on plants. Discussion on plant and community responses to understory fires will also provide guidance for determinining effects of prescribed fire.

There also is general discussion of effects of prescribed fire in each community type.

URL: http://www.fs.fed.us/rm/pubs/rmrs_gtr42_2a.pdf and http://www.fs.fed.us/rm/pubs/rmrs_gtr42_2b.pdf
Keywords: fire effects/ wildfire/ prescribed fire/ plants/ autecology/ understory burning

Brown, Rick. 2000. Thinning, fire and forest restoration: a science-based approach for National Forests in the Interior Northwest. Washington, D.C.: Defenders of Wildlife. 25 p.

Groups: hydrology; soils; vegetative effects--stands; wildlife; literature review.
Location: interior northwest.

Abstract: None

Additional notes: In the conclusion, the author states, "While there is much to be learned about the current status of forested ecosystems on National Forest lands and about the efficacy of thinning and prescribed fire to make these forests more sustainable, it appears clear that action must be taken to reverse trends of degradation, and that thinning and fire can play a role in these restoration efforts. Because thinning is a form of logging, and because prescribed fire can produce excessive smoke, runs the risk of escape, and appears to contradict decades of Smokey Bear's education about the evils of forest fires, both techniques will be controversial with at least some portions of the public. Every effort should be made to apply these tools thoughtfully, in ways and in locations where they will have the highest prospects for success and the lowest likelihood of unintended consequences. Based on current knowledge, it appears that the most credible efforts will:

- "Be part of comprehensive ecosystem and watershed restoration that addresses roads, livestock grazing, invasive exotic species, off-road vehicles, and so forth;
- Consider landscape context, including watershed condition and both habitats and populations of fish and wildlife;
- Address causes of degradation, not just symptoms;
- Provide timber only as a by-product of primary restoration objectives;
- Avoid construction of new roads;
- Be based on local assessment of presettlement conditions;
- Take place in dry forest types;
- Use fire as a restoration treatment, either alone or following thinning;
- Treat thinning slash and other surface fuels (preferably with fire);
- Retain all large, old (pre-settlement) trees and provide for their replacement over time;
- Have negligible adverse effects on soils;
- Address other vegetation in addition to trees, including noxious weeds;
- Incorporate monitoring as an essential element and cost of the project;
- Learn from monitoring and adapt management accordingly."

"It may not be feasible to fully address all of these considerations for every treatment, but managers who focus their attention on areas where these criteria can be met will have greater prospects for building the experience and credibility that will allow greater discretion in the future. It will also be essential to acknowledge how little empirical scientific study supports assumptions of the efficacy of thinning to restore habitat and reduce fire risk. While additional scientific research is necessary, much can also be learned from routine monitoring, especially if it is structured to reflect a more consistent case studies approach, which could be facilitated by regional guidance from Forest Service research stations. Support within the Forest Service and from the Congress for research, administrative studies and monitoring will be crucial to refining techniques and building public trust. As much as scientific knowledge, that trust must form the basis for successful action."

URL: None at this time. Please check back for updates.
Keywords: thinning/ prescribed fire/ forest restoration

Bull, Evelyn L.; Aubry, Keith B.; and Wales, Barbara C. 2001. Effects of disturbance on forest carnivores of conservation concern in eastern Oregon and Washington. Northwest Science. 75(Suppl.): 180-184.

Groups: wildlife; literature review.
Location: eastern Oregon and Washington.

Abstract: The effects on forest carnivores of forest insects, tree diseases, wildfire, and management strategies designed to improve forest health (for example, thinning, salvage operations, prescribed burns, and road removal) are discussed. Forest carnivores of conservation concern in eastern Oregon and Washington include the Canada lynx *(Lynx canadensis),* wolverine *(Gulo gulo),* and fisher *(Martes pennanti).* All three species depend to some degree on forest structures, stands, and landscapes created by insects, disease, and fire. Wildfire and insect outbreaks maintain a mosaic of structural stages across the landscape that are used by lynx. Thinning of dense lodgepole pine *(Pinus contorta)* stands that result largely from wildfire and insect outbreaks is detrimental to snowshoe hares *(Lepus americanus),* which are the primary prey of lynx. Fishers use large stands of mature forest and snags, hollow live trees, logs, stumps, witches-brooms, and other structures for rest and den sites. Salvage harvesting, thinning, and conversion from predominantly fir stands to ponderosa pine *(Pinus ponderosa)* may adversely affect habitat conditions for fishers. Use of roads is perhaps most detrimental to wolverines because they are easily trapped and avoid humans.

URL: None at this time. Please check back for updates.
Keywords: environmental impact/forests/habitat/population dynamics/soil/ecosystem disturbance/forest management/wildfire/human impact/disturbance/food availability/fire/man-induced effects/nature conservation/environmental management/Washington/Oregon/carnivores/Canada lynx/wolverine/fisher/snowshoe hare

Bull, Evelyn L. and Wales, Barbara C. 2001. Effects of disturbance on amphibians of conservation concern in eastern Oregon and Washington. Northwest Science. 75(Suppl.): 174-179.

Groups: wildlife; literature review.
Location: eastern Oregon and Washington.

Abstract: The effects on amphibians of forest insects, tree diseases, wildfire, and management strategies designed to improve forest health (for example, thinning, prescribed burns, road removal, and spraying with pesticides or biological microbial agents) are discussed. Those species that occur in forested habitats in eastern Oregon and Washington that are considered of concern include the Oregon spotted frog (*Rana pretiosa*), Columbia spotted frog (*R. luteiventris*), northern leopard frog (*R. pipiens*), Cascades frog (*R. cascadae*), tailed frog (*Ascaphus truei*), Larch Mountain salamander (*Plethodon larselli*), and Cope's giant salamander (*Dicamptodon copei*). Little is known regarding the effects of forest health on amphibians, although tree mortality resulting from insects and disease is unlikely to dramatically affect these species, except for the tailed frog and larch mountain salamander. Both these species depend on overstory canopy to maintain temperature and moisture conditions; timber harvest in their habitats has rendered them unsuitable. Wildfire and prescribed burning to a lesser extent, may alter the abundance of prey, coarse woody debris, and vegetation, which could influence movements and survival of dispersing amphibians. Spraying with pesticides could negatively affect these species if the abundance of their prey is decreased. Spraying with biological microbial agents is unlikely to affect prey abundance. Additional research is needed to determine if these disturbance agents are contributing to the decline of many of these amphibians.

URL: None at this time. Please check back for updates.
Keywords: environmental impact/forests/habitat/pesticides/population dynamics/temperature/soil moisture/ecosystem disturbance/forest management/wildfire/human impact/disturbance/pesticide applications/temperature effects/food availability/fire/man-induced effects/nature conservation/environmental management/*Rana pretiosa*/*Rana pipiens*/*Rana luteiventris*/*Rana cascadae*/*Ascaphus truei*/*Plethodon larselli*/*Dicamptodon copei*/Washington/Oregon/amphibians/spotted frog/Columbia spotted frog/northern leopard frog/Cascades/tailed frog/larch mountain salamander/Cope's giant salamander

Bull, Evelyn L. and Wales, Barbara C. 2001. Effects of disturbance on birds of conservation concern in eastern Oregon and Washington. Northwest Science. 75(Suppl.): 166-173.

Groups: wildlife; literature review.
Location: eastern Oregon and Washington.

Abstract: The effects on birds of forest insects, tree diseases, wildfire, and management strategies designed to improve forest health (for example, thinning, prescribed burns, road removal, and spraying with pesticides or biological microbial agents) are discussed. Those bird species of concern that occur in forested habitats in eastern Oregon and Washington include the bald eagle *(Haliaeetus leucocephalus),* peregrine falcon *(Falco peregrinus),* harlequin duck *(Histrionicus histrionicus),* upland sandpiper *(Bartramia longicauda),* northern goshawk *(Accipiter gentilis),* ferruginous hawk *(Buteo regalis),* and black rosy finch *(Leucosticte arctoa).* In addition, seven species of woodpeckers and nuthatches were considered because of their rare status. Forest disturbances that create dead trees and logs are critical to cavity-nesting birds because the dead trees with their subsequent decay provide nesting and roosting habitat. The insects associated with outbreaks or dead trees provide prey for the woodpeckers and nuthatches. The loss of nest or roost trees as a result of disturbance could be detrimental to bald eagles, goshawks, or ferruginous hawks, while the loss of canopy cover could be detrimental to harlequin ducks and goshawks or to prey of some of the raptors. The more open canopies created by thinning may be beneficial to a species like the black rosy finch, yet detrimental to some woodpeckers due to a decrease in cover. Prescribed burning may be beneficial to those woodpeckers primarily associated with ponderosa pine *(Pinus ponderosa)* stands and detrimental to other woodpeckers because of the loss of coarse woody debris. Removal of roads is likely to benefit most of these species because of the subsequent decrease in human activity. Recovery plans for bald eagles and peregrine falcons are available for managers to use in managing habitat for these species.

URL: None at this time. Please check back for updates.
Keywords: environmental impact/forests/habitat/population dynamics/ecosystem disturbance/forest management/wildfire/human impact/disturbance/food availability/fire/man-induced effects/nature conservation/environmental management/Washington/Oregon/bald eagle/peregrine falcon/harlequin duck/upland sandpiper/northern goshawk/ferruginous hawk/black rosy finch/cavity-nesting birds/birds

Bury, R. Bruce. 2004. Wildfire, fuel reduction, and herptofaunas across diverse landscape mosaics in northwestern forests. Conservation Biology. 18(4): 968-975.

Groups: literature reviews; wildlife
Location: Pacific Northwest

Abstract: The herpetofauna (amphibians and reptiles) of northwestern forests (U.S.A.) is diverse, and many species are locally abundant. Most forest amphibians west of the Cascade Mountain crest are associated with cool, cascading streams or coarse woody material on the forest floor, which are characteristics of mature forests. Extensive loss and fragmentation of habitat resulted from logging across approximately 50% of old-growth forests in northern California and approximately 80% of stands in Oregon and Washington. There is a complex landscape mosaic and overlap of northern and southern biotic elements in the Klamath-Siskiyou Region along the Oregon and California border, creating a biodiversity hotspot. The region experiences many low-severity fires annually, punctuated by periodic major fires, including the Biscuit fire, the largest in North America in 2002. In the fire's northern portion, severe fire occurred on >50% of stands of young, managed trees but on only about 25-33% of old-growth stands. This suggests that the legacy of timber harvest may produce fire-prone stands. Calls for prescribed fire and thinning to reduce fuel loads will remove large amounts of coarse woody material from forests, which reduces cover for amphibians and alters nutrient inputs to streams. Our preliminary evidence suggests no negative effects of wildfire on terrestrial amphibians, but stream amphibians decrease following wildfire. Most reptiles are adapted to open terrain, so fire usually improves their habitat. Today, the challenge is to maintain biodiversity in western forests in the face of intense political pressures designed to "prevent" catastrophic fires. We need a dedicated research effort to understanding how fire affects biota and to proactively investigate outcomes of fuel-reduction management on wildlife in western forests.

URL: http://www.blackwell-synergy.com/links/doi/10.1111/j.1523-1739.2004.00522.x/full/
Keywords: amphibians/reptiles/herpetofauna/coarse woody material/thinning/prescribed burning

Bury, R. Bruce; Major, Donald J.; and Pilliod, David. 2002. Responses of amphibians to fire disturbance in Pacific Northwest forests: a review. In: Ford, W. M.; Russell, K.R. and others, editors. The role of fire in nongame wildlife management and community restoration: traditional uses and new directions, proceedings of a special workshop; 2000 September 15; Nashville, TN. General Technical Report NE-GTR-288. USDA Forest Service: 34-42.

Groups: wildlife; literature review.
Location: Pacific Northwest.

Abstract: In western North America, major wildfires often now result in stand-replacement events and natural resources losses for many decades post-burn. Fire severity has been exacerbated by past fire suppression that has allowed large fuel load accumulations. To reduce woody debris and restore the ecological integrity of western forests, prescribed burning is increasingly used as a regional management tool. However, we do not understand the effects of either wildfire or prescribed fires on amphibians in stream, riparian and terrestrial habitats in western forests. Terrestrial amphibians, macroinvertebrates and other animals are surface active during periods of rainfall or high moisture. Wildland fire usually starts in the hot, dry summers typical of these more arid Western and Mediterranean climates and may have less effect on resident biota than prescribed fires often conducted during the late fall to spring rainy season, when there is sufficient moisture to prevent crown fires. Still, intense wildfires may result in increased erosion and sediment or changes in soil chemistry impacting downstream aquatic environments. To our knowledge, no published reports exist on effects of fire on the aquatic herpetofauna of the Pacific Northwest. Research efforts now underway include new studies of wildland fires in Oregon and Idaho on aquatic amphibians, and studies on the effects of prescribed fire on terrestrial salamanders and associated forests in the Klamath Province along the Oregon-California border. These will help evaluate the cumulative effects of fuels reduction on amphibian population and habitat structure, and provide guidelines to better manage for wildlife species characteristic of western forests. In the Pacific Northwest, investigations of fire effects on wildlife are severely lacking relative to the vast acreage, economic value, and biodiversity of its forest ecosystems. Given the increasing prominence of wildfire and prescribed burning in many western forest systems, we suggest more resources will be devoted to such research endeavors, and that they include other sensitive groups of wildlife such as mollusks.

URL: http://leopold.wilderness.net/staff/pubs/Bury_Major_Pilliod_2002.pdf
Keywords: wildlife/prescribed fire/amphibians/fire effects/wildfire

Carey, Henry and Schumann, Martha. 2003. Modifying wildfire behavior--the effectiveness of fuel treatments: the status of our knowledge. National Community Forestry Center, Southwest Region Working Paper, The Forest Trust. 26 p.

Groups: fire behavior/fuel reduction, literature synthesis.
Location: western U.S.

Abstract: None

Additional notes: This literature review assesses existing research on the effectiveness of hazardous fuel reduction in changing wildfire behavior. They reviewed papers that evaluated three types of fuel treatment in western forests--prescribed fire, mechanical thinning, and a combination of thinning and burning. The assessment focused on ponderosa pine forests.

In the Executive Summary, the authors presented these findings:

- "Although the assertion is frequently made that simply reducing **tree density** can reduce wildfire hazard, the scientific literature provides tenuous support for this hypothesis.

- The literature leaves little doubt, however, that fuel treatments can modify fire behavior. Thus, **factors other than tree density**, such as the distance from the ground to the base of the tree crown, surface vegetation and dead materials play a key role. Research has not yet fully developed the relationship among these factors in changing fire behavior.
- The **specifics** of how treatments are to be carried out and the **relative effectiveness** of alternative prescriptions in changing wildfire behavior are not supported by a significant consensus of scientific research at this point in time.
- Substantial evidence supports the effectiveness of **prescribed fire**, a treatment that addresses all of the factors mentioned above. Significantly, several **empirical** studies demonstrated the effectiveness of prescribed fire in altering wildfire behavior.
- By contrast, we found a limited number of papers on the effects of **mechanical thinning alone** on wildfire behavior. The most extensive research involved mathematical simulation of the impact of mechanical thinning on wildfire behavior. However, the results of this research are highly variable.
- A more limited number of studies addressed the effectiveness of **a combination of thinning and burning** in moderating wildfire behavior. The impacts varied, depending on the treatment of thinning slash prior to burning. Again, crown base height appeared as important a factor as tree density. The research community is still building a scientific basis for this combination of treatments.
- The proposal that **commercial logging** can reduce the incidence of canopy fire was untested in the scientific literature. Commercial logging focuses on large diameter trees and does not address crown base height the branches, seedlings and saplings which contribute so significantly to the "ladder effect" in wildfire behavior.
- Much of the research on the effectiveness of fuel treatments uses dramatically different methodology, making a comparison of results difficult. To provide a basis for analysis, we structured our review of the literature into four general groupings: observations, case studies, simulation models, and empirical studies. **Empirical studies** provide the strongest basis for evaluating treatments whereas **personal observations** are the least reliable.
- We found the fewest studies in the most reliable class--**empirical research**. We found the greatest number of studies in the least reliable class of research--reports of **personal observation**. Several other reviews of the literature confirm this finding, stating that the evidence of the efficacy of fuel treatment for reducing wildfire damage is largely **anecdotal**.
- The results of **simulation studies** are highly variable, in terms of such factors as fire spread, intensity, and the occurrence of spotting and crowning.
- Scientists recognize that large scale prescribed burning and mechanical thinning are still experimental and may yet reveal unanticipated effects on biodiversity, wildlife populations, and ecosystem function."

The authors also offered recommendations.

URL: http://www.theforesttrust.org/
Keywords: thinning/ prescribed burning/ fire behavior/ commercial logging/ fuel reduction

Cortner, Hanna; Gardner, Philip D.; and Taylor, Jonathan G. 1990. Fire hazards at the urban-wildland interface: what the public expects. Environmental Management. 14(1): 57-62.

Groups: social/human dimension/esthetics; literature review.
Location: western U.S.

Abstract: Urban-wildland issues have become among the most contentious and problematic issues for forest managers. Using data drawn from surveys conducted by the authors and others, this article discusses how public knowledge and perceptions of fire policies and fire hazards change over time, the kinds of policy responses homeowners prefer as a way of preventing fire hazards at the urban-wildland interface, and how citizens view their own obligations as participants in interface issues. These data show that public attitudes toward fire have changed significantly over the past two decades and that educating the public about fire and the managers' use of fire can have positive effects on behavior. Yet, modifying the individual's behavior in regard to interface fire risks must also deal with important issues of individual incentives, the distribution of costs, and unanticipated

policy impacts.

URL: None at this time. Please check back for updates.
Keywords: fire management/wildland-urban interface/public opinion/fire policy/risk/hazards

DeBano, Leonard F. 1991. The effect of fire on soil properties. In: Proceedings: symposium on management and productivity of western-montane forest soils; 1990 April 10-12; Boise, ID. General Technical Report INT-GTR-280. USDA Forest Service, Intermountain Forest and Range Experiment Station: 151-156.

Groups: soils; literature review.
Location: western U.S.

Abstract: Fire affects nutrient cycling and the physical, chemical, and biological properties of soils occupied by western montane forests. Combustion of litter and soil organic (OM) matter increases the availability of some nutrients, although others are volatilized (for example, N, P, S). Soil organic matter loss also affects cation exchange capacity, organic chelation, aggregate stability, macro pore space, infiltration, and soil microorganisms. Nitrogen replenishment must be emphasized when prescribed burning programs are planned or during rehabilitation following wildfires.

Additional notes: This paper provides management recommendations, including how to protect soils during and after prescribed fire. "When one plans prescribed fires, more opportunities are available for maintaining an acceptable level of OM than occur following wildfires. For example, burning prescriptions can be designed to avoid burns that consume large amounts of surface litter and soil humus. Likewise, the total combustion of large woody debris on the soil surface (logs and so forth) during the prescribed burning may not be a desirable practice. Repeated use of fire at frequent intervals probably should be avoided on relatively infertile sites where OM production is inherently low (for example, south-facing slopes), although it can play an important role in nutrient cycling in those ecosystems that experience frequent low-intensity fires (such as, ponderosa pine forests)." Special consideration must be given to both loss of nitrogen and replenishment when planning burning programs. "Important considerations to keep in mind when evaluating the effects of fire on N cycling are: size of the total N pool, type of fuel consumed, severity of the burn, and, more important, the mechanisms responsible for replacing N lost by volatilization." Treatments interfering with the establishment of postfire N-fixing plants should be avoided, particularly on infertile soils having low site potentials. Woody residue management also appears to be an important factor in N fixation and may require special attention when fire presecriptions are being developed.

URL: None at this time. Please check back for updates.
Keywords: soils/organic matter/nitrogen/fire effects/prescribed fire

DeBano, Leonard F.; Neary, Daniel G.; and Ffolliott, Peter F. 1998. Fire effects on ecosystems. New York, NY: John Wiley and Sons, Inc. 332 p.

Groups: soils; literature review.
Location: North America.

Abstract: None

Additional notes: This textbook is a literature review that covers both wildfire and prescribed fire and provides guidelines for dealing with both. Sections include: Fire Dynamics, Soil Responses, Resonses of Other Resources, and Management Implications. Within the last section is a chapter on Fire in Ecosystem Management that covers benefits, concerns, and constraints.

URL: None at this time. Please check back for updates.
Keywords: wildfire/ prescribed fire/ fire effects/ guidelines

DellaSala, Dominick A. and Frost, Evan. 2001. An ecologically based strategy for fire and fuels management in national forest roadless areas. Fire Management Today. 61(2): 12-23.

Groups: fire behavior/fuel reduction; hydrology; insects/diseases; soils; literature review.
Location: nationwide.

Abstract: None.

Additional notes: The authors sought answers to questions raised by the 2000 fire season: What evidence exists on the relationship between wildland fire and timber management in roaded vs. roadless areas? What effects might silvicultural treatments and prescribed fire have on ecosystems in roadless areas? Is there an ecologically based strategy for identifying, on a case-by-case basis, where active management might be appropriate for maintaining fire-dependent forest ecosystems? After reviewing literature, they provided the following principles for fire and fuels management:

- "Land managers need a comprehensive, landscape-level strategy for fire/fuels management that takes into account the important values associated with roadless areas and directs treatments where they are needed the most. The strategy should be based on the following principles:
- Initially limit mechanical treatments to high-priority, low-risk areas, primarily roaded areas of dense, dry forest.
- Reduce the fire risk in the wildland-rural interface by treating areas immediately adjacent to rural settlements as a first line of defense. Provide homeowners with assistance grants to reduce the fire hazard on private land by creating a defensible space around homes.
- Conduct watershed or landscape-scale assessments that identify restoration priorities before widespread fire/fuel treatments are initiated.
- Eliminate commercial incentives for mechanical removal of merchantable trees by decoupling goods from services (that is, pay a fixed fee for tree removal services that is not tied to timber volume).
- Focus on removing small-diameter trees (e.g., trees less than 12 inches [30 cm] in diameter at breast height or intermediate and suppressed understory trees) where current forest stand densities are outside the historical range of variability.
- Minimize impacts to soils, below-ground processes and related species, accumulation of surface fuels from thinning, and exposure to solar radiation and reduction of soil moisture retention.
- Conduct mechanical treatments in high-priority, low-risk areas in compliance with all relevant environmental statutes (e.g., the National Environmental Policy Act, National Forest Management Act, and Endangered Species Act)."

URL: http://www.fs.fed.us/fire/fmt/fmt_pdfs/fmn61-2.pdf
Keywords: forest fires/wildfire/fire behavior/national forests/fire danger/hazards/fuel appraisals/assessment/thinning/mechanical methods/prescribed burning/regional planning/fuel management/roadless areas/controlled burning/environmental policy/fire control/fire prevention/fire suppression/forest ecology/forest fires/forest policy/forest roads/forestry practices/forests/nature conservation

DellaSala, Dominick A.; Olson, David M.; Barth, Sara E. and others. 1995. Forest health: moving beyond rhetoric to restore healthy landscapes in the Inland Northwest. Wildlife Society Bulletin. 23(3): 346-356 .

Groups: literature review.
Location: inland Northwest.

Abstract: None

Additional notes:: This opinion paper has the following objectives: expand the scope of the forest health debate beyond just the health and marketability of trees; dispel ecological generalizations and misconceptions that have been used to support faulty forest health assumptions and to guide policy development; recommend management techniques for the appropriate use of forest health treatments; and propose a comprehensive land management strategy that addresses a broad range of forest health and socio-political issues. It briefly addresses

thinning and prescribed fire, among other treatments covered.

URL: None at this time. Please check back for updates.
Keywords: forest health/forest management/northwest/policy

Fellin, David G.; Schmidt, Wyman C.; and Carlson, Clinton E. 1984. The western spruce budworm in the Northern Rocky Mountains--ecological relations and silvicultural management strategies. In: Silvicultural management strategies for pests of the Interior Douglas-fir and grand fir forest types, symposium: proceedings; 1979 September 11-13; Spokane, WA: 81-94.

Groups: insects/diseases; literature review.
Location: Rocky Mountain West.

Abstract: None.

Additional notes: According to the stated conclusions, "Resource managers have at least three management options in their continuing struggle to deal with forests infested with western spruce budworm." Along with biological and chemical insecticides, they include "Silvicultural practices--because they alter the environment in which the budworm and all of its natural enemies live--appear to offer the ultimate long-term solution to the western spruce budworm. Fire could be used as an important silvicultural option in coniferous forests infested with the western spruce budworm. Recent prescribed natural fire policies and prescribed underburning for some areas--not currently being done specifically to reduce budworm problems--may effectively reduce the tolerant understory tree component of the forest and, consequently, create conditions much less favorable for the western spruce budworm." They provide examples from literature.

URL: None at this time. Please check back for updates.
Keywords: western spruce budworm/silvicultural management/prescribed fire/harvest/thinning

Finch, Deborah M.; Ganey, Joseph L.; Youg, Wang and others. 1997. Effects and interactions of fire, logging, and grazing. General Technical Report RM-GTR-292. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station. p. 103-136

Groups: wildlife; literature review.
Location: studies were in southwest U.S. and South Dakota.

Abstract: None

Additional notes: This chapter summarizes current knowledge about the effects of fire, logging, and grazing on coniferous forest birds and their habitat. The authors located only 7 studies about the effects of fire on birds in ponderosa pine forests, 5 were in Arizona or New Mexico and the other 2 were in Colorado and South Dakota. Only two focused on prescribed fire, one in South Dakota ponderosa pine and the other in SE Arizona pine-oak. Bock and Bock (1983) in South Dakota studied the response of breeding birds to cool-season prescribed burning in ponderosa pine forest for two years after the fires. Six species (mountain bluebird, solitary vireo, yellow-rumped warbler, western tanager, dark-eyed junco, and chipping sparrow) were more abundant on the burned areas than on unburned areas in at least 1 year. The red-breasted nuthatch was more abundant on the unburned areas in 1 year, but not in the other year. The robin was more abundant on burned plots in the first year, and on unburned plots in the second year. Horton and Mannan (1988) studied the effects of prescribed burning on cavity-nesting birds in pine-oak forest. Few differences were observed in bird populations before and after moderately intense surface fire. Only northern flickers and violet-green swallows declined in abundance in burned stands and only mountain chickadees increased. They concluded that the observed declines in the flickers and swallows were not due to a shortage of nest sites because post-fire densities of suitable snags (snags >50 cm d.b.h. in particular decay classes) exceeded densities theoretically required to support pre-fire numbers of cavity-nesting birds.

They conclude that "Limited evidence on the effects of prescribed fire on forest birds and their habitat suggests that important habitat components of forest birds [snags, logs] may be affected by prescribed fire, at least in the short term. To avoid large-scale loss of important habitat components, special techniques, including thinning dense stands and creating fire lines for snags and logs, may be required to reintroduce fire into areas where it has been excluded."

URL: None at this time. Please check back for updates.
Keywords: fire effects/ birds/ snags/ prescribed fire

Graham, Russell T.; Harvey, Alan E.; Jain, Theresa B. and others. 1999. The effects of thinning and similar stand treatments on fire behavior in western forests. **General Technical Report PNW-GTR-463. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 28 p.**

Groups: fire behavior/fuel reduction; vegetative effects--stand level; literature review.
Location: western U.S.

Abstract: In the West, thinning and partial cuttings are being considered for treating millions of forested acres that are overstocked and prone to wildfire. The objectives of these treatments include tree growth redistribution, tree species regulation, timber harvest, wildlife habitat improvement, and wildfire-hazard reduction. Depending on the forest type and its structure, thinning has both positive and negative impacts on crown fire potential. Crown bulk density, surface fuel, and crown base height are primary stand characteristics that determine crown fire potential. Thinning from below, free thinning, and reserve tree shelterwoods have the greatest opportunity for reducing the risk of crown fire behavior. Selection thinning and crown thinning that maintain multiple crown layers, along with individual tree selection systems, will not reduce the risk of crown fires except in the driest ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.) forests. Moreover, unless the surface fuels created by using these treatments are themselves treated, intense surface wildfire may result, likely negating positive effects of reducing crown fire potential. No single thinning approach can be applied to reduce the risk of wildfires in the multiple forest types of the West. The best general approach for managing wildfire damage seems to be managing tree density and species composition with well-designed silvicultural systems at a landscape scale that includes a mix of thinning, surface fuel treatments, and prescribed fire with proactive treatment in areas with high risk to wildfire.

URL: http://www.srs.fs.fed.us/pubs/viewpub.jsp?index=2979
Keywords: forest fires/ fire behavior/ fire effects/ prescribed burning/ stand structure/ thinning/ logging effects/ species diversity/ fuels

Graham, Russell T.; Jain, Theresa B.; Reynolds, Richard T. and others. 1995. The role of fire in sustaining northern goshawk habitat in Rocky Mountain forests. In: Proceedings: fire effects on rare and endangered species and habitats conference; 1995 November 13-16; Coeur d'Alene, ID; International Association of Wildland Fire.

Groups: wildlife; literature review.
Location: western U.S.

Abstract: The northern goshawk (*Accipiter gentilis*), is a northern latitude, forest dwelling raptor. In the western United States, goshawks live in most forests, including those dominated by western hemlock (*Tsuga heterophylla* (Raf.) Sarg.), lodgepole pine (*Pinus contorta* Dougl. ex. Loud.), ponderosa pine (*Pinus ponderosa* Doulg. ex Laws.), and western larch (*Larix occidentalis* Nutt.). It preys on a variety of small birds and mammals that require an array of forest conditions. Fire, being the primary disturbance mechanism throughout the Western United States, provided landscapes that contained and maintained goshawk populations. Goshawks and their prey adapted to forest conditions maintained by different fire regimes--nonlethal, mixed, variable, stand replacing, or rarely occurring. The goshawk recommendations by Reynolds and others (Reynolds, R.T., R.T. Graham, M.H. Reiser [and others]. 1992. Management recommendations for the northern goshawk in the

Southwestern United States. USDA Forest Service, RM-GTR-207, Rocky Mt. Exper. Stn, Ft. Collins, CO. 90 pp.), coupled with knowledge of fire regimes, provide guidance for designing goshawk habitat throughout the Western United States.

Additional notes: This is a literature synthesis that could be used to justify returning fire to ecosystems to provide habitat for northern goshawks; good for predicting effects.

URL: None at this time. Please check back for updates.
Keywords: northern goshawk/*Accipiter gentilis*/fire/fire regimes/ponderosa pine/western larch/lodgepole pine/western hemlock

Graham, Russell T.; Jain, Theresa Benevidez; and Harvey, Alan E. 1999. Fuel: logs, sticks, needles, duff, and much more. In: Proceeding of the conference on crossing the millennium: integrating spatial technologies and ecological principals for a new age in fire management; 1999 June 15-17; Boise, ID. Moscow, ID: University of Idaho and International Association of Wildland Fire.

Groups: soils; literature review.
Location: western U.S.

Abstract: Fuels burned by either prescribed or wildfires are complex and important components of forested ecosystems. Fine fuels consisting of fallen limbs, twigs, and leaves of shrubs and trees are rich in nutrients. If these fuels are not immediately burned, nutrients can leach from these materials into the forest floor, especially if they overwinter. Larger fuels consisting of standing dead trees, large limbs, and down logs or coarse woody debris (CWD) play critical roles in fixing and storing nitrogen (N), protecting the soil surface, and supplying organic matter to the forest floor. Up to 40 percent of the top 30 cm of a forest soil can be composed of rotten CWD buried (soil wood) in the mineral soil. In addition the litter layer (duff) composed of rotten wood, leaves, twigs, needles, cones, and other fine fuels decompose to form the humus layer. These surface layers coupled with soil wood store and release nutrients, are sites for nitrogen fixation, and provide habitat for ectomycorrhizae. Depending on the ecosystem, amounts of CWD desired for maintaining soil productivity range from 15 Mg/ha (7 tons/acre) in ponderosa pine forests of northern Arizona to 74 Mg/ha (33 tons/acre) in western hemlock forests of northern Idaho. Fires occurring when the lower organic layers are moist ensures preservation of much of the microbiological and nutrient properties of these organic components. These organic components are critical for sustaining forested ecosystems and how they are burned can have both short- and long-term impacts on forest productivity. Therefore both mechanical and fire fuel treatments used to meet reforestation and hazard reduction objectives should conserve these materials.

URL: http://jfsp.nifc.gov/conferenceproc/T-10Grahametal.pdf
Keywords: forest soils/nutrition/productivity/coarse woody debris/wildfire/prescribed fire

Graham, Russell T. and McCaffrey, Sarah. 2003. Influence of forest structure on wildfire behavior and the severity of its effects. Executive summary of a draft report. USDA Forest Service. 23 p.

Groups: fire behavior/fuel reduction; literature review.
Location: western U.S. and specifically the Hayman Fire on the front range of Colorado.

Abstract: None

Additional notes: This report is a synthesis of 153 peer-reviewed articles. It also provides anecdotal accounts of fire behavior on the Hayman Fire in 2002 in Colorado that burned through areas that had undergone fuel reduction treatments. They conclude that treatments to reduce fuels can significantly modify fire behavior and severity and reduce environmental damage caused by fire. However, weather, lack of moisture, and terrain are factors that humans can't influence. The most effective strategy for preventing crown fires in closed canopy stands is to use thinning together with other treatments, including burning, to reduce surface, ladder, and crown fuels.

Three recent examples from the Hayman Fire in Colorado illustrate the relation between surface, crown, and ladder fuels and fire behavior. The Polhemus prescribed burn in November 2001 removed most surface fuel and pruned lower live branches from trees in a ponderosa pine forest, while maintaining a desirable overstory density. These changes were sufficient to stop the Hayman Fire when it burned into the area in June 2002. On the Manitou Experimental Forest, mechanical thinning reduced density in a pure pine forest and concentrated logging slash in large piles within the Trout Creek Timber Sale. These actions resulted in an easily suppressed surface fire when the Hayman Fire burned into the area. On the other hand, all trees were killed in the Sheepnose Fuels Reduction Project within the Hayman fire. Although removing smaller trees dramatically reduced stand density, large amounts of surface fuels allowed the fire to burn intensely through the stand.

URL: http://www.fs.fed.us/projects/hfi/docs/forest_structure_wildfire.pdf (this is for the final report, which is 12 pages long and doesn't include the literature cited section).
Keywords: ponderosa pine/ fuel reduction/ thinning/ prescribed fire

Graham, Russell T.; McCaffrey, Sarah; and Jain, Theresa B. 2004. Science basis for changing forest structure to modify wildfire behavior and severity. General Technical Report RMRS-GTR-120. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station. 43 p.

Groups: fire behavior/fuel reduction; literature syntheses.
Location: interior western U.S.

Abstract: Fire, other disturbances, physical setting, weather, and climate shape the structure and function of forests throughout the Western United States. More than 80 years of fire research have shown that physical setting, fuels, and weather combine to determine wildfire intensity (the rate at which it consumes fuel) and severity (the effect fire has on vegetation, soils, buildings, watersheds, and so forth). As a result of fire exclusion, timber harvesting, and livestock grazing, millions of acres of forestlands (mainly in dry forests dominated by ponderosa pine and/or Douglas-fir) contain a high accumulation of flammable fuels compared to conditions prior to the 20th century. Forests with high stem density and fuel loading combined with extreme fire weather conditions have led to severe and large wildfires (such as those seen in the summers of 2000 and 2002 and the fall of 2003) that have put a number of important values at risk. Although homes in the path of a wildfire are perhaps the most immediately recognized value, these wildfires also put numerous other human and ecological values at risk, such as power grids, drinking water supplies, firefighter safety, critical habitat, soil productivity, and air quality.

For a given set of weather conditions, fire behavior is strongly influenced by stand and fuel structure. Crown fires in the dry forest types represent an increasing challenge for fire management as well as a general threat to the ecology of these forests and the closely associated human values. Crown fires are dependent on the sequence of available fuels starting from the ground surface to the canopy. Limiting crown fire in these forests can, thus, be accomplished by fuel management actions that first reduce surface and ladder fuels before manipulating canopy fuels. Reducing crown fire and wildland fire growth across landscapes decreases the chances of developing large wildfires that affect human values adjacent to forested areas. However, a narrow focus on minimizing crown fire potential will not necessarily reduce the damage to homes and ecosystems when fires do occur there. Homes are often ignited by embers flying far from the fire front, and by surface fires. Fire effects on ecosystems can also occur during surface fires where fine fuels and deep organic layers are sufficient to generate high temperatures for long periods.

Fuel treatments can help produce forest structures and fuel characteristics that then reduce the likelihood that wildfires will cause large, rapid changes in biophysical conditions. Fuel treatments can also help modify fire behavior sufficiently so that some wildfires can be suppressed more easily. Subsequent, sustained fuel treatments can maintain these conditions. Different fuel reduction methods target different components of the fuel bed. Thinning mainly affects standing vegetation, and other types of fuel treatments such as prescribed fire and pile burning woody fuels are needed to modify the combustion environment of surface fuels. In forests that have not experienced fire for many decades, multiple fuel treatments—that is, thinning and surface fuel reduction—may be required to significantly affect crown fire and surface fire hazard. Fuel treatments cannot

guarantee benign fire behavior but can reduce the probability that extreme fire behavior will occur. Fuel treatments can be designed to restore forest conditions to a more resilient and resistant condition than now exists in many forests, and subsequent management could maintain these conditions, particularly in dry forests (ponderosa pine and Douglas-fir) where crown fires were infrequent. The degree of risk reduction will depend to some degree on the level of investment, social and economic acceptability of treatments, and concurrent consideration of other resource values (for example, wildlife).

This report describes the kinds, quality, amount, and gaps of scientific knowledge for making informed decisions on fuel treatments used to modify wildfire behavior and effects in dry forests of the interior Western United States (especially forests dominated by ponderosa pine and Douglas-fir). A review of scientific principles and applications relevant to fuel treatment primarily for the dry forests (ponderosa pine and Douglas-fir dominated) of the Western United States is provided for the following topics: fuels, fire hazard, fire behavior, fire effects, forest structure, treatment effects and longevity, landscape fuel patterns, and scientific tools useful for management and planning.

URL: http://www.fs.fed.us/projects/hfi/docs/forest_structure_wildfire.pdf
Keywords: thinning/ fuel treatments/ prescribed fire/ dry forests/ ponderosa pine/ Douglas-fir

Gresswell, Robert E. 1999. Fire and aquatic ecosystems in forested biomes of North America. Transactions of the American Fisheries Society. 128(2): 193-221.

Groups: fisheries; literature review.
Location: western U.S.

Abstract: Synthesis of the literature suggests that physical, chemical, and biological elements of a watershed interact with long-term climate to influence fire regime, and that these factors, in concordance with the postfire vegetation mosaic, combine with local-scale weather to govern the trajectory and magnitude of change following a fire event: Perturbation associated with hydrological processes is probably the primary factor influencing postfire persistence of fishes, benthic macroinvertebrates, and diatoms in fluvial systems. It is apparent that salmonids have evolved strategies to survive perturbations occurring at the frequency of wildland fires (10^0-10^2 years), but local populations of a species may be more ephemeral. Habitat alteration probably has the greatest impact on individual organisms and local populations that are the least mobile, and reinvasion will be most rapid by aquatic organisms with high mobility. It is becoming increasingly apparent that during the past century fire suppression has altered fire regimes in some vegetation types, and consequently, the probability of large stand-replacing fires has increased in those areas. Current evidence suggests, however, that even in the case of extensive high-severity fires, local extirpation of fishes is patchy, and recolonization is rapid. Lasting detrimental effects on fish populations have been limited to areas where native populations have declined and become increasingly isolated because of anthropogenic activities. A strategy of protecting robust aquatic communities and restoring aquatic habitat structure and life history complexity in degraded areas may be the most effective means for insuring the persistence of native biota where the probability of large-scale fires has increased.

Additional notes: This literature synthesis doesn't look at prescribed fire, but good for predicting effects.

URL: None at this time. Please check back for updates.
Keywords: fish/aquatic ecosystems/fire/fire regimes/salmonids

Harrod, Richy J. 2001. The effect of invasive and noxious plants on land management in eastern Oregon and Washington. Northwest Science. 75(Suppl.): 85-90.

Groups: vegetative effects--understory; literature review.
Location: eastern Oregon and Washington.

Abstract: A key issue for forest and rangeland health and productivity in eastern Oregon and Washington is

invasive species. Although some exotic plant introductions were accidental, many were intentional for wildlife habitat improvement, ornamental purposes, wood or fiber production, soil conservation, livestock forage production, or other crop uses. Exotic species, or weeds, can be a significant component of global environmental change because of their potential to alter primary productivity, decomposition, hydrology, nutrient cycling, and natural disturbance regimes. At smaller scales, they alter the structure, composition, and successional pathways of ecosystems. They lower diversity by out-competing native plants. Disturbance caused by forest restoration activities (thinning and prescribed fire) can promote weed spread, but ultimately will improve native plant diversity and productivity, improving ecosystem resistance to weed invasion. Restoration strategies need to include consideration of weed prevention and control and restoration of natives. Prevention includes restoring ecosystem processes; control includes biological, manual, mechanical, herbicidal, and prescribed burning methods; restoration involves returning native plants to a site. Monitoring is important to provide managers with information that will allow them to evaluate restoration activities and modify ineffective restoration approaches.

URL: None at this time. Please check back for updates.
Keywords: reviews/plants/indigenous species/introduced species/weed control/forest management/land management/Washington/Oregon

Harvey, Alan E.; Geist, J. Michael; McDonald, Gerald I. and others. 1994. Biotic and abiotic processes in eastside ecosystems: the effects of management on soil properties, processes, and productivity. General Technical Report PNW-GTR-323. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 71 p.

Groups: soils; literature review.
Location: eastern Oregon and Washington.

Abstract: Productivity of forest and range land soils is based on a combination of diverse physical, chemical and biological properties. In ecosystems characteristic of eastside regions of Oregon and Washington, the productive zone is usually in the upper 1 or 2 m. Not only are the biological processes that drive both soil productivity and root development concentrated in limited organic horizons, but also they have evolved historically in a natural system that includes mostly modest surface disturbance. Typical disturbances include erosional, seismic, or tip-over events, and modest surface heating by periodic wildfire. This combination of properties and processes produces soils with an extremely wide range of productivity potential, but productivity can be highly sensitive to disturbances from heavy machinery or fire, when fuel accumulations are well beyond historical norms. Limited moisture-holding capacity and nitrogen storage often impose a need for carefully balancing developing vegetation with available soil resources.

Additional notes: See especially the section on post-1900 prescribed burning and eastside soils, p. 23.

URL: None at this time. Please check back for updates.
Keywords: soil management strategy/ soil productivity/ soil sustainability/ soil damage/ soil moisture/ soil microbiology/ soil-disease interaction/ soil-climate interaction/ soil wood/ coarse woody debris/ organic matter/ water storage and use/ nutrient cycling/ nitrogen fixation/ ectomycorrhizal activity/ carbon cycling/ harvest effects/ fire effects/ fertilizer effects/ forest health/ physical properties/ chemical properties

Harvey, Alan E.; Jurgensen, Martin F.; and Larsen, Michael J. 1979. Biological implications of increasing harvest intensity on the maintenance and productivity of forest soils. In: Symposium proceedings: environmental consequences of timber harvesting in Rocky Mountain coniferous forests; Missoula, MT. General Technical Report INT-GTR-90. Boise National Forest: USDA Forest Service, Intermountain Forest and Range Experiment Station: 211-220.

Groups: soils; literature review.
Location: Northern Rocky Mountains.

Abstract: The microbiological populations of a forest soil are largely responsible for its relative quality and productivity, within limitations of climate and geology. Organisms that contribute to decay processes, nitrogen conversions (particularly fixation) and ectomycorrhizal activity provide soils with important characteristics. All of these organisms are dependent on organic matter (biomass) input as an energy source or, after it has decayed, as an organic substrate with specific chemical and physical characteristics. Thus, there is an interdependence between above-ground (organic matter input) and below-ground (nutrient and moisture availability) processes, and this interdependence can strongly influence site productivity. Wood can be a particularly critical and functional soil organic component: its relative importance varies with sites. Its relative input to a given site and the quantity of organic reserves on that site help determine how much wood fiber can be removed without risk to future soil quality. There is an opportunity for residues management to enhance sites with inherent limitations to organic matter production and for fire management to protect sites where there are high fire risks to available organic reserves.

URL: None at this time. Please check back for updates.
Keywords: residues/fire/microbial activity/environmental impact/forest management

Howe, George E. 1995. Genetic effects of uneven-aged management. In: O'Hara, K., editor. Uneven-aged management: opportunities, constraints, and methodologies workshop proceedings; 1995 April 29; University of Montana. 27-32.

Groups: vegetative effects--stand level; literature synthesis.
Location: Northern Rocky Mountains, and specifically mentions Bitterroot National Forest in western Montana (Lick Creek).

Abstract: The probable genetic effects of uneven-aged management are assessed at the landscape and the stand level, particularly in Northern Rocky Mountain forested ecosystems. The effect of selection, random genetic drift, and other consequences of uneven-aged management on population means, genetic diversity, and inbreeding is evaluated. The author concludes that uneven-aged management, as most typically practiced in these ecosystems, has dysgenic potential. The probable exception is the dry ponderosa pine *(Pinus ponderosa)* types that are kept open to favor pine regeneration, and in which age classes are widely separated and leave trees are carefully selected for form and growth more than on the basis of diameter limit.

URL: None at this time. Please check back for updates.
Keywords: ponderosa pine/*Pinus ponderosa*/genetics/uneven-aged management/single-tree selection

Howell, Philip J. 2001. Effects of disturbance and management of forest health on fish and fish habitat in eastern Oregon and Washington. Northwest Science. 75(Suppl.): 157-165.

Groups: fisheries; literature review.
Location: eastern Oregon and Washington.

Abstract: Effects of fire, forest insects and diseases, grazing, and forest health treatments on fish populations and habitat are reviewed. Fire, insects, and disease affect fish habitat by their influence on the rate and volume of woody debris recruitment to streams, canopy cover and water temperature, stream flow, channel erosion, sedimentation, nutrients, and residual vegetation. Physical effects from fire vary greatly depending on fire severity and extent, geology, soil, topography, and orientation of the site, and subsequent precipitation. Most effects moderate within a decade. Post-fire erosion and wood recruitment are also influenced by fire lines, road construction, and timber harvest. Although some disturbances, such as severe fire and subsequent floods, appear catastrophic, and effects may last decades or centuries, natural disturbances help create and maintain diverse, productive aquatic habitats. Recolonization of fish populations following wildfires can be rapid and is related to occurrence of local refugia, life history patterns, access for migratory forms, and distribution of the species. In most livestock studies, grazing negatively affected fish habitat and populations, but results may vary depending on sites and specific grazing management. Effective approaches to grazing management similarly depend on the specific application and the commitment of operators and managers. Restoration of the structure, function, and

processes of watersheds more similar to those with which native species evolved may favor those species; however, there is little documentation of the aquatic effects of those activities. Risk from vegetative treatments may be minimized by experimenting outside of critical areas (in other words, conserving key habitats and populations, focusing intensive treatments on upland sites). Use of more benign techniques (for example, lower-impact logging systems) and pulsed treatments consistent with characteristics of natural disturbance regimes are other considerations for achieving both terrestrial and aquatic objectives.

Additional notes: In the section on Forest Health and Productivity Treatments, the author states, "There is little documented evidence to date to support the hypothesis that forest health treatments to manage overstory vegetation (for example, thinning, timber harvest, prescribed fire) promote native aquatic species and discourage invasions by non-native forms. The effects of those treatments will depend on what specific activities are undertaken and the success of the mitigation."

URL: None at this time. Please check back for updates.
Keywords: fish/aquatic ecosystems/fire effects/prescribed burning/thinning/harvest/forest health treatments/insects/disease/post-fire erosion

Hungerford, Roger D.; Harrington, Michael G. Frandsen William H.; Ryan, Kevin C. and others. 1991. Influence of fire on factors that affect site productivity. In: Harvey, A. E. and Neuenschwander, L. F., compilers. Proceedings: management and productivity of western-Montana forest soils; 1990 April 10-12; Boise, ID. General Technical Report INT-GTR-280. Ogden, UT: USDA Forest Service, Intermountain Research Station: 32-50.

Groups: fire behavior/fuel reduction; insects/diseases; soils; vegetative effects--stand level; literature review.
Location: western North America.

Abstract: Presettlement fire played an important role in nutrient cycling, plant succession, diversity, and stand dynamics in coniferous forests of western North America. Prescribed fire can maintain site quality and contribute to control of insect and disease problems while reducing wildfire hazard. Fire effects on soils are largely governed by interactions between fuel consumption and soil characteristics that influence soil heating. Many impacts on vegetation and site productivity are also related to soil heating.

URL: None at this time. Please check back for updates.
Keywords: soil/fire effects/soil heating/site productivity/nutrient cycling/plant succession/prescribed fire

Johnson, E. A. and Miyanishi, K. 1995. The need for consideration of fire behavior and effects in prescribed burning. Restoration Ecology. 3(4): 271-278.

Groups: fire behavior/fuel reduction; literature review.
Location: North America.

Abstract: Prescribed burns are increasingly being used in ecological restoration and vegetation management. Despite the accumulation of scientific information on fire behavior and fire effects, however, in many cases fires are prescribed without consideration of such information and often simply because of evidence of past fires. Rather than basing fire management plans on ideas of the historical “natural” occurrence of fire, we present the case for fire management being based on the fire effects desired. Effective fire management and development of proper fire prescriptions require an understanding of fire processes and heat transfer that explain fire behavior characteristics, as well as an understanding of how fire behavior is coupled to specific fire effects. We provide a basic introduction to these concepts and processes, which will help in understanding the importance of having a more technical understanding of fire. The discussion includes the processes of heat transfer and the relative role of various fuel variables in these processes, as well as the concepts of fire intensity, rate of spread, fuel consumption, duff consumption, fire frequency, and the ecological effects associated with variation in these characteristics of fire behavior.

Additional notes: This paper does not present research results but is more of a literature review designed to lead to a better understanding of fire behavior and effects.

URL: None at this time. Please check back for updates.
Keywords: prescribed burning/fire effects/fire behavior/fire management/heat transfer/fuel consumption/duff consumption/fire frequency

Jurgensen, M. F.; Harvey, A. E.; Graham, R. T. and others. 1997. Impacts of timber harvesting on soil organic matter, nitrogen, productivity, and health of Inland Northwest forests. Forest Science. 43(2): 234-251.

Groups: soils; literature review.
Location: Inland Northwest.

Abstract: Soil organic components are important factors in the health and productivity of Inland Northwest forests. Timber harvesting and extensive site preparation (piling, windrowing, or scalping) reduces the amount of surface organic material (woody residues and forest floor layers) over large areas. Some wildfires and severe prescribed burns can have similar consequences. Such organic matter reductions can have important implications for soil chemical, biological, and physical properties.

A number of studies have linked substantial reduction in mycorrhizae development and tree growth to high levels of soil disturbance, or removal of organic horizons. Timber harvesting also removes a large percentage of coarse woody debris, which has unknown ramifications on soil productivity. Current woody residue guidelines in this region recommend leaving <10 to 125 Mg/ha on site to replace woody materials lost during harvesting operations. Large amounts of soil nitrogen (>500 kg/ha) can also be lost from timber harvesting and site preparation, especially when using prescribed fire. The time required to replace this lost nitrogen may range from <10 to >275 yr, and depends on the severity of site treatments, presence or absence of nitrogen-fixing plants, and amounts of atmospheric deposition.

Maintaining adequate amounts of organic matter on some forest sites in the Inland Northwest may temporarily increase the risk of wildfire or favor the activity of certain insects or disease fungi. However, carefully planned prescribed burns and mechanical site preparation can be practiced on most sites with relatively low impacts on soil organic levels, while accomplishing the important forest management objectives of fuel reduction, seedbed preparation, and reducing competing vegetation. Organic matter management will be the most difficult on very dry sites, with their historically low soil organic and nitrogen content, and high fire potential. The maintenance of adequate soil organic matter levels is critical for sustaining forest health and productivity under the variable moisture and temperature conditions of this region. Thus, soil organic components will become more important in the future as ecosystem management systems are developed for western forests.

URL: None at this time. Please check back for updates.
Keywords: harvest/logging/site preparation/soil organic matter/mycorrhizae/nitrogen fixation/plant residues/nitrogen/soil fertility/prescribed burning/forest health/Washington/Idaho/Oregon/Montana/mounding/scalping/woody residues

Kauffman, J. Boone. 1992. Prescribed fire in forest vegetation management: a research synthesis. In: Workshop on forest vegetation management without herbicides; 1992 February 18-19; Corvallis, OR. Oregon State University: 25-27.

Groups: vegetative effects--understory; literature review.
Location: Sierra Nevadas of California.

Abstract: None

Additional notes: This research synthesis discusses the use of prescribed fire in natural resource management, with an emphasis on its use for decreasing woody competition by decreasing seed banks of species like

Ceanothus spp. and by increasing sprouting mortality. It mostly cites research from the Sierra Nevadas of California.

URL: None at this time. Please check back for updates.
Keywords: prescribed burning/forest vegetation management/understory

Kotliar, Natasha B.; Hejl, Sallie J.; Hutto, Richard L. and others. 2002. Effects of fire and post-fire salvage logging on avian communities in conifer-dominated forests of the western United States. Studies in Avian Biology. 25: 49-64.

Groups: wildlife; literature review.
Location: western U.S.

Abstract: Historically, fire was one of the most widespread natural disturbances in the western United States. More recently, however, significant anthropogenic activities, especially fire suppression and silvicultural practices, have altered fire regimes; as a result, landscapes and associated communities have changed as well. Herein, we review current knowledge of how fire and post-fire salvaging practices affect avian communities in conifer-dominated forests of the western United States. Specifically, we contrast avian communities in 1) burned vs. unburned forest, and 2) unsalvaged vs. salvage-logged burns. We also examine how variation in burn characteristics (e.g., severity, age, size) and salvage logging can alter avian communities in burns.

Of the 41 avian species observed in three or more studies comparing early post-fire and adjacent unburned forests, 22% are consistently more abundant in burned forests, 34% are usually more abundant in unburned forests, and 44% are equally abundant in burned and unburned forests or have varied responses. In general, woodpeckers and aerial foragers are more abundant in burned forest, whereas most foliage-gleaning species are more abundant in unburned forests. Bird species that are frequently observed in stand-replacement burns are less common in understory burns; similarly, species commonly observed in unburned forests often decrease in abundance with increasing burn severity. Granivores and species common in open-canopy forests exhibit less consistency among studies. For all species, responses to fire may be influenced by a number of factors including burn severity, fire size and shape, proximity to unburned forests, pre- and post-fire cover types, and time since fire. In addition, post-fire management can alter species' responses to burns. Most cavity-nesting species do not use severely salvaged burns, whereas some cavity-nesters persist in partially salvaged burns. Early post-fire specialists, in particular, appear to prefer unsalvaged burns. We discuss several alternatives to severe salvage-logging that will help provide habitat for cavity nesters.

We provide an overview of critical research questions and design considerations crucial for evaluating the effects of prescribed fire and other anthropogenic disturbances, such as forest fragmentation. Management of native avifaunas may be most successful if natural disturbance regimes, including fire, are permitted to occur when possible. Natural fires could be augmented with practices, such as prescribed fire (including high-severity fire), that mimic inherent disturbance regimes.

URL: None at this time. Please check back for updates.
Keywords: burn severity/cavity-nesters/fire effects/fire suppression/passerine birds/prescribed fire/salvage logging/silviculture/snags/wildland fire/woodpeckers

Lindeburgh, S. B. 1990. Effects of prescribed fire on site productivity: a literature review. Land Management Report 66. British Columbia Ministry of Forests. 20 p.

Groups: soils; literature review.
Location: British Columbia.

Abstract: Slashburning, or prescribed fire, is a commonly used site preparation practice in British Columbia. The literature reviewed in this report deals primarily with the effects of prescribed fire on site productivity. Results from different studies are often difficult to compare because of the large variability among sites and

inconsistent reporting.

Prescribed fire can benefit or hurt site productivity, depending on such variables as, the amount and type of slash, the fire weather indices, the timing of logging and burning, and the ecological characteristics of the site.

Additional notes: Because of the complexity of burning, it is difficult to make general statements on how slashburning affects site productivity. However, two conclusions seem to be consistent in the literature: 1) lower severity fires have a lower risk of causing site degradation than higher severity fires; and 2) at any given fire severity, drier nutrient-poor sites have a higher risk of being degraded than moister nutrient-rich sites.

URL: None at this time. Please check back for updates.
Keywords: prescribed fire/ slash burning/ fire effects

Lotan, James E.; Brown, James K.; and Neuenschwander, Leon F. 1985. Role of fire in lodgepole pine forests. In: Baumgartner, David M.; Krebill, Richard G.; Arnott, James T. and others, compilers/editors. Lodgepole pine: the species and its management; 1984 May 8-10 and 14-16; Spokane, WA and Vancouver, BC. Pullman, WA: Washington State University, Cooperative Extension: 133-152.

Groups: literature review.
Location: Rocky Mountains.

Abstract: Fire is one of the most important factors involved in the establishment and development of many lodgepole pine forests in North America. In the Rocky Mountains lodgepole pine is usually considered a fire-maintained seral type. But even there fires vary greatly in frequency, intensity, size, and other characteristics. A particular fire regime greatly affects forest succession, longevity of the species, stocking, and species composition; and fire also influences the incidence of insects and diseases. Fuel quantity changes over time and with it fire behavior potentials in natural and slash fuels. Fire behavior potentials are greatest when buildup of dead fuel coincides with development of understory conifers. Most fires are low intensity, creeping, surface fires, but high intensity crown fires during severe weather burn the most acreage. Fires, stand development, mortality influences, and fuel accumulation interact in a complex network. Sound management of lodgepole pine requires that we understand the complexities of lodgepole pine ecology, including the role of fire, and manage within that context.

Additional notes: This paper discusses fire regimes, fire behavior, fuel dynamics, community dynamics, succession, cone serotiny, stand establishment and development, and insect and disease relationships in lodgepole pine forests. This is a literature review and synthesis of existing knowledge on lodgepole pine management.

URL: None at this time. Please check back for updates.
Keywords: lodgepole pine/wildfire/prescribed fire/burning/slash burning/fire history/fire regimes

Martin, R. E. and Dell, John D. 1978. Planning for prescribed burning in the Inland Northwest. General Technical Report, PNW-GTR-76. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 67 p.

Groups: literature synthesis.
Location: Inland Northwest.

Abstract: Fire has historically played a role in forests and ranges of the inland Northwest. This guide has been prepared to help managers understand the role of fire and the potential uses of fire and to plan for fire use in managing these lands. Sections deal with these topics, and steps in planning a prescribed burn are outlined. A sample burning situation illustrates the planning and execution of a prescribed burn. References are given to help the reader locate pertinent information.

Additional notes: This is a literature synthesis and doesn't present research results. Given the date of this publication, more recent literature likely will be more suitable for planning prescribed burns.

URL: None at this time. Please check back for updates.
Keywords: fire use/ fire effects/ fire planning/ fire management/ prescribed burning

Martin, Robert E. and Driver, Charles H. 1982. Factors affecting antelope bitterbrush reestablishment following fire. In: Tiedemann, Arthur R. and Johnson, Kendall L., compilers. Proceedings--research and management of bitterbrush and cliffrose in western North America; 1982 April 13-15; Salt Lake City, UT. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station and Utah State University: 266-279.

Groups: vegetative effects--understory; literature review.
Location: western U.S.

Abstract: Successful sprouting of bitterbrush after fire is controlled by such factors as plant genetics and morphology, plant age, competition, soil type, burning conditions, fuel load, past history, browsing pressure, and others. Seedling establishment depends on such factors as seed supply, rodent population, site, and others. Discussion centers on assessing the effects of fire on bitterbrush stands.

URL: None at this time. Please check back for updates.
Keywords: bitterbrush/antelope bitterbrush/fire effects/sprouting/seedlings

Maxell, Bryce A. 2000. Management of Montana's amphibians: a review of factors that may present a risk to population viability and accounts on the identification, distribution, taxonomy, habitat use, natural history, and the status and conservation of individual species. Missoula, MT: University of Montana, Wildlife Biology Program. 161 p.

Groups: wildlife; literature review.
Location: data are from throughout U.S., applied to Montana.

Abstract: None

Additional notes: This literature review provides species accounts for Montana's amphibians, giving information on identification, distribution, taxonomy, habitat use/natural history, and status and conservation. It also discusses impacts of disturbances on amphibians, including timber harvest, and fire (including prescribed fire) and fire management activities. Recommendations are based on knowledge of amphibian life history requirements and minimal formal research that is available on the effects of these disturbances. One of these applicable to the Northern Rockies was a study of long-toed salamanders in Douglas-fir forests in the Swan River Valley of Montana. McGraw (1997 M.Sc. Thesis, Univ. of Montana, Missoula) found that areas where overstory removal (250-300 trees harvested per ha) and new forestry (leave 13-25 dominant trees per ha and retain all snags and hardwoods) harvest techniques were applied had less ground cover, higher soil temperatures, and 75 percent fewer terrestrial salamanders than control plots. He suggested that retention of greater amounts of all types of forest debris and understory vegetation may mitigate these impacts.

URL: None at this time. Please check back for updates.
Keywords: amphibians/ management effects/ logging/ fire/ prescribed fire/ roads/ water impoundments/ recreation/ harvest

Meehan, William R. 1991. Influences of forest and rangeland management on salmonid fishes and their habitats. American Fisheries Society Special Publication 19. Bethesda, MD: American Fisheries Society.

Groups: fisheries; literature review.

Location: western North America.

Abstract: None

Additional notes: This text is useful for predicting effects of activities on salmonid habitats and populations. Chapter 6, Timber Harvesting, Silviculture, and Watershed Processes, and Chapter 14, Responses of Salmonids to Habitat Changes, are especially useful for timber harvest projects. There is not much mention of fire effects except for a brief discussion of effects of wildfire. Most studies cited concerning timber harvest deal with clearcutting.

URL: None at this time. Please check back for updates.
Keywords: fish/ timber harvest/ clearcutting

Megahan, Walter F. 1981. Effects of silvicultural practices on erosion and sedimentation in the interior west--a case for sediment budgeting. In: Proceedings: Interior West watershed management; 1980 April 8-10; Washington State University. Pullman WA: Washington State University Cooperative Extension publication: 169-181.

Groups: soils; literature review.
Location: interior western U.S.

Abstract: Accelerated surface and mass erosion are often caused by silvicultural practices in the interior western United States. Onsite erosional impacts may also be manifested at downstream locations as increased sedimentation. Expressed per unit area of soil disturbing practice, roads are the primary cause of accelerated erosion and sedimentation. Logging activities can also increase erosion and effects can be magnified by slash burning and wildfire. Increased surface erosion from logging tends to be greatest on south aspects and lowest on north aspects. An understanding of erosional processes is important to efficiently reduce surface and mass erosion. Sediment budgeting is an important consideration for evaluating the amount and effects of erosion and the resulting downstream sedimentation.

Additional notes: There is minor mention of prescribed fire and partial cutting.

URL: None at this time. Please check back for updates.
Keywords: erosion/sedimentation/surface erosion/mass erosion/channel erosion/sediment storage/watershed management/silviculture/road construction/forest fires/logging/sediment budget

Mitchell, Russel G. 1990. Effects of prescribed fire on insect pests. Corvallis, OR: Oregon State University Press.

Groups: insects/diseases; literature review.
Location: Pacific Northwest.

Abstract: Several insect pests spend part of their life cycle on the forest floor and can be directly affected by underburning the infested forest. Many defoliating insects and most seed and cone insects, for example, are vulnerable to this treatment. Pests associated with logging and thinning slash live under the bark of the slash and are also subject to direct control by fire. However, these kinds of treatment have limitations and must be approached carefully to achieve the control objectives.

Many of the interactions between fire and insects are indirect. For example, trees with more than 50 percent of their crowns scorched by fire usually become attractive to bark beetles, which could be the desired result if the goal of the burn was to remove undesirable tree species or reduce the number of trees in an overstocked stand. Sometimes, however, large trees intended for the final crop are also scorched and attacked by these pests.

Prescribed underburning to maintain stands at some intermediate (seral) level of succession could be the most

valuable use of fire in pest management. Wildfire control in the last 75 years--combined with intensive logging of ponderosa pine--has permitted vast acreages of ponderosa pine to be replaced by more shade-tolerant tree species dominated by true firs, a favored host of the Douglas-fir tussock moth and the western spruce budworm. Accordingly, these two pests are now greater problems throughout the West than they were 50 years ago. The status of other insect pests like the mountain pine beetle has also been elevated owing to the effects of wildfire control programs. Because the wildfire control policy will likely continue in most commercial forests, prescribed burning will often be needed to prevent the creation of forests excessively vulnerable to insect pests.

Clearly, the effects of prescribed burning on forest insect pests can be both positive and negative. But it is also clear that most of the negative aspects are trivial and that when prescribed burning is used carefully and intelligently it can be an extremely useful tool in the management of forest insect pests.

URL: None at this time. Please check back for updates.
Keywords: insects/ understory burning/ prescribed fire/ ponderosa pine/ pests/ forest pests

National Wildfire Coordinating Group, Fire Use Working Team. Fire Effects Guide (NFES 2394) [Web Page]. 2001. Available at: http://fire.fws.gov/ifcc/monitor/FEG.pdf.

Groups: literature review.
Location: nationwide.

Abstract: None

Additional notes: This paper has some discussion of fire and prescribed fire effects on various resources. Among other subjects, it is a good source for hard-to-find information on archeological sites, but papers cited are hard to find.

URL: http://fire.fws.gov/ifcc/monitor/FEG.pdf
Keywords: fire effects/wildlife/fuel reduction/air quality/soils/water/fire behavior

Neary, Daniel G.; Klopatek, Carole C.; DeBano, Leonard F. and others. 1999. Fire effects on belowground sustainability: a review and synthesis. Forest Ecology and Management. 122: 51-71.

Groups: soils; literature review.
Location: nationwide.

Abstract: The overall effects of fire on ecosystems are complex, ranging from the reduction or elimination of aboveground biomass to impacts on belowground physical, chemical and microbial mediated processes. Since a key component of overall ecosystem sustainability occurs belowground, recovery is tied to the soil's physical, chemical, and biological functions and processes. Depending on several fire severity measures, changes in belowground components can be either beneficial or deleterious to the entire ecosystem. Low-impact burning can promote a herbaceous flora, increase plant available nutrients, and thin over-crowded forests, all of which can foster healthy systems. Severe fires can often cause changes in successional rates, alter above- and belowground species composition, generate volatilization of nutrients and ash entrainment in smoke columns, produce rapid or decreased mineralization rates, alter C : N ratios, and result in subsequent nutrient losses through accelerated erosion, leaching or denitrification. In addition, changes in soil hydrologic functioning, degradation of soil physical properties, decreases in micro- and macrofauna, and alterations in microbial populations and associated processes can occur. The direct effect of fire on belowground systems is a result of the burning severity, which integrates aboveground fuel loading (live and dead), soil moisture and subsequent soil temperatures, and duration of the burn. The time for recovery of belowground systems will not only depend on the burning intensity and its effect on key ecosystem processes and components, but also on the previous land-use practices. Thus, the impacts of fire on belowground systems can be highly variable and may not be predictable. Our paper is a general review of the effects of fire on belowground systems with emphasis placed on the changes in physical, biogeochemical, and biological properties of soils and the resulting consequences

these changes have for ecosystem sustainability.

URL: None at this time. Please check back for updates.
Keywords: fire/soils/physical properties/microbial ecology/nutrients/organic matter

Niwa, Christine G.; Peck, Robert W.; and Torgerson, Torolf R. 2001. Soil, litter, and coarse woody debris habitats for arthropods in eastern Oregon and Washington. Northwest Science. 75(Suppl.): 141-148.

Groups: insects/diseases; soils; literature review.
Location: eastern Oregon and Washington.

Abstract: Arthropods within soil, litter, and coarse woody debris play vital roles in maintaining soil fertility, health, and productivity. Arthropods shred plant material, help mineralize nutrients for plants, act as predators, and serve as food for other wildlife. Some species or groups of species are potentially valuable for monitoring forest health. Natural and human-caused disturbance may immediately kill many arthropods, but changes to habitat structure are likely to cause longer-term effects on their community compositions. Fire effects on arthropods may be minimized if refugia of litter and coarse woody debris are retained. Possible effects of timber harvesting on arthropods include mechanical effects on soil and litter, microclimate changes, and the addition of organic matter to the forest floor. Soil compaction reduces pore size, which may result in loss of habitat and decreased nutrient retention, and changes the microbial and nematode communities, which can affect nutrient cycling and food resources for microarthropods. Thresholds required for healthy ecosystem function, and predictive and decision-support tools that include these components in relation to disturbances are not available.

Additional notes: Although it is mostly a literature review, this paper provides some unpublished results from studies done on prescribed burns.

URL: None at this time. Please check back for updates.
Keywords: soil/arthropods/insects/coarse woody debris

Noste, Nonan V. 1984. Influence of fire severity on response of evergreen ceanothus. In: Lotan, James E. and Brown, James K., compilers. Fire's effects on wildlife habitat--symposium proceedings; 1984 March 21; Missoula, MT. 91-96.

Groups: vegetative effects--understory; literature review.
Location: western North America.

Abstract: Fire plays an important role in *Ceanothus velutinus* habitat. Its impact varies with season and severity of fire. Knowledge of the interaction between fire severity and evergreen ceanothus habitat can assist managers in estimating the effect of fire on evergreen ceanothus and in developing burning prescriptions.

Additional notes: This paper emphasizes management strategies for using fire to encourage or discourage ceanothus reproduction and growth. In addition to reporting on species characteristics and fire severity relationship, the paper gives post-treatment results of fall and spring prescribed burns. Ceanothus cover increased after the spring burn, mostly because plants resprouted from root stocks. Ceanothus cover decreased after the fall burn, then started increasing again, again mostly due to resprouting. There were more seedlings established after the fall burn than the spring burn.

URL: None at this time. Please check back for updates.
Keywords: *Ceanothus velutinus*/ceanothus/prescribed burning/fire effects/wildlife/wildfire

Noste, Nonan V. and Bushey, Charles L. 1987. Fire response of shrubs of dry forest habitat types in Montana and Idaho. General Technical Report INT-GTR-239. Ogden, UT: USDA Forest Service, Intermountain Research Station. 22 p.

Groups: vegetative effects--understory; literature review.
Location: Idaho and Montana.

Abstract: Information on biological attributes and response to fire has been summarized for 20 shrub species associated with dry forest habitat types of Idaho and Montana. The effect of fire on shrubs is an important element in planning prescribed fire treatments designed to modify the shrub component of a stand. Information on individual species' biological attributes and response following fire has been synthesized from literature sources. Foresters responsible for planning fire management and specifying burn objectives need such information to design prescribed fire treatments that alter the shrub component of a stand.

URL: None at this time. Please check back for updates.
Keywords: shrubs/ fire effects/ prescribed fire/ ponderosa pine/ Douglas-fir/ limber pine

Page-Dumroese, Deborah; Jurgensen, Martin F.; and Harvey, Alan E. 2003. Fire and fire-suppression impacts on forest-soil carbon. Boca Raton, FL: CRC Press: 201-210.

Groups: soils; literature review.
Location: western U.S.

Abstract: None

Additional notes: This chapter is a review of literature and discusses the impact of fire on soil carbon pools, recovery after fire, the effects of a fire-suppression policy on soil carbon, methods to estimate carbon losses from fire, and the implications of fire management on soil carbon cycling and sequestration. Concerning prescribed fire and other treatments to reduce fuels, the authors state:

"Many ecosystems, particularly in the western United States, are now overloaded with surface fuels that have accumulated from fire suppression. This type of stand condition, with large amounts of surface fuel, is conducive to wildfire and can trigger catastrophic changes in soil productivity if fire severity is high...Much of a forest stand's C storage likely occurs above ground or in the deeper mineral soil horizons...Therefore, changes in mineral soil C (or lack of change) may not be an indicator of total-site C losses, since most C losses from fire occur in the forest floor material. Maintaining total-soil-profile C levels and soil productivity while reducing wildfire incidence in fire-suppressed stands will likely be achieved through a variety of strategies aimed at developing stands consisting of multiple species and multiple ages rather than managing for one species or age...This change in structure and age will also affect biological decomposition. Increased biological decomposition, along with prescribed fire, thinning, and salvage logging, can all be used to reduce fuel loads to help protect the soil resource.

"While it seems desirable to accelerate burning frequency in fire-dependent ecosystems that have not experienced recent fires, this could lead to changes in the cycling of soil nutrients (e.g., N, P, S), loss of soil water-holding capacity, increased soil hydrophobicity, alteration of microbial communities, and impared long-term soil productivity through loss of organic matter on some sites. A lowering of soil productivity after fire would also reduce future soil C sequestration, since biomass production in the subsequent stands would be less...However, the extent and impact of such soil changes under controlled burning conditions are largely unknown, but need to be researched as part of any large-scale ecosystem fire management plan."

URL: None at this time. Please check back for updates.
Keywords: soils/ carbon/ carbon sequestration/ forest soil/ fire/ fire-suppression/ prescribed burning/ thinning/ soil productivity

Pearson, Dean E. 1999. Small mammals of the Bitterroot National Forest: a literature review and annotated bibliography. General Technical Report RMRS-GTR-25. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station. 63 p.

Groups: wildlife; literature review.
Location: western Montana and Northern Rocky Mountains.

Abstract: Small mammal literature from western Montana and the Northern Rocky Mountains was reviewed to assess the ecological role of small mammals on the Bitterroot National Forest of western Montana and in the Northern Rocky Mountains. The goal was to understand how small mammals related to succession and how proposed ecosystem management goals would affect small mammals, the predators they support, and the roles they play in forest ecosystem functions. Small mammals fulfill numerous important roles in forest ecosystems by supporting a wide range of predators, dispersing seeds and mycorrhizal spores, altering the composition of vegetative communities through herbivory and seed predation, and preying on insects. Coarse woody debris (CWD) is among the most important habitat components for forest small mammals. Guidelines are suggested for managing CWD for small mammals with an emphasis on CWD recruitment.

Additional notes: This paper can be used to predict effects of prescribed fire.

URL: None at this time. Please check back for updates.
Keywords: small mammals/ coarse woody debris/ Montana

Peters, Robert L.; Frost, Evan; and Pace, Felice. 1996. Managing for forest ecosystem health: a reassessment of the "forest health crisis." Washington, D.C.: Defenders of Wildlife.

Groups: fire behavior/fuel reduction; insects/diseases; vegetative effects--stand level; literature review.
Location: western U.S.

Abstract: None

Additional notes: In the conclusion, the authors state, “Recent congressional and Forest Service initiatives aimed at solving the purported "forest health emergency" are likely to further degrade, rather than restore, forest ecosystems. At best, these initiatives are driven by major ecological misconceptions that include: 1) reliance on a narrow definition of forest health biased toward timber production that fails to recognize or address declines in biodiversity, soils, water quality and other ecological values not directly associated with tree health; 2) exaggeration of the severity and geographic extent of problems with fire, insects, and disease, and mischaracterization of these problems as a "crisis;" and 3) promotion of widespread salvage logging as a means for restoring "forest health," despite the fact that salvage logging damages soils, water quality and wildlife habitat and has yet to be shown effective at reducing fire risks on a landscape scale.

"To the contrary, we conclude that: 1) long-term sustainability of forest ecosystems requires adopting a definition of health that recognizes the need to maintain all components of the ecosystem; 2) insects, disease, and fire are integral parts of forest ecosystems, and while there may be increased activity of these agents in some specific areas, these disturbances are not so widespread or severe as to constitute a "crisis;" and 3) while thinning and prescribed fire offer some potential for improving ecosystem health in some areas, salvage logging is usually not appropriate because it is likely to result in more environmental damage than would be caused by wildfire, insects, or disease. What is needed is a clear set of objectives for maintaining and restoring ecosystem health and a coordinated strategy to achieve those objectives that minimizes risks to the numerous values and services provided by federal forests.”

URL: http://www.defenders.org/bio-fh00.html
Keywords: salvage logging/ forest health/ thinning/ prescribed fire/ restoration

Pilliod, David S.; Bury, R. Bruce; Hyde, Erin J. and others. 2003. Fire and amphibians in North America. Forest Ecology and Management. 178(2003): 163-181.

Groups: wildlife; literature review.

Location: North America.

Abstract: Information on amphibian responses to fire and fuel reduction practices is critically needed due to potential declines of species and the prevalence of new, more intensive fire management practices in North American forests. The goals of this review are to summarize the known and potential effects of fire and fuels management on amphibians and their aquatic habitats, and to identify information gaps to help direct future scientific research. Amphibians as a group are taxonomically and ecologically diverse; in turn, responses to fire and associated habitat alteration are expected to vary widely among species and among geographic regions. Available data suggest that amphibian responses to fire are spatially and temporally variable and incompletely understood. Much of the limited research has addressed short-term (1-3 years) effects of prescribed fire on terrestrial life stages of amphibians in the southeastern United States. Information on the long-term negative effects of fire on amphibians and the importance of fire for maintaining amphibian communities is sparse for the majority of taxa in North America. Given the size and severity of recent wildland fires and the national effort to reduce fuels on federal lands, future studies are needed to examine the effects of these landscape disturbances on amphibians. We encourage studies to address population-level responses of amphibians to fire by examining how different life stages are affected by changes in aquatic, riparian, and upland habitats. Research designs need to be credible and provide information that is relevant for fire managers and those responsible for assessing the potential effects of various fuel reduction alternatives on rare, sensitive, and endangered amphibian species.

Additional notes: The following come from the section "Potential effects of management activities associated with fire and fuel reduction:"

Prescribed burning—"In a recent review, Russell et al. (1999) suggested that prescribed fire would likely benefit herpetofauna in the southeastern coastal plain and other fire-maintained ecosystems by restoring historical mosaics of successional stages, habitat structures, and vegetative species compositions. Returning fire to riparian forests may also benefit amphibians by reducing forest canopy cover and creating breeding habitat, particularly if hydroperiods are extended due to reduced evapotranspiration. Stream amphibians may be negatively affected by prescription burning if surface erosion results in sedimentation and thus subsequent loss of breeding, feeding, and cover habitats. Megahan et al. (1995) report that surface erosion rates on burned areas in granitic watersheds can be 66 times greater than on undisturbed slopes, and annual sediment yields can be elevated for 10 years or more.

"Russell et al. (1999) argue that any fire-induced mortality or decrease in herpetofaunal diversity in a particular patch will be outweighed by increased habitat heterogeneity and maintenance of preferred or required habitat resources. Although positive relationships between amphibian abundance and prescribed burning have been reported for a few amphibian species in North America, we caution against making management decisions based on relationships that result from studies with small sample sizes and limited geographic area (Russell et al., 1999). Furthermore, Russell et al. (1999) recommend that future prescribed fire studies should have more rigorous experimental designs, including larger sample sizes, pre-fire baseline data, more carefully selected controls, and better replication."

Mechanical fuel reduction, thinning, and logging—"To our knowledge, no studies have directly examined the effects of thinning understory brush or removing coarse woody debris on amphibians, although the effects of logging on amphibians are fairly well documented (Bury and Corn 1988; Corn and Bury 1989; Welsh 1990; Dupuis and Steventon 1999; Naughton et al. 2000). If thinning understory "ladder" fuels results in increased air temperatures, decreased soil moisture, and lower habitat complexity, amphibian populations could decline in thinned forests (Dupuis and Steventon 1999). We need more research on what habitats are suitable for amphibians in undisturbed forests versus forests where understory has been removed.

"The use of timber harvest to simulate fire has been proposed under the framework of ecosystem management, and some land managers are attempting to simulate natural fire mosaics using selective harvesting practices. Constible et al. (2001) tested this concept by comparing amphibian populations in undisturbed, harvested, and naturally burned landscapes in the mixed conifer boreal forests of northeastern Alberta. In an attempt to simulate fire mosaics, harvested areas were cut in varying shapes and sizes (5-60 ha) and had at least one clump of mixed age trees per hectare with unmerchantable timber, snags, understory, downed logs, and slash piles. In

both terrestrial and lake margin habitats, researchers could not detect consistent differences between burned or logged areas, but suggested that wood frogs and boreal chorus frogs require extensive ground cover and moist soil conditions, both of which can be reduced after burning or logging (Constible et al. 2001). To our knowledge, there is no other information on harvesting as a surrogate for fire as related to amphibians."

URL: None at this time. Please check back for updates.
Keywords: amphibians/aquatic ecosystems/fuel reduction/prescribed fire/wildland fire

Potter, Deborah Ulinski and Fox, Douglas G. 1996. Clean air and healthy ecosystems: managing emissions from fires. In: Ffolliott, Peter F.; DeBano, Leonard F.; Baker, Malchus B., Jr. and others, technical coordinators. Effects of fire on Madrean Province ecosystems: a symposium proceedings; General Technical Report RM-GTR-289. Ogden, UT: USDA Forest Service Rocky Mountain Research Station: 205-216.

Groups: air quality; literature review.
Location: nationwide.

Abstract: After nearly a century of avid fire suppression, land managers are substantially increasing prescribed burning to meet ecosystem management objectives. As scientists and managers we need to accurately quantify the capacity of airsheds to assimilate smoke and related atmospheric pollutants from wildfire and prescribed fire within acceptable limits for air quality. Conversely, we need to quantify increases in ecosystem health that result from prescribed fire, as well as the ecological cost of fire suppression. Resolutions for prescribed burning programs to protect both qulaity of soil, water, and air, and foster healthy ecosystems are presented. This includes a discussion of revised models and current efforts to quanitify how prescribed fire can be used to offset wildfire emissions.

URL: None at this time. Please check back for updates.
Keywords: air quality/prescribed burning/smoke/wildfire

Ream, Catherine H. 1981. The effects of fire and other disturbances on small mammals and their predators: an annotated bibliography. General Technical Report INT-GTR-106. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station. 55 p.

Groups: wildlife; literature review.
Location: North America.

Abstract: This report contains an annotated bibliography of the effects of fire, logging, grazing, and spraying on small mammals and their predators. Each citation lists keywords. A brief summary of the general effects of fire on some of the more common small mammals in western coniferous forests is included.

Additional notes: This bibliography provides an overview of fire effects on small mammals and may be useful to predict effects of prescribed fire. The responses of small mammal populations to fire and other disturbances are directly related to the modification of vegetation and food sources. Shrews require a mat of ground vegetation for cover. They are temporarily eliminated from areas where the fire has removed the duff and ground vegetation and will not return until a ground cover develops. Rabbit and snowshoe hare habitat will be unsuitable where fire removes shrubs and small, pole-sized conifers used for food and cover. High beaver populations have historically followed disturbances such as fire or logging that initiate a succesional sequence in which aspen is an intermediate stage. Fire may improve chipmunk habitat by creating openings, especially if the openings contain logging slash or rock outcrop cover. Chipmunks also increase with the establishment of seed- and fruit-producing plants. Ground squirrels benefit from fire and other disturbances that remove forest canopy. Red and flying squirrels need trees for denning and will use fire-killed trees if they are surrounded by living trees. Red squirrels feed on conifer seeds, so require live mature trees for a food source. Flying squirrels feed mostly on fungi and may use fire-created openings for foraging. Pocket gophers benefit from disturbance which removes the forest canopy, scarifies the soil, and results in the development of an herbaceous vegetation food source, Deer mice are pioneer species, so benefit from disturbances that result in early seral stages. A hot

fire that destroys the surface organic layer will eliminate red-backed and other voles from an area. Logging improves the growth of forbs by decreasing competition for light and soil moisture, which benefits voles in the *Microtus* genus, but *Clethrionomys* populations (red-backed voles) are usually decimated by the removal of the forest canopy.

URL: None at this time. Please check back for updates.
Keywords: fire effects/ small mammals/ mammals/ prescribed fire/ wildfire

Rieman, Bruce and Clayton, Jim. 1997. Wildfire and native fish: issues of forest health and conservation of sensitive species. Fisheries. 22(11): 6-15.

Groups: fisheries; hydrology; literature review.
Location: western U.S.

Abstract: Issues related to forest health and the threat of larger, more destructive wildfires have led to major new initiatives to restructure and recompose forest communities in the western United States. Proposed solutions will depend, in part, on silvicultural treatments and prescribed burning. Large fires can produce dramatic changes in aquatic systems, including altered sediment and flow regimes, fish mortality, and even local extinctions. Responses of salmonid populations to large disturbances such as fire indicate that complexity and spatial diversity of habitats are important to the resilience and persistence of populations. Some populations retain the ecological diversity necessary to persist in the face of large fires, and natural events such as wildfire have been important in creating and maintaining habitat diversity. Although timber harvest and fire can precipitate similar changes in watershed processes, we do not necessarily expect the physical and ecological consequences of large fires and timber harvest to be the same. We agree that healthy forests are fundamental to healthy aquatic ecosystems. In their haste to restore unhealthy forests, however, managers must take care to avoid simplistic solutions that compound problems already present in the management of aquatic ecosystems and native fishes. Management to restore ecological structure, composition, and process is largely experimental and potentially risky. We propose that the mosaic of conditions in both terrestrial and aquatic systems provides an opportunity to learn and adapt new management without placing key remnant aquatic habitats and populations at risk.

URL: None at this time. Please check back for updates.
Keywords: prescribed fire/thinning/fuel reduction/fish/aquatic habitat/restoration

Russell, Kevin R.; Van Lear, David H.; and Guynn, David C., Jr. 1999. Prescribed fire effects on herpetofauna: review and management implications. Wildlife Society Bulletin. 27(2): 374-384.

Groups: wildlife; literature review.
Location: North America, but most studies cited are from southern U.S.

Abstract: None

Additional notes: The authors reviewed currently available information concerning effects of prescribed burning on amphibians and reptiles. They considered both direct responses of herpetofauna to fire and indirect effects via changes in upland and aquatic habitats. Most information comes from the southern and eastern USA. Currently available information indicates that fire in general has little direct effect on most amphibians and reptiles. Any fire-induced mortality that occurs presumably is outweighed by maintaining preferred or required habitat features. In upland habitats, because prescribed burning often maintains or restores species composition and structure of naturally fire-dependent upland vegetation, herpetofauna historically adapted to these habitats not only tolerate but also benefit from such treatments. Negative impacts of prescribed fire on herpetofauna likely are greatest for species requiring leaf litter or other surface cover that is burned. Post-fire soil erosion can alter breeding habitat due to sedimentation. Prescribed fire also can be an important tool to maintain aquatic habitats because it reduces accumulation of organic matter that allows succession of isolated wetlands to shrub thickets and eventually closed-canopy stands. Although fire-induced disturbance may decrease herpetofaunal

diversity within a particular patch, a mosaic of successional stages and habitat structures should increase diversity on a broader scale.

URL: None at this time. Please check back for updates.
Keywords: amphibians/reptiles/fire effects/disturbance/fire/habitat diversity/herpetofauna/management/prescribed fire

Ryan, Kevin C. 1982. Evaluating potential tree mortality from prescribed burning. In: Baumgartner, David M., editor. Site preparation and fuels management on steep terrain; 1982 February 15-17; Spokane, WA. Pullman, WA: Washington State University Cooperative Extension: 167-179.

Groups: vegetative effects--trees; literature review.
Location: western U.S.

Abstract: Prescribed burning is increasingly being used under standing timber for site preparation and fuels management. Managers need guidelines for determining species and individual tree characteristics that are potentially capable of incuring minimal injury from a fire treatment.

A synthesis of literature on tree mortality resulting from prescribed burning is presented. Emphasis is primarily on the direct effects of fire on tree crown and boles. Models for predicting crown scorch and cambial kill are described. Guidelines are offered for minimizing fire related injury to the residual stand and evaluating the need for salvaging fire damaged trees.

Additional notes: In the summary, the author states, “Three types of fire damage, if excessive, result in tree mortality: foliage scorch and bud kill in the crown, cambial kill on the bole, and root kill. Fire managers should fully appreciate that each is controlled by a different aspect of the fire, and the conditions or prescription under which the fire burns.

"Crown scorch is determined primarily by flame length, which in turn, depends upon how rapidly fine fuels are ignited. Windspeed and air temperature are of secondary importance. The prescribed flame lengths should be low enough to insure maintenance of an adequate crown ratio for subsequent growth. The ignition pattern should be designed to maintain the prescribed flame length. This is accomplished by controlling the depth of the flaming zone through variation of strip firing width.

"Bole damage is determined primarily by the duration of burning in woody fuels. Bole damage can be minimized by selecting moisture conditions that limit the consumption of large woody fuels to the minimum consistent with other objectives. The amount of large woody fuel that can be safely consumed increases as the bark thickness of the leave trees increases. When both high levels of fuel consumption and tree survival are desired, additional steps should be taken to protect the trees.

"Root damage is determined primarily by the amount of duff that is consumed. Managers should prescribe the minimum reduction essential for adequate site preparation. Burning should be avoided when the lower duff moisture content is less than 35 percent. Large, thick-barked ponderosa pine and western larch with thick bark at the base are a possible exception to this rule.

"Leave trees in prescribed burn areas should be selected with the above considerations in mind.”

URL: None at this time. Please check back for updates.
Keywords: prescribed burning/fire effects/forest trees/mortality

Sandberg, David V.; Ottmar, Roger D.; Peterson, Janice L. and others. 2002. Wildland fire in ecosystems: effects of fire on air. General Technical Report RMRS-GTR-42 Vol. 5. USDA Forest Service, Rocky Mountain Research Station. 79 p.

Groups: air quality; literature review.
Location: North America.

Abstract: This state-of-knowledge review about the effects of fire on air quality can assist land, fire, and air resource managers with fire and smoke planning, and their efforts to explain to others the science behind fire-related program policies and practices to improve air quality. Chapter topics include air quality regulations and fire; characterization of emissions from fire; the transport, dispersion, and modeling of fire emissions; atmospheric and plume chemistry; air quality impacts of fire; social consequences of air quality impacts; and recommendations for future research.

URL: http://www.fs.fed.us/rm/pubs/rmrs_gtr42_5.html
Keywords: air quality/ smoke/ policy/ fire/ emissions

Saveland, James M. and Bunting, Stephen C. 1987. Fire effects in ponderosa pine forests. In: Ponderosa pine--the species and its management: symposium proceedings; 1987 September 29-October 1; Spokane, WA. Pullman, WA: Washington State University, Cooperative Extension: 125-131.

Groups: vegetative effects--stand level; vegetative effects--understory; literature review.
Location: Selway-Bitterroot Wilderness of northern Idaho and western Montana.

Abstract: Fire has always been a significant ecological force in ponderosa pine communities. Thus, prescribed fire can be used to thin stands, eliminate thickets, increase forage yields, improve species composition, encourage sprouting of desirable woody species, and reduce wildfire hazards. This paper recounts some observations made on fires allowed to burn in the Selway-Bitterroot Wilderness and then explores recent research on fire effects on both the overstory and understory of ponderosa pine communities.

URL: None at this time. Please check back for updates.
Keywords: wildfire/ponderosa pine/prescribed fire/fire effects/understory burning

Scott, Donald W.; Szymoniak, John; and Rockwell, Victoria. 1996. Entomological concerns regarding burn characteristics and fire effects on tree species during prescribed landscape burns: burn severity guidelines and mitigation measures to minimize fire injuries. La Grande, OR: USDA Forest Service, Pacific Northwest Region, Wallowa-Whitman National Forest, Blue Mountains Pest Management Zone. 48 p.

Groups: insects/diseases; vegetative effects--trees; literature review.
Location: Blue Mountains of northeastern Oregon.

Abstract: None

Additional notes: In the summary, the authors state, “Just as it is important to minimize injury and weakening of trees during harvest activities to avoid future insect or disease problems, it is equally important to minimize the level of injury to trees after a prescribed fire for the same reason. We have described conditions of fire-injury that may result in the attraction of insect populations of significant concern to stand health and tree survival after a fire, regardless of fire origin. Under favorable conditions, populations of tree-killing bark beetles can, and do, build up very quickly in the presence of suitable habitat (i.e., fire-weakened hosts). An increased awareness of the fire-injury conditions that favor these buildups can help establish thresholds of acceptable damage from a prescribed fire.

"The increasing areas of eastside forests that annually burn in lightning-caused wildfires, and the increased use of landscape underburning to achieve ecosystem management objectives dictates the need for better information on insect-fire interactions and fire effects on 1) tree and vegetation survival, recovery, and growth; 2) forest pathogens; 3) soil and hydrologic processes; and 4) wildlife populations and habitat. The burn-severity guidelines given here address, at least in part, some of these issues. Specifically, we have presented guidelines that will: 1) assist resource managers in identifying and assessing risk of tree mortality from fire and/or insects

after prescribed burns or natural wildfires; 2) assist planning teams to achieve resource management objectives for prescribed fires or landscape underburns while establishing acceptable levels of post-fire mortality risk; and 3) assist fire planners in developing or refining burn prescriptions that avoid unacceptable losses of trees from heat injuries and insects after treatment.

"To provide practical solutions and mitigation for tree survival when carrying out burn prescriptions under varying conditions, we offer the fire planner a set of guidelines. The guidelines can be implemented in part or in total, or modified within reason, to meet the needs of individual prescribed fire situations. The guidelines are not intended as direction, but only as suggestions to help achieve post-treatment resource and fire objectives, and avoid untoward consequences from fire or insects during, and after, landscape underburning."

Guidelines cover the following: 1) "determine acceptable mortality "risk" levels for desirable trees;" 2) "minimize crown injury;" 3) "minimize root injury;" 4) "minimize stem injury;" 5) "modify characteristics of available fuels to optimize conditions for desired fire behavior;" 6) "modify ignition patterns to manage the amount of fuel that is burning at any one time;" 7) "reduce heavy fuels during harvest operations or use a 2-tiered fuels treatment approach when predicted fuel loadings are excessive and could result in flame lengths that would cause excessive injury to crowns;" and 8) "utilize the mosaic burn patterns of landscape underburning to emulate the diversity of natural, historical fire patterns and processes across the landscape."

They also state that , "As a final recommendation, we place heavy emphasis on the need to conduct post-treatment monitoring of fire effects. Follow-up evaluations are essential to measure results against expectations, and to identify unanticipated problems. These activities are inherent to adaptive management."

URL: http://www.fs.fed.us/pnw/lagrande/bmpmsc.htm
Keywords: insects/ prescribed fire/ fire-injured trees/ bark beetles/ tree survival

Smith, Jane Kapler. Fire Effects Information System [Web Page]. Available at: http://www.fs.fed.us/database/feis/.

Groups: fisheries; vegetative effects--stand level; vegetative effects--trees; vegetative effects--understory; wildlife; literature review.
Location: North America.

Abstract: The Fire Effects Information System (FEIS) provides up-to-date information about fire effects on plants and animals. It was developed at the United States Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory in Missoula, Montana.

The FEIS database contains literature reviews, taken from current English-language literature of almost 900 plant species, about 100 animal species, and 16 Kuchler plant communities found on the North American continent. The emphasis of each review is fire and how it affects each species. Background information on taxonomy, distribution, basic biology, and ecology of each species is also included. Reviews are thoroughly documented, and each contains a complete bibliography. Managers from several land management agencies (United States Department of Agriculture, Forest Service and United States Department of Interior, Bureau of Indian Affairs, Bureau of Land Management, Fish and Wildlife Service, and National Park Service) identified the species to be included in the database. Those agencies funded the original work and continue to support maintenance and updating of the database.

URL: http://www.fs.fed.us/database/feis/
Keywords: fire effects/wildlife/plants

---. 2000. Wildland fire in ecosystems: effects of fire on fauna. General Technical Report RM-GTR-42 Vol. 1. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station. 83 p.

Groups: wildlife; literature review.

Location: North America.

Abstract: Fires affect animals mainly through effects on their habitats. Fires often cause short-term increases in wildlife foods that contribute to increases in populations of some animals. These increases are moderated by the animals' ability to thrive in the altered, often simplified, structure of the post-fire environment. The extent of fire effects on animal communities generally depends on the extent of change in habitat structure and species composition caused by fire. Stand-replacement fires usually cause greater changes in the faunal communities of forests than in those of grasslands. Within forests, stand-replacement fires usually alter the animal community more dramatically than understory fires. Animal species are adapted to survive the pattern of fire frequency, season, size, severity, and uniformity that characterized their habitat in presettlement times. When fire frequency increases or decreases substantially or fire severity changes from presettlement patterns, habitat for many animal species declines.

Additional notes: This literature review can be used to predict effects of prescribed fire on wildlife species. Also, by using appropriate search terms on the electronic version, a reader can quickly find papers and results relevant to prescribed fire in this area. Discussion on wildlife responses to understory fires will also provide guidance for determining effects of prescribed fire.

URL: None at this time. Please check back for updates.
Keywords: fire effects/ fire management/ fire regime/ habitat/ succession/ wildlife/ wildfire/ prescribed fire/ understory burning

Tiedemann, Arthur R.; Klemmedson, James O.; and Bull, Evelyn L. 2000. Solution of forest health problems with prescribed fire: Are forest productivity and wildlife at risk? Forest Ecology and Management. 127(1-3): 1-18.

Groups: vegetative effects--stand level; wildlife; literature review.
Location: Blue Mountains of Oregon and Washington and the Intermountain area.

Abstract: Advanced forest succession and associated accumulations of forest biomass in the Blue Mountains of Oregon and Washington and Intermountain area have led to increased vulnerability of these forests to insects, diseases, and wildfire. One proposed solution is large-scale conversion of these forests to seral conditions that emulate those assumed to exist before European settlement: open-spaced stands (ca. 50 trees per ha), consisting primarily of ponderosa pine (*Pinus ponderosa* Laws.) and western larch (*Larix occidentalis* Nutt.). We question how well presettlement forest conditions are understood and the feasibility and desirability of conversion to a seral state that represents those conditions. Current and future expectations of forest outputs and values are far different from those at presettlement times. Emphasis on prescribed fire for achieving and maintaining this conversion raises questions about how well we understand fire effects on forest resources and values. We consider here potential effects of prescribed fire on two key aspects of forest management-productivity and wildlife. Use of large-scale prescribed fire presents complex problems with potential long-term effects on forest resources. Before implementing prescribed fire widely, we need to understand the range of its effects on all resources and values. Rather than attempting to convert forests to poorly described and understood presettlement seral conditions, it would seem prudent to examine present forest conditions and assess their potential to provide desired resource outputs and values. Once this is achieved, the full complement of forest management tools and strategies, including prescribed fire, should be used to accomplish the desired objectives. We suggest a more conservative approach until prescribed fire effects are better understood.

URL: None at this time. Please check back for updates.
Keywords: ecosystems/forestry practices/forests/habitat alterations/habitat management/management/snags/succession/wildlife/wildlife/habitat relationships/fire/dead wood/biomass/decomposition/forest floor/down wood/fuels/nutrients

USDA Forest Service. 2000. Survivability and deterioration of fire-injured trees in the northern Rocky Mountains: a review of the literature. Report 2000-13, Part 1. Missoula, MT: Northern Region, Forest Health

Protection Unit, Missoula Field Office. 10 p.

Groups: insects/diseases; vegetative effects--trees; literature review.
Location: northern Rocky Mountains.

Abstract: None.

Additional notes: In the summary, the authors state that, “Much remains to be learned before we will be able to accurately predict which trees will succumb to the effects of a wild or prescribed fire, which will survive, and which of those may ultimately be killed by bark beetles. Some of the more severely affected trees will unquestionably die; some of the least affected will no doubt survive. Trees between the two extremes are ones most difficult to predict because of their varying susceptibility to bark beetles, the effects of post-fire weather, and other site/stand factors difficult to measure and not well-understood. Susceptibility to bark beetles is determined by: 1) amount of damage and a tree's response to it, 2) populations of bark beetles in the vicinity of damaged trees, 3) weather for several months to several years prior to and following the fire, and 4) time of year fire occurs. In addition, a complex of factors--some more fully understood than others--are involved in a tree's survivability. Not the least of those are its pre-fire physiological condition, an array of abiotic site factors, a host of potentially damaging biotic agents, and interactions among all of them.

"Realistically, we will never unfailingly predict either post-fire survival or death for all trees. But reasonably reliable estimates, sufficient for most management decisions, are possible if all parameters we can measure are adequately considered.”

URL: None at this time. Please check back for updates.
Keywords: bark beetles/ wildfire/ prescribed fire/ tree survival/ Douglas-fir/ ponderosa pine/ lodgepole pine/ Engelmann spruce/ subalpine fir/ western larch/ grand fir

Walstad, John D.; Radosevich, Steven R.; and Sandberg, David V. 1990. Natural and prescribed fire in Pacific Northwest forests. Corvallis, OR: Oregon State University Press. 317 p.

Groups: fire behavior/fuel reduction; fisheries; hydrology; insects/diseases; social/human dimensions/esthetics; soils; vegetative effects--stand level; vegetative effects--trees; vegetative effects--understory; wildlife; literature review.
Location: Pacific Northwest.

Abstract: None.

Additional notes: This text discusses the uses, benefits, and effects of prescribed fire in the Pacific Northwest, including eastern Oregon and Washington. Prescribed fire is defined as both broadcast burning after harvest and underburning. Chapter 2 provides an overview of the book. This is a synthesis of literature and personal knowledge, with authors including many of the leading researchers on fire effects and prescribed fire. Major sections include: Natural History and Ecology; Application of Prescribed Fire; Interactions of Prescribed Fire with Forest Protection Considerations; Effects of Prescribed Fire on Forest Productivity; Effects of Prescribed Fire on Nontimber Resources; Public Attitudes and Regulation of Prescribed Fire in Forest Ecosystems; and Integration. Each of the 20 chapters in these sections starts with an executive summary and ends with a list of literature cited and other key references.

URL: None at this time. Please check back for updates.
Keywords: prescribed burning/ fire effects/ soils/ wildlife/ air quality/ public attitudes/ fuel reduction/ insects/ diseases/ water quality/ water quantity/ fish/ economics

Wells, Carol G.; Campbell, Ralph E.; DeBano, Leonard F. and others. 1979. Effects of fire on soil: a state-of-knowledge review. General Technical Report WO-GTR-7. USDA Forest Service. 34 p.

Groups: soils; literature review.
Location: nationwide.

Abstract: None.

Additional notes: This state-of-knowledge review that came from a workshop in 1978 provides information on the effects of fire on soils, showing that fire intensity and the resulting degree of exposure of mineral soil to heat govern the degree of response to all soil properties investigated. The information in the publication can be used to plan prescription fires by helping managers understand the effects of different types and frequency of fires, but the paper doesn't present new research specifically of prescribed fire effects.

URL: None at this time. Please check back for updates.
Keywords: soil/ fire effects/ fire intensity

Wondzell, Steven M. 2001. The influence of forest health and protection treatments on erosion and stream sedimentation in forested watersheds of Eastern Oregon and Washington. Northwest Science. 75 (Suppl.): 128-140.

Groups: soils; literature review.
Location: eastern Oregon and Washington.

Abstract: A variety of Forest Health and Protection treatments have been proposed to reduce long-term risks to forests from wildfire, insects, and disease. This review examines the potential effects of these treatments on sediment production in watersheds, channel forming processes, riparian vegetation, and risks posed to riparian zones. Wildfires can affect upland erosion; however, erosion from prescribed fires burning the same area should be much smaller. Dense riparian vegetation might help regulate the amount of sediment that reaches streams, but this effect would be strongly dependent on the geomorphic setting. Forest pathogens are not expected to cause accelerated erosion and stream sedimentation directly, but indirect effects might be substantial if they lead to increased wildfire. The largest risk of accelerated erosion is expected from ground-disturbing activities during fuels reduction treatments, such as construction of roads and firebreaks or salvage logging or thinning. Intense grazing has changed composition and cover of riparian vegetation, leading to bank erosion, and in many places, widening or incision of stream channels. Improved grazing prescriptions can result in major changes to riparian vegetation, but response of channel morphology will most likely be slow. Most of the studies reviewed were conducted at the site or small-watershed scale. Consequently, conclusions at these scales are generally well supported by the available literature. The cumulative effects of forest health and protection treatments imposed across a large region are difficult to assess, however. Given the current state of knowledge, dramatically changing forest land use practices across eastern Oregon and Washington--including the widespread use of prescribed fires, salvage logging, and mechanical fuel treatments--is a long-term, landscape-scale experiment, the cumulative effects of which are unknown.

Additional notes: The authors caution that the analysis should be considered preliminary.

URL: None at this time. Please check back for updates.
Keywords: erosion/forest health/forest pests/grazing/insect pests/plant pests/protection/riparian vegetation/risk/sediment/sedimentation/streams/watersheds

Yount, J. David and Niemi, Gerald J. 1990. Recovery of lotic communities and ecosystems from disturbance--a narrative review of case studies. Environmental Management. 14(5): 547-569.

Groups: hydrology; literature review.
Location: case studies from throughout the U.S.

Abstract: We present a narrative account of case studies of the recovery of flowing water systems from disturbance, focusing on the investigators' conclusions about recovery time and the factors contributing to

recovery. We restrict our attention to case studies in which the recovery of some biological property of the system has been examined, excluding those that deal only with physical or chemical properties. Although natural processes and rates of recovery are emphasized, studies of reclamation or restoration of damaged ecosystems are included where they contribute to an understanding of recovery processes.

For the majority of studies examined, the systems recovered quite rapidly. The most commonly cited reasons for short recovery times were: 1) life history characteristics that allowed rapid recolonization and repopulation of the affected areas, 2) the availability and accessibility of unaffected upstream and downstream areas and internal refugia to serve as sources of organisms for repopulation, 3) the high flushing rates of lotic systems that allowed them to quickly dilute or replace polluted waters, and 4) the fact that lotic systems are naturally subjected to a variety of disturbances and the biota have evolved life history characteristics that favor flexibility or adaptability. In general, longer recovery times were observed in disturbances, such as channelization, that resulted in alterations to physical conditions.

This review also indicates that much of our knowledge of recovery in lotic ecosystems is fragmented and uncoordinated. In addition to establishing the bounds of recovery time, our review identifies some research gaps that need to be filled.

Additional notes: This literature/case study review doesn't deal with fuel reduction, but the conclusions could be applied to disturbances involving prescribed fire and thinning.

URL: None at this time. Please check back for updates.
Keywords: aquatic ecosystem/fish/lotic systems/disturbance/recovery time

Air Quality

There are only three papers in this section. This is a good example of a resource where scientific principles may be all we have or need to have to assess effects of prescribed fire on air quality. Also, given the small scale of most prescribed fires, it would be infeasible to study the effects on air quality.

Hardy, Colin C.; Ottmar, Roger D.; Peterson, J. L. and others. 2001. Smoke management guide for prescribed and wildland fire: 2001 edition. PMS 420-2. Boise, ID: National Wildfire Coordinating Group. 226 p.

Groups: air quality.
Location: U.S.

Abstract: None

Additional notes: This guide provides fire management and smoke management practitioners with a fundamental understanding of fire emissions processes and impacts, regulatory objectives, and tools for the management of smoke from fires. It is intended to provide national guidance for the planning and management of smoke from prescribed fires to achieve air quality requirements through better smoke management practices.

URL: http://www.fs.fed.us/pnw/pubs/ottmar-smoke-management-guide.pdf
Keywords: smoke/wildfire/prescribed burning/air quality

Potter, Deborah Ulinski and Fox, Douglas G. 1996. Clean air and healthy ecosystems: managing emissions from fires. In: Ffolliott, Peter F.; DeBano, Leonard F.; Baker, Malchus B., Jr. and others, technical coordinators. Effects of fire on Madrean Province ecosystems: a symposium proceedings; General Technical Report RM-GTR-289. Ogden, UT: USDA Forest Service Rocky Mountain Research Station: 205-216.

See Literature Reviews.

Sandberg, David V.; Ottmar, Roger D.; Peterson, Janice L. and others. 2002. Wildland fire in ecosystems: effects of fire on air. General Technical Report RMRS-GTR-42 Vol. 5. USDA Forest Service, Rocky Mountain Research Station. 79 p.

See Literature Reviews.

Economics

There are 14 papers that cover economics. Most of them use real costs, while some predict costs of treatments and alternatives. Although most of the rest of this bibliography does not include modeling studies, this section on economics does include some models.

Arno, Stephen F. and Allison-Bunnell, Steven. 2002. Flames in our forest: disaster or renewal? Washington, DC: Island Press.

Groups: economics; fire behavior/fuel reduction; vegetative effects--stand level.
Location: western US.

Abstract: None

Additional notes: Chapter 9 is "Fire-prone forests: can we adapt to them?" and Chapter 10 is "Restoring nature's creative force." Using a combination of literature citation, personal experience, and anecdotal information from others, the authors discuss the value of prescribed fire and thinning to restore forested lands. There are several stories of fire intensity decreasing upon entering treated areas, and others of fires burning through previously treated areas that hadn't been maintained by subsequent prescribed burns. They also discuss the benefits and risks of prescribed fire. For example, according to a GAO report from 1999, the cost of prescribed burning to reduce fuels and avoid damaging overstory trees varies from about $30 to $400 per acre. In contrast, suppression of a wildfire in the residential forest zone commonly costs more than $1000 per acre, and the fire often kills most of the trees.

URL: None at this time. Please check back for updates.
Keywords: prescribed fire/ understory burning/ ecosystem management

Arno, Stephen F. and Harrington, Michael G. 1998. The Interior West: managing fire-dependent forests by simulating natural disturbance regimes. In: Forest management into the next century: what will make it work?; 1997 November 19-21; Spokane, WA. Madison, WI : Forest Products Society and USDA Forest Service: 53-62.

See Fire Behavior and Fuel Reduction.

Fiedler, Carl E.; Keegan, C. E., III; Wichman, Daniel P. and others. 1999. Product and economic implications of ecological restoration. Forest Products Journal. 49(2): 19-23.

Groups: economics.
Location: western U.S.

Abstract: The call for ecological restoration of declining forest conditions in the western United States has raised concerns about a fundamental change toward smaller, lower-value timber products flowing from national forest lands. The objective of this study was to evaluate restoration prescriptions for three widely occurring ponderosa pine stand conditions, and determine the degree to which the value of product removals might underwrite treatment costs. In mature pine conditions on terrain suitable for ground-based harvest equipment (in other words, $\leq$ 35 percent slope), a comprehensive restoration prescription produced a net revenue of $950/acre with a roundwood-pulpwood market, and $875/acre without one. On terrain >35 percent slope requiring cable-yarding systems, net values were $600/acre with a pulpwood market, and $500/acre without. In contrast, thinning-from-below using ground-based equipment required a $50/acre subsidy with a pulpwood market, and $300/acre without one. Using cable systems, a subsidy of $300/acre would be needed with a pulpwood market, and $600/acre without one. In dense second-growth conditions using ground-based equipment, the restoration

prescription produced $500/acre with a pulpwood market, and $325/acre without. With cable systems, this prescription produced $75/acre with a pulpwood market, but required a subsidy of $100/acre without one. Using ground-based equipment in moderately open conditions, the restoration prescription needed a $50/acre subsidy with a pulpwood market, and $75/acre without. Corresponding shortfalls with cable systems were $250/acre and $275/acre, respectively. Results show the importance of selecting: 1) comprehensive prescriptions over thinning-from-below for restoring mature stands; and 2) dense second-growth stands over moderately open ones in terms of treatment priority.

URL: None at this time. Please check back for updates.
Keywords: economics/treatment costs/restoration/ponderosa pine/*Pinus ponderosa*

Jolley, Stephen M. 2001. Fighting fire without fire: biomass removal as a prelude to prescribed fire. Fire Management Today. 61 (3): 23-25.

Groups: economics.
Location: western U.S.

Abstract: None.

Additional notes: This article compares costs and timelines using three different hypothetical scenarios for fuels reduction on 500 acres in western forest ecosystems. In scenario I, trees are removed and marketed to offset operational costs; the desired stand condition would be reached in 3-6 years at a profit of $70-$75/acre. Scenario II would not include harvesting merchantable trees; the desired stand condition would be reached in 3-6 years at a cost of $315-$365/acre. In scenario III, only prescribed fire would be used; the desired stand condition would be reached in 25-30 years at a cost of $375-$750/acre. Prescribed fire has other drawbacks besides costs: reduced air quality, it doesn't contribute to community stability, and resource risk to resources if a prescribed fire escapes. This is not a study of actual costs but more of a modeling exercise.

URL: http://www.fs.fed.us/fire/fmt/fmt_pdfs/fmt61-3.pdf
Keywords: forest fire/wildfire/fire danger/prescribed burning

Keegan, Charles E., III and Fiedler, Carl E. 2000. Synergy between ecological needs and economic aspects of ecosystem restoration . In: Smith, Helen Y., Editor. The Bitterroot Ecosystem Management Project: what we have learned--symposium proceedings; 1999 May 18-20; Missoula, MT. Proceedings RMRS-P-17. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station: 74-76.

Groups: economics.
Location: Inland Northwest.

Abstract: The implementation of properly designed treatments to restore and sustain desired forest conditions in the Inland Northwest, besides moving forest stands more rapidly to an ecologically desirable and sustainable condition, can generate positive revenues from the timber to be removed. These treatments also have potential to increase the number of relatively high paying jobs, especially in rural areas where per capita incomes are nearly 30 percent below those of urban areas. In contrast the much-proposed thin-from-below prescription commonly does not fully accomplish ecological goals and often requires a subsidy of several hundred dollars per acre to implement.

Additional notes: The comprehensive restoration treatment included low thinning in which nearly all trees <9 in d.b.h. were cut, modified selection cutting to reduce density and promote regeneration of ponderosa pine, and improvement cutting to remove most Douglas-fir/true firs as well as low-quality trees of all species not reserved for other purposes. The target stand density following these treatments was 50 sq ft/acre. The thin-from-below prescriptions was aimed at cutting most, or nearly all, of the trees ≤9 in d.b.h., with trees <5 in d.b.h. cut and slashed and those from 5 to 9 in d.b.h. removed. The comprehensive restoration approach would generate $300 to more than $1000/acre while the thin-from-below approach would likely require a subsidy.

URL: None at this time. Please check back for updates.
Keywords: economics/costs/benefits/thinning/ponderosa pine

Keegan, Charles E., III; Fiedler, Carl E.; and Stewart, Fred J. 1995. Cost of timber harvest under traditional and "new forestry" silvicultural prescriptions. Western Journal of Applied Forestry. 10(1): 36-42.

Groups: economics.
Location: western Montana.

Abstract: Harvest costs were estimated for New Forestry silvicultural prescriptions designed for application on national forest lands in western Montana. Estimates were derived using an expert opinion format and were compared using constant dollars with actual 1991 costs based on more traditional prescriptions. Costs were developed for three major logging systems (tractor with hand-felling, tractor with mechanical-felling, and uphill skyline with hand-felling) and four major stand types [lodgepole pine (*Pinus contorta*), mature ponderosa pine (*P. ponderosa*)/Douglas-fir (*Pseudotsuga menziesii*), second-growth pine/fir, and mixed conifer]. Average harvest costs for New Forestry prescriptions ranged from no increase to 48 percent ($72/mbf) higher. In light of stumpage price increases of >$200/mbf since 1991, these increased costs should be a minor factor in determining the feasibility of future timber harvest.

Additional notes: Prescriptions varied by stand type and included clearcuts, shelterwood cuts, group selections cuts, and individual tree selection cuts.

URL: None at this time. Please check back for updates.
Keywords: economics/costs/benefits/thinning/ponderosa pine/Douglas-fir/lodgepole pine/mixed conifer forest/clearcut/shelterwood cut/selection cutting

Kilgore, Bruce M. and Curtis, George A. 1987. Guide to understory burning in ponderosa pine-larch-fir forests in the Intermountain West. General Technical Report INT-GTR-233. Ogden, UT: USDA Forest Service, Intermountain Research Station. 39 p.

Groups: economics.
Location: seven National Forests in Montana and Oregon.

Abstract: This guide summarizes the objectives, prescriptions, and techniques used in prescribed burning beneath the canopy of ponderosa pine stands, and stands of ponderosa pine mixed with western larch, Douglas-fir, or grand fir. The guide is based on information from 12 Districts in seven National Forests in Montana and Oregon that have active programs of understory burning in several specific kinds of forest vegetation-SAF cover types--interior ponderosa pine, western larch, interior Douglas-fir, and grand fir. Information is based on interviews with Forest managers and a 2-day workshop.

The sizes of current programs ranged from more than 6,000 acres per year in the six districts in the Northern Region (Montana and Idaho) to nearly 36,000 acres in the six Districts in the Pacific Northwest Region (Oregon and Washington). Costs ranged from $2 per acre in spring burning to more than $250 per acre in fall burning. The guide covers cost management, resource management, fire objectives, burning constraints, and situations requiring great caution. The guide explains how to develop burning prescriptions based on the experience of burning experts, combined with recent findings at the Forest Service Intermountain Fire Sciences Laboratory, Missoula, MT.

Topographic factors (aspect, slope, elevation), fuel quantity and moisture levels, weather factors, and timing all play key roles in developing a burning prescription.

Preburn preparation, involving thorough unit layout and planning, firelines, appropriate protection for leave trees, and other fuel treatment, combined with particular ignition techniques and firing patterns, is essential to

successful understory burning in this vegetation type. Most experienced burners recommend starting with small units and building toward larger ones.

Good programs are usually tied to a positive attitude toward use of prescribed fire. Patience is essential in understory burning, and best results are often achieved with small crews.

It is important to know the relationship between fuel moisture and fuel consumption. Understory burning in this forest type requires hard work and careful preparation. It may take two or three prescribed burns over an extended period of time to meet all desired objectives.

Additional notes: The information in this paper is based on managers' experience, not on a research study.

URL: None at this time. Please check back for updates.
Keywords: prescribed fire/ ponderosa pine/ Douglas-fir/ western larch/ grand fir/ understory burning

Lynch, Dennis L. and Mackes, Kurt. 2003. Costs for reducing fuels in Colorado forest restoration projects. In: Omi, Philip N. and Joyce, Linda A., technical editors. Fire, fuel treatments, and ecological restoration: conference proceedings; 2002 April 16-18; Fort Collins, CO. Proceedings RMRS-P-29. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station: 167-175.

Groups: economics.
Location: Colorado.

Abstract: The costs to either mechanically remove or mechanically treat forest fuels are examined for various Colorado sites. In the ponderosa pine and mixed conifer zones, no ideal treatment system exists yet for forest restoration through fuel reduction. Each site requires its own ecological analysis. Costs for forest restoration varies by ecological prescription, forest and terrain conditions, and market availability for potential products. In most cases, it may cost too much to remove material or treat areas. Logging may be the most economical method if markets for products exist and processing facilities are nearby.

Additional notes: In the conclusions, the authors state that they believe value-added product development potential is likely to be highest in the utilization of the 8" to 11.9" material found on treatment sites. This material, and the 12" + diameter class material, may be able to offset costs of cutting, handling, processing, and transporting the low value chip material found in the 3" to 7.9" diameter classes.

URL: http://www.fs.fed.us/rm/pubs/rmrs_p029.html
Keywords: costs/economics/thinning/ponderosa pine/mixed conifer forest/fuel reduction

McIver, James D. 1998. Economics and environmental effects of fuel reduction at Limber Jim. Technical notes from the Blue Mountains Natural Resources Institute, BMNRI-TN-10. LaGrande, OR: 12 p.

Groups: economics; fire behavior/fuel reduction; soils.
Location: Wallowa-Whiteman National Forest in Oregon.

Abstract: Fuel reduction by mechanical thinning and removal was studied in mixed-conifer stands on Limber Jim ridge, La Grande District, Wallowa-Whitman National Forest, between 1995 and 1997. Mixed-conifer stands on this ridge had some of the highest fuel loads on La Grande District, up to 80 tons per acre. A single-grip harvester was coupled with either a skyline yarder or a forwarder, and fuel reduction, soil disturbance, and operational economics were measured in three replicate stands. The two retrieval systems achieved nearly identical patterns of fuel and standing stem reduction, with 53 percent of fuel and 36 percent of stems left after harvest in all units. In forwarder units more total material was removed per acre compared to skyline units (57.1 tons v. 48.1 tons), though this difference was not statistically significant. About 80 percent of the total material removed was dead. The only difference in pattern of fuel reduction was for the 9.1-20 in. size class, where skyline retrieval left 45 percent of pre-treatment fuel, compared to 74 percent for the forwarder. Soil disturbance

was statistically identical for the two retrieval systems, with 6.0 percent area disturbed for the forwarder, and 7.3 percent for the skyline yarder; both retrieval methods were well within the 15 percent Region 6 standard, assuming 5 percent disturbance for existing roads. However, the pattern of soil disturbance was different for the two systems, with the forwarder causing signficantly more compaction than the skyline yarder (1.7 percent v. 0.2 percent; P=0.03); there was a trend toward less displacement with the use of the forwarder (4.3 percent v. 7.0 percent; P=0.13). Overall, the entire project was a narrow economic success, at just over $10/ton profit. Revenue in skyline units was slightly higher than forwarder units ($63/ton v. $61/ton); this difference was due to the slightly greater harvest of sawlog material in the skyline units. However, operational cost was $71/ton in the skyline units, and $42/ton in the fowarder units. This difference resulted in a net revenue loss of $10/ton in the skyline units, and in a net revenue gain of $19/ton in the forwarder units. Relatively flat ground and small-diameter/low-value material clearly favored the fowarding machine at Limber Jim; a larger average stem size and greater slope deflection would likely favor the skyline system. These results are discussed in the context of adaptive management, in which operational experiments provide information that allows the manager to assess economic/environmental tradeoffs inherent in management decisions.

URL: http://www.fs.fed.us/pnw/bmnri/pubs/tn10.pdf
Keywords: fuels/ fire control/ fire ecology/ logging effects/ thinning/ mechanical methods/ harvesters/ economics/ environmental impact/ national forests

Rummer, Bob; Prestemon, Jeff; May, Dennis and others. 2003. A strategic assessment of forest biomass and fuel reduction treatments in western states. USDA, Forest Service, Research and Development in partnership with the Western Forest Leadership Coalition. 21 p.

See Hydrology.

Saveland, James M. 1987. Using prescribed fire to reduce the risk of large wildfires: a break-even analysis. In: Proceedings of the ninth conference of fire and meteorology; 1987 April 21-24; San Diego, CA. Boston, MA: American Meteorological Society: 119-122.

Groups: economics.
Location: Nez Perce National Forest, northcentral Idaho.

Abstract: None

Additional notes: This paper examines the monetary tradeoffs of investing in a prescribed fire program in natural fuels to reduce the probability of large, costly fires. It uses a break-even analysis to look at the financial trade-offs of suppressing large fires compared to conducting an annual prescribed fire program, using an example from the Nez Perce National Forest. The paper concludes by stating that there is an opportunity for large financial gains in prescribed burning of natural fuels in critical areas. Further research is needed to determine the effect of prescribed burning on the magnitude of change of the probability of large, severe fires.

URL: None at this time. Please check back for updates.
Keywords: economics/prescribed fire/break-even analysis

Scott, Joe. 1998. Reduce fire hazards in ponderosa pine by thinning. Fire Management Notes. 58(1): 20-25.

Groups: economics.
Location: Lolo National Forest in western Montana.

Abstract: None.

Additional notes: Four rectangular 6-acre (2.4 ha) treatment areas in stands of ponderosa pine (*Pinus ponderosa*) and Douglas-fir (*Pseudotsuga menziesii*) with an understory of grasses, snowberry, kinnikinnick,

ninebark, and serviceberry, were established in the Ninemile Ranger District, Montana. These stands had not been subject to burning since approximately 1900. Three thinning treatments to reduce fire hazard were developed with a second objective of improving forest health while maintaining the esthetic values of the forest. Treatment #1: minimum impact, meaning lightly thinned; slash small Douglas-firs, and existing dead and down fuels were hand-piled and burned after drying for one summer. Treatment #2: revenue production, stand density was reduced by 50 percent by harvesting all sizes of trees. This produced pulp logs and medium sawlogs. Slash was piled at a landing and burned after drying. Treatment #3: forest restoration, stand density was reduced 50 percent by removal of the smallest, weakest trees. Slash was spread evenly in the stand to allow nutrients to recycle. After the slash had dried for one summer it was broadcast-burned in the autumn. Treatment #1 was favored for esthetic value and was moderately effective in reducing the fire hazard. Treatment #2 generated the largest income, was effective at reducing the fire hazard, and ranked high esthetically. Treatment #3 was the most effective in reducing fire hazard. However, esthetic quality was low.

URL: http://www.fs.fed.us/fire/fmt/fmt_pdfs/fmn58-1.pdf
Keywords: aesthetics/esthetics/ponderosa pine/Douglas-fir/thinning/slash burning/broadcast burning/fuel reduction/economics

Scott, Joe H. 1998. Fuel reduction in residential and scenic forests: a comparison of three treatments in a western Montana ponderosa pine stand. Research Paper RMRS-RP-5. Rocky Mountain Research Station, USDA Forest Service. 19 p.

See Fire Behavior and Fuel Reduction.

--. 1996. Reducing forest fire hazard in residential and scenic areas: a case study comparing three treatments in a western Montana ponderosa pine stand. Final Report RJVA #92685. Missoula, MT: Intermountain Fire Sciences Laboratory. 48 p.

See Social and Human Dimensions, and Esthetics.

Fire Behavior and Fuel Reduction

These 44 papers address how effectively thinning and/or prescribed fire treatments succeeded in changing fire behavior or reducing fuel levels. In some cases, papers are included that just barely mention fuel reduction. In other cases, it was the main focus of the article.

Agee, James K.; Bahro, Berni; Finney, Mark A. and others. 2000. The use of fuelbreaks in landscape fire management. Forest Ecology and Management. 127 (1-3): 55-66.

See Literature Reviews.

Arno, Stephen F. and Allison-Bunnell, Steven. 2002. Flames in our forest: disaster or renewal? Washington, DC: Island Press.

See Economics.

Arno, Stephen F. and Harrington, Michael G. 1998. The Interior West: managing fire-dependent forests by simulating natural disturbance regimes. In: Forest management into the next century: what will make it work?; 1997 November 19-21; Spokane, WA. Madison, WI : Forest Products Society and USDA Forest Service: 53-62.

See Fire Behavior and Fuel Reduction.

Arno, Stephen F.; Harrington, Michael G.; Fiedler, Carl E. and others. 1995. Restoring fire-dependent ponderosa pine forests in western Montana. Restoration and Management Notes. 13(1): 32-36.

See Vegetative Effects—Understory.

Barbouletos, Catherine S.; Morelan, Lynette Z.; and Carroll, Franklin O. 1998. We will not wait: why prescribed fire must be implemented on the Boise National Forest. In: Pruden, Teresa L. and Brennan, Leonard A., editors. Proceedings: 20th Tall Timbers fire ecology conference; 1996 May 7-10; Boise, ID. Tallahassee, FL: Tall Timbers Research Station: p. 27-30.

Groups: fire behavior/fuel reduction.
Location: Boise National Forest in Idaho.

Abstract: Understanding ecosystem dynamics is important for the successful restoration of fire-excluded ponderosa pine (*Pinus ponderosa*) stands on the Boise National Forest. It is important that such management and restoration actions be undertaken on the Boise National Forest immediately, and that such actions be based on working hypotheses. Management strategies can be modified as hypotheses are supported or refuted. Silvicultural treatments, such as thinning, prescribed burning, and reforestation, can simulate disturbance regimes that have influenced these forests for over 10,000 years. Forest managers will never have sufficient information to make fully informed management decisions. However we currently have adequate information on criteria such as fire-return intervals and appropriate stand structure, to use as a basis for initiating restoration efforts on large areas of ponderosa pine stands that have been fire-excluded on the Boise National Forest.

Additional notes: There is no research reported in this paper. It is included because the authors give anecdotal accounts of two crown fires that changed to ground fires on areas that had been previously thinned and/or treated with prescribed fire on the Boise National Forest.

URL: None at this time. Please check back for updates.
Keywords: thinning/prescribed burning/reforestation/fire return intervals/fuel reduction

Brown, James K. and Johnston, Cameron M. 1987. Predicted residues and fire behavior in small-stem lodgepole pine stands. In: Management of small-stem stands of lodgepole pine: workshop proceedings; 1986 June 30-July 2; Fairmont Hot Springs, MT. General Technical Report INT-GTR-237. Ogden, UT: USDA Forest Service, Intermountain Research Station: 151-161.

Groups: fire behavior/fuel reduction.
Location: Deerlodge, Lewis and Clark, and Gallatin National Forests of Montana.

Abstract: Fuel loading, fireline intensity, and expected fire size were determined after harvesting small-stem lodgepole pine stands. Curves relating predicted fireline intensity to slash fuel loading and windspeed are presented. Removing about 15 tons per acre of residues reduced fireline intensity by half, but in some situations it still was too high to allow direct suppression. Effects of cutting level, method of felling, fuel removal, lopping, and slash age on expected fire size were evaluated. Commercial thinning with directional felling reduced expected fire size to that of undisturbed forest within 5 years. Nominal lopping was ineffective in reducing expected fire size. Methods for managers to use in appraising slash fuel hazard are reviewed. Economic analysis of fuel treatment is discussed.

URL: None at this time. Please check back for updates.
Keywords: conifers/forest fires/fire danger/fuels/slash/thinning/ecology/pines/lodgepole pine/*Pinus contorta*

Brown, James K.; Marsden, Michael A.; Ryan, Kevin C. and others. 1985. Predicting duff and woody fuel consumed by prescribed fire in the Northern Rocky Mountains. Research Paper INT-RP-337. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station. 23 p.

Groups: fire behavior/fuel reduction; soils.
Location: western Montana (Flathead and Lolo National Forests and University of Montana's Lubrecht Experimental Forest) and northern Idaho (Coeur d'Alene Reservation).

Abstract: Relationships for predicting consumption of forest floor duff and downed, dead, woody fuel were determined to assist managers in planning prescribed fires. Data were analyzed from three previous prescribed fire studies in slash and nonslash fuels in cover types comprising a mixture of western larch, Douglas-fir, ponderosa pine, lodgepole pine, Engelmann spruce, subalpine fir, and grand fir. Duff depth reduction, percentage duff depth reduction, and percentage mineral soil are shown as regression functions of lower duff moisture content, entire duff moisture content, National Fire-Danger Rating System (NFDR) 1,000-hour moisture content, Canadian Adjusted Duff Moisture Code, preburn downed woody fuel loading, and preburn duff depth. Tests of the duff consumption relationships against other published data support their wide application.

Lower duff moisture content was the best predictor. Preburn downed woody fuel loading was of minor importance in the relationships. The NFDR 1,000-hour moisture predicted duff consumption with adequate precision for general guidance in developing fire prescriptions.

The NFDR 1,000-hour moisture was a better predictor of duff consumption and lower duff moisture than were two Canadian Duff Moisture Codes. The relationship between percentage mineral soil exposure and percentage duff reduction indicates that combustion in duff progresses both downward and laterally.

Consumption of downed woody fuel correlated strongly with preburn loadings. Percentage consumption, however, related weakly to all independent variables. Consumption differed substantially between slash (81 percent) and nonslash (46 percent). An evaluation of Sandberg and Ottmar's (1983) diameter reduction model based on large pieces of fresh slash under-estimated by 35 percent the consumption of mostly rotten nonslash

fuels, indicating the extent that consumption differs between sound and rotten material.

URL: None at this time. Please check back for updates.
Keywords: fuel consumption/ duff/ down wood/ forest fuels/ prescribed fire

Brown, Richard T.; Agee, James K.; and Franklin, Jerry F. 2004. Forest restoration and fire: principles in the context of place. Conservation Biology. 18(4): 903-912.

See Literature Reviews.

Carey, Henry and Schumann, Martha. 2003. Modifying wildfire behavior--the effectiveness of fuel treatments: the status of our knowledge. National Community Forestry Center, Southwest Region Working Paper, The Forest Trust. 26 p.

See Literature Reviews.

Carlton, Donald W. and Pickford, Stewart G. 1982. Fuelbed changes with aging of slash from ponderosa pine thinnings. Journal of Forestry. 80(2): 91-93, 107.

Groups: fire behavior/fuel reduction; soils.
Location: eastside Cascade Range of Washington.

Abstract: (Part of this abstract has been deleted. See the original paper for the least-squares equation). Fuel loading stratified by standard fuel size classes and fuelbed depth data from 11 precommercially thinned stands of ponderosa pine (*Pinus ponderosa* Dougl. ex Laws) indicated that changes in slash fuelbeds varying in age from 0 to 17 years can be described mathematically as a function of slash age and basal area of trees removed…Prescribed burning produced changes in loading and bed depth that were the equivalent of 2 to 20 or more years of natural aging. These results should be of use to land managers, but since they are from one drainage of the eastern side of the Cascade Range in Washington they may need adjusting before being applied to other areas.

Additional notes: Burning produced reductions in depth of fuelbed equivalent to an aging period of 8 years in burns conducted in the spring, and at least 20 years for fall burns.

URL: None at this time. Please check back for updates.
Keywords: fire/fire danger/conifers

DellaSala, Dominick A. and Frost, Evan. 2001. An ecologically based strategy for fire and fuels management in national forest roadless areas. Fire Management Today. 61(2): 12-23.

See Literature Reviews.

Fiedler, Carl E.; Arno, Stephen F.; and Harrington, Michael G. 1996. Flexible silviculture and prescribed burning approaches for improving health of ponderosa pine forests. In: Covington, W. and Wagner, P. K., technical coordinators. Conference on adaptive ecosystem restoration and management: restoration of Cordilleran conifer landscapes of North America; General Technical Report RM-GTR-278. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station: 69-74.

Groups: fire behavior/fuel reduction; vegetative effects--stand level.
Location: Bitterroot National Forest (Lick Creek) and Lubrecht Experimental Forest of western Montana.

Abstract: Prior to 1900, open stands of large, fire-resistant ponderosa pine (occasionally with western larch) covered extensive areas of the West. Since the early 1900s, virtual elimination of low-intensity fires in ponderosa pine and pine/mixed conifer forests has resulted in major ecological disruptions. Today, many stands support dense thickets of small trees (often firs), and manifest insect/disease infestation and high potential for severe wildfire. These forests cover tens of millions of acres and are the focus of forest health concerns. Restoration efforts are complicated by profound changes in stand composition and structure, poor tree vigor, and fuel accumulation. Returning fire under these conditions could fatally damage already stressed overstory trees. Restoring more natural and sustainable conditions often requires a combination of silvicultural tree removal in terms of species, number, and size. In some stands, thinning from below will be sufficient, while in others, selection cutting will be needed to reduce overstory density and allow regeneration of shade-intolerant species. Depending on overstory composition and observed regeneration patterns, openings may require planting to ensure regeneration of desired species. Because fire was historically the primary disturbance agent in ponderosa pine/larch types, prescribed fire should be considered in any restoration efforts. However, most forests in need of restoration cannot be effectively treated by fire alone. Linking appropriate silvicultural and prescribed fire is the key to restoration. Prescribed fire is generally the most effective means of reducing high fire hazard, eliminating large numbers of understory trees, stimulating seral herbaceous and shrubby vegetation, creating receptive seedbed, and transforming nutrients into an available form. However, after decades of fire exclusion, existing forest conditions require a cautious but determined approach to fire application.

Additional notes: This publication reports on early results of treatments at the Lick Creek site in the Bitterroot National Forest and at the University of Montana's Lubrecht Experimental Forest, mostly concerning amount of fuel reduction accomplished.

URL: None at this time. Please check back for updates.
Keywords: ponderosa pine/*Pinus ponderosa*/fuel reduction/prescribed burning/selection cutting

Graham, Russell T.; Harvey, Alan E.; Jain, Theresa B. and others. 1999. The effects of thinning and similar stand treatments on fire behavior in western forests. General Technical Report PNW-GTR-463. Portland, OR : USDA Forest Service, Pacific Northwest Research Station. 28 p.

See Literature Reviews.

Graham, Russell T.; Harvey, Alan E.; Jurgensen, Martin F. and others. 1994. Managing coarse woody debris in forests of the Rocky Mountains. Research Paper INT-RP-477. Ogden, UT: USDA Forest Service, Intermountain Research Station. 13 p.

See Soils.

Graham, Russell T. and McCaffrey, Sarah. 2003. Influence of forest structure on wildfire behavior and the severity of its effects. Executive summary of a draft report . USDA Forest Service. 12 p.

See Literature Reviews.

Graham, Russell T.; McCaffrey, Sarah; and Jain, Theresa B. 2004. Science basis for changing forest structure to modify wildfire behavior and severity. General Technical Report RMRS-GTR-120. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station. 43 p.

See Literature Reviews.

Hardy, Colin C. and Arno, Stephen F. 1996. The use of fire in forest restoration--proceedings: annual

meeting of the Society for Ecological Restoration; 1995 September 14-16; Seattle, WA. General Technical Report INT-GTR-341. Ogden, UT: USDA Forest Service, Intermountain Research Station.

See Vegetative Effects at the Stand Level.

Harrington, Michael. 1999. Effects of ecosystem-based management treatments: prescribed burn weather, fuel moistures, and fuel reduction on all cutting units. In Smith, Helen Y and Arno, Stephen F., editors. Eighty-eight years of change in a managed ponderosa pine forest. General Technical Report RMRS-GTR-23. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station: 27-28.

Groups: fire behavior/fuel reduction.
Location: Bitterroot National Forest in western Montana (Lick Creek).

Abstract: None

Additional notes: At the Lick Creek site in western Montana, the U.S. Forest Service applied a different kind of silvicultural cutting treatment for each of three experimental stands consisting of 80 to 100 acres each. Within each silvicultural cutting system, they applied different underburning strategies as well as no burn treatments. In the shelterwood cutting units, some subunits were not burned, some had a wet burn (low fuel consumption), and some had a dry burn (high fuel consumption). In the selection cutting units, some subunits were not burned, some had an intermediate burn, and some acted as controls with no cut but with a burn. In the commercial thinning units, some had no burn, some had a fall burn, and some had a spring burn. Woody fuels were measured before and after burning and 48 duff spikes were placed in each replicate to measure total duff depth and consumption. Fuel loadings and percent reduction for each treatment are presented. A significant portion of the pre-existing and slash fuel were consumed by the prescribed fires. None of the treatments, including those under very dry conditions, resulted in excessively negative impacts.

URL: None at this time. Please check back for updates.
Keywords: commercial thinning/ selection cutting/ shelterwood cut/ ponderosa pine/ Douglas-fir/ partial cutting/ prescribed burning/ fuel consumption

---. 1999. Effects of ecosystem-based management treatments: stand structure response to harvesting and prescribed burning on shelterwood cutting and commercial thinning units. In Smith, Helen Y and Arno, Stephen F., editors. Eighty-eight years of change in a managed ponderosa pine forest. General Technical Report RMRS-GTR-23. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station: 28-31.

See Vegetative Effects at the Stand Level.

Hirsch, Kelvin and Pengelly, Ian. 1999. Fuel reduction in lodgepole pine stands in Banff National Park. In: Proceeding of the conference on crossing the millennium: integrating spatial technologies and ecological principals for a new age in fire management; 1999 June 15-17; Boise, ID. Moscow, ID: University of Idaho and International Association of Wildland Fire. 6 p.

Groups: fire behavior/fuel reduction.
Location: Banff National Park, Canada.

Abstract: Over the last decade fire managers in Banff National Park have embarked on a comprehensive fuels management program of which one aspect has been fuel reduction treatments near structures or facilities (for example, homes, campground, hotels). These treatments included the reduction of dead and down woody surface material (for example, logs, branches, twigs), removal of coniferous understory trees, pruning, and overstory thinning. Detailed measurements of all flammable material above mineral soil were made at four plots within the treated areas and four plots in stands immediately adjacent to the treatments. The fuel treatments resulted in a 3-, 4-, and 6-fold decrease in crown bulk density, stand density, and dead and down woody

material, respectively. The change in surface fuel loading caused a 50 percent reduction in the potential surface fire intensity. Based on Van Wagner's theories, the likelihood of crown fire initiation was significantly reduced and the rate of spread required to sustain continuous crowning rose almost 4 times.

URL: http://jfsp.nifc.gov/conferenceproc/P-09Hirschetal.pdf
Keywords: lodgepole pine/*Pinus contorta*/fuel reduction/thinning/pruning/fire behavior

Hungerford, Roger D.; Harrington, Michael G.; Frandsen William H.; Ryan, Kevin C. and others. 1991. Influence of fire on factors that affect site productivity. In: Harvey, A. E. and Neuenschwander, L. F., compilers. Proceedings: management and productivity of western-Montana forest soils; 1990 April 10-12; Boise, ID. General Technical Report INT-GTR-280. Ogden, UT: USDA Forest Service, Intermountain Research Station: 32-50.

See Literature Reviews.

Johnson, E. A. and Miyanishi, K. 1995. The need for consideration of fire behavior and effects in prescribed burning. Restoration Ecology. 3(4): 271-278.

See Literature Reviews.

Kalabokidis, Kostas D. and Omi, Philip N. 1998. Reduction of fire hazard through thinning/residue disposal in the urban interface. International Journal of Wildland Fire. 8(1): 29-35.

Groups: fire behavior/fuel reduction.
Location: near Rocky Mountain National Park in Colorado.

Abstract: Alternative fire hazard reduction techniques are needed for managing fuel profiles in forest ecosystems located within the so-called wildland-urban interface. The present study includes experimental fuel manipulations initiated along the Rocky Mountain National Park interface with residential areas in Colorado, USA. Three thinning/slash disposal treatments were applied on two lodgepole pine (*Pinus contorta*) stands: thinning with whole-tree removal; thinning with stem removal--lopping and scattering; and thinning with stem removal--hand piling and burning. Results indicate that treatments reduced surface fire behavior parameters, bringing them down and closer to limits of direct attack methods. Crown fire potential was decreased not only because of canopy removal, but also as a result of potential reduction in heat generated by surface fuels. Projected fire behavior for the thinning-without-slash-removal scenario indicates the possibility of serious control problems with major fire runs and crown fires given an outbreak.

URL: None at this time. Please check back for updates.
Keywords: forest fires/fuels management/wildland-urban interface/Colorado/lodgepole pine/*Pinus contorta*

Kalabokidis, Kostas D. and Wakimoto, Ronald H. 1992. Prescribed burning in uneven-aged stand management of ponderosa pine/Douglas-fir forests. Journal of Environmental Management. 34 (3): 221-235.

Groups: fire behavior/fuel reduction; soils; vegetative effects--stand level.
Location: western Montana (Lubrecht Experimental Forest and Champion Timber lands).

Abstract: The purpose of this study was to examine the effects of low intensity prescribed fires on wildfire hazard reduction, site preparation, and tree mortality of uneven-aged managed ponderosa pine/Douglas-fir (*Pinus ponderosa/Pseudotsuga menziesii*) forests. The study also provided the opportunity to determine the effects of uneven-aged silviculture on fire hazards. Burning followed the individual-tree selection cutting and full-tree utilization of an uneven-aged silvicultural prescription, which was developed for two stands in western Montana. Prescribed burning, following the full-tree utilization, proved to have no usefulness on fire hazard

reduction. Uneven-aged cutting without any fuel management treatment showed substantial fire behavior potential, far beyond the control limit of direct attack methods. Residual duff depth was not significantly different between the burned and the unburned treatment units. Mineral soil exposure of the burned unit was significantly greater than the unburned unit in only one of the study stands. Removal of the litter fuels was significantly greater in the burned units, contributing to a receptive seedbed for natural regeneration of shade-intolerant tree species. Fire succeeded in eliminating Douglas-fir regeneration. Losses of ponderosa pine seedlings were substantial, but a few saplings and seedlings did survive the fire. Fire also killed 6.5 to 9 percent of the overstory trees (over 3 m in height). Overstory mortality was statistically significant, but this mortality was confined to smaller trees (less than 12 cm in d.b.h.). Guidelines are offered for a safe and effective prescribed burning under standing timber in ponderosa pine stands.

URL: None at this time. Please check back for updates.
Keywords: ponderosa pine/Douglas-fir/forest regeneration/silviculture/forestry/fire hazard reduction/fire management/prescribed burning/uneven-aged management/fuel reduction/site preparation/species manipulation

Landsberg, J. D.; Cochran, P. H.; Finck, M. M. and others. 1984. Foliar nitrogen content and tree growth after prescribed fire in ponderosa pine. Research Note PNW-RP-412. Pacific Northwest Forest and Range Experiment Station, USDA Forest Service. 15 p.

See Vegetative Effects—Trees.

Martin, Robert E.; Kauffman, J. Boone; and Landsberg, Joan D. 1989. Use of prescribed fire to reduce wildfire potential. In: Berg, Neil H., technical coordinator. Proceedings of the symposium on fire and watershed management; 1988 October 26-28; Sacramento, CA. General Technical Report PSW-GTR-109. USDA Forest Service, Pacific Southwest Research Station: 17-22.

Groups: fire behavior/fuel reduction.
Location: some of case studies were in central Oregon and northcentral Washington.

Abstract: Fires were part of our wildlands prehistorically. Prescribed burning reduces fire hazard and potential fire behavior primarily by reducing fuel quantity and continuity. Fuel continuity should be considered on the micro scale within stands, the mid-scale among, and the macro-scale among watersheds or entire forests. Prescribed fire is only one of the tools which can be used to reduce fire hazard, but it can be effective at all scales.

Additional notes: This paper presents several case studies showing a change in wildfire behavior as a result of previous prescribed burning treatments. Several of the case studies were in central Oregon and northcentral Washington.

URL: None at this time. Please check back for updates.
Keywords: prescribed burning/wildfire/fire behavior/Oregon/Washington/fire hazard

Martin, Robert E.; Landsberg, Johanna D.; and Kauffman, J. Boone. 1998? Effectiveness of prescribed burning as a fire prevention measure. In: International workshop on prescribed burning: proceedings; 1988; Avignon, France: INRA Station of Mediterranean Silviculture: 31-44.

Groups: fire behavior/fuel reduction.
Location: Washington, Oregon, and California.

Abstract: Prescribed fire can have important uses in silviculture and fire prevention. The uses for silviculture are varied, but fire is not utilized anywhere near its potential in this important area. Fire is also underutilized for fuels reduction in fire prevention, but can help with modifying several fuel characteristics.

The most obvious effect of fire on fuels is to reduce quantity. In entering a forest stand with fire, it is probably best to enter with a moderate fuel consumption burn. Damage to the residual stand is far less than when fuel consumption is high. Further, escape potential is less so fewer personnel and equipment are necessary for holding, mop-up, and patrol. Burning may even be conducted faster, thus helping to compensate for the expense of a second burn.

Breaking of vertical continuity is another very important effect of prescribed burning for fire prevention. Once the probability of wildfires torching the crown is reduced significantly, ability of fire personnel to contain wildfires in forest stands is enhanced greatly. Damage to crowns, either from scorching or torching is also greatly reduced.

Prescribed fire can be used to reduce horizontal continuity, thus reducing fire spread in surface fuels. In forest stands, trees rapidly put down more biomass, so horizontal continuity may be restored rapidly.

When prescribed fires burn the smaller branches off dead and down fuels, the larger stems drop closer to the ground. In effect, this increases the compactness of the fuel bed, which should decrease fire spread potential. In addition, the fuels often remain moist longer and decay faster.

Finally, prescribed fire will generally remove a higher proportion of fine fuels. The effect is to give a higher proportion of larger fuel particles, or fuel particles, even though the large particles are also reduced. Removal of the fine particles would reduce the potential fire behavior.

Fire can be a very useful tool in forests and other wildland systems. Its use would often reintroduce a natural component of the systems, but also enhance resource management and fire prevention.

Additional notes: The authors collected data from 7 sites that had been prescribed burned, then measured dead and down fuels and shrub biomass. They then used models to predict potential fire behavior and the effects fires would have on forest stands.

URL: None at this time. Please check back for updates.
Keywords: fuel reduction/prescribed burning/fire behavior

Martinson, Erik; Omi, Philip N.; and Shepperd, Wayne. 2003. Part 3: Effects of fuel treatments on fire severity. General Technical Report RMRS-GTR-114. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station. 396 p.

Groups: fire behavior/fuel reduction.
Location: Hayman Fire on front range of Colorado.

Abstract: None

Additional notes: In the summary, the authors state: “each of the different types of fuel modification encountered by the Hayman Fire had instances of success as well as failure in terms of altering fire spread or severity. The most obvious effects were produced by the Polhemus prescribed burn, the Sheepnose timber harvest, and the prescribed fires associated with the Big Turkey wildfire in the Turkey Rock area…The Hayman Fire was clearly unable to burn into the Polhemus burn area even as a heading fire under the most extreme weather conditions. Without surface fuel removal, most of the trees in Sheepnose sale were killed, but the thinning obviously restricted fire behavior to a surface fire with reduced fire severity compared to crown fire in surrounding untreated stands. Acting together, two prescribed burns (Turkey Rx1990, Rx1995) and the Big Turkey wildfire (1998) appeared to have temporarily prevented a crown fire on June 17 along a 2-mile section of the eastern perimeter, although this area burned the following day.

"There is much variation and uncertainty in effects of individual treatment units or types. However, the detailed analysis of treatments encountered by the Hayman Fire supports the following general conclusions:

- Extreme environmental conditions (winds, weather, and fuel moisture) and the large size of the Hayman Fire that developed on June 9 overwhelmed most fuel modifications in areas burned by the heading fire that day.
- With some exceptions, fuel treatments did not stop the fire but did in many cases change fire behavior and effects. The ones that did are special cases because of their recent occurrence that should not be generalized for expectations for fuel treatment performance. Fuel treatments can be expected to change fire behavior but not stop fires from burning.
- Under more moderate wind and humidity conditions, recent prescribed burns appeared to have lower fire severity than older burns.
- Landscape effects of treatment units and previous wildfires were important in changing the progress of the fire.
- Fuel treatment size relative to the size of the wildfire was probably important to the impact on both progress and severity within the treatment unit. Large areas were more effective than small fuel breaks. Under extreme conditions, spotting easily breached narrow treatments and the rapid movement of the fire circumvented small units.
- No fuel treatments were encountered when the fire was small. The fire had time and space to become large and generate a convection column before encountering treatment units. Fuel treatments may have been more effective in changing fire behavior if they were encountered earlier in the progression of the Hayman Fire.
- Few fuel modifications had been performed recently, leaving most of the landscape within the final fire perimeter with no treatment or only older modifications. This is significant because the high degree of continuity in age and patch structure of fuels and vegetation facilitates development of large fires that, in turn, limit the effectiveness of isolated treatments encountered by the large fire."

URL: http://www.fs.fed.us/rm/pubs/rmrs_gtr114.html
Keywords: wildfire/ fuel treatments/ thinning/ prescribed fire/ stand structure/ treatment effectiveness

Martinson, Erik J. and Omi, Philip N. 2003. Performance of fuel treatments subjected to wildfires. In: Omi, Philip N. and Joyce, Linda A., technical editors. Fire, fuel treatments, and ecological restoration: conference proceedings; 2002 April 16-18; Fort Collins, CO. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station: 7-13.

Groups: fire behavior/fuel reduction.
Location: western U.S.

Abstract: Fire severity was evaluated in eight recent wildfires with standardized methods in adjacent treated and untreated stands. Sampled sites occurred in a variety of conifer forests throughout the western United States. Treatments included reduction of surface fuels and crown fuels, both in isolation and in combination. Synthesis of our results indicates that treatment effectiveness is related to differences in tree size (mean diameter) between treated and untreated stands ($p<0.001$), as well as estimated historic fire frequency ($p<0.1$). Our results suggest that fuel treatments will be most effective when they complement ecosystem restoration objectives, such as the removal of small trees from ecosystems that historically experienced frequent fire.

Additional notes: Two of the wildfires were in California; the rest were in Montana, Washington, Arizona, Mississippi, New Mexico, and Colorado. Their results unanimously indicate that fuel treatments reduced wildfire severity in treated areas. Crown scorch averaged 38 percent in treated areas across the eight study sites, versus 84.5 percent in untreated areas. Nonetheless, treatment effects among the study sites were variable in their significance, with much of the variability explained by site characterisitcs, particularly the differences in mean tree diameter between treated and untreated areas. Treatments that increase the average diameter of residual trees through removal of the smallest stems appear most effective.

URL: http://www.fs.fed.us/rm/pubs/rmrs_p029.html
Keywords: fire behavior/fire severity/fuel treatments/fuel reduction/prescribed fire/thinning/ponderosa pine/mixed conifer forest

McIver, James D. 1998. Economics and environmental effects of fuel reduction at Limber Jim. Technical notes from the Blue Mountains Natural Resources Institute, BMNRI-TN-10. LaGrande, OR: 12 p.

See Economics.

McLean, Herbert E. 1993. The Boise quickstep: a plan to restore the health of this Idaho national forest . American Forests. 99(Jan/Feb): 11-14.

Groups: fire behavior/fuel reduction.
Location: Boise National Forest in southern Idaho.

Abstract: None.

Additional notes: In August 1992, a wildfire burned more than 257,000 acres of range and forest lands near Boise, Idaho, fueled by high fuel loads, steep slopes, and low humidity. Fire suppression costs came to $16 million. However, in Tiger Creek, the crown fire skirted a particular 2,500 acre stand of ponderosa pines, leaving it the only surviving stand of trees within miles. The Tiger Creek stand had been commercially thinned, then "defueled" by the use of prescribed fire. The article discusses the implications of this for the management of other western forests. It mentions the Tiger Creek stand as an example of where thinning worked to prevent wildfire going through an area, but doesn't give more than a few details.

URL: None at this time. Please check back for updates.
Keywords: national forests-Idaho/forest management/forest fires/forest health/thinning

Norum, Rodney A. 1976? Fire intensity-fuel reduction relationships associated with understory burning in larch/Douglas-fir stands. In: Proceedings, Tall Timbers fire ecology conference and land management symposium ; 1974 October 8-10; Missoula, Montana. Tallahassee, FL.: Tall Timbers Research Station: 559-572.

Groups: fire behavior/fuel reduction.
Location: Lubrecht Experiment Station in western Montana.

Abstract: None

Additional notes: This project was designed to sample a wide range of burning conditions using understory burns in a mature stand of Douglas-fir and western larch. Nine of the 20 prescribed fires were conducted from early May to the first of July. The remaining 11 were burned from early September to mid-October. According to the summary, "Fuel consumption ranged from zero to near complete, yet complete control of the fires was retained. However, as fuel consumption increases, so does damage to the stand in the form of cambium death and crown scorch. Nevertheless, reasonable tradeoffs are possible. Several fires were conducted that consumed as much as 80 percent of the fuel, burning 25 to 35 tons per acre of down dead woody material and killing no more than 10 percent of the trees larger than 5 inches d.b.h. Five fires killed no trees of this size, which shows that significant fuel reduction can be accomplished without undue damage to trees. Estimates of fuel consumption, fire intensity, crown-scorch height, degree of cambium damage, and duff depth reduction, and other important fire results can be made from preburn measurement of fuels, burning conditions, and tree characteristics. An acceptable set of tradeoffs in desired objectives will have to be based on such estimates, and the fires conducted accordingly."

URL: None at this time. Please check back for updates.
Keywords: *Pseudotsuga menziesii*/*Larix*/forest management/prescribed burning/research/Rocky Mountains/Douglas-fir/western larch

Omi, Philip N. and Martinson, Erik J. 2002. Effects of fuels treatment on wildfire severity. Submitted to the

Joint Fire Science Program Governing Board. Fort Collins, CO: Western Forest Fire Research Center, Colorado State University. 36 p.

Groups: fire behavior/fuel reduction.
Location: central Colorado.

Abstract: The severity and extent of wildfires in recent years have increased public awareness of a widespread fuels problem in the nation's wildlands. Federal land management agencies have responded with plans to greatly expand fuel treatment programs. However, scant information exists on fuel treatment efficacy for reducing wildfire severity.

We investigated the severity of four recent wildfires that burned into existing fuel treatment areas. Treatments included repeated prescribed fires, single prescribed fires, debris removal, and mechanical thinning both with and without slash removal. All treatments were accomplished less than 10 years prior to wildfire occurrence. The historic fire regime of all sampled ecosystems was of the short fire return interval type and included Mississippi slash pine, California Douglas-fir, and ponderosa pine in Colorado and New Mexico.

Crown fire hazard (height to crown, crown bulk density, and basal area), fire resistance (height and diameter), and fire severity (scorch height, crown volume scorch, stand damage, and depth of ground char) were compared between treated and untreated areas. Our results unanimously indicate that treated stands experience lower fire severity than untreated stands that burn under similar weather and topographic conditions. Correlations between fire severity indicators and measures of crown fire hazard and fire resistance were generally good, but individual sites provide unique lessons that illustrate the importance of treating fuel profiles in their entirety.

The 20th Century has demonstrated clearly the futility of attempts to eliminate fire from natural landscapes. Society must learn to live with fire and the détente can be realized only through the medium of fuel treatments. Both the small percentage of wildfires that encounter fuel treatments and the small scale of treatments within the wildfires we investigated suggest the enormity of the task at hand.

Additional notes: The study site in central Colorado was ponderosa pine with lodgepole pine and Douglas-fir in the understory.

URL: None at this time. Please check back for updates.
Keywords: fire behavior/ fire severity/ fuel treatments/ fuel reduction/ prescribed fire/ thinning/ ponderosa pine

Peters, Robert L.; Frost, Evan; and Pace, Felice. 1996. Managing for forest ecosystem health: a reassessment of the "forest health crisis." Washington, D.C.: Defenders of Wildlife.

See Literature Reviews.

Pollet, Jolie and Omi, Philip N. 2002. Effect of thinning and prescribed burning on crown fire severity in ponderosa pine forests. International Journal of Wildland Fire. 11(1): 1-10.

Groups: fire behavior/fuel reduction.
Location: Montana, Washington, California, and Arizona.

Abstract: Fire exclusion policies have affected stand structure and wildfire hazard in North American ponderosa pine forests. Wildfires are becoming more severe in stands where trees are densely stocked with shade-tolerant understory trees. Although forest managers have been employing fuel treatment techniques to reduce wildfire hazard for decades, little scientific evidence documents the success of treatments in reducing fire severity. Our research quantitatively examined fire effects in treated and untreated stands in western United States national forests. Four ponderosa pine sites in Montana, Washington, California, and Arizona were selected for study. Fuel treatments studied include: prescribed fire only, whole-tree thinning, and thinning followed by prescribed fire. On-the-ground fire effects were measured in adjacent treated and untreated forests.

We developed *post facto* fire severity and stand structure measurement techniques to complete field data collection. We found that crown fire severity was mitigated in stands that had some type of fuel treatment compared to stands without any treatment. At all four of the sites, the fire severity and crown scorch were significantly lower at the treated sites. Results from this research indicate that fuel treatments, which remove small diameter trees, may be beneficial for reducing crown fire hazard in ponderosa pine sites.

Additional notes: Sites with mechanical fuel treatment appear to have more dramatically reduced fire severity compared to the site with prescribed fire only. Apparently, mechancial fuel treatments at three of the sites allow for more precise and controlled results compared to a prescribed fire. For example, mechanical fuel treatment programs may specify the exact number of post-treatment residual trees per hectare and the treatment can be applied uniformly across the stand. By contrast, prescribed fuel treatment often varies across a stand and results in less precise stand structure changes.

URL: http://www.publish.csiro.au/?nid=115&issue=611
Keywords: controlled burning/crown/fire behavior/forest fires/fuels/scorch/stand structure/thinning

Pollet, Jolie and Omi, Philip N. 1999. Effect of thinning and prescribed burning on wildfire severity in ponderosa pine forests. In: Proceeding of the conference on crossing the millennium: integrating spatial technologies and ecological principals for a new age in fire management; 1999 June 15-17; Boise, ID. Moscow, ID: University of Idaho and the International Assocociation of Wildland Fire: 137-141.

Groups: fire behavior/fuel reduction.
Location: Montana, Washington, California, and Arizona.

Abstract: None

Additional notes: This study tested whether fuel treatments affected fire severity in four wildfires burning in ponderosa pine forests in Washington (Tyee site), Montana (Webb site), Arizona (Hochderffer site), and California (Cottonwood site). In the results section, the authors state, “The treated plots in this study have lower fire severity ratings and less crown scorch than the untreated plots. From these results we infer that the types of fuel treatments studied reduce fire severity rating and crown scorch. The treated plots burned less severely in terms of below-ground fire severity. Based on the statistical results and field reconnaissance, sites with mechanical fuel treatment appear to have more dramatically reduced fire severity compared to sites with prescribed fire only. Although fire severity ratings and percent crown scorch are lower at treated plots and higher at untreated plots at all sites, the Webb site’s differences were the least extreme. Apparently, mechanical fuel treatments at the Tyee, Cottonwood, and Hochderffer sites allow for more precise and controlled results compared to prescribed fire. For example, mechanical fuel treatment programs may specify the exact number of post-treatment residual trees per hectare and the treatment can be applied uniformly across the stand. By contrast, prescribed fire fuel treatment often varies across a stand and results in less precise stand structure changes.

"For the Webb, Tyee, and Cottonwood sites, the stand characteristics contributed to the differences in fire severity. The fuel treatments at these three sites resulted in forests with much lower density and larger trees. Stands with fewer trees have less continuous crown and ladder fuels. Larger trees generally have crowns higher off the ground and have thicker bark which makes them more fire resistant. This twofold benefit of treated stands results in lower potential for crown fire initiation and propagation and for less severe fire effects. Stand structure for the Hochderffer site is not significantly different among the treated and untreated stands; other factors contributed to less severe fire effects in the treated stands since fire severity and percent crown scorch differences cannot be explained by stand structure manipulations.”

URL: http://jfsp.nifc.gov/conferenceproc/T-03Polletetal.pdf
Keywords: ponderosa pine/prescribed fire/thinning/fire severity/fuel treatments/fuel reduction/wildfire

Scott, Joe H. 1998. Development of two indices of crown fire hazard and their application in a western

Montana ponderosa pine stand. Missoula, MT: University of Montana. 75 p. Thesis.

Groups: fire behavior/fuel reduction.
Location: Lolo National Forest in western Montana.

Abstract: Quantitative assessment of surface fire potential is possible with Rothermel's mathematical fire spread model. However, no quantitative means of comparing crown fire potential is available. In this thesis, two ordinal indices of crown fire potential, the Torching Index and the Crowning Index, have been developed for comparing the relative susceptibility of different stands to crown fire. The indices are derived from links among Van Wagner's transition criteria and Rothermel's models of surface and crown fire spread rate.

The indices are then used to compare the effectiveness of hazard reduction treatments in a western Montana ponderosa pine stand. Three contrasting thinning treatments to reduce fire hazard were implemented in a 100-year-old ponderosa pine/Douglas-fir (*Pinus ponderosa/Pseudotsuga menzesii*) stand on the Lolo National Forest, Montana. All treatments included a commercial thinning designed to reduce crown fuels and provide revenue to offset costs. Treatment 1 "was minimum impact," Treatment 2 was "revenue production," and Treatment 3 was "forest restoration."

Total surface fuel loadings were reduced slightly by all treatments, but fine fuel load increased except in Treatment 3. All treatments raised crown base height and reduced crown bulk density, making crown fires less likely.

The potential for passive crown fire was reduced by all treatments except Treatment 2. Torching Index values for the treated stands ranged from 135 to 256, while the untreated stand was 188. The Crowning Index increased to 33-43 in the treated stands from a base of 28 in the untreated stand, indicating a reduced potential for active crown fire.

All treatments generated income in excess of treatment cost. Treatment 2 produced a net income of $832 per acre treated, Treatment 3 earned $222 per acre and Treatment 1 generated $156 per acre for 1996 costs and revenue.

All treatments were both effective at reducing forest fuels and financially feasible. Individual preference, suitability for a particular site, or compatibility with other resource objectives may guide the choice of treatment.

URL: None at this time. Please check back for updates.
Keywords: ponderosa pine/ Douglas-fir/ fuel loading/ fuel reduction/ crown fire potential/ thinning/ economics

---. 1998. Fuel reduction in residential and scenic forests: a comparison of three treatments in a western Montana ponderosa pine stand. Research Paper RMRS-RP-5. Rocky Mountain Research Station, USDA Forest Service. 19 p.

Groups: economics; fire behavior/fuel reduction; social/human dimensions/esthetics.
Location: Lolo National Forest in western Montana.

Abstract: Three contrasting thinning treatments to reduce fire hazard were implemented in a 100-year-old ponderosa pine/Douglas-fir (*Pinus ponderosa/Pseudotsuga menziesii*) stand on the Lolo National Forest, MT. All treatments included a commercial thinning designed to reduce crown fuels and provide revenue to offset costs. The treatments are outlined as follows:

1. Minimum impact: light commercial thinning from below, with slash hand-piled and burned.
2. Revenue production: moderate commercial thinning from above, whole-tree harvest.
3. Forest restoration: moderate commercial thinning from below, with broadcast burn.

Total surface fuel loadings were reduced slightly by all treatments, but fine fuel load increased except in

treatment 3. All treatments raised crown base height and reduced crown bulk density, making crown fires less likely.

All treatments generated income in excess of treatment cost. Treatment 2 produced a net income of $832 per acre treated, treatment 3 earned a net income of $222 per acre, and Treatment 1 generated a net income of $156 per acre in 1996 dollars.

Analysis of the aesthetic quality of treated stands revealed that Treatment 1 was the most preferred, even over the untreated stand, and Treatment 3 the least preferred. Transitivity of preferences indicates that the preferences were not strong, indicating that the treatments actually have similar aesthetic value. A severely burned but otherwise untreated stand, when included in the analysis, was preferred even less than Treatment 3.

All treatments used in this demonstration were effective at reducing forest fuels and cost-feasible while maintaining or improving aesthetic quality. Individual preference, suitability for a particular site, or compatibility with other resource objectives may guide the choice of treatment.

URL: None at this time. Please check back for updates.
Keywords: coniferous forests/ crown/ stand density/ forest fires/ fuels/ income/ thinning/ fire danger/ fire control/ costs/ controlled burning/ whole tree logging/ slash/ burning/ logging/ forest economics/ coniferous forests/ stand density/ aesthetics/ esthetics

Steele, Robert W. 1980. Postharvest residue burning under alternative silvicultural practices. Research Note INT-RN-293. USDA Forest Service, Intermountain Forest and Range Experiment Station. 7 p.

Groups: fire behavior/fuel management.
Location: Lubrecht Experimental Forest in western Montana.

Abstract: Prescribed burning of logging slash was done in clearcut, overstory removal, and understory cutting units in a Douglas-fir stand on the Lubrecht Experimental Forest near Missoula, Mont. The burning prescriptions and actual burning conditions are described. Data on preharvest, postharvest, and postburn conditions are reported.

Additional notes: In the understory removal, the number of sawtimber (>9 inches d.b.h.) Douglas-fir was reduced from 50 to 15 stems per acre and the number of ponderosa pine and western larch remained the same at <20 stems per acre. Poles (5-9 inches d.b.h.) decreased from 55 to 30 stems Douglas-fir per acre, and the ponderosa pine and western larch remained at <30 stems per acre. Total number of trees per acre remaining after harvest was 58, containing 1,122 cubic ft per acre. The results of the prescribed burn in the understory removal unit showed that only 34 percent of the total fuel was consumed, because of the limited amount of fine fuel and the moisture levels being at the high end of the prescription.

URL: None at this time. Please check back for updates.
Keywords: controlled burning/ natural regeneration/ site preparation/ thinning/ methodology/ advance growth/ burning/ conifers/ prescribed burning/ fire/ fuels management/ logging slash

Wakimoto, Ronald H.; Pfister, Robert D.; and Kalabokidis, Konstandinos. 1988. Evaluation of alternative fire hazard reduction techniques in high-hazard, high-value, and high-use forests. In: Schmidt, Wyman C., compiler. Proceedings: future forests of the mountain west--a stand culture symposium; INT-GTR-243. Ogden, UT: USDA Forest Service Intermountain Forest and Range Experiment Station: 401-402.

Groups: fire behavior/fuel reduction.
Location: Lubrecht Experimental Forest in western Montana.

Abstract: None

Additional notes: The objective of this study was to determine the relative cost and effectiveness of six alternative slash disposal treatments aimed at reducing fire incidence (ignition), rate of spread (control), intensity (damage), and resistance to control (difficulty of fireline construction). The treatments were applied to a stand of second-growth ponderosa pine, Douglas-fir, western larch, and lodgepole pine that had been logged by individual tree selection a year earlier. Treatments included the following: 1) bulldozer pile and burn; 2) lop and scatter; 3) removal of pieces larger than 3 inches in diameter by farm tractor; 4) firewood removal and leave material smaller than 3 inches diameter; 5) firewood removal and lop material smaller than 3 inches diameter; and 6) firewood removal and hand pile and burn material smaller than 3 inches diameter. The authors conclude that "All six treatments showed significantly reduced fire potential and predicted fire behavior within the limit of manual attack methods." Results of costs were not provided.

URL: None at this time. Please check back for updates.
Keywords: ponderosa pine/Douglas-fir/fuel reduction/slash disposal

Walstad, John D.; Radosevich, Steven R.; and Sandberg, David V. 1990. Natural and prescribed fire in Pacific Northwest forests. Corvallis, OR: Oregon State University Press. 317 p.

See Literature Reviews.

Weaver, Harold. 1947. Fire--nature's thinning agent in ponderosa pine stands. Journal of Forestry. 45: 437-444.

Groups: fire behavior/fuel reduction; vegetative effects--stand level.
Location: Colville Indian Reservation in north-central Washington.

Abstract: The potentialities of fire as a thinning agent were shown by a study of the age-size relationship in a stagnated unburned stand and in stands of similar origin that had been thinned accidentally by fire. The author states that by the use of controlled fire, he has accomplished satisfactory thinning of dense reproduction stands over many hundreds of acres.

Additional notes: This is one of the first studies to look at use of controlled fire as a thinning agent.

URL: None at this time. Please check back for updates.
Keywords: prescribed fire/ponderosa pine/controlled burning

Zimmerman, G. Thomas and Neuenschwander, Leon F. 1983. Fuel-load reductions resulting from prescribed burning in grazed and ungrazed Douglas-fir stands. Journal of Range Management. 36(3): 346-350.

Groups: fire behavior/fuel reduction.
Location: University of Idaho Experimental Forest east of Moscow, Idaho.

Abstract: Prescribed understory burning was carried out in both grazed and ungrazed Douglas-fir stands on the University of Idaho Experimental Forest. Burning conditions were moderately cool with 10-hr time-lag fuel moisture varying from 11 to 19 percent. Preburn and postburn fuel loadings were determined by use of the planar intersect method. Preburn data indicated greater fuel accumulations in grazed stands, 55,460 kg/ha, as compared to ungrazed stands, 44,710 kg/ha. Difficulty in achieving a satisfactory rate-of-spread and fire intensity was encountered due to the combined effects of a very dry summer followed by a wet fall. Moist conditions on the study site, lack of fine fuels, and accumulation of heavy fuels in the grazed portion produced a burn of patchy nature. Fire rate of spread varied from 0 to 183 cm/minute with flame height up to 91 cm. Result was a fuel reduction of 60.2 percent in the grazed stand and 35.2 percent in the ungrazed stand. Prolonged grazing in this area had created a dense, overstocked stand with insufficient fine fuels to carry a fire, which severely limited the effectiveness of prescribed burning.

URL: None at this time. Please check back for updates.
Keywords: forest litter/prescribed burning/grazing/fire effects/Idaho

Zimmerman, G. Thomas and Omi, Philip N. 1998. Fire restoration options in lodgepole pine ecosystems. In: Pruden, Teresa L. and Brennan, Leonard A., editors. Proceedings: 20th Tall Timbers fire ecology conference; 1996 May 7-10; Boise, ID. Tallahassee, FL: Tall Timbers Research Station: 285-297.

Groups: fire behavior/fuel reduction.
Location: Colorado and Glacier National Park in northwestern Montana.

Abstract: Ecosystem management strategies embraced by natural resource management agencies advocate increased application of prescribed fire on a landscape scale. These strategies are formulated in response to interpretations of wildland ecosystem health, both real and perceived. These strategies are also advancing from reevaluation of traditional fire exclusion policies and small-scale stand management practices to larger scale applications. Implications of past management, although most apparent in areas that have experienced frequent fire occurrence, are also evident in ecosystems that historically experienced mixed fire regimes. These effects are manifested in the form of alterations in stand age distributions, stand structure, fuel accumulation, insect and disease proliferation and intensification, and potential fire intensity, frequency, and spread rates.

Lodgepole pine (*Pinus contorta*) represents an example of an ecosystem that historically experienced what can be categorized as a mixed fire regime, in other words, infrequent high-intensity stand-replacing fires in conjunction with frequent low- to moderate-intensity surface fires. Management of lodgepole pine forests must involve consideration of fire restoration needs. These needs pose challenges having much greater complexity than those in systems where fire restoration objectives involve less risky fire applications. Prerequisite to undertaking and implementing successful restoration and management of fire in lodgepole pine is a comprehensive understanding of the role of fire in this type. Such an understanding must balance many variables including fire regimes, fire behavior, fuel dynamics, community dynamics, succession, cone serotiny, stand establishment, and insect and disease interrelationships. This paper addresses several available options for utilizing management-ignited prescribed fire and prescribed natural fire strategies for ecosystem restoration objectives in lodgepole pine communities.

Additional notes: This paper presents a synopsis of available options for fire restoration in lodgepole pine ecosystems based on a review of two preliminary case examples of fire applications and management, one in Colorado and the other in Glacier National Park. There is little here on effects, although they mention that on the Colorado site, surface fuel loading accumulates rapidly following fire and in many cases, exceeds preburn levels. Postfire observations of burns conducted since 1982 show that in addition to fire-caused mortality, *Ips* beetles are responsible for elevated mortality rates in trees weakened by stem char and crown scorch. Accelerated fuel accumulation can combine with tree regeneration to present highly flammable situations.

URL: None at this time. Please check back for updates.
Keywords: lodgepole pine/*Pinus contorta*/prescribed fire/forest restoration/insects/pathogens

Fisheries

There were only seven papers that looked at effects of fuel reduction treatments on fisheries, and all of them were literature syntheses. Similar to studies on air quality, studies of effects of thinning and prescribed fire on fisheries are probably limited by the scale of the operations. Still, the literature reviews provide valuable information particularly on the role and effects of fire on fish populations and habitats.

Bisson, Peter A.; Rieman, Bruce E.; Luce, Charlie and others. 2003. Fire and aquatic ecosystems of the western USA: current knowledge and key questions. Forest Ecology and Management. 171(1-2): 213-229.

See Literature Reviews.

Gresswell, Robert E. 1999. Fire and aquatic ecosystems in forested biomes of North America. Transactions of the American Fisheries Society. 128(2): 193-221.

See Literature Reviews.

Howell, Philip J. 2001. Effects of disturbance and management of forest health on fish and fish habitat in eastern Oregon and Washington. Northwest Science. 75(Suppl.): 157-165.

See Literature Reviews.

Meehan, William R. 1991. Influences of forest and rangeland management on salmonid fishes and their habitats. American Fisheries Society Special Publication 19. Bethesda, MD: American Fisheries Society.

See Literature Reviews.

Rieman, Bruce and Clayton, Jim. 1997. Wildfire and native fish: issues of forest health and conservation of sensitive species. Fisheries. 22(11): 6-15.

See Literature Reviews.

Smith, Jane Kapler. Fire Effects Information System [Web Page]. Available at: http://www.fs.fed.us/database/feis/

See Literature Reviews.

Walstad, John D.; Radosevich, Steven R.; and Sandberg, David V. 1990. Natural and prescribed fire in Pacific Northwest forests. Corvallis, OR: Oregon State University Press. 317 p.

See Literature Reviews.

Hydrology

There were 12 papers that addressed water and watershed issues. Most also addressed either soils or fisheries. As with some other sections, the scale of most projects makes it difficult to address watershed effects.

Alexander, Robert R. 1986. Silvicultural systems and cutting methods for old-growth lodgepole pine forests in the Central Rocky Mountains. General Technical Report RM-GTR-127. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 31 p.

See Literature Reviews.

Bisson, Peter A.; Rieman, Bruce E.; Luce, Charlie and others. 2003. Fire and aquatic ecosystems of the western USA: current knowledge and key questions. Forest Ecology and Management. 171(1-2): 213-229.

See Literature Reviews.

Brown, Rick. 2000. Thinning, fire and forest restoration: a science-based approach for National Forests in the Interior Northwest. Washington, D.C.: Defenders of Wildlife. 25 p.

See Literature Reviews.

DellaSala, Dominick A. and Frost, Evan. 2001. An ecologically based strategy for fire and fuels management in national forest roadless areas. Fire Management Today. 61(2): 12-23.

See Literature Reviews.

Elliot, William J. and Robichaud, Peter R. 2001. Comparing erosion risks from forest operations to wildfire. In: International mountain logging and 11th Pacific Northwest skyline logging symposium.

Groups: hydrology.
Location: Idaho, western Montana, eastern Oregon, and central Washington.

Abstract: Wildfire and forest operations remove vegetation and disturb forest soils. Both of these effects can lead to an increased risk of soil erosion. Operations to reduce forest fuel loads, however, may reduce the risk of wildfire. This paper presents research and modeling results that show that under many conditions, carefully planned operations with adequate buffers, result in lower long-term erosion rates than experienced following wildfire, which is inevitable if fuel loads are not reduced. The effects of reducing fire-induced flood flows on forest stream systems, however, are unknown.

Additional notes: The purpose of this paper was to compare erosion rates following forest disturbances, such as thinning and prescribed fire, to erosion rates following wildfires.

URL: http://depts.washington.edu/sky2001/proceedings/papers/Elliot.pdf
Keywords: soil erosion/forest operations/forest fires/WEPP

Newman, Howard C. and Schmidt, Wyman C. 1979? Silviculture and residue treatments affect water used by a larch/fir forest. In: Environmental consequences of timber harvesting in Rocky Mountain coniferous

forests, symposium proceedings; 1979 September 11-13; General Technical Report INT-GTR-90. Ogden, Utah: USDA Forest Service, Intermountain Forest and Range E xperiment Station.: 75-110.

Groups: hydrology; soils.
Location: Flathead National Forest in northwestern Montana (Coram Experimental Forest).

Abstract: Three silvicultural systems--clearcut, shelterwood, and group selection--were coupled with four residues treatments, ranging from intensive to conventional utilization and broadcast burning, to evaluate the environmental effects of harvesting larch/Douglas-fir forests in Montana. Effects of the 12 treatment combinations on accumulated precipitation, water used during the growing season, and soil water status during the year, were evaluated for the first 4 years after harvesting. The study was conducted on a steep east aspect at about 4,500 ft (1,370 m) elevation.

Silvicultural treatments increased the amount of precipitation that reached the forest floor, most in clearcuts and group selections and less in shelterwoods. Snow accumulation, which accounted for about 50 percent of the annual precipitation, increased about 80 percent in clearcuts, 50 percent in group selections, and 40 percent in shelterwoods when compared to uncut mature forest. During the growing season, the uncut mature forest used about 75 percent of the total annual precipitation. Differences in water use following harvesting were less than expected. Shelterwoods used about 4 percent, group selections 10 percent, and clearcuts 11 percent less than the uncut control. Rapid revegetation on all harvested areas, the residual stand in the shelterwoods, and soil water deficits in the uncut forest apparently ameliorated some differences between uncut forest and treated areas. As a function of differences in accumulated precipitation, and water use during the growing season, water present in the soil profile remained highest on clearcuts and lowest in uncut mature forest, with shelterwood and group selections falling between the two. Residue treatments had relatively minor effects on precipitation accumulation, water use, and soil water status. Of these, the two treatments with broadcast burning had the greatest effect.

URL: None at this time. Please check back for updates.
Keywords: water use/precipitation/soil water/*Larix occidentalis*/*Pseudotsuga menziesii*/larch/Douglas-fir/silvicultural systems/residues management/broadcast burning/clearcut/shelterwood cut/group selection/Northern Rocky Mountains/evapotranspiration

Rieman, Bruce and Clayton, Jim. 1997. Wildfire and native fish: issues of forest health and conservation of sensitive species. Fisheries. 22(11): 6-15.

See Literature Reviews.

Robichaud, P. R. 2000. Fire effects on infiltration rates after prescribed fire in Northern Rocky Mountain forests, USA. Journal of Hydrology. 231-232: 220-229.

Groups: hydrology; soils.
Location: Bitterroot National Forest of western Montana and Boise National Forest of central Idaho.

Abstract: Infiltration rates in undisturbed forest environments are generally high. These high infiltration rates may be reduced when forest management activities such as timber harvesting and/or prescribed fires are used. Post-harvest residue burning is a common site preparation treatment used in the Northern Rocky Mountains, USA, to reduce forest fuels and to prepare sites for natural and artificial tree regeneration. Prescribed burn operations attempt to leave sites with the surface condition of a low-severity burn. However, some of the areas often experience surface conditions associated with a high-severity burn which may result in hydrophobic or water repellent conditions. In this study, infiltration rates were measured after logging slash was broadcast burned from two prescribed burns. The two sites were in Northern Rocky coniferous forests of Douglas-fir/lodgepole pine and ponderosa pine/Douglas-fir. Simulated rainfall was applied to one-square meter plots in three, 30-min applications at 94 mm/h within the three surface conditions found after the burn: unburned-undisturbed areas, low-severity burn areas, and high-severity burn areas.

Runoff hydrographs from the rainfall simulations were relatively constant from the plots that were in unburned-undisturbed areas and in areas subjected to a low-severity burn. These constant runoff rates indicate constant hydraulic conductivity values for these surface conditions even though there was variation between plots. Hydrographs from the rainfall simulation plots located within areas of high-severity burn indicate greater runoff rates than the plots in low-severity burn areas especially during the initial stages of the first rainfall event. These runoff rates decreased to a constant rate for the last 10 min of the event. These results indicate hydrophobic or water repellent soil conditions, which temporarily cause a 10-40 percent reduction in hydraulic conductivity values when compared to a normal infiltrating soil condition. Since variability was high for these forest conditions, cumulative distribution algorithms of hydraulic conductivity provide a means to account for the inherent variability associated with these hillslopes and different surface conditions cause by fire.

URL: None at this time. Please check back for updates.
Keywords: erosion/fires/forests/hydraulic conductivity/hydrographs/hydrology/hydrophobic materials/Idaho/infiltration/Montana/Northern Rocky Mountains/prediction/rainfall/rates/runoff/simulation/soil erosion/soils/spatial variations

Rummer, Bob; Prestemon, Jeff; May, Dennis and others. 2003. A strategic assessment of forest biomass and fuel reduction treatments in western states. USDA, Forest Service, Research and Development in partnership with the Western Forest Leadership Coalition. 21 p.

Groups: economics; hydrology.
Location: western U.S.

Abstract: None

Additional notes: The objective of this assessment was to characterize, at a regional scale, forest biomass that can potentially be removed to implement the fuel reduction and ecosystem restoration objectives of the National Fire Plan for the western US. In the summary, the authors state, "In the 15 western states there are at least 28 million acres of forest that could benefit from some type of mechanical treatment to reduce hazardous fuel loading. It is estimated that about 60 percent of this area could be operationally accessible for treatment with a total biomass treatment volume of 345 million bone dry tons (bdt). Two-thirds of this forest area is on public lands. Most of the volume is in trees 6 inches diameter and greater that have conventional utilization opportunities. Transportation cost and distance to markets, however, may preclude actual recovery. Treatment costs are increased by the need to treat large numbers of low-volume stems less than 4 inches in diameter. Gross costs can range from $35 to over $1000 per acre depending on type of operation, terrain, and number of trees to be treated. Some areas likely will be prohibitively expensive to treat, although cost estimates presented here may be high because they are based on the use of conventional timber harvesting systems applied to small diameter treatments. Implementation of any significant fuel reduction effort will generate large volumes of biomass and require the development of additional workforce and operations capacity in western forests."

In the conclusions, the authors state, "Initial estimates of sediment yield from alternative treatments clearly indicated that active management is less detrimental than wildfire on an area affected basis. Steeper ground and wetter ecoregions showed higher sediment yields than lower slopes or drier sites. On a landscape level, the cumulative effect would depend on the scale of treatment. However, given the overall average sediment yields, the effect of 70 acres of thinning tratment would be about the same effect of 1 acre consumed by wildfire." Prescribed fire treatments are estimated to yield about 1.6 times more sediment than thinning, and wildfire is estimated to yield about 65.1 to 67.8 times more sediment than thinning. The sediment yield estimates came from modeling.

URL: None at this time. Please check back for updates.
Keywords: forest biomass/ thinning/ prescribed burning/ sediment yield

Spencer, Craig N.; Gabel, Kristin Odney; and Hauer, F. Richard. 2003. Wildfire effects on stream food webs

and nutrient dynamics in Glacier National Park, USA. Forest Ecology and Management. 178(2003): 141-153.

Groups: hydrology.
Location: Glacier National Park in northwestern Montana.

Abstract: We documented immediate and mid-term (5 years) impacts on streams from a large (15,500 ha) wildfire in northwestern Montana. Fire-related impacts were ecosystem-wide, extending from water chemistry to fish. During the initial firestorm, phosphorus and nitrogen levels increased 5- to 60-fold above background levels resulting from aerial deposition from smoke and ash. Nutrients returned to background concentrations within several weeks after the fire. During subsequent years, nutrient concentrations periodically increased in fire-impacted sites compared to reference sites, especially during spring run-off.

Evidence of post-fire changes was also documented in the aquatic food web via stable isotope analyses. Macroinvertebrates and fish from fire-impacted sites were significantly more enriched in ^{15}N and depleted in ^{13}C than consumers from forested reference sites ($P < 0.001$). The post-fire isotopic shift in consumers was consistent with increased utilization of algae and/or other autochthonous food sources together with decreased reliance on terrestrial leaf litter and other allochthonous food sources. Such a post-fire shift from a detritus based on a periphyton-based food web fits predictions of the river continuum concept following canopy removal and nutrient enrichment.

Following decades of active fire suppression, forest managers are now contemplating aggressive efforts to reduce the fuel build-up noted in forests throughout the western US. Such efforts could involve increased use of fire and mechanical thinning and harvest. Results from our work and others suggest that expanded fire activity could mobilize substantial quantities of highly available nutrients to lakes and streams. With significant nutrient delivery mechanisms involving water, as well as airborne transport via smoke and ash, the potential for increased nutrient loadings to surface waters could extend well beyond the catchment of any particular fire. As natural resource managers contemplate expanding the use of fire as a forest restoration tool, they face the dilemma that such efforts could run counter to a decades-long effort to reduce nutrient loadings to lakes and other surface waters threatened by eutrophication.

Additional notes: Although this paper addresses a wildfire, the authors comment on possible effects of returning fire as a disturbance.

URL: None at this time. Please check back for updates.
Keywords: wildfire/stream food webs/nutrients/stable isotopes

Walstad, John D.; Radosevich, Steven R.; and Sandberg, David V. 1990. Natural and prescribed fire in Pacific Northwest forests. Corvallis, OR: Oregon State University Press. 317 p.

See Literature Reviews.

Yount, J. David and Niemi, Gerald J. 1990. Recovery of lotic communities and ecosystems from disturbance--a narrative review of case studies. Environmental Management. 14(5): 547-569.

See Literature Reviews.

Insects and Diseases

There are several types of studies included in these 27 studies. Most of the studies refer to the effects of the treatments on reducing the incidence of diseases or insect infestations. A few studies look at the effects of prescribed fire or thinning on populations of other insect species that are part of the forest ecosystem.

Amman, Gene D. 1989. Why partial cutting in lodgepole pine stands reduces mountain pine beetle. In: Proceedings: symposium on the management of lodgepole pine to minimize losses to the mountain pine beetle. General Technical Report INT-GTR-262. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station: 48-59.

Groups: insects/diseases.
Location: Kootenai and Lolo National Forests of western Montana and Shoshone National Forest of western Wyoming.

Abstract: Thinning stands of lodgepole pine (*Pinus contorta* Douglas var. *latifolia* Engelmann) greatly minimized tree losses to mountain pine beetles (*Dendroctonus ponderosae* Hopkins). Although losses were reduced immediately following thinning, trees did not respond with increased growth until the second year after thinning. Tree losses in partial cut stands were more closely related to large tree diameter than to tree vigor indices.

Beetles were trapped in thinned stands for several years after thinnings were completed but were infesting only a few of the residual trees. The altered microclimate of the stands is suspected of being the factor most likely affecting beetle behavior.

Thinning lodgepole pine stands increased light intensity, wind movement, insulation, and temperature. Temperatures on the south exposure of tree trunks and of soil were significantly higher in thinned than unthinned stands.

Additional notes: Partial cutting tests on the Shoshone National Forest included the following: 1) diameter limit thinnings that removed all trees 7, 10, or 12 inches and larger d.b.h.; 2) spaced thinnings leaving the 50 best trees per acre; and 3) untreated control stands. On the Kootenai and Lolo National Forests, partial cutting tests included the following: 1) diameter limit thinnings that removed all trees 10 or 12 inches and larger d.b.h.; 2) spaced thinnings that left residual basal areas of 80, 100, or 120 ft^2 basal area per acre; and 3) control stands.

URL: None at this time. Please check back for updates.
Keywords: lodgepole pine/*Pinus contorta*/thinning/mountain pine beetle/*Dendroctonus ponderosae*

Brennan, Leonard A. and Hermann, Sharon M. 1994. Prescribed fire and forest pests: solutions for today and tomorrow. Journal of Forestry. 92(11): 34-37.

See Literature Reviews.

Cochran, P. H. and Dahms, Walter G. 2000. Growth of lodgepole pine thinned to various densities on two sites with differing productivities in central Oregon. Research Paper PNW-RP-520. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 59 p.

See Vegetative Effects at the Stand Level

Cruickshank, M. G.; Morrison, D. J.; and Punja, Z. K. 1997. Incidence of Armillaria species in

precommercial thinning stumps and spread of *Armillaria ostoyae* to adjacent Douglas-fir trees. Canadian Journal of Forest Research. 27(4): 481-490.

Groups: insects/diseases.
Location: southern interior British Columbia.

Abstract: The frequency of *Armillaria* species in precommercial thinning stumps and the interaction at root contacts between Douglas-fir *(Pseudotsuga menziesii* (Mirb.) Franco) crop trees and stumps colonized by *Armillaria ostoyae* (Romagn.) Herink were investigated at sites in four biogeoclimatic zones along a transect from the coast through the southern interior of British Columbia. The frequency of stumps colonized by *A. ostoyae* and *Armillaria sinapina* Berube & Dessureault varied among lower, mid, and upper slope transects. On coastal sites, *A. sinapina* dominated fresh hygrotopes and *A. ostoyae* dominated slightly dry hygrotopes, and the frequency of both fungi was low on moist hygrotopes. On interior sites, *A. ostoyae* was found over all hygrotopes, but with lower frequency on the driest sites. The distribution of the two Armillaria species on sites is apparently determined by anoxia associated with periodic soil saturation, by drying of the soil, and by host response limiting spread of pathogenic species. At root contacts between colonized stump roots and crop tree roots, transfer and infection by *A. ostoyae* occurred more frequently in moist biogeoclimatic zones than dry ones. Lesion size on crop tree roots was related to inoculum volume at some sites and to stump root diameter at others. The percentage of lesions on roots at which crop trees formed callus was associated with tree bole volume. The results indicate that there will be crop tree mortality following precommercial thinning, especially where inoculum levels are high in the Interior Cedar-Hemlock and Interior Douglas-fir biogeoclimatic zones.

URL: None at this time. Please check back for updates.
Keywords: *Pseudotsuga menziesii*/Armillaria/species diversity/disease surveys/colonization/thinning/stumps

DellaSala, Dominick A. and Frost, Evan. 2001. An ecologically based strategy for fire and fuels management in national forest roadless areas. Fire Management Today. 61(2): 12-23.

See Literature Reviews.

Fellin, David G. 1980. Effect of silvicultural practices, residue utilization, and prescribed fire on some forest floor arthropods. In: Proceedings, environmental consequences of timber harvesting in Rocky Mountain coniferous forests; 1979 September 11-13; Missoula, MT. General Technical Report INT-GTR-90. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station: 287-316.

Groups: insects/diseases.
Location: Flathead National Forest in western Montana.

Abstract: The combined effects of two silvicultural practices--shelterwood and clearcutting--and two residue management practices--intense fiber removal (utilization) and residue removal by prescribed fire--on forest floor arthropods (macrofauna} are discussed. Arthropods most abundant on the study area and most affected by treatments were spiders (Arachnida:Araneida), ants (Hymenoptera: Formicidae), and beetles (Coleoptera), especially the families Carabidae and Staphylinidae.

Although some populations increased between treatments or years, most treatments adversely affected most groups of macrofauna, particularly the second and third year, respectively, after burning and harvesting. Prescribed burning of residues stimulated a resurgence of some groups. The five treatments studied could be ranked in a decreasing impact on forest floor fauna in the following order: shelterwood cutting and leave residues, shelterwood and burn residues, shelterwood and mechanically remove residues (intense fiber utilization), clearcut and burn residues, clearcut and mechanically remove residues. Management implications of the effects of these harvesting and residue treatments on surface arthropods are discussed.

Additional notes: This study looked at silvicultural systems in western larch/Douglas-fir forests in the Flathead National Forest in Montana. The macrofauna insects studied include the larger arthropods that reside on the soil

surface. The study lasted three years. Management implications look at the roles of these insects, such as that of regulating numbers of insects harmful to trees.

URL: None at this time. Please check back for updates.
Keywords: silviculture/forest residue/fire/arthropods/macrofauna

Fellin, David G. 1980. Populations of some forest litter, humus, and soil arthropods as affected by silvicultural practices, residue utilization, and prescribed fire. In: Proceedings: environmental consequences of timber harvesting in Rocky Mountain coniferous forests; 1979 September 11-13; Missoula, MT. General Technical Report INT-GTR-90. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station: 317-334.

Groups: insects/diseases.
Location: Flathead National Forest, western Montana.

Abstract: The combined effects of two silvicultural practices--shelterwood and clearcutting--and two residue management practices--intense fiber removal (utilization) and resldue removal by prescribed fire--on forest litter, humus, and soil arthropods (mesofauna) are discussed. Arthropods most abundant on the study area and most affected by treatment were mites (Arachnida, Acarina) and springtails (Insecta, Collembola). These and other arthropods collected are listed and their seasonal and vertical distribution presented. Preliminary results of these four treatments are presented, and the management implications of the harvesting and residue utilization treatments discussed.

Additional notes: This study looked at silvicultural systems in western larch/Douglas-fir forests in the Flathead National Forest in Montana. The mesofauna insects studied include the intermediate size arthropods that inhabit the soil surface and forest soil. The results given are only for the first year of a three-year study.

URL: None at this time. Please check back for updates.
Keywords: silviculture/forest residue/fire/arthropods/mesofauna

Fellin, David G.; Schmidt, Wyman C.; and Carlson, Clinton E. 1984. The western spruce budworm in the Northern Rocky Mountains--ecological relations and silvicultural management strategies. In: Silvicultural management strategies for pests of the Interior Douglas-fir and grand fir forest types, symposium proceedings; Spokane, WA. 81-94.

See Literature Reviews.

Filip, Gregory M.; Fitzgerald, Stephen A.; and Ganio, Lisa M. 1999. Precommercial thinning in a ponderosa pine stand affected by Armillaria root disease in central Oregon: 30 years of growth and mortality. Western Journal of Applied Forestry. 14(3): 144-148.

Groups: insects/diseases; vegetative effects--stand level.
Location: Deschutes National Forest in central Oregon.

Abstract: A 30-yr-old stand of ponderosa pine was precommercially thinned in 1966 to determine the effects of thinning on tree growth and mortality caused by Armillaria root disease in central Oregon. After 30 yr, crop tree mortality was significantly (P = 0.02) less in thinned plots than in unthinned plots. Tree diameter growth was not significantly (P = 0.17) increased by thinning. Crop-tree basal area/ac growth was significantly (P = 0.03) greater in thinned plots. Apparently, from a root disease perspective, precommercial thinning of pure ponderosa stands significantly decreases the incidence of crop-tree mortality after 30 yr and significantly increases basal area/ac growth but not individual tree diameter growth. Recommendations for thinning based on stand density index (SDI) are given.

Additional notes: The article ends with the following: "As a general recommendation, in pure ponderosa pine stands, thin early when trees are small to reduce slash and stump size, and thin heavy to reduce density, increase growth increment, and prevent mortality from root disease and bark beetles." In this study area, the pine overstory was harvested before thinning and the naturally regenerated pine understory was about 30 yr old when thinned. Another paper in this bibliography by Filip and others (1989) gives the 20-yr results of this treatment.

URL: None at this time. Please check back for updates.
Keywords: *Pinus ponderosa*/Armillaria/plant diseases/measurement/mortality/Deschutes National Forest (OR)/precommercial thinning/root disease/fungal disease

Filip, Gregory M.; Goheen, Donald J.; Johnson, David W. and others. 1989. Precommercial thinning in a ponderosa pine stand affected by Armillaria root disease: 20 years of growth and mortality in central Oregon. Western Journal of Applied Forestry. 4(2): 58-59.

Groups: insects/diseases; vegetative effects--stand level.
Location: Deschutes National Forest in central Oregon.

Abstract: A naturally regenerated stand of ponderosa pine (*Pinus ponderosa*) was thinned in 1966 to determine the effects of spacing on crop-tree mortality caused by Armillaria root disease in central Oregon. After 20 years, crop-tree mortality in unthinned plots exceeded that in the thinned plots (1.6 vs. 0.8 trees/ac/yr). Crop-tree diameter growth, however, was greater in thinned plots (0.2 vs. 0.1 in./yr). Forest managers should not defer thinning of similar stands because of Armillaria root disease.

Additional notes: Another paper in this bibliography by Filip and others (1999) gives the 30-yr results of this treatment.

URL: None at this time. Please check back for updates.
Keywords: *Pinus ponderosa*/*Armillaria ostoyae*/thinning/root rots/mortality/fungus control/Oregon

Filip, Gregory M. and Yang-Erve, Lisa. 1997. Effects of prescribed burning on the viability of *Armillaria ostoyae* in mixed-conifer forest soils in the Blue Mountains of Oregon. Northwest Science. 71 (2): 137-144.

Groups: insects/diseases.
Location: Malheur National Forest in northeastern Oregon.

Abstract: This study evaluated the influence of prescribed burning, soil depth, antagonistic fungi (*Trichoderma harzianum* Rifai), and time since burning on the viability of the root pathogen *Armillaria ostoyae* (Romagnesi) Herink in wood pieces buried in the soil of a mixed-conifer forest in northeastern Oregon. Red alder (*Alnus rubra* Bong) stem segments colonized with *A. ostoyae* were buried at two soil depths in plots that were burned and not burned. Half of the Armillaria segments were buried with segments of *T. harzianum*. Prescribed burning in the fall significantly reduced the recovery of *A. ostoyae* immediately after the burn at a soil depth of 8 cm but not at a soil depth of 30 cm. Adding *T. harzianum* inoculum to the soil did not appear to reduce *A. ostoyae* recovery immediately after the fire, but effects appeared after several months. Differences may also be due to the timing (fall or spring) of the prescribed burns. The effects of fire either natural or prescribed on pathogenic and saprophytic fungi may greatly influence infections of woody roots, subsequent disease occurrence, and patterns of tree mortality.

URL: None at this time. Please check back for updates.
Keywords: Blue Mountains/mixed conifer forest/prescribed burning/recovery/soil depth/terrestrial ecology/tree mortality/viability/fungi/red alder/microorganisms

Gerson, Elizabeth A. and Kelsey, Rick G. 1997. Attraction and direct mortality of pandora moths, *Coloradia pandora* (Lepidoptera: Saturniidae), by nocturnal fire. Forest Ecology and Management. 98 (1): 71-75.

Groups: insects/diseases.
Location: Deschutes National Forest in Oregon.

Abstract: The attraction of nocturnal moths to candles and other sources of light has long been observed, but fire as a potential source of mortality to moths in ecosystems with frequent fire regimes has been overlooked. A prescribed burn was conducted shortly after dark in a central Oregon ponderosa pine forest during the flight period of the endemic defoliator *Coloradia pandora* (Blake). Attraction to the fire and partial consumption by flames caused direct mortality estimated at 2.2 percent to 17.1 percent of the local pandora moth population. In field tests with projected light, pandora moths did not discriminate among colors in the visible spectrum. Moths did not respond to projected light for at least 1 hour after dusk, indicating that timing and duration of the prescribed fire may have limited the mortality.

URL: None at this time. Please check back for updates.
Keywords: nocturnal fire/attraction effect/direct mortality/moths/pandora moth/ponderosa pine/fire/prescribed fire/*Pinus ponderosa*/*Coloradia pandora*/phototaxis/fire-insect interactions

Gibson, Kenneth E. 1989. Partial cutting (sanitation thinning) to reduce mountain pine beetle-caused mortality. In: Proceedings: symposium on the management of lodgepole pine to minimize losses to the mountain pine beetle; 1988 July 12-14; Kalispell, MT. General Technical Report INT-GTR-262. Ogden, UT: USDA Forest Service, Intermountain Research Station: 45-47.

Groups: insects/diseases.
Location: Lolo, Kootenai, and Flathead National Forests in western Montana.

Abstract: Data collected over the past decade have shown partial cutting to be a viable management alternative in lodgepole pine stands threatened by mountain pine beetle. Now this strategy is being used operationally as an alternative to clearcutting. Criteria for selecting suitable stands are included.

Additional notes: The partial cutting treatments were some reported in McGregor and others (1987) from the Lolo and Kootenai National Forests, and some work done on the Flathead National Forest by Bollenbacher. On the Lolo and Kootenai National Forests, there were three levels of diameter limit cutting (all trees >7, >10 in d.b.h., and >12 in d.b.h.) and three levels of spaced thinnings (80, 100, and 120 sq ft/ac). Results were similar for all treatments. On the Flathead National Forest, stands were thinned from 164-183 sq ft of basal area down to 92, 112, and 143 sq ft. Larger, more vigorous trees were left, so average stand diameter increased from 7-8 inches d.b.h. to 8-9.5 inches.

URL: None at this time. Please check back for updates.
Keywords: *Pinus contorta* /lodgepole pine/thinning/mountain pine beetle/partial cutting

Hungerford, Roger D.; Harrington, Michael G.; Frandsen, William H.; Ryan, Kevin C. and others. 1991. Influence of fire on factors that affect site productivity. In: Harvey, A. E. and Neuenschwander, L. F., compilers. Proceedings: management and productivity of western-Montana forest soils; 1990 April 10-12; Boise, ID. General Technical Report INT-GTR-280. Ogden, UT: USDA Forest Service, Intermountain Research Station: 32-50.

See Literature Reviews.

Johnstone, W. D. 2002. Thinning lodgepole pine in southeastern British Columbia: 46-year results. Working Paper. Victoria, BC: Research Branch, British Columbia Ministry of Forestry. 26 p.

See Vegetative Effects at the Stand Level.

Koonce, Andrea L. 1981. Interactions between fire and dwarf mistletoe in ponderosa pine. Oregon State University. 58 p. Dissertation.

Groups: insects/diseases.
Location: unknown.

Abstract: In a study of the effects of dwarf mistletoe [*Arceuthobium americanum*] on fuel in precommercial ponderosa pine stands, dwarf mistletoe and healthy stands were sampled by vertical planar intercept and whole tree biomass sampling techniques to measure fuel loading in ground and crown fuels. Differences in size, distribution and vitality of fuel were shown to depend on stand structure and disease expression parameters. In studies of the effects of prescribed burning on dwarf mistletoe in ponderosa pine, eight understory prescribed burns were examined at two locations before and after burning for changes in dwarf mistletoe vitality and distribution. Mistletoe reduction resulted from killing infected understory trees and "pruning" dwarf mistletoe plants and infected branches from crop trees. The degree of control was related to fire severity, original levels of mistletoe infection, stand structure and fuel conditions.

URL: None at this time. Please check back for updates.
Keywords: forests/ weeds/ weed control/ cultural control/ burning

McGregor, Mark D.; Amman, Gene D.; Schmitz, Richard F. and others. 1987. Partial cutting lodgepole pine stands to reduce losses to the mountain pine beetle. Canadian Journal of Forest Research. 17: 1234-1239.

Groups: insects/diseases.
Location: Kootenai and Lolo National Forests in western Montana.

Abstract: Partial cutting prescriptions were applied in the fall of 1978 through the early winter of 1980 to lodgepole pine stands (*Pinus contorta* Douglas var. *latifolia* Engelmann) threatened by mountain pine beetle (*Dendroctonus ponderosae* Hopkins) in the Kootenai and Lolo National Forests in western Montana, U.S.A. Partial cutting prescriptions consisted of removing from separate stands all trees 17.8, 25.4, and 30.5 cm and larger diameter at breast height (d.b.h.), and prescriptions leaving 18.4, 23.0, and 27.6 m^2 basal area per hectare. In thinned stands, the first 5 years' results following cutting showed greatly reduced tree losses to mountain pine beetle when compared with untreated stands ($P < 0.01$) on both forests. There were no significant differences in tree losses among partial cut treatments ($P > 0.05$). Post-treatment mortality of lodgepole pine 12.7 cm and larger d.b.h. to mountain pine beetle averaged 4.0 to 38.6 percent on the Kootenai and 6.0 to 17.1 percent on the Lolo in treated stands, compared with averages of 93.8 and 73.1 percent in untreated stands. Partial cutting appears to be useful for reducing lodgepole losses to mountain pine beetle.

URL: None at this time. Please check back for updates.
Keywords: lodgepole pine/thinning/insects/mountain pine beetle/partial cutting

Mitchell, Janet L. 2001. Commercial thinning of mature lodgepole pine: results of "beetle proofing" research in the East Kootenays. Victoria, BC: Canadian Forest Service; British Columbia Ministry of Forests. 5 p.

Groups: insects/diseases.
Location: East Kootenays of southeastern British Columbia.

Abstract: None

Additional notes: This fact sheet presents 5-year results of "beetle proofing" research in the East Kootenays of southeastern British Columbia. The objectives of the research are to determine if: 1) susceptibility to mountain pine beetle is lowered; 2) commercial thinning is economically feasible; 3) stand growth response will increase volume or value yield this rotation; 4) a shelterwood regeneration system can be initiated for the next rotation; and 5) wildlife habitat values and visual quality can be maintained. The prescription being tested is a 2-pass shelterwood or clearcut with reserves in 70-110 year old stands of lodgepole pine. In the first pass, stands are

thinned from below to 4-meter or 5-meter inter-tree spacing. On the second pass, overstory trees are removed to release/initiate regeneration. Fertilizer (200 kg N/ha) was applied to part of each treatment three growing seasons after harvest.

URL: http://dsp-psd.pwgsc.gc.ca/Collection/Fo42-320-2001E.pdf
Keywords: *Pinus contorta* / thinning/ pest control/ fertilization/ shelterwood cut/ *Dendroctonus monticolae*/ British Columbia

Mitchell, Russel G. 1990. Effects of prescribed fire on insect pests. Corvallis, OR: Oregon State University Press.

See Literature Reviews.

Niwa, Christine G.; Peck, Robert W.; and Torgerson, Torolf R. 2001. Soil, litter, and coarse woody debris habitats for arthropods in eastern Oregon and Washington. Northwest Science. 75(Suppl.): 141-148.

See Literature Reviews.

Peters, Robert L.; Frost, Evan; and Pace, Felice. 1996. Managing for forest ecosystem health: a reassessment of the "forest health crisis." Washington, D.C.: Defenders of Wildlife.

See Literature Reviews.

Ross, Darrell W. 1995. Short-term impacts of thinning ponderosa pine on pandora moth densities, pupal weights, and phenology. Western Journal of Applied Forestry. 10 (3): 91-94.

Groups: insects/diseases.
Location: Deschutes National Forest in Oregon.

Abstract: Second-growth ponderosa pine (*Pinus ponderosa*) stands with outbreak populations of the pandora moth (*Coloradia pandora*) were thinned from below removing about half of the basal area. Thinning had no effect on pandora moth pupal density or weight, or emerging adult density in the following generation. However, adult emergence and egg hatch occurred 7-10 days earlier in thinned plots compared with unthinned plots. Egg and larval densities on a foliage weight basis were not significantly different between thinned and unthinned plots. Thinning stands infested with pandora moth will not significantly affect the course of an outbreak for at least one generation. Timing of direct controls for the pandora moth should consider the effect of stand density on insect phenology.

URL: None at this time. Please check back for updates.
Keywords: *Coloradia pandora*/*Pinus ponderosa*/animals/arthropods/gymnosperms/insects/invertebrates/plants/spermatophytes/vascular plants/direct control timing/egg density/forestry/larval density

Schmitz, Richard F.; McGregor, Mark D.; Amman, Gene D. and others. 1989. Effect of partial cutting treatments of lodgepole pine stands on the abundance and behavior of flying mountain pine beetles. Canadian Journal of Forest Research. 19(5): 566-574.

Groups: insects/diseases.
Location: Kootanai and Lolo National Forests of western Montana.

Abstract: Passive barrier traps deployed at three heights above ground were used to determine the effect of five intensities of partial cutting of lodgepole pine (*Pinus contorta* Dougl. ex Loud. var. latifolia Engelm.) and two unthinned check stands on response of flying mountain pine beetles (*Dendroctonus ponderosae* Hopkins) from 1980 to 1983 on two sites in western Montana. Percentages of mountain pine beetles caught 4 years after thinning were significantly greater in the least severely thinned (27.6 m^2 basal area/ha) treatment (27%) and the unthinned check (28%) than in the 25.4 cm diameter limit (8%) and the 23.0 m^2 basal area/ha (7%) thinnings ($P < 0.05$). Numbers of mountain pine beetles trapped in the 18.4 m^2 basal area/ha thinning did not differ significantly from other treatments. The proportions of mountain pine beetles caught at three trapping heights differed significantly ($P < 0.05$), totaling 63, 28, and 9% at midbole, midcrown, and 1.8 m above ground, respectively. Fewer trees were killed in relation to the numbers of mountain pine beetles trapped in the most severely thinned stands. However, tree mortality rates could not be attributed to thinning-induced changes in tree vigor. These findings, and the preference of flying mountain pine beetles for the midbole stratum, suggest that stand environment is an important factor regulating the severity of tree killing.

URL: None at this time. Please check back for updates.
Keywords: *Pinus contorta* /*Dendroctonus ponderosae*/pests/forest products

Scott, Donald W.; Szymoniak, John; and Rockwell, Victoria. 1996. Entomological concerns regarding burn characteristics and fire effects on tree species during prescribed landscape burns: burn severity guidelines and mitigation measures to minimize fire injuries. La Grande, OR: USDA Forest Service, Pacific Northwest Region, Wallowa-Whitman National Forest, Blue Mountains Pest Management Zone. 48 p.

See Literature Reviews.

USDA Forest Service. 2000. Survivability and deterioration of fire-injured trees in the northern Rocky Mountains: a review of the literature. Report 2000-13, Part 1. Missoula, MT: Northern Region, Forest Health Protection Unit, Missoula Field Office. 10 p.

See Literature Reviews.

Walstad, John D.; Radosevich, Steven R.; and Sandberg, David V. 1990. Natural and prescribed fire in Pacific Northwest forests. Corvallis, OR: Oregon State University Press. 317 p.

See Literature Reviews.

Waltz, Amy E. M. and Covington, W. Wallace. 2001. Butterfly response and successional change following ecosystem restoration. In: Vance, Regina K.; Edminster, Carleton B.; Covington, W. Wallace and others, compilers. Conference proceedings--ponderosa pine ecosystems restoration and conservation: steps toward stewardship; 2000 April 25-27; Flagstaff, AZ. Proceedings RMRS-P-22. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station: 88-94.

Groups: insects/diseases.
Location: northern Arizona.

Abstract: The Lepidoptera (butterflies and moths) can be useful indicators of ecosystem change as a result of a disturbance event. We monitored changes in butterfly abundance in two restoration treatment units paired with adjacent untreated forest at the Mt. Trumbull Resource Conservation Area in northern Arizona. Restoration treatments included thinning trees to density levels comparable to densities at the time of Euro-American settlement, and reintroducing a low to medium intensity fire to the system. One unit was treated in 1996, the second in 1998. Butterfly communities, nectar availability, and herbaceous species richness were compared between treated and adjacent control forests, and between 3-year post-treatment and 1-year post-treatment forests. Butterfly species richness and abundance were two and three times greater, respectively, in restoration

treatment units than in adjacent control forests. Nectar plant species richness ranged from two to 10 times greater in restoration treatments than in adjacent control forests. Comparisons of the 3-year post-treatment unit with the 1-year post-treatment unit showed little difference in butterfly species richness and abundance, although no statistical comparisons can be made due to sample size. These restoration treatments offer a unique opportunity to study responses to and recovery from disturbance and restoration at a landscape level.

URL: None at this time. Please check back for updates.
Keywords: insects/butterflies/moths/lepidoptera/prescribed fire/thinning/restoration treatment

Social and Human Dimensions, and Esthetics

This category is a catch-all for the various types of studies that address human issues related to thinning and prescribed fire. Some of the 26 studies address the esthetics of treatments, comparing treatments with an alternative such as stand-replacement fire or comparing among various treatments. Other studies address public perceptions about treatments. Cohen's papers address the treatments needed near homes if the goal is to protect structure loss. There's also one study that addresses the ethics of prescribed fire. These papers are included because they may help those planning fuel treatments.

Alexander, Robert R. 1986. Silvicultural systems and cutting methods for old-growth lodgepole pine forests in the Central Rocky Mountains. General Technical Report RM-GTR-127. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 31 p.

See Literature Reviews.

Benson, Robert E. 1999. Effects of ecosystem-based management treatments: effect of management activities on esthetics, all cutting units. In Smith, Helen Y and Arno, Stephen F., editors. Eighty-eight years of change in a managed ponderosa pine forest. General Technical Report RMRS-GTR-23. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station: 44-45.

Groups: social/human dimensions/esthetics.
Location: Lolo National Forest, western Montana.

Abstract: None

Additional notes: At the Lick Creek site in western Montana, the U.S. Forest Service applied a different kind of silvicultural cutting treatment for each of three experimental stands consisting of 80 to 100 acres each, with some units receiving prescribed burning and some not burned. Scenic quality of different treatments was analyzed using three techniques that used photos of sites two growing seasons after harvest. The most preferred was the preharvest selection stand, typically open and park-like with large yellow-barked pine. Viewers also liked the preharvest scenes in areas that were shelterwood cut or thinned, but their preferences were not as distinct. Least preferred scenes were postharvest areas where slash remained or where there was evidence of recent burning such as partially burned slash or charred trees. It appears from this study and others that efforts to return stands to conditions similar to those in the early part of the century will result in more visually pleasing scenery than if overstocked thinckets develop.

URL: None at this time. Please check back for updates.
Keywords: commercial thinning/ selection cutting/ shelterwood cut/ ponderosa pine/ Douglas-fir/ partial cutting/ prescribed burning/ aesthetics/ scenic quality/ esthetics

--. 1996. Esthetic evaluation of harvest activities, Six Mile Area, Lolo National Forest. INT Order-43-0353-6-0138. Missoula, MT: USDA Intermountain Research Station. 15 p.

Groups: social/human dimensions/esthetics.
Location: Lolo National Forest, western Montana.

Abstract: None

Additional notes: In the conclusion, the author states, "Viewer preferences among several harvest treatments in the Six Mile area were measured using [photo] triads, a comparative judgement technique. Results indicated that thinning with slash piled and burned or slash removed were slightly preferred over uncut stands, and were

somewhat more strongly preferred over areas that had broadcast burning or underburning. Although preferences were fairly distinct between most preferred and least preferred treatments, the differences were not as distinct among several treatments. The areas were all fairly similar in appearance, and apparently viewers did not detect any features that had strong influence on their preferences either positive or negative. There was a fairly high degree of intransitivity, that is preferences between two treatments were often reversed. Analysis of photos using Scenic Beauty Estimation prediction models gave similar results, with no features leading to strong like or dislike ratings.

"It appears that if harvest activities are conducted with care as seemed to be the case in this study, any of the planned treatments could result in similar scenic qualities, and decisions between treatments could be based on other factors such as wildlife or cost."

Treatments included: 1) dominant and co-dominant trees retained, slash piles and burned--this treatment had the highest preference score; 2) dominant and co-dominant trees cut, slash removed in tree length skidding; 3) dominant and co-dominant trees cut, slash spread and broadcast burned; 4) uncut; 5) a hot underburn made for wildlife purposes, which resulted in considerable tree mortality--this treatment had the lowest preference score. The treatments took place in 1995 and the paper was published in June 1996. There's no indication as to when after the treatments the photos were taken.

URL: None at this time. Please check back for updates.
Keywords: harvest/ aesthetics/ esthetics/ thinning/ underburning

Brunson, Mark W. and Reiter, Douglas K. 1996. Effects of ecological information on judgments about scenic impacts of timber harvest. Journal of Environmental Management . 46(1): 31-41.

Groups: social/human dimensions/esthetics.
Location: Corvallis, Oregon.

Abstract: The public is unlikely to accept ecosystem management practices unless they believe its ecological benefits outweigh its potentially adverse impacts. This study tested whether information about ecological benefits of ecosystem management can improve acceptance of impacts to visual resources. Students and office workers rated photographs of forest stands showing traditional and ecosystem management timber harvests. Half of the respondents first heard a 5 minute informational message about ecosystem management; the other half did not. Acceptability scores for some ecosystem management stands exceeded those for clear cuts or commercially thinned stands. Ratings varied significantly for different views of the same stand, but not between students and office workers or between message and control groups. However, there was a significant interactive effect: office workers who heard the message, rated the ecosystem managed stands as *more acceptable*than did the control group, while students who heard the message judged the stands as *less acceptable*. Managers hoping to influence public beliefs about ecosystem management must craft informational messages carefully, because poorly targeted messages may have unintended effects.

Additional notes: Treatments included one stand representing natural conditions (old growth), two stands representing traditional harvest (clearcut and early commerical thinning), and four representing ecosystem management conditions (group selection, snag-retention clearcut, and two-story cut).

URL: http://www.elsevier.com/locate/issn/0301-4797
Keywords: scenic quality/ecosystem management/timber harvest/information/public acceptability

Burchfield, Jim. 2001? National conference on the social acceptability of fuel treatments on western public lands; 2000 October 22-24; Missoula, MT. Missoula, MT: Bolle Center for People and Forests, The University of Montana.

Groups: social/human dimensions/esthetics.
Location: western U.S.

Abstract: None

Additional notes: This conference "created a problem-solving experience for key scientists, policy makers, and practitioners in the treatment of forest and grassland fuels to accomplish the following objectives: 1) promote greater understanding of the variation of social acceptance of fuel treatments based on social, economic, and political conditions; and 2) develop focused research questions to assess the processes and practices affecting the social acceptance of fuel treatments." Social scientists gave presentations on social acceptability research and participatory approaches in fuels and fire management.

URL: None at this time. Please check back for updates.
Keywords: fuel treatments/public opinion/social acceptability/social concerns/public participation

Carpenter, Edwin H.; Taylor, Jonathan G.; Cortner, Hanna J. and others. 1986. Targeting audiences and content for forest fire information programs. Journal of Environmental Education. 17(3): 33-42.

Groups: social/human dimensions/esthetics.
Location: Tuscon, Arizona area.

Abstract: Data from three independently conducted public opinion surveys indicate a high level of support for management practices initiated and controlled by the manager. Additional analysis performed on one of the data sets further reveals the extent to which sociodemographic characteristics and beliefs about the effects of fire in forest environments predict public approval. Based on the analyses, recommendations are made concerning the appropriate audiences and content to target in the design of fire information programs to effectively communicate new fire management objectives and plans.

Additional notes: In the conclusion, the authors makes the following statement: "Since public acceptance of allowing fires to burn increases as more information about the fire is given and as control is specified, fire information programs should clearly describe situations where fire needs to be suppressed and situations where fire can be used to achieve beneficial management objectives. The content of fire information programs needs to be directed toward a broad, cross-section of adults, addressing directly those factors, such as fire size, intensity, and impact upon animals, that can cause emotional concern when individuals visualize an undefined forest fire. Program content should also include discussions of the beneficial effects that can be realized from lightning-caused as well as manager-set prescribed fires, and the manager's role in controlling and accepting the responsibility and risks for a fire labeled 'prescribed.'"

URL: None at this time. Please check back for updates.
Keywords: public opinion/social factors/prescribed fire/wildfire/public information

Cohen, Jack D. 1999. Reducing the wildland fire threat to homes: where and how much? (draft). General Technical Report PSW-GTR-173. USDA Forest Service, Pacific Southwest Research Station: 189-195.

Groups: social/human dimensions/esthetics.
Location: none.

Abstract: Understanding how ignitions occur is critical for effectively mitigating home fire losses during wildland fires. The threat of life and property losses during wildland fires is a significant issue for Federal, State, and local agencies that have responsibilities involving homes within and adjacent to wildlands. Agencies have shifted attention to communities adjacent to wildlands through pre-suppression and suppression activities. Research for the Structure Ignition Assessment Model (SIAM) that includes modeling, experiments, and case studies indicates that effective residential fire loss mitigation must focus on the home and its immediate surroundings. This has significant implications for agency policy and specific activities such as hazard mapping and fuel management.

Additional notes: The modeling, crown fire experiments, and case studies show that effective fuel modification for reducing potential wildland/urban interface fire losses need only occur with 40 m of a home. Home losses can be effectively reduced by focusing mitigation efforts on the structure and its immediate surroundings. Reducing home ignitability is key.

URL: http://www.firelab.org/fbp/fbppubs/fbppdf/cohen/reducingwlfire.pdf
Keywords: fuel reduction/ home protection/ home ignitability/ wildland-urban interface/ wildland fuels/ SIAM model

--. 2000. What is the wildland fire threat to homes? Flagstaff, AZ: Thompson Memorial Lecture, April 10, 2000, School of Forestry, Northern Arizona University.

Groups: social/human dimension/esthetics.
Location: none.

Abstract: None

Additional notes: In the conclusion, the author states that, "SIAM [Structure Ignition Assessment Model] modeling, crown fire experiments, and case studies indicate that the characteristics of a home and its immediate surroundings determine a home's ignition potential during wildland fires. For this context, we can refer to the home and its immediate surroundings as the home ignition zone…And we can refer to the ignition potential within the home ignition zone as home ignitability. The home ignition zone extends to a few tens of meters around a home not hundreds of meters or beyond. Home ignitions and thus, the W-UI [Wildland-Urban Interface] fire loss problem principally depend on home ignitability.

"Wildland fuel reduction beyond the home ignition zone does not necessarily change home ignitability; therefore, wildland fuel reduction does not necessarily mitigate the W-UI fire loss problem. Consequently, if home ignitability is not considered for reducing W-UI losses, extensive wildland fuel reduction must eliminate a home's exposure to flames and particularly firebrands. Thus, wildland fuel reduction that is effective for reducing the wildland fire intensity might be insufficient for reducing the destruction of highly ignitable homes…In contrast, a low home ignition potential reduces the chances of fire destruction without extensive wildland fuel reduction…These findings indicate that the W-UI fire loss problem is a home ignitability issue largely independent of landscape fuel reduction issues."

URL: None at this time. Please check back for updates.
Keywords: fuel reduction/ home protection/ home ignitability/ wildland-urban interface/ wildland fuels/ SIAM model

Cortner, Hanna; Gardner, Philip D.; and Taylor, Jonathan G. 1990. Fire hazards at the urban-wildland interface: what the public expects. Environmental Management. 14(1): 57-62.

See Literature Reviews.

Cortner, Hanna J.; Taylor, Jonathan G.; Carpenter, Edwin H. and others. 1990. Factors influencing Forest Service fire managers' risk behavior. Forest Science. 36(3): 531-548.

Groups: social/human dimension/esthetics.
Location: western U.S.

Abstract: Fire managers from five western regions of the USDA Forest Service were surveyed to determine which decision factors most strongly influenced their fire-risk behavior. Three fire-decision contexts were tested: Escaped Wildfire, Prescribed Burning, and Long-Range Fire Budget Planning. Managers first responded to scenarios constructed for each decision-making context. Various types of risk were manipulated in each context to determine what factors could influence a shift in risk behavior. Following the presentation of

scenarios, managers rated and ranked decision factors that might influence their decision-making on fire. Results show that safety, the resources at risk, public opinion, and the reliability of information were important influences on manager decisions. Local or regional policy changes and personal considerations had less influence. Manager ratings and ranking of what factors are important in fire decision-making were consistent with fire-risk decisions taken in each of the three decision contexts. Fire-risk behavior also varied from one geographic region to another and from one fire-decision context to another. Depending on the kinds of risks managers perceived, their decisions shifted along the risk-avoidance/risk-taking continuum.

URL: None at this time. Please check back for updates.
Keywords: risk/prescribed fire/wildfire/opinion survey/safety/fire management/fire policy/decision-making/forest fire

Dickman, Donald I. and Rollinger, Jeannette L. 1998. Fire for restoration of communities and ecosystems. Bulletin of the Ecological Society of America. 79(2): 157-180.

Groups: social/human dimensions/esthetics.
Location: western U.S.

Abstract: None

Additional notes: These are notes on a symposium held at the ESA Annual Meeting in Albuquerque, NM on August 11, 1997. Among other papers, they summarized a paper by Jane Kapler Smith, Clinton Carlson, and Stephen McCool that discussed the social context for restoring fire-adapted ecosystems in the West. Their thesis was that fire cannot be restored to ecosystems unless we can relate the need to do so to the public. Members of the public need to be informed, or better still, involved in the planning stages of ecosystem restoration. In response to the survey question, "Should prescribed fire be used to increase ecosystem diversity," 75 percent responded "Yes" or had no opinion. However, they were wary of expert opinion. The authors conclude that the following paradigm should be adopted by managers using fire in ecosystem restoration when dealing with the public: Inform--listen--accomodate needs--mutually learn.

URL: None at this time. Please check back for updates.
Keywords: prescribed fire/ecosystem restoration/social aspects

Hesseln, Hayley; Loomis, John B.; and González-Cabán, Armando. 2003. The effects of fire on hiking demand: a travel cost study of Colorado and Montana. In: Omi, Philip N. and Joyce, Linda A., technical editors. Fire, fuel treatments, and ecological restoration: conference proceedings; 2002 April 16-18; Fort Collins, CO. Proceedings RM-P-29. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station: 177-186.

Groups: social/human dimensions/esthetics.
Location: national forests in Colorado and Montana.

Abstract: Surveys were conducted on 33 sites within National Forests in Colorado and Montana to test how forest fires affected recreation demand in the two states. Data were collected on the actual number of visits and on the intended number of visits if the area had been subject to a recent high intensity crown fire, a recent prescribed fire, or an old crown fire (all depicted in photos). A travel cost model was estimated by pooling actual and intended visitation responses in both states. Results indicate that Montana hikers take slightly more trips but have lower net benefits or consumer surplus ($12 per trip) than do Colorado visitors ($55 per trip). Also, the demand functions do not react similarly to prescribed fires. Whereas annual values in Colorado increase over time, there were no significant changes in visitation or net benefits for Montana respondents. However, demand functions do react similarly in response to crown fires, resulting in a decrease in visitation and value over time. This latter result provides evidence in support of increased fuels management as outlined by the National Fire Plan.

Additional notes: One form of fire was prescribed fire.

URL: http://www.fs.fed.us/rm/pubs/rmrs_p029.html
Keywords: aesthetics/esthetics/economics/travel cost model/prescribed fire/wildfire/hiking demand

Hodgson, Ronald W. 1995. Strategies for and barriers to public adoption of fire safe behavior. In: Weise, David R. and Martin, Robert E., technical coordinators. The Biswell symposium: fire issues and solutions in urban interface and wildland ecosystems; 1994 February 15-17; Walnut Creek, CA. General Technical Report PSW-GTR-158. Albancy, CA: USDA Forest Service, Pacific Southwest Research Station: 93-99.

Groups: social/human dimensions/esthetics.
Location: Sierra-Cascades foothills of California.

Abstract: A recent survey of people living in wildland-urban intermix neighborhoods in a portion of the Sierra-Cascade foothills identified perceptions of defensible space that block its rapid and widespread adoption. A companion survey described communication channels used by residents to acquire information about landscaping and identified opinion leadership characteristics. Neither lack of awareness of the wildfire threat, lack of basic knowledge of defensible space, nor skepticism about defensible space effectiveness were a barrier to adoption of wildfire defenses by property owners. Perceived costs and labor requirements, lack of specific knowledge about how to do the required work, lack of time or assistance to do the work, and the difficulty of disposing of large amounts of brush generated in the initial conversion to defensible space were serious barriers. Biomass harvesting was experimented with to dispose of brush and to cover some of the costs of initial conversion. Social marketing and community organization methods were used to promote and carry out the project. The approach proved effective. Results showed excellent promise for the use of biomass harvesting in thickly settled subdivisions.

URL: None at this time. Please check back for updates.
Keywords: community response/ecosystem management/fire ecology/fire management/fuel management/prescribed burning

Kumagai, Yoshitaka and Daniels, Steven E. 2002. Social science in fuel management: an annotated bibliography on prescribed fire. Research Contribution, Corvallis. Corvallis, OR: Forest Research Laboratory, Oregon State University. 42 p.

Groups: social/human dimensions/esthetics.
Location: North America.

Abstract: This annotated bibliography is collected from professional journals in natural resource management and sociology, conference proceedings, and technical reports. It is categorized into thirteen sections: acceptability, fire in wilderness, general, history, institutions, media, policy, public attitude toward wildfire, public involvement, public perception of prescribed burning, risk perception, social psychology, and wildland-urban interface.

URL: http://www.cof.orst.edu/cof/pub/home/rc/RC36.pdf
Keywords: prescribed burning/ controlled burning/ fires/ fuels/ perception/ attitudes/ public opinion/ risk assessment/ bibliographies/ wildland/ urban interface

Manfredo, Micheal J.; Fishbein, Martin; Haas, Glenn E. and others. 1990. Attitudes toward prescribed fire policies. Journal of Forestry. 19-23.

Groups: social/human dimensions/esthetics.
Location: Wyoming, Montana, and nationwide.

Abstract: None

Additional notes: In the conclusion, the authors state, “While biological information may provide support for a prescribed fire policy in areas managed with a preservation mandate, that alone is not sufficient justification for its implementation. Fire policy has a critical sociopolitical component, and the fact that people appear poorly informed about the outcomes of fire policy and fire effects adds controversy. The fires of 1988 and the subsequent policy reevaluation reinforce what most managers realize: modern forestry is heavily involved in educating and communicating with the public. Because national attitudes differ widely, policy-makers face major hurdles in establishing fire policies that will be approved by a majority of the public. This provides a challenge to managers as they focus educational efforts on a better understanding of the effects of fire and fire policy.”

This study focused on social considerations of a fire policy--particularly attitudes, beliefs, and behavioral intentions regarding fire policy and knowledge about the effects of wildfire. Surveys collected data in 1989 for the affected region (Wyoming and Montana because they are near Yellowstone National Park) and the nation.

URL: None at this time. Please check back for updates.
Keywords: prescribed fire/Wyoming/Montana/Yellowstone/fire policy/public opinion

McCaffrey, Sarah M. 2004. Fighting fire with education: what is the best way to reach out to homeowners? Journal of Forestry. 102(5): 12-19.

Groups: Social/Human Dimensions/Esthetics.
Location: Nevada

Abstract: Better understanding is needed of what makes educational efforts most effective in increasing public support for wildfire management and mitigation efforts. Results of a mail survey of homeowners in Incline Village, Nevada, indicate that personalized contact is key in the educational process and that which type of contact--government or personal--is more influential depends on the type of practice involved. Notably, prescribed burning appears to have more in common with defensible space than with thinning in terms of how homeowners respond to educational efforts.

Additional notes: The authors says in the conclusion that, "coupling educational materials with more-personalized contact appears to be the most effective method for providing information on wildfire management and mitication." She also states that "The positive effect of educational materials are not inherently ignotred; rather, to be effective, materials may need to be placed directly into people's hands and not delivered impersonally via mailings, display tables, or newsstands."

URL: None at this time. Please check back for updates.
Keywords: communication/public perception/wildfire/wildland-urban interface/fuel reduction/prescribed burning

Scott, Joe H. 1998. Fuel reduction in residential and scenic forests: a comparison of three treatments in a western Montana ponderosa pine stand. Research Paper RMRS-RP-5. Rocky Mountain Research Station, USDA Forest Service. 19 p.

See Fire Behavior and Fuel Reduction.

--. 1996. Reducing forest fire hazard in residential and scenic areas: a case study comparing three treatments in a western Montana ponderosa pine stand. Final Report RJVA#92685. Missoula, MT: Intermountain Fire Sciences Laboratory. 48 p.

Groups: economics; social/human dimensions/esthetics.

Location: Lolo National Forest in western Montana.

Abstract: None.

Additional notes: In the conclusion, the author states, “This project has demonstrated several alternative thinning methods to reduce forest fire hazard and improve forest health in esthetically-sensitive residential and recreational forests. All of the treatments developed in this study seem to be appropriate for reducing fire hazard in a sensitive and cost-effective manner. Although the treatments are quite similar in design and implementation, there are differences between them, both significant and subtle, which make them appropriate in different situations.

"Treatment 1: Minimum Impact. This treatment is highly favored for its esthetic quality, being preferred over not only the other treatments, but over the untreated stand as well. The treatment was moderately effective in reducing fire hazard by reducing fine fuels, raising the live crown base heights, removing ladder fuels, and spacing tree crowns. Although this treatment produced significantly less net income than the others, it nonetheless more than paid for itself, providing a return of $246/ac to the landowner. This treatment is favored on small private residential properties where aesthetic values are high and too-low stand densities are avoided for privacy reasons. The Forest Service may find such a treatment useful in areas with very high recreational values in which there is significant public concern over too much harvesting.

"Suggested or possible changes to this treatment include a lower residual stand density, perhaps of about 85 sq. ft. per acre, if the thinning is still done from below, leaving the largest, healthiest trees. The aesthetic acceptance of this treatment is probably derived from the nature of the thinning (from below), but also from the intensive logging and slash disposal methods. A broadcast burn could probably be implemented in this treatment without significant degradation of aesthetic quality if it is conducted after the slash fuels have been disposed of. A burn conducted in slash fuels would likely result in too much bark char or mortality. The additional cost of the burn may make the treatment unable to pay for itself.

"Treatment 2: Generate Short-term Income. This treatment was certainly effective at its emphasis of providing income. It produced more income than the other treatments…and was effective at reducing the fire hazard by thinning the overstory, and ranked high aesthetically. This type of treatment is appropriate on a wide range of public and private land.

"There is little that could be changed in this treatment to improve its effectiveness. Additional slash treatments such as a broadcast burn could not be justified in light of the income-producing emphasis. Mechanized logging equipment should consistently provide the most cost-effective harvesting in this forest type. Any further reduction in basal area would probably produce an unacceptable aesthetic condition, especially since the thinning is from above. Care must be exercised when implementing a high thinning to avoid ’high grading.’ The goal of a high thinning is to leave a high-quality stand of trees by thinning in the dominant and co-dominant crown classes.

"Treatment 3: Forest Health. This appears to represent a middle ground treatment that balances aesthetics, income production and forest health--truly an 'ecosystem management' treatment with broad application. Any treatment which couples a low thinning with a broadcast burn will significantly reduce wildfire hazard; the data show that this treatment was certainly the most effective of the three in reducing fire hazard. Even with the high cost of the broadcast burn this treatment showed a modest return per acre. Unfortunately, esthetic quality suffers whenever a broadcast burn chars the boles of trees. This type of thinning and burning treatment has broad applicability on public and increasingly on private lands in the pine type.

"Some changes could be made to improve this treatment. In this implementation, slash was back-hauled from the landing and spread with the grapple skidder in order to retain as much of the nutrient base on the forest floor as possible. While this practice may have long-term benefits for forest productivity, when coupled with a prescribed burn the increased fuel loads may lead to increased fire-caused mortality, bark char, and crown scorch, with negative implications for aesthetics. It may be more practical to dispose of the landing slash in a landing pile and broadcast burn the natural fuel bed with the small amount of slash left after a mechanized logging operation. The residual basal area could probably also be reduced slightly, bringing in more income and

perhaps helping to create more 'natural' conditions, without adversely effecting stand aesthetics."

URL: None at this time. Please check back for updates.
Keywords: aesthetics/ esthetics/ ponderosa pine/ Douglas-fir/ thinning/ slash burning/ broadcast burning/ fuel reduction/ economics

Shindler, Bruce. 1997. Public perspectives on prescribed fire and mechanical thinning. Blue Mountains Natural Resources Institute. 4 p.

Groups: social/human dimensions/esthetics.
Location: Blue Mountains for northeastern Oregon.

Abstract: None.

Additional notes: The following came from the author's conclusions: Most citizens surveyed were receptive to both mechanical thinning/removal and prescribed fire as fuel reduction methods in the Blue Mountains. Large majorities agreed with their use for specific management purposes and were willing to live with the resulting effects. The majority of respondents preferred thinning/removal to prescribed fire, primarily because of the retention of products in thinning operations, and the negative effects of risk in prescribed fire operations.

This study further supports the contention that although strong voices have been critical of Forest Service policies to manage the fire issue, "the general public in the study area is in support of the Forest Service increasing its efforts to use prescribed fire and mechanical thinning in the Blue Mountains. It is also likely that the public would prefer the agency to provide stronger leadership locally, particularly if this direction includes increased interaction with communities.

"While these findings reflect the views of the general public, recent history indicates that numerous factors play a role in shaping forest policy. Even though people are receptive to these methods and ideas, many will be waiting to see how well they work before making final judgements. Informative programs that help people understand ecosystem management practices, and inclusive ones where people can contribute to plans involving difficult but necessary tradeoffs, often mean the difference between success and frustration."

This publication presents a partial summary of findings from public opinion surveys conducted in the Blue Mountains communities in 1996.

URL: http://www.fs.fed.us/pnw/bmnri/pubs/tn9.pdf
Keywords: thinning/ prescribed fire/ fuel reduction/ public/ public opinion

Strohmaier, David J. 2000. The ethics of prescribed fire: a notable silence. Ecological Restoration. 18(1): 5-9.

Groups: social/human dimensions/esthetics; wildlife.
Location: nationwide.

Abstract: None

Additional notes: This is an opinion paper. The author poses this question: Do we need a professional ethic for the use of prescribed burning in restoration, particularly as it relates to its effects on individual animals? Public discussion about prescribed burning among restorationists is confined almost entirely to questions of achieving some desired future condition on the land. Language in environmental assessments reflecting concern for individual animals is either totally lacking, or is based on concern for rare, endangered, or other special-status species. When, where, and how we accomplish restoration work is a matter of ethics in that they affect the likelihood of killing and suffering of individual animals. No matter how carefully we plan and carry out burns, some animals will be killed, inured, or displaced, as they might in a wildfire. Nevertheless, this does not exempt us from the hard work of grappling with the ethics of prescribed fire, and ethically contextualizing burns by

asking when, where, and how to conduct a project.

URL: None at this time. Please check back for updates.
Keywords: ethics/prescribed fire/wildlife

Taylor, Jonathan G.; Cortner, Hanna J.; Gardner, Philip D. and others. 1986. Recreation and fire management: public concerns, attitudes, and perceptions. Leisure Sciences. 8(2): 167-187.

Groups: social/human dimensions/esthetics.
Location: Tucson, Arizona and nationwide.

Abstract: Data from three separate but related surveys address the linkages between recreation and public perception of and attitudes toward fire management. Recreation ranks high among alternative forest resource uses and is a serious concern vis-a-vis fire effects. Public acceptance of new fire-management policies may be greater and more sophisticated than commonly thought. Public knowledge of fire effects and tolerance of light-intensity fires can be increased through use of educational materials. However, there is some evidence that increases in knowledge and tolerance may not affect perceptual judgments of recreational acceptability or scenic beauty. Some recreational activities, particularly camping, show considerable sensitivity to fire effects. New fire-management policies and educational programs will need to account for increasing sophistication in the public's understanding and tolerance of fire, as well as for different impacts that fire may have on various outdoor recreation activities.

Additional notes: Of the three surveys used, one represented a nationwide sample and the other two sampled the general public in Tucson, Arizona.

URL: None at this time. Please check back for updates.
Keywords: recreational acceptability/public attitudes/fire management/prescribed fire/scenic beauty/fire policy

Taylor, Jonathan G. and Daniel, Terry C. 1983. Perceived scenic and recreational quality of forest burn areas. In: Proceedings--wilderness fire symposium; 1983 November 15-18; General Technical Report INT-GTR-182. Ogden, UT: USDA Forest Service, Intermountain Research Station: 398-406.

Groups: social/human dimensions/esthetics.
Location: southwestern Arizona.

Abstract: Public panels rated ponderosa pine forest scenes showing 1 to 5 years of recovery from severe fire or from light fire, for their scenic quality and recreational acceptability. Scenic quality ratings improved relative to unburned areas from 3 to 5 years following light fire but seriously declined for 5 or more years following severe fire. Recreational acceptability was also more adversely affected by severe fire than by light fire, but effects varied depending upon recreation activity type. Respondents that were provided fire effects information beforehand had different levels of fire knowledge and fire tolerance, but receiving this information did not change ratings of scenic quality or recreational acceptability. Overall, respondents supported prescribed burning policy.

URL: None at this time. Please check back for updates.
Keywords: ponderosa pine/fire/scenic quality/aesthetics/esthetics/recreation/prescribed fire/public opinion/public

Taylor, Jonathan G. and Daniel, Terry C. 1984. Prescribed fire: public education and perception. Journal of Forestry. 82(6): 361-365.

Groups: social/human dimensions/esthetics.
Location: Tucson, Arizona.

Abstract: A sample drawn from the population of Tucson, Arizona, rated slides of forest scenes for scenic quality and acceptability for recreation. The scenes showed ponderosa pine areas that were unburned or had had light or severe fire 1 to 5 years previously. Participants also read brochures about fire effects, and took a post test that measured both fire knowledge and attitude. Their ratings of the slides indicated that scenic quality was improved by light fires but diminished by severe burns. Acceptability ratings for recreation differed with the kind of recreation contemplated, with camping showing the greatest sensitivity to fire effects. With slight variation by type of presentation, the brochures increased respondents' knowledge and tolerance of fire but did not affect ratings of scenic or recreational quality. Overall, respondents supported prescribed burning.

URL: None at this time. Please check back for updates.
Keywords: ponderosa pine/fire/scenic quality/aesthetics/esthetics/recreation/prescribed fire/public opinion/public

Toman, Eric and Shindler, Bruce. 2003. Hazardous fuel reduction in the Blue Mountains: public attitudes and opinions. In: Omi, Philip N. and Joyce, Linda A., technical editors. Fire, fuel treatments, and ecological restoration: conference proceedings; 2002 April 16-18; Fort Collins, CO. Proceedings RMRS-P-29. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station: 241-254.

Groups: social/human dimensions/esthetics.
Location: Blue Mountains region of Oregon and Washington.

Abstract: Resource managers in the Blue Mountains region of eastern Oregon and Washington are utilizing prescribed fire and mechanized thinning treatments to reduce hazardous fuel loads and restore forest health. This paper uses panel data from a mail survey administered to the same individuals in 1996 and 2000 to measure change in public attitudes and opinions about fire management programs. Respondents are knowledgeable about, and supportive of, prescribed fire and thinning practices; prefer interactive over uni-directional education programs; and desire a role in management decision-making. While findings were generally similar throughout the study period, significant changes suggest a declining relationship between the Forest Service and Blue Mountains residents.

Additional notes: Based on a 15-question True/False quiz, participants appeared significantly more knowledgeable about the effects of thinning than about prescribed fire. Concerning sources of information about natural resource issues, newspapers/magazines and friends were the most useful sources and the only ones to receive a moderate to high rating by the majority of the respondents. The usefulness of timber groups rose since 1996 and that of the Forest Service fell. The lowest ratings were for radio, environmental groups, and the internet. Concerning specific Forest Service information programs, the following received the highest usefulness ratings: Smokey, elementary school educational programs, conversations with agency personnel, interpretive information, and guided field trips. Lowest usefulness ratings were for Environmental Impact Statements, information videos, and Forest Service internet pages. Four of the most highly rated programs were interactive--elementary school programs, conversation with agency personnel, interpretive centers, and guided field trips, indicating greater dividends may be achieved from this form of outreach. Of the interactive programs, only Forest Service public meetings failed to resonate with a majority of the respondents. Of the unidirectional programs, four--Smokey, television messages, newsletters, and prescribed fire brochures--were useful to a majority of respondents.

The authors recommend the following basic strategies: 1) capitalize on existing public knowledge and support for fuel reduction; 2) focus on relations with citizens; and 3) develop a comprehensive communication strategy that includes opportunities for interaction at the community or individual level.

URL: http://www.fs.fed.us/rm/pubs/rmrs_p029.html
Keywords: prescribed fire/thinning/fuel reduction/public opinion/public/management

Walstad, John D.; Radosevich, Steven R.; and Sandberg, David V. 1990. Natural and prescribed fire in

Pacific Northwest forests. Corvallis, OR: Oregon State University Press. 317 p.

See Literature Reviews.

Weldon, Leslie A. C. 2002. Dealing with public concerns in restoring fire to the forest. Tree Farmer. March/April: 35-37.

Groups: social/human dimensions/esthetics.
Location: Bitterroot Valley of western Montana.

Abstract: None.

Additional notes: In this article, the author describes challenges of restoring fire to forests, shares opinions of some people from western Montana regarding prescribed fire, examines major barriers to public acceptance, and suggests ways to increase public support for fire restoration. The goal is to restore ecological health and productivity to forests in the West by the expanded use of fire as a management tool. Active public support is critical to success in reaching this goal. Managers must place a priority on public participation as a key step in planning and implementing a growing prescribed fire program.

Social assessments, such as the one completed in the Bitterroot Valley, are tools for understanding public attitudes, concerns, and suggestions regarding prescribed fire programs that, in turn, can lead to effective partnerships in building support.

URL: None at this time. Please check back for updates.
Keywords: social assessment/public opinion/public participation/public/prescribed fire

Soils

Fifty-one studies addressed effects of fuel reduction treatments, mostly prescribed fire, on soils. Many studies of prescribed fires were, until the last decade or so, actually addressing slash-burning. This bibliography left out many of those papers unless there was some indication that the burning was more of an understory burn, or if the study addressed the effects of various temperatures and burning time on soils.

Agee, James K. 1996. Achieving conservation biology objectives with fire in the Pacific Northwest. Weed Technology. 10(2): 417-421.

See Literature Reviews.

Brown, James K.; Marsden, Michael A.; Ryan, Kevin C. and others. 1985. Predicting duff and woody fuel consumed by prescribed fire in the Northern Rocky Mountains. Research Paper INT-RP-337. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station. 23 p.

See Fire Behavior and Fuel Reduction.

Brown, Rick. 2000. Thinning, fire and forest restoration: a science-based approach for National Forests in the Interior Northwest. Washington, D.C.: Defenders of Wildlife. 25 p.

See Literature Reviews.

Busse, M. D.; Cochran, P. H.; and Barrett, J. W. 1996. Changes in ponderosa pine site productivity following removal of understory vegetation. Soil Science Society of America Journal. 60(Nov-Dec): 1614-1621.

See Vegetative Effects—Understory.

Carlton, Donald W. and Pickford, Stewart G. 1982. Fuelbed changes with aging of slash from ponderosa pine thinnings. Journal of Forestry. 80(2): 91-93, 107.

See Fire Behavior and Fuel Reduction.

Choromanska, U. and DeLuca, T. H. 2001. Prescribed fire alters the impact of wildfire on soil biochemical properties in a ponderosa pine forest. Soil Science Society of America Journal. 65(Jan-Feb): 232.

Groups: soils.
Location: Bitterroot National Forest in western Montana (Lick Creek).

Abstract: Although studies have addressed the influence of fire on soil biochemical processes, there have been no reports on how prescribed fire followed by wildfire influences microbial activity and nutrient cycling. Over a 21-mo period we monitored changes in soil nitrogen (N) and carbon (C) of a ponderosa pine (*Pinus ponderosa* P.&C. Lawson) and Douglas-fir [*Pseudotsuga menziesii* var. *glauca* (Beissn.) Franco] forest (both O horizon and 0-10 cm of mineral soil) that had been exposed either to prescribed fire (PB), wildfire (WF), prescribed fire three months prior to wildfire (PBWF), or no fire as an unburned control. Total N, potentially mineralizable N (PMN), NH_4^+-N and NO_3^--N concentrations in surface (0-10 cm) mineral soils were significantly increased immediately after WF. Soils exposed to prescribed fire prior to wildfire also had elevated concentrations of total

N, PMN and NH_4^+-N, but were significantly lower than in WF alone. Potentially mineralizable N was significantly reduced on all fire-exposed sites from 9 months to the end of the study period. Although mineral soil NO_3^--N concentrations in fire-exposed soils were similar to the unburned control 12 months after fire, resin sorbed NO_3^--N was 88 micrograms per capsule in WF soils vs. 24 micrograms per capsule in PBWF soils, and 1.3 micrograms per capsule in the unburned control. Microbial biomass in the WF mineral soils was as low as 52 micrograms per gram 21 months after fire while microbial biomass in PBWF soils remained above 100 micrograms per gram throughout the study. It appears that prescribed fire prior to wildfire may attenuate the effects of wildfire on soil and may have predisposed the microbial community to the effects of heating.

Additional notes: This study took place on the Bitterroot National Forest in western Montana. The wildfire occurred three months after the prescribed burn. The wildfire-only affected portion experienced complete stand mortality and 100% fien fuel consumption, while the portion that had been prescribed burned followed by a wildfire experienced 50% stand mortality and 70% fuel consumption.

URL: None at this time. Please check back for updates.
Keywords: soils/fire effects/prescribed fire/wildfire/nitrogen/carbon/ponderosa pine/Douglas-fir/nutrient cycling/microbial activity

DeBano, Leonard F. 1991. The effect of fire on soil properties. In: Proceedings: symposium on management and productivity of western-montane forest soils; 1990 April 10-12; Boise, ID. General Technical Report INT-GTR-280. USDA Forest Service, Intermountain Forest and Range Experiment Station: 151-156.

See Literature Reviews.

DeBano, Leonard F.; Neary, Daniel G.; and Ffolliott, Peter F. 1998. Fire effects on ecosystems. New York, NY: John Wiley and Sons, Inc. 332 p.

See Literature Reviews.

DellaSala, Dominick A. and Frost, Evan. 2001. An ecologically based strategy for fire and fuels management in national forest roadless areas. Fire Management Today. 61(2): 12-23.

See Literature Reviews.

DeLuca, T. H. and Zouhar, K. L. 2000. Effects of selection harvest and prescribed fire on the soil nitrogen status of ponderosa pine forests. Forest Ecology and Management. 138 (1-3): 263-271.

Groups: soils.
Location: western Montana (Lick Creek on the Bitterroot National Forest, Lubrecht Experimental Forest, and E/L Ranch in the Blackfoot Valley).

Abstract: One hundred years of timber harvest and reduced fire frequency have resulted in the conversion of once open stands of ponderosa pine (*Pinus ponderosa*) forests to dense forests dominated by Douglas-fir (*Pseudotsuga menziesii*). Selection harvest and harvest with prescribed fire have been identified as possible tools to restore ponderosa pine stands to pre-settlement stand structures. Case studies were performed at three separate sites in western Montana to assess the influence of selection harvest and prescribed burning on soil N dynamics. These sites had been exposed to either selection harvest, selection harvest with prescribed burning, or a no-treatment control 0 (Lubrecht Experimental Forest), 2 (E/L Ranch), or 11 (Lick Creek Demonstration Site) years prior to initial soil analyses. Replicate soil samples were collected over at least two growing seasons at each site and analyzed for total C and N, potentially mineralizable N (PMN), short-term soil respiration rates, soil microbial biomass N, extractable NH_4^+ and NO_3^-, and soluble sugars (measured as 0.5 M K_2SO_4 extractable

anthrone reactive carbon (KARC)). Selection harvest without prescribed burning had little or no influence on levels of available N or microbial activity relative to the control at all three sites. Selection harvest with prescribed fire, however, significantly increased extractable NH_4^+, NO_3^- and KARC immediately following treatment. Such differences were not observed 2 or 11 years following treatment. Potentially mineralizable N was significantly increased immediately following fire, but decreased to levels lower than the control 1 year following treatment. Levels of PMN were also found to be less than the control 2 and 11 years after treatment. Similarly, microbial biomass N was elevated immediately following prescribed burning, but was significantly lower than the control for up to 11 years following prescribed burning. Levels of mineralizable N were lowered within a year of treatment as a result of (1) N loss during soil heating, (2) N loss to plant uptake, and (3) potential leaching losses. The effect of reduced mineralizable N on long-term site productivity is not clear, however, these losses of N from the ecosystem should be considered along with stand mortality and yield when assessing the potential sustainability of forest management strategies.

URL: None at this time. Please check back for updates.
Keywords: ponderosa pine/Douglas-fir/microorganisms/nitrogen/microbial ecology/mineralization/prescribed fire/selection harvest effect/soil fertility status/fire exclusion/available nitrogen

DeLuca, Thomas H. 2000. Soils and nutrient considerations. In: Smith, Helen Y., Editor. The Bitterroot Ecosystem Management Project: what we have learned--symposium proceedings; 1999 May 18-20; Missoula, MT. Proceedings RMRS-P-17. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station: 23-25.

Groups: soils.
Location: western Montana, including Lick Creek on the Bitterroot National Forest and Lubrecht Experimental Forest.

Abstract: Fire suppression has resulted in a buildup of forest litter and an accumulation of organic nitrogen, and a decrease in available potassium. This has changed the historic structure of soils and their nutrient content. Studies at 15 sites in Montana have looked at a wide range of changes in soil productivity following prescribed fire. Results indicate obvious benefits to the soils from reduction in fuel loading through fire, and renewed growth of desirable understory plants.

Additional notes: The author's investigations have demonstrated that prescribed fire following selection or shelterwood harvest results in a short-term increase in mineral N followed by a long term decline in available N. However, a history of fire exclusion has probably left these forests with a lower density of N-fixing plants than occurred historically. Decreases in available N are paralleled by a decrease in microbial activity. At first glance, a decrease in total mineralizable N in forests that have generally been considered N deficient may seem like a negative impact of reintroducing fire. However, the reduced stand density following fire has lower N demand, and the decline in available N may actually have several positive effects such as: 1) a more balanced ratio of N:K, thereby resulting in lower susceptibility to disease or insect attack; 2) a greater ability of native N-fixing species to colonize sites following fire, thus providing a more labile form of N compared to the recalcitrant N associated with duff or resident soil organic matter; and 3) a decrease in the ease with which non-native plant species compete with native species.

URL: None at this time. Please check back for updates.
Keywords: ponderosa pine/*Pinus ponderosa*/prescribed fire/soil nutrients/soil productivity/nitrogen

Graham, Russell T.; Harvey, Alan E.; Jurgensen, Martin F. and others. 1994. Managing coarse woody debris in forests of the Rocky Mountains. Research Paper INT-RP-477. Ogden, UT: USDA Forest Service, Intermountain Research Station. 13 p.

Groups: fire behavior/fuel reduction; soils.
Location: western U.S.

Abstract: Coarse woody debris is a major component of Rocky Mountain forests. Debris has many functions

ranging from soil protection to wildlife and microbial habitat. The management of coarse woody debris is critical for maintaining functioning ecosystems in the Rocky Mountains. These forests have great diversity, with each forest habitat type developing and retaining different amounts of debris. Fourteen habitat types were examined, ranging from ponderosa pine (*Pinus ponderosa*) habitat types of Arizona to subalpine fir (*Abies lasiocarpa*) habitat types of western Montana. Coarse woody debris management recommendations were developed by using ectomycorrhizae as a bioindicator of healthy, productive forest soils. These recommendations are intentionally conservative to ensure that enough organic matter is available after timber harvest to maintain long-term forest productivity.

Additional notes: Management recommendations in this paper include use of prescribed fire for managing coarse woody debris. If properly handled, nutrient losses can be minimal during prescribed fires.

URL: None at this time. Please check back for updates.
Keywords: coarse woody debris/ ectomycorrhizae/ soil productivity/ soil/ organic matter/ harvest/ prescribed fire

Graham, Russell T.; Jain, Theresa Benevidez; and Harvey, Alan E. 1999. Fuel: logs, sticks, needles, duff, and much more. In: Proceeding of the conference on crossing the millennium: integrating spatial technologies and ecological principals for a new age in fire management; 1999 June 15-17; Boise, ID. Moscow, ID: University of Idaho and International Association of Wildland Fire.

See Literature Reviews.

Grier, Charles C. 1990. Effects of prescribed springtime underburning on production and nutrient status of a young ponderosa pine stand. In: Tecle, Aregai; Covington, W. Wallace; and Hamre, R. H., editors. Multiresource management of ponderosa pine forest symposium; 1989 November 14-16; Flagstaff, AZ: 71-76.

Groups: soils; vegetative effects--stand level.
Location: east slope of the Cascades in northcentral Washington.

Abstract: The effects of prescribed fuel-reduction fire were examined experimentally in a 43-year-old *Pinus ponderosa* Laws, stand in north central Washington state. The stand had been precommercially thinned 14 years before this study. Competitive mortality indicated residual trees had fully reoccupied the site. Treatments were: unburned control, light burn (existing fuel load of 30 Mg per ha and heavy burn (fuel added to total 85 Mg per ha). Relative to before-fire values, pine fine root biomass (<2 mm diameter) in the top 5 cm of soil had increased 50% on the control plots, stayed the same on the light burn plots and decreased 63% on the heavy burn plots when measured two weeks after the fire. Needle litterfall in the control plot during the year after burning was 0.66 Mg per ha while that on the light and heavily burned plots was 2.1 and 2.2 times control plot values. The amount of nitrogen and phosphorus returned in litterfall was 2- and 3-times control amounts on the light and heavy burn plots. Wood biomass increment of the burned plots was consistently about 10% greater than control before the fire. The year after burning, the light and heavy burn plots had wood biomass increment 66% and 52% of control values. Spring burning occurs when roots of trees are adapted to cold soils. Heat from fires was measurable at 10 cm and may have brought soil temperatures above the lethal temperatures for cold-adapted roots. Root mortality appears to have caused the observed changes in production and nutrient status.

Additional notes: The objective of this research was to investigate the possibility of fine root mortality occurring as a result of spring underburning in ponderosa pine stands. Specifically, the objectives were to: 1) determine the amount of fine root mortality resulting from fires in average and heavy fuels; 2) determine the changes in productivity, if any, resulting from fire-caused root mortality; and 3) determine the changes in nutrient distribution in stands subjected to underburning.

URL: None at this time. Please check back for updates.
Keywords: prescribed burning/ponderosa pine/*Pinus ponderosa*/fire effects/roots/growth

Halvorson, Curtis H. 1982. Rodent occurrence, habitat, disturbance, and seed fall in a larch-fir forest. Ecology . 63(2): 423-433.

Groups: soils.
Location: western Montana.

Abstract: Small mammal population changes were measured for five years (1970-1974) by live trapping on broadcast burned western larch *(Larix occidentalis)/*Douglas-fir *(Pseudotsuga menziesii)* clearcuts and in uncut timber on a north and south slope in incut timber on a north and south slope in western Montana. Four species comprised 96 percent of the 1324 animals caught: deer mice *(Peromyscus maniculatus)* 42 percent, red-backed voles *(Clethrionomys gapperi)* 27 percent, red-tailed chipmunks *(Eutamias ruficaudus)* 22 percent, and long-tailed voles *(Microtus longicaudus)* 5 percent. Deer mice and chipmunks were common on clearcut and timber plots. The red-backed vole and long-tailed voles were associated with moist sites but showed local allopatry. The red-backed voles were present only under tree canopy and the long-tailed vole was found only in absence of tree canopy. A hard burn effect was to eliminate most of the organic mantle and small mammals except deer mice, who existed as the single species for two years, and as 80-90 percent of numbers for five postburn years. A light burn that left duff intact was associated with retention of species diversity and a low initial postburn (two years) mammal population, followed by the largest increases. Numbers of deer mice varied inversely with numbers of red-backed voles in the timber. Deer mice increased sharply on all plots the first fall after a heavy seed crop, an occurrence reported by other workers.

From these pattern observations it is theorized that red-backed voles may dominate deer mice, but a heavy seed crop can temporarily enhance competitive standing of deer mice. An open xeric pioneering situation (hard burn) was conducive to consistently high deer mouse populations. The most obvious habitat feature associated with an inverse spatial relationship between the two voles was tree canopy. The long-tailed vole may be further discriminated against by drier habitats. Clearcutting appeared to be the principal determinant of total population size, but burn intensity seemed to influence species composition.

Additional notes: This study deals with clearcuts but has interesting finding on effect of burned soil.

URL: None at this time. Please check back for updates.
Keywords: clearcut/broadcast burning/habitat associations/old growth/western larch/*Larix occidentalis*/Douglas-fir/*Pseudotsuga menziesii*/red-backed voles/*Clethrionomys gapperi*/dominance/red-tailed chipmunks/*Eutamias ruficaudus*/fire/long-tailed voles/*Microtus longicaudus*/deer mouse/*Peromyscus maniculatus*/seed crop

Harrington, Michael. 1999. Effects of ecosystem-based management treatments: influence of selection harvest and prescribed fire on soil nitrogen. In Smith, Helen Y and Arno, Stephen F., editors. Eighty-eight years of change in a managed ponderosa pine forest. General Technical Report RMRS-GTR-23. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station: 37-38.

Groups: soils.
Location: Bitterroot National Forest in western Montana (Lick Creek).

Abstract: None

Additional notes:: At the Lick Creek site in western Montana, the U.S. Forest Service applied a different kind of silvicultural cutting treatment for each of three experimental stands consisting of 80 to 100 acres each. Within each silvicultural cutting system, they applied different underburning strategies as well as no burn treatments. In the selection cutting units, some subunits were not burned, some had an intermediate burn, and some acted as controls with no cut but with a burn. A pilot study was conducted to determine initial impacts of harvesting and burning on extractable mineral nitrogen--ammonium (NH_4^+) and nitrate (NO_3^-)--which is typically limiting in Inland West forest soils. Before burning, all treatments had similarly low levels of extractable mineral nitrogen (N) in the upper 2 inches of mineral soil. Immediately after the burn, N levels increased to about 20 parts per million (ppm) and were still at 16 ppm by the end of the first growing season. N

in the no-burn and control treatments remained virtually unchanged during this first season. Over the next 8 to 12 months, N in the burn treatment decreased as it was likely sequestered by plants and microorganisms as well as leached to lower soil depths. By 17 months, the burn treatment N was still more than twice that of the others. This difference had diminished by the start of the second year after treatment.

In the 2- to 6-inch soil layer, changes were expectedly less dramatic. N in the burn treatment continued to increase incrementally from about 1 ppm before burning to a high of 3 ppm 24 months later. In the other treatments, N was also measured at 1 ppm before burning but increased to only about 1.5 ppm during the next 24 months.

URL: None at this time. Please check back for updates.
Keywords: selection cutting/ ponderosa pine/ Douglas-fir/ partial cutting/ prescribed burning/ soil nitrogen/ nitrogen

Hartford, Roberta A. and Frandsen, William H. 1992. When it's hot, it's hot...or maybe it's not! (surface flaming may not portend extensive soil heating). International Journal of Wildland Fire. 2(3): 139-144.

Groups: soils.
Location: western Montana and northern Idaho.

Abstract: Fire effects on a plant community, soil, and air are not apparent when judged only by surface fire intensity. The fire severity or fire impact can be described by the temperatures reached within the forest floor and the duration of heating experienced in the vegetation, forest floor, and underlying mineral soil. Temporal distributions of temperatures illustrate heat flow in duff and mineral soil in three instrumented plots: two with slash fuel over moist duff and one with litter fuel over dry duff. Fires in the two slash fuel plots produced substantial flame lengths but minimal heating in the underlying mineral soil. In contrast, smoldering combustion in the dry duff plot produced long duration heating with nearly complete duff consumption and lethal temperatures at the mineral soil surface. Moisture content of duff and soil were key variables for determining fire impact on the forest floor.

Additional notes: This paper illustrates temperature histories in forest floor duff and mineral soil underlying burning slash and ground fuel, and also shows the contribution of moisture in limiting fire impact.

URL: None at this time. Please check back for updates.
Keywords: temperature/duff/smoldering/Northern Rocky Mountains/*Larix occidentalis*/*Abies lasiocarpa*

Harvey, A. E.; Jurgensen, M. F.; and Larsen, M. J. 1981. Organic reserves: importance to ectomycorrhizae in forest soils of western Montana. Forest Science. 27(3): 442-445.

Groups: soils.
Location: Flathead County in western Montana (Coram Experimental Forest).

Abstract: The important attributes contributed to forest soils by organic matter make it imperative to determine the quantity and type required to sustain good forest tree growth. Quantitative measurement of soil humus, decayed wood, and charcoal as related to numbers of active ectomycorrhizal root tips (in random soil cores from old-growth sites in western Montana) showed both positive and negative relationships with organic matter. Increased quantities of organic material, to 45 percent by volume of the top 30 cm of soil, were associated with increased numbers of ectomycorrhizae. At 45 percent organic matter or above, numbers of ectomycorrhizae decreased. Study results also showed association with soil organic matter had a relatively greater positive effect on ectomycorrhizae of the dry site than the moist sites.

Additional notes: Although this study didn't look at disturbed sites, it provides recommendations to retain a moderate quantity of large woody materials to provide the parent materials for decayed soil wood in resulting mature ecosystems. Leaving too much woody material could also be a potential problem because of increased

fire intensity if the area burns.

URL: None at this time. Please check back for updates.
Keywords: woody residues/fuels/forest fires/soil quality/fungi/decomposition products/soil organic matter

Harvey, A. E.; Larsen, M. J.; and Jurgensen, M. F. 1980. Partial cut harvesting and ectomycorrhizae: early effects in Douglas-fir-larch forests of western Montana. Canadian Journal of Forest Research. 10(3): 436-440.

Groups: soils.
Location: Flathead County in western Montana (Coram Experimental Forest).

Abstract: Numbers of ectomycorrhizae were assessed 3 years after harvesting approximately 50 percent of the overstory in two Douglas-fir-larch stands in western Montana, one was subjected to intensive residue removal, the other broadcast burned I year after harvest. Numbers of active ectomycorrhizal root tips were significantly reduced in the broadcast burned stand compared to either the intensively utilized stand or to an adjacent, undisturbed stand. This indicates that on difficult-to-regenerate sites, particularly where soil organic matter is low, it may be advantageous to dispose of slash created in partial cuts by means other than burning.

Additional notes: This study looked at the early effects of partial stand cutting, combined with intensive fiber removal or underburning, on ectomycorrhizal activity in Coram Experimental Forest, MT.

URL: None at this time. Please check back for updates.
Keywords: prescribed burning/soils/ectomycorrhizal roots/pH/Douglas-fir-larch forest/Montana/Douglas-fir/western larch

Harvey, Alan E.; Geist, J. Michael; McDonald, Gerald I. and others. 1994. Biotic and abiotic processes in eastside ecosystems: the effects of management on soil properties, processes, and productivity. General Technical Report PNW-GTR-323. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 71 p.

See Literature Reviews.

Harvey, Alan E.; Jurgensen, Martin F.; and Larsen, Michael J. 1979. Biological implications of increasing harvest intensity on the maintenance and productivity of forest soils. In: Symposium proceedings: environmental consequences of timber harvesting in Rocky Mountain coniferous forests; Missoula, MT. General Technical Report INT-GTR-90. Boise National Forest: USDA Forest Service, Intermountain Forest and Range Experiment Station: 211-220.

See Literature Reviews.

Hungerford, Roger D.; Harrington, Michael G.; Frandsen William H.; Ryan, Kevin C. and others. 1991. Influence of fire on factors that affect site productivity. In: Harvey, A. E. and Neuenschwander, L. F., compilers. Proceedings: management and productivity of western-Montana forest soils; 1990 April 10-12; Boise, ID. General Technical Report INT-GTR-280. Ogden, UT: USDA Forest Service, Intermountain Research Station: 32-50.

See Literature Reviews.

Jurgensen, M. F.; Harvey, A. E.; Graham, R. T. and others. 1997. Impacts of timber harvesting on soil organic matter, nitrogen, productivity, and health of inland Northwest forests. Forest Science. 43(2): 234-251.

See Literature Reviews.

Kalabokidis, Kostas D. and Wakimoto, Ronald H. 1992. Prescribed burning in uneven-aged stand management of ponderosa pine/Douglas-fir forests. Journal of Environmental Management. 34 (3): 221-235.

See Fire Behavior and Fuel Reduction.

Landsberg, J. D. and Cochran, P. H. 1980. Prescribed burning effects on foliar nitrogen content in ponderosa pine. In: Martin, Robert E.; Edmonds, Robert L.; Faulkner, Donald A. and others, Editors. Proceedings of the 6th Conference on Fire and Forest Meteorology ; 1980 April 22-24; Seattle, WA. Bethesda, MD: Society of American Foresters: 209-213.

See Vegetative Effects—Trees.

Landsberg, J. D.; Cochran, P. H.; Finck, M. M. and others. 1984. Foliar nitrogen content and tree growth after prescribed fire in ponderosa pine. Research Note PNW-RP-412. Portland, OR: Pacific Northwest Forest and Range Experiment Station, USDA Forest Service. 15 p.

See Vegetative Effects—Trees.

Lindeburgh, S. B. 1990. Effects of prescribed fire on site productivity: a literature review. Land Management Report 66. British Columbia Ministry of Forests. 20 p.

See Literature Reviews.

Massman, W. J.; Frank, J. M.; Shepperd, W. D. and others. 2003. In situ soil temperature and heat flux measurements during controlled surface burns at a southern Colorado forest site. In: Omi, Philip N. and Joyce, Linda A., technical editors. Fire, fuel treatments, and ecological restoration: conference proceedings; 2002 April 16-18; Fort Collins, CO. Proceedings RMRS-P-29. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station: 69-87.

Groups: soils.
Location: title says "southern Colorado" but study was in central Colorado

Abstract: This study presents in situ soil temperature measurements at 5-6 depths and heat flux measurements at 2-5 depths obtained during the fall/winter of 2001/2002 at seven controlled (surface) fires within a ponderosa pine forest site at the Manitou Experimental Forest in central Colorado. Six of these burns included three different (low, medium, and high) fuel loadings under both a closed-canopy forested site and an open forest with a grassy meadow understory. The fuel loading for the seventh burn was a conical pile of slash about 6 m in height and 9 m in diameter and was intended to duplicate the structure and loading of a slash pile resulting from mechanical harvesting activities. One basic purpose of this initial experiment was to assess how well some commercially available soil heat flux plates would perform at high temperatures. The data presented here include soil temperatures, heat fluxes, and depth and duration of the thermal energy penetration into the soils. The maximum surface heat fluxes were estimated to be about 2400 Watts/meter^2 [Wm^{-2}] at the slash pile burn site, 2300 Wm^{-2} at the high fuel meadow site, and 3000 Wm^{-2} at the high fuel forested site. Extrapolated surface temperatures are about 436 C at the slash burn site, 359 C at the high fuel meadow site, and 95 C at the high fuel forested site. Recovery of a normal daily temperature cycle depended on fire duration and fuel loading. The recovery times were between 16 and 20 hours at the high fuel sites, about half this time at the medium fuel sites, and less that 2 hours at the low fuel sites. However, the recovery time at the slash pile site was about 2 weeks. Although further tests and refinements are planned, the present results suggest not only that soil heat flux can be

reliably measured during controlled burns, but that soil temperatures and heat flux can differ significantly with different fuel loadings.

URL: http://www.fs.fed.us/rm/pubs/rmrs_p029.html
Keywords: ponderosa pine/soil/soil temperature/heat flux/prescribed fire/fuel loading

McIver, James D. 1998. Economics and environmental effects of fuel reduction at Limber Jim. Technical notes from the Blue Mountains Natural Resources Institute, BMNRI-TN-10. LaGrande, OR. 12 p.

See Economics.

Megahan, Walter F. 1981. Effects of silvicultural practices on erosion and sedimentation in the Interior West--a case for sediment budgeting. In: Proceedings: Interior West watershed management; 1980 April 8-10; Washington State University. Pullman WA: Washington State University Cooperative Extension publication: 169-181.

See Literature Reviews.

Metz, Louis J. and Farrier, M. H. 1973. Prescribed burning and populations of soil mesofuana. Environmental Entomology. 2(3): 433-440.

Groups: soils; wildlife.
Location: South Carolina.

Abstract: Mesofauna was collected over a period of 10 months on plots which were not burned (control), burned periodically, and burned annually. The number of animals on the control and periodic burn plots was significantly greater than on the annual burn plots. Although more animals were recovered from the control plots than the periodic burn plots, the difference was not significant. The length of time for recovery of the mesofaunal population after a periodic burn was not determined but is less than 44 months. When mesofaunal populations were sampled immediately before and after burning on a plot burned annually, the number of animals was reduced drastically.

Additional notes: This study was done in South Carolina in the early 1970s. The results may not be applicable to the West, but the author states that essentially no work has been done on the effect of prescribed burning on soil fauna.

URL: None at this time. Please check back for updates.
Keywords: wildlife/fire/prescribed burning/soil/eastern USA/South Carolina

Monleon, Vicente J. and Cromack, Kermit, Jr. 1996. Long-term effects of prescribed underburning on litter decomposition and nutrient release in ponderosa pine stands in central Oregon. Forest Ecology and Management. 81 (1-3): 143-152.

Groups: soils.
Locations: Deschutes National Forest in central Oregon.

Abstract: The effects of low-intensity prescribed underburning on the rates of litter decomposition and N and P release in ponderosa pine (*Pinus ponderosa* Dougl. ex. Laws) stands were studied by a litter-bag technique for 18 months in sites burned 0.3, 5, or 12 years earlier. Litter decomposition rates (k) were low, between 0.15 and 0.28/year, and were significantly ($P < 0.1$) reduced by prescribed fire on the sites burned 0.3 and 12 years earlier. However, the reduction in decomposition rates was small, from 0.22 to 0.19/year on the sites burned 12

years earlier, and from 0.172 to 0.167/year on the sites burned 0.3 year earlier. Nitrogen tended to be immobilized in the decomposing litter, while P was rapidly released, suggesting that these ecosystems are limited by N but not by P. Nitrogen showed a distinctive seasonal pattern of net immobilization during winter and a net release during summer. Prescribed burning significantly increased the release of N and P from the litter on the sites burned 5 years earlier, a pattern that may indicate changes in microbial activity in the forest floor. However, there were no significant differences in nutrient dynamics on the remaining sites.

URL: None at this time. Please check back for updates.
Keywords: environmental sciences/ecology/forestry/litter decomposition rate/nitrogen/nutrients/nutrient release/phosphorous release/prescribed burning/underburning/ponderosa pine/*Pinus ponderosa*/prescribed fire

Monleon, Vicente J.; Cromack, Kermit, Jr.; and Landsberg, Johanna D. 1997. Short- and long-term effects of prescribed underburning on nitrogen availability in ponderosa pine stands in central Oregon. Canadian Journal of Forest Research. 27 (3): 369-378.

Groups: soils.
Location: Deschutes National Forest in central Oregon.

Abstract: The effects of prescribed underburning on soil total C pools, total and inorganic N pools, and in situ net N mineralization were examined during a 1-year study in ponderosa pine (*Pinus ponderosa* Dougl. ex P. & C. Laws.) sites that had been experimentally burned 4 months, 5 years, or 12 years earlier. At the sites burned 4 months previously, total C concentration and inorganic N concentration increased significantly ($p < 0.1$) after prescribed burning, compared with unburned controls. However, inorganic N concentration declined during the 1-year duration of this study to reach the levels of the control plots at the end of the second growing season. At the site burned 5 years previously, total C and N concentrations, inorganic N concentration, and net N mineralization decreased significantly after prescribed burning. At the sites burned 12 years previously, N and C pools were not affected, but net N mineralization decreased significantly after burning. The decrease in net N mineralization is likely caused by a decrease in substrate quantity 5 years after burning, and by changes in substrate quality 12 years after burning. A long-term decrease in net N mineralization in the N-poor ponderosa pine stands of central Oregon may result in a decrease in long-term site productivity and may explain the observed pattern of long-term decrease in stand growth after prescribed burning.

URL: None at this time. Please check back for updates.
Keywords: forestry/forestry method/long-term effects/nitrogen availability/prescribed underburning/short-term effects/site productivity/tree growth/ponderosa pine/prescribed fire

Neary, Daniel G.; Klopatek, Carole C.; DeBano, Leonard F. and others. 1999. Fire effects on belowground sustainability: a review and synthesis. Forest Ecology and Management. 122: 51-71.

See Literature Reviews.

Newland, J. A. and DeLuca, T. H. 2000. Influence of fire on native nitrogen-fixing plants and soil nitrogen status in ponderosa pine/Douglas-fir forests in western Montana. Canadian Journal of Forest Research. 30(2): 274-282.

Groups: soils.
Location: Bitterroot and Lolo National Forests in western Montana.

Abstract: Nitrogen fixing plants have been reported to play an important role in replacing N lost from soil in fire dominated ecosystems. Exclusion of fire from ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.)/Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) forests of western Montana has led to widespread changes in forest structure, composition, and function including a potential reduction in the occurrence of N-fixing plant species. We investigated the effect of fire exclusion and reintroduction of fire on the frequency, occurrence, and function

of native N-fixing plant species at 11 paired burned and unburned sites in western Montana. These pairs had been either undisturbed since the early 1900s or had been repeatedly opened by logging and (or) fire over the last 80-100 years. Although the percent cover of N-fixing plants was low at all sites, the cover and frequency of N-fixing plants were significantly greater in sites exposed to fire than in the unburned sites and greater in repeatedly opened sites than in undisturbed sites. In contrast, levels of available N were significantly lower in burned sites compared with unburned sites and in repeatedly opened sites. Nitrogen-fixing plants may have played an important role in maintaining productivity in frequently burned ponderosa pine forests but now appear to be suppressed in fire-excluded forests.

Additional notes: The purpose of this study was to access whether wildfire, prescribed fire, and fire exclusion have influenced the presence and abundance of native N-fixing plant species and whether this change is reflected in the soil N status. Six wildfire sites and five prescribed fire sites were studied (two on the Lolo National forest and three on the Bitterroot National Forest at Lick Creek).

URL: None at this time. Please check back for updates.
Keywords: nitrogen fixing plants/*Pseudotsuga menziesii*/*Pinus ponderosa*/fire exclusion/reintroduction of fire/frequently burned ponderosa pine forests/fire-excluded forests

Newman, Howard C. and Schmidt, Wyman C. 1979? Silviculture and residue treatments affect water used by a larch/fir forest. In: Environmental consequences of timber harvesting in Rocky Mountain coniferous forests, symposium proceedings; 1979 September 11-13; General Technical Report INT-GTR-90. Ogden, Utah: USDA Forest Service, Intermountain Forest and Range Experiment Station.: 75-110.

See Hydrology.

Nissley, S. D.; Zasoski, R. J.; and Martin, R. E. 1980. Nutrient changes after prescribed surface burning of Oregon ponderosa pine stands. In: Martin, Robert E.; Edmonds, Robert L.; Faulkner, Donald A. and others, editors. Proceedings of the 6th Conference on Fire and Forest Meteorology; 1980 April 22-24; Seattle, WA. Bethesda, MD: Society of American Foresters: 214-219.

Groups: soils.
Location: Pringle Falls Experimental Forest in central Oregon.

Abstract: None

Additional notes: The effects of prescribed burning on the N, P, K, Ca and Mg contents of litter, duff, understory biomass, heated foliage samples, and soil samples were investigated in ponderosa pine stands. In the summary, the authors state, "The effects of light surface burns on ponderosa pine stands resulted in an average N loss of 38% when adjusted for weight loss differences between control and burn plots. Loss of S from the duff and litter layer on two plots averaged 43%, some of which may have leached into the soil. Loss of N appears to be well correlated with fuel consumption as judged by changes in duff and litter pH values. Because the majority of nutrients are contained in the duff layer of the stands investigated, burning prescriptions should be formulated to recognize this distribution. High fuel consumption that consumes the duff and litter can be expected to evacuate N and possibly S from the site. It remains for future research to determine whether this nutrient loss will have a significant effect on site productivity. Well-documented permanent growth plots are needed."

URL: None at this time. Please check back for updates.
Keywords: nutrients/forestry practices/controlled burning/soil

Niwa, Christine G.; Peck, Robert W.; and Torgerson, Torolf R. 2001. Soil, litter, and coarse woody debris habitats for arthropods in eastern Oregon and Washington. Northwest Science. 75(Suppl.): 141-148.

See Literature Reviews.

Page-Dumroese, Deborah; Jurgensen, Martin F.; and Harvey, Alan E. 2003. Fire and fire-suppression impacts on forest-soil carbon. Chapter 13 In Kimble, J.M.; Heath, Linda S.; Birdsey, Richard A.; and Lal, R., editors. The potential of U.S. forest soils to sequester carbon and mitigate the greenhouse effect. Boca Raton, FL: CRC Press: 201-210.

See Literature Reviews.

Peters, Gregory. 2002. Effects of thinning, prescribed burning, and burning season on the physiological performances of ponderosa pine. Missoula, MT: University of Montana. 60 p. Thesis.

See Vegetative Effects—Trees.

Robichaud, P. R. 2000. Fire effects on infiltration rates after prescribed fire in Northern Rocky Mountain forests, USA. Journal of Hydrology. 231-232: 220-229.

See Hydrology.

Ryan, K. C. and Frandsen, W. H. 1991. Basal injury from smoldering fires in mature *Pinus ponderosa* Laws. International Journal of Wildland Fire. 1(2): 107-118.

See Vegetative Effects—Trees.

Smith, Helen Y. and Arno, Stephen F. 1999, editors. Eighty-eight years of change in a managed ponderosa pine forest. General Technical Report RM-GTR-23. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station. 55 p (plus photos).

See Vegetative Effects at the Stand Level.

Stark, N. and Steele, R. 1977. Nutrient content of forest shrubs following burning. American Journal of Botany. 64(10): 1218-1224.

See Vegetative Effects—Understory.

Stark, Nellie M. 1977. Fire and nutrient cycling in a Douglas-fir/larch forest. Ecology. 58 (1): 16-30.

Groups: soils.
Location: Lubrecht Experimental Forest in western Montana.

Abstract: Twenty control burns performed with a wide range of fuel loadings and moisture conditions were used to study the effectiveness of old fuel reduction under standing Douglas-fir/larch forest. This paper reports the influence of burning on nutrient retention and loss from the soil. Sixty percent of the fires were successful in reducing residual fuels with no accelerated loss of nutrients below the root zone. Net losses of Ca^{+2} and Mg^{+2} occurred below the root zone when soil surface temperature exceeded 300^{o} C, but were insignificant when soil surface temperatures remained below 200-300^{o} C. No other elements were lost (net) from the soil as a result of burning. Precipitation on control soils delivers as much Ca^{+2} as is normally lost below the root zone in the absence of fire. Iron concentration in the soil water is a good indicator of the intensity of burn. The hotter the

fire, the less iron in the soil water as a result of the alkaline pH. Ash shows a definite pattern of nutrient release under the influence of precipitation. Homogeneous subsamples of litter showed predictable nutrient losses when ignited at different temperatures. Overland flow and surface erosion are of little significance on this soil type. Decomposition of Douglas-fir litter was only slightly more rapid on hot burned substrates than on control (unburned) substrates. When the biological life concept was applied to this soil, it showed that this soil is young and capable of withstanding many years of cyclic intensive burns.

Additional notes: This study took place in western Montana. The Douglas-fir/western larch trees were approximately 70 years old.

URL: None at this time. Please check back for updates.
Keywords: Montana/ash/decomposition/soil/precipitation/losses from soil/nutrients/forestry practices/controlled burning/soil types-ecological/forest soils/cycling/effects/fire effects/soil chemistry/fire danger/Douglas-fir/*Pseudotsuga menziesii*/*Larix occidentalis*/western larch

Tiedemann, A. R. 1987. Combustion losses of sulfur from forest foliage and litter. Forest Science. 33(1): 216-223.

Groups: soils.
Location: soils came from north-central Washington.

Abstract: Sulfur (S) content of samples of ponderosa pine (*Pinus ponderosa* Dougl. Ex Laws.), Douglas-fir (*Pseudotsuga menziesii* [Mirb.] Franco), Sitka alder (*Alnus sinuata* [Regel] Rydb.), snowbrush ceanothus (*Ceanothus velutinus* [Dougl.]), and forest litter combusted in an aerated muffle furnace at 375°-575°, 575°-775°, 775°-975°, and 975°-1,175° C for 5, 30, and 60 min was compared with S content of unburned samples. Sulfur losses at 375°-575° C for 5 min ranged from 24 to 79% of S contained in unburned material. At 975°-1,175° C for 60 min, losses ranged from 61 to 92%. Results suggest that prescribed burning and wildfire could potentially cause substantial volatilization losses of S from foliage and litter.

URL: None at this time. Please check back for updates.
Keywords: *Pinus ponderosa*/*Pseudotsuga menziesii*/*Alnus sinuata*/*Ceanothus velutinus*/prescribed burning/wildfire/plant nutrients/site productivity/fire

Tiedemann, Arthur R. and Woodard, Paul M. 2002. Multiresource effects of a stand-replacement prescribed fire in the *Pinus contorta-Abies lasiocarpa* vegetation zone of central Washington. General Technical Report PNW-GTR-535. La Grande, OR: U.S. Forest Service, Pacific Northwest Research Station. 26 p.

See Wildlife.

Walstad, John D.; Radosevich, Steven R.; and Sandberg, David V. 1990. Natural and prescribed fire in Pacific Northwest forests. Corvallis, OR: Oregon State University Press. 317 p.

See Literature Reviews.

Wells, Carol G.; Campbell, Ralph E.; DeBano, Leonard F. and others. 1979. Effects of fire on soil: a state-of-knowledge review. General Technical Report WO-GTR-7. USDA Forest Service. 34 p.

See Literature Reviews.

Wondzell, Steven M. 2001. The influence of forest health and protection treatments on erosion and stream

sedimentation in forested watersheds of eastern Oregon and Washington. Northwest Science. 75(Suppl.): 128-140.

See Literature Reviews.

Zouhar, Kristin L. and DeLuca, Thomas H. 1999. Effects of ecosystem-based management treatments: microbial response and nitrogen availability, selection cutting unit. In Smith, Helen Y and Arno, Stephen F., editors. Eighty-eight years of change in a managed ponderosa pine forest. General Technical Report RMRS-GTR-23. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station: 38-40.

Groups: soils.
Location: Bitterroot National Forest in western Montana (Lick Creek).

Abstract: None

Additional notes: At the Lick Creek site in western Montana, the U.S. Forest Service applied a different kind of silvicultural cutting treatment for each of three experimental stands consisting of 80 to 100 acres each. Within each silvicultural cutting system, they applied different underburning strategies as well as no burn treatments. In the selection cutting units, some subunits were not burned, some had an intermediate burn, and some acted as controls with no cut but with a burn. In the summer of 1995, the authors initiated a study of soil nutrient relationships. Soils are shallow to moderately deep, derived from highly weathered granitic parent material, and classified as Totelake series, sandy-skeletal, mixed, frigid, Typic Ustochrepts. Results are given for carbon, nitrogen (N), potassium, magnesium, and pH. They also provide results concerning extractable mineral nitrogen, potentially mineralizable N, microbial biomass N, resin extractable N, microbial respiration rates, and soluble sugars. It appears that the pool of mineralizable N may be reduced by the combination of selection harvest with prescribed fire but it is not clear whether this reduction may ultimately have an adverse effect on site productivity if this drop in available N balances nutriendt availability.

URL: None at this time. Please check back for updates.
Keywords: selection cutting/ ponderosa pine/ Douglas-fir/ partial cutting/ prescribed burning/ soil nitrogen/ microbial response

Vegetative Effects at the Stand Level

The greatest number of papers addressed effects of treatments on vegetation. They often fell into other categories also, such as fire behavior and fuel reduction. This bibliography separates vegetative effects into three categories: effects at the stand level, effects on individual trees, and effects on the understory. This first category, vegetative effects at the stand level, includes 46 papers that address effects on density, basal area, diversity, and stand structure.

Arno, Stephen F. 1999. Effects of ecosystem-based management treatments: tree regeneration--natural regeneration, shelterwood cutting unit. In Smith, Helen Y and Arno, Stephen F., editors. Eighty-eight years of change in a managed ponderosa pine forest. General Technical Report RMRS-GTR-23. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station: 35.

Groups: vegetative effects--stand level.
Location: Bitterroot National Forest, Montana (Lick Creek).

Abstract: None

Additional notes: This report gives results on regeneration of ponderosa pine and Douglas-fir five years after a shelterwood cut that reduced basal area of the overstory from an average of 117 to 52 ft^2 per acre followed by either a high fuel consumption burn, a low consumption burn, or no burn. Regeneration of ponderosa pine averaged 281 trees per acre in the no-burn and both-burn treatments. Average post-treatment regeneration of Douglas-fir was greater in the no-burn (309 trees per acre) than in the burn treatments (84 trees in low consumption and 56 in high consumption). Advance regeneration that had survived treatments was entirely Douglas-fir and was abundant in the cut/no burn treatment where it averaged 1,321 trees per acre, but absent from the burned units.

URL: None at this time. Please check back for updates.
Keywords: regeneration/ shelterwood cut/ ponderosa pine/ Douglas-fir/ partial cutting/ prescribed burning

Arno, Stephen F. and Allison-Bunnell, Steven. 2002. Flames in our forest: disaster or renewal? Washington, DC: Island Press.

See Economics.

Arno, Stephen F. and Harrington, Michael G. 1998. The Interior West: managing fire-dependent forests by simulating natural disturbance regimes. In: Forest management into the next century: what will make it work?; 1997 November 19-21; Spokane, WA. Madison, WI : Forest Products Society and USDA Forest Service: 53-62.

Groups: economics; fire behavior/fuel reduction; vegetative effects--stand level.
Location: Bitterroot and Lewis and Clark National Forests.

Abstract: Many Western forest ecosystems have been and will continue to be heavily influenced by the role of fire. Ecosystem-based management recognizes the need to sustain ecological processes while meeting societal needs. This paper presents examples of research and demonstration projects based on concepts of ecosystem-based management that are being conducted in historically low-severity fire regimes where ponderosa pine was the dominant tree, and in high-severity fire regimes where lodgepole pine was dominant. These experimental projects apply a combination of silvicultural cutting and prescribed burning treatments to mimic natural processes while providing forest products and ecological and social values.

Additional notes: This mostly reports on the treatments used or planned at sites on the Bitterroot National

Forest and Lewis and Clark National Forest. The only results given refer to the fuel reduction accomplished in the understory and an informal economic analysis in one area.

URL: None at this time. Please check back for updates.
Keywords: ponderosa pine/*Pinus ponderosa*/lodgepole pine/*Pinus contorta*/thinning/prescribed fire/economics

Arno, Stephen F.; Harrington, Michael G.; Fiedler, Carl E. and others. 1995. Restoring fire-dependent ponderosa pine forests in western Montana. Restoration and Management Notes. 13(1): 32-36.

See Vegetative Effects—Understory.

Bella, I. E. and De Franceschi, J. P. 1982. Growth of lodgepole pine after mechanical strip thinning in Alberta: 15-year results. The Forestry Chronicle. 58(3): 131-135.

See Vegetative Effects--Trees.

Bock, Carl E. and Bock, Jane H. 1983. Responses of birds and deer mice to prescribed burning in ponderosa pine. Journal of Wildlife Management. 47(3): 836-840.

See Wildlife.

Brown, Rick. 2000. Thinning, fire and forest restoration: a science-based approach for National Forests in the Interior Northwest. Washington, D.C.: Defenders of Wildlife. 25 p.

See Literature Reviews.

Busse, Matt D.; Simon, Steven A.; and Riegel, Gregg M. 2000. Tree-growth and understory responses to low-severity prescribed burning in thinned *Pinus ponderosa* forests of central Oregon. Forest Science. 46 (2): 258-268.

See Vegetative Effects—Understory.

Cochran, P. H. and Barrett, James W. 1995. Growth and mortality of ponderosa pine poles thinned to various densities in the Blue Mountains of Oregon. Research Paper PNW-RP-483. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 27 p.

Groups: vegetative effects--stand level; vegetative effects--trees.
Location: Blue Mountains, Malheur National Forest, Oregon.

Abstract: Growth and mortality in a ponderosa pine (*Pinus ponderosa* Dougi. ex Laws.) stand were investigated for 24 years. High mortality rates from mountain pine beetle (*Dendroctonus ponderosae* Hopkins) occurred on some plots where values for stand density index exceeded 140. Periodic annual increments for quadratic mean diameters decreased curvilinearly as stand density increased, whereas periodic annual increments of gross basal area and gross cubic volume increased curvilinearly with increasing stand density. Cubic volume yield at a stand age of 84 years increased linearly with increasing density. Mean annual increments of board foot volume increased with time and show no signs of leveling off at a stand age of 84 years. Mean annual basal area and volume growth of the 30 largest trees per acre decreased with increasing levels of stand density. Ponderosa pine on low sites should be managed at low stand densities to avoid problems with mountain pine beetle and to produce large trees in a reasonable time period. Long rotations are probably

possible for this species.

Additional notes: This study looked at growth and mortality for 6 growing stock levels in a pole stand. Plots were thinned initially and again at the end of the 10th and 19th growing seasons.

URL: None at this time. Please check back for updates.
Keywords: growth/ mortality/ mountain pine beetle/ ponderosa pine/ Blue Mountains (Oregon)/ forest health/ thinning

---. 1999. Thirty-five-year growth of ponderosa pine saplings in response to thinning and understory removal. Research Paper PNW-RP-512. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 28 p.

Groups: vegetative effects--stand level.
Location: Pringle Falls Experimental Forest, 35 mi southwest of Bend, Oregon.

Abstract: Diameter increments for individual trees increased curvilinearly and stand basal area increments decreased curvilinearly as spacing increased from 6.6 to 26.4 feet. Average height growth of all trees increased linearly, and stand cubic volume growth decreased linearly as spacing increased. Large differences in tree sizes developed over the 35 years of study with various spacing treatments. Plots without understory grew more during the first 20 years of study but soil quality decreased. During the last 15 years, growth rates on plots without understory were not superior to plots with understory when adjusted to common basal areas and volumes. Growth rates for the largest trees on the plots were decreased by competition from smaller trees. After 35 years, total cubic volume yield decreased linearly as spacing increased but Scribner board-foot yields increased curvilinearly as spacing increased, and spacings of 13.2, 18.7, and 26.4 feet produced about the same board-foot yield. Live crown ratios increased with increasing spacing, primarily because of increased height growth. Twenty years after thinning, crown width increased curvilinearly as spacing increased and was greater in the absence of understory. Crown cover appeared to be linearly related to stand density index. Mortality was so low that there was no practical difference in net and gross 35-year mean annual growth of cubic volume and basal area. Spacing for precommercial thinnings on similar sites should be at least 14 feet and much higher spacings could be warranted if managers wish to grow stands of large-diameter trees with low mortality from bark beetles.

URL: http://www.srs.fs.usda.gov/pubs/viewpub.jsp?index=2908
Keywords: *Pinus ponderosa*/ logging effects/ brush control/ thinning/ growth effects/ growth rate/ understory/ stand density/ spacing/ mortality/ Oregon/ saplings

---. 1998. Thirty-five-year growth of thinned and unthinned ponderosa pine in the Methow Valley of northern Washington. Research paper PNW-RP-502. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 24 p.

See Vegetative Effects—Trees.

Cochran, P. H. and Dahms, Walter G. 2000. Growth of lodgepole pine thinned to various densities on two sites with differing productivities in central Oregon. Research Paper PNW-RP-520. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 59 p.

Groups: insects/diseases; vegetative effects--stand level.
Location: Deschutes National Forest, Oregon.

Abstract: Plots in highly productive and moderately productive natural lodgepole pine stands were repeatedly thinned to one of five growing stock levels (GSLs) in two levels of growing-stock studies. Bole area was used to define GSLs. A linear, relation between stand density index (SDI) and bole area was found after each

thinning in the highly productive stand, but the slope for this relation decreased with successive thinnings as tree size increased. A curvilinear SDI-bole area relation occurred after thinning in the moderately productive stand where the upper limit of bole area was higher. A given level of bole area apparently does not represent a constant level of competition across a range of stand diameters. Incidences of mortality caused by mountain pine beetle were low at SDIs below 170. Managing lodgepole pine at densities not exceeding SDI 170 when 9-inch diameter trees are present apparently lowers the probability of serious mountain pine beetle outbreaks. A concave curvilinear decrease in diameter growth with increasing GSL occurred on both sites, and a linear decrease in live crown ratios with increasing GSL occurred on the high site. A significant decrease in height growth with increasing GSL was not detected on either site. A convex curvilinear increase in gross total cubic-volume growth occurred with increasing GSL. Maximum gross cubic volume PAIs for both sites occurred at SDIs equivalent to 95 percent of the normal stand density (SDI 277). Maximum cumulative net cubic-volume (total and merchantable) and board-foot yields were produced at an intermediate GSL on the high site. Little difference in the yields occurred with the four highest GSLs at the intermediate site. Net total cubic-volume yields for the three highest GSLs were greater than the net total cubic-volume yield for unmanaged lodgepole pine stands predicted from yield tables at comparable sites and ages. Net total cubic-volume mean annual increments (MAIs) culminate at 70 years for unmanaged lodgepole pine stands in south-central Oregon. Values of net cubic-volume MAIs for unmanaged stands range from 23.6 to 71 ft^3/acre/yr. Higher net cubic-volume MAIs were found in this study for the three highest GSLs on the high site even though culmination perhaps has occurred only for the lowest GSL. Culmination of MAIs on the intermediate site has probably not occurred even at 77 years of age. This study has not continued long enough to determine the approximate age of culmination with certainty for either cubic or board-foot volumes. Ponderosa pine outgrew lodgepole pine for the range of stand ages where the growth of both species was examined (33 to 58 years). Ponderosa pine, however, should not be planted on lodgepole pine sites on flats and basins because ponderosa pine is more susceptible to damage by radiation frost. Keeping lodgepole pine stands between SDI 114 and 170 (41 and 61 percent of the normal SDI 277) once stands reach commercial size should result in capturing between 63 and 87 percent of the potential total cubic-volume production after the first commercial entry. Unmanaged lodgepole pine stands in south-central Oregon are relatively short lived, and their QMDs seldom exceed 10 inches. Early spacing control coupled with later commercial thinnings should reduce mortality considerably, allow most of the wood produced to be captured by merchantable trees, and greatly increase QMDs and live crown ratios over unmanaged stands at the same age. These stands would be more pleasing visually, certain species of wildlife may benefit, and stand rotation ages may be longer.

URL: http://www.fs.fed.us/pnw/pubs/rp520.pdf
Keywords: *Dendroctonus ponderosae*/ mountain pine beetle/ pests/ *Pinus contorta*/ lodgepole-pine/ growth/ site productivity/ *Pinus ponderosa*/ ponderosa pine/ Oregon/ thinning/ forestry method/ stand density

Cochran, P. H. and Seidel, K. W. 1999. Growth and yield of western larch under controlled levels of stocking in the Blue Mountains of Oregon. Research Paper PNW-RP-517. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 35 p.

Groups: vegetative effects--stand level; vegetative effects--trees.
Location: Blue Mountains of Oregon.

Abstract: Repeated thinning to five growing-stock levels resulted in widely differing tree sizes and volumes per acre after 30 years. Largest trees but the least cubic-volume yield per acre were produced in the heaviest thinning level, whereas highest board-foot yields were found in intermediate thinning levels. Partial defoliation by larch casebearer (*Coleophora laricella* Hubner), drought, and top damage from ice occurred, and site trees grew less in height than expected during the 30-year study. Curvilinear increases in periodic annual increments of both basal area and cubic volume generally occurred with increasing stand density, but increments dropped off at the highest stand densities for some periods. Anticipated patterns for these increments were found after fitting a model that included stand density index, height increments of site trees, and dummy variables for periods as independent variables. Heavy thinning did not increase the age of culmination of cubic-volume mean annual increment as expected. Thinning stands of larch to densities as low as 50 percent of "normal" results in little loss of basal-area growth, a moderate loss in volume production, and a large increase in tree diameter.

Thinning is necessary in many larch stands to maintain vigorous, rapidly growing trees. Thinning levels will greatly affect the appearance of future stands.

URL: http://www.fs.fed.us/pnw/pubs/rp_517.pdf
Keywords: *Coleophora laricella*/ pests/ *Larix occidentalis*/ western larch/ yield/ Blue Mountains/ Oregon/ ice damage/ injury/ controlled stocking/ forestry method/ drought

Fiedler, Carl E. 1999. Effects of ecosystem-based management treatments: stand structure in response to selection cutting and burning. In Smith, Helen Y and Arno, Stephen F., editors. Eighty-eight years of change in a managed ponderosa pine forest. General Technical Report RMRS-GTR-23. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station: 31-34.

See Vegetative Effects—Trees.

Fiedler, Carl E. 2000. Restoration treatments promote growth and reduce mortality of old-growth ponderosa pine (Montana). Ecological Restoration. 18: 117-119.

See Vegetative Effects—Trees.

Fiedler, Carl E.; Arno, Stephen F.; and Harrington, Michael G. 1996. Flexible silviculture and prescribed burning approaches for improving health of ponderosa pine forests. In: Covington, W.and Wagner, P. K., technical coordinators. Conference on adaptive ecosystem restoration and management: restoration of Cordilleran conifer landscapes of North America; General Technical Report RM-GTR-278. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station: 69-74.

See Fire Behavior and Fuel Reduction.

Filip, Gregory M.; Fitzgerald, Stephen A.; and Ganio, Lisa M. 1999. Precommercial thinning in a ponderosa pine stand affected by Armillaria root disease in central Oregon: 30 years of growth and mortality. Western Journal of Applied Forestry. 14(3): 144-148.

See Insects and Diseases.

Filip, Gregory M.; Goheen, Donald J.; Johnson, David W. and others. 1989. Precommercial thinning in a ponderosa pine stand affected by Armillaria root disease: 20 years of growth and mortality in central Oregon. Western Journal of Applied Forestry. 4(2): 58-59.

See Insects and Diseases.

Graham, Russell T.; Harvey, Alan E.; Jain, Theresa B. and others. 1999. The effects of thinning and similar stand treatments on fire behavior in western forests. General Technical Report PNW-GTR-463. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 28 p.

See Literature Reviews.

Grier, Charles C. 1990 Effects of prescribed springtime underburning on production and nutrient status of a young ponderosa pine stand. In: Tecle, Aregai; Covington, W. Wallace; and Hamre, R. H., editors. Multiresource management of ponderosa pine forest symposium; 1989 November 14-16; Flagstaff, AZ: 71-76.

See Soils.

Hardy, Colin C. and Arno, Stephen F. 1996. The use of fire in forest restoration--proceedings: annual meeting of the Society for Ecological Restoration; 1995 September 14-16; Seattle, WA. General Technical Report INT-GTR-341. Ogden, UT: USDA Forest Service, Intermountain Research Station.

Groups: fire behavior/fuel reduction; vegetative effects--stand level.
Location: Inland West

Abstract: The 26 papers in this publication address the current knowledge of fire as a disturbance agent, fire history and fire regimes, applications of prescribed fire for ecological restoration, and the effects of fire on the various forested ecosystems of the north-western United States. The main body of this document is organized in three sections: Assessing Needs for Fire in Restoration; Restoration of Fire in Inland Forests; and Restoration in Pacific Westside Forests.

Additional notes: This is a valuable general reference, but discussion of effects of treatments are more thoroughly discussed in other papers published by the authors contributing to these proceedings, which are listed separately in this bibliography.

URL: http://www.fs.fed.us/rm/pubs/int_gtr341/index.html
Keywords: forest restoration/fire/prescribed fire/fire effects

Harrington, Michael. 1999. Effects of ecosystem-based management treatments: stand structure response to harvesting and prescribed burning on shelterwood cutting and commercial thinning units. In Smith, Helen Y and Arno, Stephen F., editors. Eighty-eight years of change in a managed ponderosa pine forest. General Technical Report RMRS-GTR-23. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station: 28-31.

Groups: fire behavior/fuel reduction; vegetative effects--stand level.
Location: Bitterroot National Forest in western Montana (Lick Creek).

Abstract: None

Additional notes: At the Lick Creek site in western Montana, the U.S. Forest Service applied a different kind of silvicultural cutting treatment for each of three experimental stands consisting of 80 to 100 acres each. Within each silvicultural cutting system, they applied different underburning strategies as well as no burn treatments. In the shelterwood cutting units, some subunits were not burned, some had a wet burn (low fuel consumption), and some had a dry burn (high fuel consumption). In the commercial thinning units, some had no burn, some had a fall burn, and some had a spring burn. The objective was to reduce basal area in the over-stocked and smallest merchantable size classes (7 to 5 inches d.b.h.) retaining 40 ft^2 per acre in the shelterwood and 50 ft^2 per acre in the commercial area to allow increased growth and health of residual large trees and a reduction in crown fire hazard. The harvesting in both areas was conservative, leaving an unplanned excess of about 10 ft^2 per acre. However, small trees made up 4 to 5 ft^2 per acre of this excess. Fire mortality was expected and desired, especially in the smaller sizes in which about 60 percent of the trees were killed. Most of this size class, which were Douglas-fir or poor quality pines, remain in the no-burn treatment and continue to represent an undesirable condition in terms of competition and ladder fuels. Mortality of the larger trees averaged about 12 percent in the shelterwood and only 3 percent in the commercial thin study. This difference was likely due to greater fire injury due to warmer temperatures and more liberal ignition in the shelterwood units. Some overstory mortality was anticipated with burning, and in this case it further reduced the excess stand density.

URL: None at this time. Please check back for updates.
Keywords: commercial thinning/ selection cutting/ shelterwood cut/ ponderosa pine/ Douglas-fir/ partial cutting/ prescribed burning/ stand structure

Harrington, Michael G. and Kelsey, Rick G. 1979. Influence of some environmental factors on initial establishment and growth of ponderosa pine seedlings. Research Paper INT-RP-230. Ogden, UT: USDA Forest Service, Intermountain Research Station. 26 p.

Groups: vegetative effects--stand level.
Location: western Montana (Lubrecht Experimental Forest)

Abstract: Study plots were established to determine the effects of various environmental factors on ponderosa pine seed germination and initial seedling establishment and growth. A series of soil surface treatments were performed on plots in two locations: within or under the influence of overstory pine trees and in openings away from the pine influence. Seed germination was significantly greater in the opening plots. The overstory canopy and forest floor restricted the amount of precipitation, light, and heat reaching the soil and probably decreased germination. Cutworms, birds, and small mammals caused the greatest seedling mortality. The largest seedlings occurred in the fire treated plots (burned in fall). This was attributed to an increased nutrient supply and reduction of competition. Opengrown seedlings were larger than those growing under the overstory canopy. Amount of sunlight, degree of competition, and susceptibility to injury because of location appeared to be the major factors contributing to the seedling size differences. Because of abnormally high precipitation during the growing season, results may not be typical of average growing seasons.

URL: None at this time. Please check back for updates.
Keywords: fire/ regeneration/ ponderosa pine/ prescribed fire/ seedlings

Heath, R. and Alfaro, R. I. 1990. Growth response in a Douglas-fir/lodgepole pine stand after thinning of lodgepole pine by the mountain pine beetle: a case study. Journal of the Entomological Society of British Columbia. 87(December): 16-21.

See Vegetative Effects—Trees.

Howe, George E. 1995. Genetic effects of uneven-aged management. In: O'Hara, K., editor. Uneven-aged management: opportunities, constraints, and methodologies workshop proceedings; 1995 April 29; University of Montana: 27-32.

See Literature Reviews.

Hungerford, Roger D.; Harrington, Michael G.; Frandsen William H.; Ryan, Kevin C. and others. 1991. Influence of fire on factors that affect site productivity. In: Harvey, A. E. and Neuenschwander, L. F., compilers. Proceedings: management and productivity of western-Montana forest soils; 1990 April 10-12; Boise, ID. General Technical Report INT-GTR-280. Ogden, UT: USDA Forest Service, Intermountain Research Station: 32-50.

See Literature Reviews.

Johnstone, W. D. 1981. Precommercial thinning speeds growth and development of lodgepole pine: 25-year results. Edmonton, Alberta: Environment Canada, Northern Forest Research Centre. 30 p.

Groups: vegetative effects--stand level; vegetative effects--trees.
Location: Alberta.

Abstract: The effects of thinning 22-year-old fire-origin lodgepole pine (*Pinus contorta* Dougi. var. *latifolia* Engelm.) are analyzed 25 years after treatment. Four spacings between 1.5 X 1.5 m and 3.7 X 3.7 m plus a rethinning 15 years later of an original 1.8 X 1.8 m spacing were carried out in west-central Alberta. The results

are presented for individual trees, the entire stand, and 500 crop trees per hectare. Thinning improved individual tree growth, particularly diameter growth, with the greatest response occurring at the widest spacing. The thinning also resulted in larger and faster growth of average stand values. In the thinned plots all per-hectare stand values except basal area were as large as or larger than those in the unthinned plots. Percentage survival was higher on the more heavily thinned plots. All average and per-hectare crop-tree values were larger for thinned than for unthinned stands.

URL: None at this time. Please check back for updates.
Keywords: thinning/ precommercial thinning/ lodgepole pine/ growth

---. 2002. Thinning lodgepole pine in southeastern British Columbia: 46-year results. Working Paper. Victoria, BC: Research Branch, British Columbia Ministry of Forestry. 26 p.

Groups: insects/diseases; vegetative effects--stand level; vegetative effects--trees.
Location: southeastern British Columbia.

Abstract: The effects of thinning 53-year-old, fire-origin lodgepole pine *(Pinus contorta* Dougl. var. *latifolia* Engelm.) are reported 46 years after treatment. Five thinning treatments plus unthinned controls were established in plots in the Montane Spruce biogeoclimatic zone in southeastern British Columbia. Although tree-size responses were substantial in relative terms, the absolute responses to thinning were small. On an area basis, the response to thinning can be substantial, particularly when the net periodic annual increment of the thinned plots is compared to that of the un-thinned controls. During the 46-year observation period, the plots were attacked by mountain pine beetle *(Dendroctonus ponderosae* Hopkins), and the results of the study tend to support the theory that heavy thinning may help to beetle-proof lodgepole pine stands.

Additional notes: The area was treated in 1952. From 1980-1983, the stand came under severe attack by mountain pine beetles and high mortality of pine was observed in some of the plots. The treatment prescriptions' percent normal yield/approximate spacing/actual trees per ha were: 1) no thinning/4868 trees/ha; 2) 100 percent/2.13 m/2898; 3) 80 percent/2.44 m/2218; 4) 60 percent/2.90 m/1884; 5) 40 percent/3.66 m/1325; and 6) 20 percent/4.88 m/754.

URL: http://www.for.gov.bc.ca/hfd/pubs/docs/Wp/Wp63.pdf
Keywords: lodgepole pine/ mountain pine beetle/ thinning/ *Dendroctonus ponderosae*/ insects

Kalabokidis, Kostas D. and Wakimoto, Ronald H. 1992. Prescribed burning in uneven-aged stand management of ponderosa pine/Douglas-fir forests. Journal of Environmental Management. 34 (3): 221-235.

See Fire Behavior and Fuel Reduction.

Kilgore, Bruce M. 1986. Evaluating direct response to understory burning in a pine-fir-larch forest in Glacier National Park. In: Lucas, R. C., compiler. National Wilderness Research Conference: current research; 1985 July 23-26; Colorado State University, Fort Collins, CO. General Technical Report INT-GTR-212. Ogden, UT: USDA Forest Service, Intermountain Research Station: 26-34.

See Vegetative Effects—Understory.

Leuschen, T. J. 1996. Restoring fire to mixed conifer forests in the Northern Cascades. In: Hardy, Colin C. and Arno, Stephen F., editors. The use of fire in forest restoration--proceedings: annual meeting of the Society for Ecological Restoration; 1995 September 14-16; Seattle, WA. General Technical Report INT-GTR-341. Ogden, UT: USDA Forest Service, Intermountain Research Station: 77.

Groups: vegetative effects--stand level.
Location: Methow Valley of northcentral Washington.

Abstract: None

Additional notes: A 200-acre unit in ponderosa pine mixed conifer stands was treated by using overstory removal, precommercial thinning, and prescribed fire. The author concluded that "prescribed fire was successful in killing the majority of the undesirable understory trees. Additional thinning may be required. The large diameter ponderosa pine and Douglas-fir seed trees had adequate survival, and natural regeneration appears to be adequate. This application of several ignition methods, combined with mechanical treatments such as felling of some understory trees, was a highly successful project. We restored the desired conditions, creating opportunities for subsequent maintenance using low intensity, non-lethal fires."

URL: None at this time. Please check back for updates.
Keywords: understory burning/prescribed fire/ponderosa pine/precommercial thinning

McCaughey, Ward W.; Theroux, Leon J.; and Carlson, Clinton E. 1999. Effects of ecosystem-based management treatments: artificial regeneration, shelterwood cutting unit. In Smith, Helen Y and Arno, Stephen F., editors. Eighty-eight years of change in a managed ponderosa pine forest. General Technical Report RMRS-GTR-23. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station: 35-36.

Groups: vegetative effects--stand level; vegetative effects--trees.
Location: Bitterroot National Forest in western Montana (Lick Creek).

Abstract: None

Additional notes: This report gives results on artificial regeneration (planting ponderosa pine and western larch seedlings) five years after a shelterwood cut in a ponderosa pine/Douglas-fir forest that reduced basal area of the overstory from an average of 117 to 52 ft^2 per acre followed by either a high fuel consumption burn, a low consumption burn, or no burn. Percentage survival of ponderosa pine and western larch slowly declined over the first 4 years following planting. Percentage survival of ponderosa pine was consistently near 65 percent with either burn treatment, while survival of western larch is higher than pine on the dry burn and lower on the other treatments. Growth rate was generally good for both species although it was necessary to use mesh seedling tubes to protect seedlings from browse damage by elk.

URL: None at this time. Please check back for updates.
Keywords: regeneration/ artificial regeneration/ shelterwood cut/ ponderosa pine/ Douglas-fir/ western larch/ partial cutting/ prescribed burning

Peters, Gregory. 2002. Effects of thinning, prescribed burning, and burning season on the physiological performances of ponderosa pine. Missoula, MT: University of Montana. 60 p. Thesis.

See Vegetative Effects—Trees.

Peters, Robert L.; Frost, Evan; and Pace, Felice. 1996. Managing for forest ecosystem health: a reassessment of the "forest health crisis." Washington, D.C.: Defenders of Wildlife.

See Literature Reviews.

Rose, Jeffrey A. and Eddleman, Lee E. 1994. Ponderosa pine and understory growth following western juniper removal. Northwest Science. 68(2): 79-85.

See Vegetative Effects—Understory.

Saveland, James M. and Bunting, Stephen C. 1987. Fire effects in ponderosa pine forests. In: Ponderosa pine--the species and its management: symposium proceedings; 1987 September 29-October 1; Spokane, WA. Pullman, WA: Washington State University, Cooperative Extension: 125-131.

See Literature Reviews.

Shearer, Raymond C. and Schmidt, Jack A. 1999. Natural regeneration after harvest and residue treatment in a mixed conifer forest of northwestern Montana. Canadian Journal of Forest Research. 29 (2): 274-279.

Groups: vegetative effects--stand level.
Location: Flathead National Forest in northwestern Montana (Coram Experimental Station).

Abstract: In 1974, two clearcuts, two shelterwoods, and two sets of eight group selections (equally divided between two elevation zones) were harvested on the Coram Experimental Forest in northwestern Montana. Four levels of tree and residue utilization were compared. Moist fuels on approximately half of each area were poorly burned by prescribed fires in September 1975. Natural regeneration on these treatments was compared in 1979, 1987, and 1992. Regeneration of western larch (*Larix occidentalis* Nutt.) began in 1975 on soil exposed during yarding of logs and continued mostly in 1977 and 1979 on these scarified sites and other burned areas. Competing vegetation curtailed establishment of larch seedlings much past 1979 on these sites. Few Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) regenerated before 1979 but aggressively established through 1992. Engelmann spruce (*Picea engelmannii* Parry) and subalpine fir (*Abies lasiocarpa* (Hook.) Nutt) regeneration began in 1979 and is increasing slowly throughout the area. Western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) and western red cedar (*Thuja plicata* Donn.) also slowly regenerate in moister areas of the lower elevation units.

URL: None at this time. Please check back for updates.
Keywords: burning/clearcut/elevation/mixed conifer forest management/moisture/post-harvest natural regeneration/prescribed fire/residue treatment/shelterwood cut/site-scarification/vegetation competition management/western red cedar/western larch/subalpine fir/Douglas-fir/Engelmann spruce/western hemlock

Smith, Helen Y. and Arno, Stephen F., editors. 1999. Eighty-eight years of change in a managed ponderosa pine forest. General Technical Report RM-GTR-23. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station. 55 p (plus photos).

Groups: soils; vegetative effects--stand level; vegetative effects--trees; vegetative effects--understory.
Location: Bitterroot National Forest in western Montana (Lick Creek).

Abstract: This publication gives an overview of structural and other ecological changes associated with forest management and fire suppression since the early 1900s in a ponderosa pine forest, the most widespread forest type in the western United States. Three sources of information are presented: 1) changes seen in a series of repeat photographs taken between 1909 and 1997 at 13 camera points; 2) knowledge from 19 authors who have investigated effects of recent ecosystem-based management treatments; integrated with 3) findings of forest changes related to earlier treatments and to succession. The contributing authors discuss effects of historical silviculture and recent ecosystem-based management treatments, including an evaluation of various burning prescriptions in terms of tree response, undergrowth, soils, wildlife habitat, and esthetics and public acceptance.

Additional notes: This is a compilation of papers and the individual papers are listed within this bibliography.

URL: None at this time. Please check back for updates.
Keywords: ecosystem-based management/ forest succession/ prescribed fire/ ponderosa pine/ *Pinus ponderosa*

Smith, Jane Kapler. Fire Effects Information System [Web Page]. Available at: http://www.fs.fed.us/database/feis/.

See Literature Reviews.

Sullivan, Thomas P.; Sullivan, Druscilla S.; Lindgren, Pontus M. and others. 2002. Influence of conventional and chemical thinning on stand structure and diversity of plant and mammal communities in young lodgepole pine forest. Forest Ecology and Management. 170(1-3): 173-187.

See Wildlife.

Sullivan, Thomas P.; Sullivan, Druscilla S.; and Lindgren, Pontus M. F. 2001. Stand structure and small mammals in young lodgepole pine forest: 10-year results after thinning. Ecological Applications. 11(4): 1151-1173.

See Wildlife.

Tiedemann, Arthur R.; Klemmedson, James O.; and Bull, Evelyn L. 2000. Solution of forest health problems with prescribed fire: Are forest productivity and wildlife at risk? Forest Ecology and Management. 127(1-3): 1-18.

See Literature Reviews.

Tiedemann, Arthur R. and Woodard, Paul M. 2002. Multiresource effects of a stand-replacement prescribed fire in the *Pinus contorta-Abies lasiocarpa* vegetation zone of central Washington. General Technical Report PNW-GTR-535. La Grande, OR: U.S. Forest Service, Pacific Northwest Research Station. 26 p.

See Wildlife.

Walstad, John D.; Radosevich, Steven R.; and Sandberg, David V. 1990. Natural and prescribed fire in Pacific Northwest forests. Corvallis, OR: Oregon State University Press. 317 p.

See Literature Reviews.

Weaver, Harold. 1947. Fire--nature's thinning agent in ponderosa pine stands. Journal of Forestry. 45: 437-444.

See Fire Behavior and Fuel Reduction

Youngblood, Andrew and Riegel, Gregg. 1999 Reintroducing fire in eastside ponderosa pine forests: a long-term test of fuel treatments. In: Proceedings from the Joint Fire Science conference and workshop; 1999 June 15-17; Boise, ID. University of Idaho and the International Association of Wildland Fire: 142-150.

Groups: vegetative effects--stand level; vegetative effects--understory.
Location: Deschutes National Forest in central Oregon.

Abstract: Coniferous forests east of the crest of the Cascade Range in Oregon and Washington have changed substantially in the last 100 years. Much of this change, manifested in accumulated litter and dead and dying trees, increased stand densities, altered species compositions, and disruption of historic insect population levels, can be attributed to decades of fire exclusion and past management activities. The current structure and composition of many eastside forest stands, especially late-successional and old-growth ponderosa pine stands,

places them at greater risk of replacement from wildfire. Throughout the West, forest managers are interested in prescribing a series of repeated underburns to return fire to pre-exclusion frequencies and intensities, and thereby maintain and protect old-growth structural characteristics. Yet there is little quantitative information available on the effect of repeated prescribed fires in these high-risk systems. We describe a long-term study designed to develop a better understanding of key ecosystem attributes and functions that may be affected by reintroducing fire in fire-dependent ecosystems. Our work is focused on ponderosa pine (*Pinus ponderosa*)/bitterbrush (*Purshia tridentata*) stands within the 581-hectare Metolius Research Natural Area on the Deschutes National Forest in central Oregon, an area currently exhibiting symptoms of fire exclusion including reduced rates of tree growth, accumulated litter and ladder fuels, senescent shrubs, and dense regeneration of *Pinus ponderosa*. Burns at 5-, 10-, and 20-year intervals were chosen to resemble natural fire-return intervals and were initiated beginning in 1992. Initial results compare horizontal and vertical structure components of trees in late-successional/old-growth forests and how these components are modified by periodic fire, how underburns affect understory plant species diversity, and the relation between overstory canopy cover and understory species composition and cover. We believe this study will increase our understanding of how natural disturbances and human-caused manipulations can affect forest health over a long time, and lead to new options for protecting old-growth structural characteristics.

Additional notes: These are initial results of a long-term study.

URL: None at this time. Please check back for updates.
Keywords: fire restoration/fuel reduction/long-term study/ponderosa pine/*Pinus ponderosa*/prescribed fire

Vegetative Effects—Trees

This second category of treatment effects on vegetation, vegetative effects—trees, includes 40 papers that address effects on tree height and diameter growth and mortality.

Bella, I. E. and De Franceschi, J. P. 1982. Growth of lodgepole pine after mechanical strip thinning in Alberta: 15-year results. The Forestry Chronicle. 58(3): 131-135.

Groups: vegetative effects--stand level; vegetative effects--trees.
Location: Alberta.

Abstract: An operational thinning in a 25-year-old lodgepole pine *(Pinus contorta* Dougl. var. *latifolia* Engelm.) stand in Alberta resulted in nearly a 50 percent increase in diameter at breast height (d.b.h.) and height increment in the last 5 years. Initial stand density had no effect on d.b.h. increment beyond that of initial tree size. The release effect extended throughout the narrow (around 1.5 m) leave strips. Mortality continued to occur at about the same rate in both treated and untreated plots, thus reducing the need for follow-up selective thinning. Although the treated area had much lower stand volumes, it has a faster growth rate and may catch up or even surpass the untreated area in merchantable yield at harvest.

URL: None at this time. Please check back for updates.
Keywords: lodgepole pine/*Pinus contorta*/thinning/growth rate/strip thinning

Bevins, Collin D. 1980. Estimating survival and salvage potential of fire-scarred Douglas-fir. Research Note INT-RN-287. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station. 8 p.

Groups: vegetative effects--trees.
Location: west-central Montana.

Abstract: A dichotomous event regression model is used to estimate survival of fire-injured interior Douglas-fir (*Pseudotsuga menziesii* var. *glauca*) 1 year after burning. A preliminary salvage marking guide is presented based upon stem diameter at breast height and crown scorch height.

Additional notes: This study looks at survival 1 year following understory burning in 19 plots on a variety of sites with different fuel loads, fuel moistures, and weather conditions. Fire intensities were low to moderate. The study is restricted to mortality resulting from fire injury only, and not as a result of subsequent insect or disease infestation. They gathered data on 176 trees $\geq$ 5 in d.b.h. Seventy-five (43 percent) of the 176 Douglas-fir were dead 1 year following fire. Surviving trees tended to be taller and have greater stem diameters than those that died. Surviving trees also had lower scorch heights and percentage of live crown scorched than the dead trees.

URL: None at this time. Please check back for updates.
Keywords: Douglas-fir/ crown scorch/ postfire mortality/ timber salvage

Brown, James K. and Smith, Jane Kapler. 2000. Wildland fire in ecosystems: effects of fire on flora. General Technical Report RMRS-GTR-42 Vol. 2. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station. 257 p.

See Literature Reviews.

Busse, M. D.; Cochran, P. H.; and Barrett, J. W. 1996. Changes in ponderosa pine site productivity following removal of understory vegetation. Soil Science Society of America Journal. 60(Nov-Dec): 1614-1621.

See Vegetative Effects—Understory.

Busse, Matt D.; Simon, Steven A.; and Riegel, Gregg M. 2000. Tree-growth and understory responses to low-severity prescribed burning in thinned *Pinus ponderosa* forests of central Oregon. Forest Science. 46 (2): 258-268.

See Vegetative Effects—Understory.

Cochran, P. H. and Barrett, James W. 1995. Growth and mortality of ponderosa pine poles thinned to various densities in the Blue Mountains of Oregon. Research Paper PNW-RP-483. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 27 p.

See Vegetative Effects—Trees.

---. 1998. Thirty-five-year growth of thinned and unthinned ponderosa pine in the Methow Valley of northern Washington. Research paper PNW-RP-502. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 24 p.

Groups: vegetative effects--stand level; vegetative effects--trees.
Location: Methow Valley, northern Washington.

Abstract: It is commonly expected that self-thinning will maintain small-diameter stands at near- normal densities and allow dominant trees to grow reasonably well. Such self-thinning did not occur in the unthinned plots in a thinning study in the Methow Valley of northern Washington, even though there was some suppression-caused mortality. A shift from suppression-caused mortality to insect-caused mortality took place when quadratic mean diameters (QMDs) reached 7 inches. Thinning to spacings wider than 9.3 feet reduced growth of both basal area and cubic volume per acre but greatly increased growth of board-foot volume per acre, and diameter and height growth. Periodic annual increments of cubic volume and QMD are curvilinearly related to stand density index. Growth of the largest 62 trees per acre was clearly reduced by the presence of smaller trees in the stand. Density management is necessary to produce reasonable growth rates of even the largest trees in the stand and to speed the development of mid-seral conditions.

URL: http://www.fs.fed.us/pnw/pubs/rp_502.pdf
Keywords: Methow-Valley/ Washington/ thinning/ forestry method/ cubic volume/ growth/ mortality/ insect pests/ suppression/ quadratic mean diameter/ mountain pine beetle/ *Dendroctonus ponderosae*/ seral condition/ forest health

Cochran, P. H. and Seidel, K. W. 1999. Growth and yield of western larch under controlled levels of stocking in the Blue Mountains of Oregon. Research Paper PNW-RP-517. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 35 p.

See Vegetative Effects at the Stand Level.

Fiedler, Carl E. 1999. Effects of ecosystem-based management treatments: stand structure in response to selection cutting and burning. In Smith, Helen Y and Arno, Stephen F., editors. Eighty-eight years of change in a managed ponderosa pine forest. General Technical Report RMRS-GTR-23. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station: 31-34.

Groups: vegetative effects--stand level; vegetative effects--trees.
Location: Bitterroot National Forest in western Montana (Lick Creek).

Abstract: None

Additional notes: At the Lick Creek site in western Montana, the U.S. Forest Service applied a different kind of silvicultural cutting treatment for each of three experimental stands consisting of 80 to 100 acres each. Within each silvicultural cutting system, they applied different underburning strategies as well as no burn treatments. In the selection cutting units, some subunits were not burned, some had an intermediate burn, and some acted as controls with no cut but with a burn. Following selection cutting, the treated units averaged about 60 trees per acre and 50 ft^2 of basal area per acre, which translates into a 70 percent reduction in trees per acre and 55 percent in basal area per acre. The bulk of the density reduction occurred in the smaller diameter classes (fig. 20).

Growth responses are compared among the three treatments. Results are based on trees living at the end of the first 5 years of the study. Leave trees were marked in all units prior to randomly assigning the cutting and burning treatments. This approach ensured that post-treatment growth responses were compared among similar trees in each treatment. Based on measurements of comparable trees in all three treatments, average annual diameter increment ranged from a low of 0.08 inch in the uncut control, to 0.10 inch in the cut/burn treatment, to a high of 0.13 inch in the cut/no-burn treatment.

Annual height growth varied little among the three treatments, averaging 0.6 ft in both the control and cut/burn treatments, and 0.7 ft in the cut/no-burn treatment. Average annual basal area increment varied from 0.8 ft^2 per acre in the uncut control, to 0.7 ft^2 per acre in the cut/burn treatment, to 1.1 ft^2 per acre in the cut/ no-burn treatment. Average annual volume increments for 1993 to 1997 were also nearly identical for the control and cut/ burn treatments. Annual cubic volume growth was 32 ft^3 per acre per year in the control versus 31 ft^3 per acre per year in the cut/burn treatment. Cubic volume growth was considerably higher in the cut/no-burn treatment, averaging 43 ft^3 per acre per year. Trends in annual board foot volume growth by treatment mirrored those for cubic foot volume growth.

The positive influence of density reduction on growth in the selection cut/no-burn treatment should have been realized in the cut/burn treatment as well because both received the same selection cutting treatment. However, the beneficial effects of reduced competition from cutting were apparently almost entirely offset by the short-term deleterious effects of reintroducing fire after nearly 100 years without frequent burning. Crown scorch, root damage, and cambial injury at the root collar may all have contributed to reduced tree stem growth in this treatment relative to the cut/no-burn treatment over the first 5 years of the study.

Total 5-year mortality varied considerably among the three treatments but was highest in the selection cut/burn treatment. Virtually no trees died in the selection cut/no-burn treatment, whereas mortality in the control was intermediate to the other two treatments.

Fire was the major cause of mortality in the selection cut/burn treatment, killing 18 percent of the trees in the 4-inch diameter class, and 2 to 4 percent of the trees in the 8- through 16-inch classes. No trees larger than 16 inches died due to the effects of fire, and virtually all of the mortality attributed to fire occurred in the first 2 years of the study. Bark beetles were an important mortality factor in the selection cut/burn treatment, accounting for 4 to 12 percent mortality in the 4- through 20-inch diameter classes, and 25 percent of the trees $\geq$ 28-inches. In contrast, no trees of any size were killed by beetles in the selection cut/no burn treatment, and only sporadic mortality due to this factor was observed in the control treatment.

URL: None at this time. Please check back for updates.
Keywords: selection cutting/ ponderosa pine/ Douglas-fir/ partial cutting/ prescribed burning/ stand structure/ mortality

Fiedler, Carl E. 2000. Restoration treatments promote growth and reduce mortality of old-growth ponderosa pine (Montana). Ecological Restoration. 18: 117-119.

Groups: vegetative effects--stand level; vegetative effects--trees.
Location: Blackfoot Valley area of western Montana.

Abstract: None

Additional notes: Two restoration prescriptions were used in two old-growth ponderosa pine stands in western Montana. One was a cut/no burn treatment in which they removed most of the ladder fuel layer, and used selection cutting to create openings for regenerating shade-intolerant pine and to increase the vigor of the remaining trees. They also removed nearly all of the Douglas-fir. The cut/burn treatment was the same, followed by a one-time prescribed burn of the ground layer in the fall of 1984.

Measurements "show differences among treatments in terms of growth rates, stand structure, and composition and vigor of regeneration. Compared to the control, diameter growth in the treated areas has increased in all size classes, especially in the largest class. For example, trees greater than 22 inches d.b.h. increased in diameter by 1.4 and 1.3 inches in the cut/burn and cut/no-burn treatments, respectively. By comparison, similar sized trees in the control plots increased only 0.5 inch. Increased diameter growth of smaller trees in the two treated plots indicates that large tree recruitment will likely occur faster in these areas as well."

Treated areas "had greater numbers of seedlings in general, and of ponderosa pine seedlings in particular, than the control plots. Furthermore, they rated 48 and 47 ponderosa pine seedlings per acre in the cut/burn and cut/no burn treatments, respectively, as having good vigor. Only seven pine seedlings per acre in the control received that rating. Perhaps most significantly, ponderosa pine outnumbered Douglas-fir seedlings approximately 24:1 in the cut/burn treatment, and 17:1 in the cut/no burn treatment, while Douglas-fir seedlings outnumbered pine by more than 2:1 in the control plots.

"Mortality of large trees (greater than 16 inches d.b.h.) was also lower in the cut/no burn and cut/burn treatments than in the control. An average of 0.4 large trees per acre died in each of the treated areas over the 15-year period, whereas an average of 2.2 trees per acre died in the control plots, mainly from an infestation of westem pine beetle."

URL: None at this time. Please check back for updates.
Keywords: restoration/prescribed fire/thinning/ponderosa pine/Douglas-fir/treatment effects

Harrington, M. G. 1993. Predicting *Pinus ponderosa* mortality from dormant season and growing season fire injury. International Journal of Wildland Fire. 3(2): 65-72.

Groups: vegetative effects--trees.
Location: southwestern Colorado.

Abstract: Understory prescribed burning was conducted in an immature *Pinus ponderosa* (ponderosa pine) stand in southwestern Colorado during three seasons, late spring, midsummer, and autumn. Tree mortality from various levels of crown scorch was compared for the different seasons of injury. A total of 526 trees of different sizes, with crown scorch ranging from 20 to 100 percent , were monitored annually for 10 years.

Over 80 percent of the 10-year mortality from injury in all three seasons had occurred by year 3, with over 90 percent occurring by year 4. Mortality of trees scorched in the spring and summer was about 2.5 times greater than that in the autumn for similar crown damage. Most trees larger than 18 cm in diameter survived autumn injury, even with greater than 90 percent scorching. Following spring and summer injury, trees smaller than 10 cm in diameter died readily with greater than 50 percent scorching, but about 90 percent crown scorch was required by large trees to be lethal.

A logistic regression model was developed to predict the probability of mortality given tree size, scorch class, and season of injury. Because mortality was similar within scorch classes less than 90 percent, they were combined into a single class. Scorch thresholds with large increases in mortality occurred at 90 percent and 100

percent crown scorch. The season variable includes two groups, dormant (autumn) and growing (spring and summer). Use of this model to predict mortality of immature *P. ponderosa* is appropriate where stand, fuel, and fire conditions resemble those of this study.

URL: None at this time. Please check back for updates.
Keywords: *Pinus ponderosa*/gymnosperms/plants/spermatophytes/vascular plants/Colorado/crown scorch/fire effects/mathematical model/mortality prediction model, ponderosa pine

Harrington, Michael. 1999. Effects of ecosystem-based management treatments: wildlife snag production, commercial thinning, and shelterwood cutting units. In Smith, Helen Y and Arno, Stephen F., editors. Eighty-eight years of change in a managed ponderosa pine forest. General Technical Report RMRS-GTR-23. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station: 43-44.

Groups: vegetative effects--trees; wildlife.
Location: Bitterroot National Forest in western Montana (Lick Creek).

Abstract: None

Additional notes: At the Lick Creek site in western Montana, the U.S. Forest Service applied a different kind of silvicultural cutting treatment for each of three experimental stands consisting of 80 to 100 acres each. Within each silvicultural cutting system, they applied different underburning strategies as well as no burn treatments. In the shelterwood cutting units, some subunits were not burned, some had a wet burn (low fuel consumption), and some had a dry burn (high fuel consumption). In the commercial thinning units, some had no burn, some had a fall burn, and some had a spring burn. Because of past cutting of low vigor trees and firewood gathering, few quality wildlife snags existed in the Lick Creek research area. An opportunity arose to study the efficacy of artificially producing snags. Fire was used to mortally injure snag candidates compared with mechanically injured trees in a study to observe longevity and quality of artificially created snags. At 4 years after the mechanical girdling, only one bull pine remained alive and all intermediate and old-growth trees were dead. Of the 36 fire-girdled trees, 10 were still alive including three bull pines, five intermediates, and two old-growth. A few of these may still die but most probably will survive. There were no additional changes 5 years after girdling. Four trees have fallen. Two bull pines fell 4 years after mechanical girdling and two intermediate pines fell 4.5 years after fire girdling. This indicates that decay is occurring and additional falling should be imminent. A few of the new snags have recent bird cavities, which also indicates the presence of sapwood decay.

URL: None at this time. Please check back for updates.
Keywords: commercial thinning/ selection cutting/ shelterwood cut/ ponderosa pine/ Douglas-fir/ partial cutting/ prescribed burning/ snags/ artificial snags/ snag retention

Harrington, Michael G. 1996. Fall rates of prescribed fire-killed ponderosa pine. Research Paper INT-RP-489. Ogden, UT: USDA Forest Service, Intermountain Research Station. 7 p.

Groups: vegetative effects--trees.
Location: southwestern Colorado.

Abstract: Prescribed underburning was carried out in three seasons in a second-growth ponderosa pine stand in southwestern Colorado. After burning, 526 trees with various levels of crown scorch were tagged and surveyed annually for 10 years to evaluate mortality and subsequent tree fall. Of the 123 dead trees, 75 percent fell within the study period. Even though a smaller percentage of autumn-killed trees fell than spring-or summer-killed trees (62 percent versus 78 percent), the difference was not significant. Fall rate differences were not noted among trees from 2 to 16 inches d.b.h. Two factors stood out as significant in evaluating tree fall differences following fire mortality: percent crown scorch and length of time between fire injury and death. Trees that died with greater than 80 percent crown scorch had about an 80 percent probability of falling within the 10 years regardless of length of survival after injury. Trees that died from less than 80 percent crown scorch and that died

within the first postburn year had a 75 percent probability of falling. However, trees that died from less than 80 percent crown scorch but that survived for 2 or 3 postfire years had a 27 percent probability of falling. Even though this study was relatively short, these findings have significance for those concerned about the quality of standing dead trees for wildlife habitat and about the rate of down, woody fuel build-up after prescribed burning.

URL: None at this time. Please check back for updates.
Keywords: prescribed fire/ coarse woody debris/ snags/ snag survival/ ponderosa pine/ fall rates/ fire effects

Heath, R. and Alfaro, R. I. 1990. Growth response in a Douglas-fir/lodgepole pine stand after thinning of lodgepole pine by the mountain pine beetle: a case study. Journal of the Entomological Society of British Columbia. 87(December): 16-21.

Groups: vegetative effects--stand level; vegetative effects--trees.
Location: Cariboo Forest Region of British Columbia.

Abstract: Diameter growth response was measured in a mixed stand of lodgepole pine, *Pinus contorta* Dougl. ex Loud, and interior Douglas-fir, *Pseudotsuga menziesii* var *glauca* (Beissn.) Franco, in the Cariboo Forest Region of British Columbia [Canada], 14 years after an outbreak of the mountain pine beetle, *Dendroctonus ponderosae* Hopkins, killed 76 percent of the pine. Nearly all Douglas-fir and a large proportion of the lodgepole pine responded to the beetle-induced thinning with a diameter growth increase which persisted 14 years after the infestation. Douglas-fir trees gained an average 1.4 cm or 11.7 percent in diameter over the estimated size the trees would have reached in the absence of the thinning effect. Annual growth rates of Douglas-fir in the post-outbreak period averaged 2 percent per year without the beetle-induced thinning and 2.9 percent after thinning. The surviving lodgepole pine trees gained an average 1 cm or 5.4 percent in diameter over the size the trees would have reached in the absence of the thinning effect. In the post-outbreak period, annual diameter growth rates of the pine doubled from 0.4 percent per year without the thinning, to 0.8 percent per year with thinning. The thinning response in Douglas-fir was inversely related to the initial diameter and age of the trees at the start of the infestation but that of pine was not.

Additional notes: Thinning resulted from mountain pine beetle activity, not human efforts.

URL: None at this time. Please check back for updates.
Keywords: *Pinus contorta* /*Pseudotsuga menziesii* var *glauca*/*Dendroctonus ponderosae*/diameter increase/age dependence/Cariboo Forest/British Columbia/lodgepole pine/Douglas-fir/mountain pine beetle/insects/growth response

Johnstone, W. D. 1981. Precommercial thinning speeds growth and development of lodgepole pine: 25-year results. Edmonton, Alberta: Environment Canada, Northern Forest Research Centre. 30 p.

See Vegetative Effects at the Stand Level.

---. 2002. Thinning lodgepole pine in southeastern British Columbia: 46-year results. Working Paper. Victoria, BC: Research Branch, British Columbia Ministry of Forestry. 26 p.

See Vegetative Effects at the Stand Level.

Landsberg, J. D. and Cochran, P. H. 1980. Prescribed burning effects on foliar nitrogen content in ponderosa pine. In: Martin, Robert E.; Edmonds, Robert L.; Faulkner, Donald A. and others, editors. Proceedings of the 6th Conference on Fire and Forest Meteorology; 1980 April 22-24; Seattle, WA. Bethesda, MD: Society of American Foresters: 209-213.

Groups: soils; vegetative effects--trees.
Location: Deschutes National Forest in Oregon.

Abstract: Folliar nitrogen concentrations at the midcrown position were found to vary with the season but not with the treatment for ponderosa pine forest areas subjected to a high fuel consumption (HFC) or a moderate fuel consumption (MFC) prescribed burn, or a no-burn control. Average midcrown foliar nitrogen concentrations were 1.01 percent in May prior to the onset of growth, fell to a low of 0.83 percent in June, and then rose to a season-end high of 1.15 percent in September.

The HFC and MFC prescribed burns produced losses of 20 percent and 4 percent of the needle mass, respectively. The total nitrogen content of the foliage at the end of growth in August was 81, 95, and 99 kilograms per hectare (kg/ha), and at the end of the sampling season in September it had reached 89, 105, and 108 kg/ha for the HFC, MFC, and the control units, respectively.

Additional notes: This study followed changes in ponderosa pine foliar N levels through the first growing season following prescribed burning to determine if foliar N content changed differently with time for three treatments (control, moderate, and high fuel consumption prescribed burns).

URL: None at this time. Please check back for updates.
Keywords: forestry practices/controlled burning/responses/nutrients/foliage/fire effects/cycling/conifers/plant composition

Landsberg, J. D.; Cochran, P. H.; Finck, M. M. and others. 1984. Foliar nitrogen content and tree growth after prescribed fire in ponderosa pine. Research Note PNW-RN-412. Portland, OR: Pacific Northwest Forest and Range Experiment Station, USDA Forest Service. 15 p.

Groups: fire behavior/fuel reduction; soils; vegetative effects--trees.
Location: Deschutes National Forest in Oregon.

Abstract: This initial study of prescribed burning in ponderosa pine (*Pinus ponderosa* Dougl. &x Laws.) stands in central Oregon showed that all periodic annual growth increments were reduced for trees alive four growing seasons later. Height growth was reduced 8 percent in areas burned by fires with moderate fuel consumption and 18 percent in areas with high fuel consumption. Basal area growth was reduced 16 percent in the moderate fuel consumption areas and 28 percent in the high fuel consumption areas; volume growth declined 23 percent at both levels of fuel consumption.

Foliar nitrogen (N) concentration was not affected by the prescribed fires; however, total foliar N content was reduced immediately after burning, and it remained depressed four growing seasons later after the burned areas had recovered from crown scorch. Foliar N content was significantly correlated with the observed reductions in periodic annual increments. Prescribed fire needs additional evaluation for a longer period and in additional ponderosa pine communities to determine long-term effects.

Additional notes: Burning with appropriate fuel moisture conditions produced an average reduction of 35 percent in woody fuel and an average reduction of 49 percent in duff depth in the moderate fuel consumption units, whereas in the high fuel consumption burns the woody fuel load was reduced 69 percent and the duff depth 88 percent.

URL: None at this time. Please check back for updates.
Keywords: fire effects/ cycling/ increment/ volume/ height/ basal-area/ foliage/ fires/ plant composition/ nitrogen/ conifers/ pines/ prescribed burning/ ponderosa pine/ foliar nitrogen/ height increment/ basal area increment/ volume increment

Latham, P. and Tappeiner, J. 2002. Response of old-growth conifers to reduction in stand density in western

Oregon forests. Tree Physiology. 22(2-3): 137-146.

Groups: vegetative effects--trees.
Location: southern Cascades in SW Oregon

Abstract: The positive growth response of healthy young trees to density reduction is well known. In contrast, large old trees are usually thought to be intrinsically limited in their ability to respond to increased growing space; therefore, density reduction is seldom used in stands of old-growth trees. We tested the null hypothesis that old-growth trees are incapable of responding with increased growth following density reduction. The diameter growth response of 271 Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco), ponderosa pine (*Pinus ponderosa* Dougl. ex Laws), and sugar pine (*Pinus lambertiana* Dougl.) trees ranging in age from 158 to 650 years was examined 20 to 50 years after density reduction. Density reduction involved either light thinning with removal of less vigorous trees, or shelterwood treatments in which overstory trees were not removed. Ratios of basal area growth after treatment to basal area growth before treatment, and several other measures of growth, all indicated that the old trees sometimes benefited and were not harmed by density reduction. Growth increased by 10 percent or more for 68 percent of the trees in treated stands, and nearly 30 percent of trees increased growth by over 50 percent. This growth response persisted for at least 20 years. During this 20-year period, only three trees in treated stands (1.5 percent) exhibited a rapid decrease in growth, whereas growth decreased in 64 percent of trees in untreated stands. The length of time before a growth response to density reduction occurred varied from 5 to 25 years, with the greatest growth response often occurring 20 to 25 years after treatment. These results have important implications both for the basic biology of aging in woody plants as well as for silvicultural practices in forests with old-growth trees.

URL: None at this time. Please check back for updates.
Keywords: old growth/conifers/forest management/growth/stand structure/basal area growth/density reduction/*Pinus lambertiana*/*Pseudotsuga menziesii*/*Pinus ponderosa*/ponderosa pine/Douglas-fir/sugar pine/thinning/tree vigor

McCaughey, Ward W.; Theroux, Leon J.; and Carlson, Clinton E. 1999. Effects of ecosystem-based management treatments: artificial regeneration, shelterwood cutting unit. In Smith, Helen Y and Arno, Stephen F., editors. Eighty-eight years of change in a managed ponderosa pine forest. General Technical Report RMRS-GTR-23. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station: 35-36.

Groups: vegetative effects--stand level; vegetative effects--trees.
Location: Bitterroot National Forest in western Montana (Lick Creek).

Abstract: None

Additional notes: This report gives results on artificial regeneration (planting ponderosa pine and western larch seedlings) five years after a shelterwood cut in a ponderosa pine/Douglas-fir forest that reduced basal area of the overstory from an average of 117 to 52 ft^2 per acre followed by either a high fuel consumption burn, a low consumption burn, or no burn. Percentage survival of ponderosa pine and western larch slowly declined over the first 4 years following planting. Percentage survival of ponderosa pine was consistently near 65 percent with either burn treatment, while survival of western larch is higher than pine on the dry burn and lower on the other treatments. Growth rate was generally good for both species although it was necessary to use mesh seedling tubes to protect seedlings from browse damage by elk.

URL: None at this time. Please check back for updates.
Keywords: regeneration/ artificial regeneration/ shelterwood cut/ ponderosa pine/ Douglas-fir/ western larch/ partial cutting/ prescribed burning

Peters, Gregory. 2002. Effects of thinning, prescribed burning, and burning season on the physiological performances of ponderosa pine. Missoula, MT: University of Montana. 60 p. Thesis.

Groups: soils; vegetative effects--stand level; vegetative effects--trees.
Location: Bitterroot National Forest in western Montana (Lick Creek).

Abstract: Low elevation ponderosa pine *(Pinus ponderosa* Dougl. ex. Laws.) forests of the northern Rocky Mountains historically experienced frequent, low intensity fires that maintained open, uneven-aged stands. A century of fire suppression has led to denser ponderosa pine forests with higher competition for resources, higher tree stress, and greater risk of insect attack and stand destroying fire. Active management intended to restore historical stand conditions includes selective thinning and prescribed fire application. Little is known about the differential effects of these management practices on the physiological performance of ponderosa pine. We examined the performance of second growth ponderosa pine trees nine years after the application of four treatments: thinning, thinning followed by spring (wet) prescribed fire, thinning followed by fall (dry) prescribed fire, and unthinned control stands. We measured stand structural characteristics, resource availability, and tree performance parameters in three replicates of each treatment at the Lick Creek Experimental Site in the Bitterroot National Forest. Thinning resulted in similar reductions in basal area in each thinned and burned stand relative to control stands. Soil moisture availability did not differ between any treatment over the field season. Soil chemical analyses revealed lower late-spring available ammonium in control stands relative to all others and lower time-integrated nitrate availability in burned stands than in thinned only or control stands. Trees of similar size and structure in thinned stands and in both of the thinned and burned stand types displayed higher rates of maximum, area-based photosynthesis (A_{area}), lower levels of water stress *(Psi),* and higher rates of diameter growth than trees in control stands over the course of the growing season. These results reflect an overall improvement in long-term physiological performance of trees in the actively managed stands relative to trees in unmanaged control stands. None of several leaf level characteristics, including specific leaf area (SLA), mass-based leaf nitrogen content (N_{leaf}), carbon isotope discrimination (*Delta*), and nitrogen isotope ratio ($delta^{15}N$) was significantly different between any of the four treatments. We found no evidence that long-term physiological performance of second growth ponderosa pine is affected by the application of either spring or fall prescribed fire to thinned stands.

URL: None at this time. Please check back for updates.
Keywords: ponderosa pine/ thinning/ prescribed fire/ tree physiology/ soil moisture/ soil chemistry/ soil

Reinhardt, Elizabeth D. and Ryan, Kevin C. 1988. Eight-year tree growth following prescribed underburning in western Montana Douglas-fir/western larch stand. General Technical Report INT-GTR-387. Ogden, UT: USDA Forest Service, Intermountain Research Station. 6 p.

Groups: vegetative effects--trees.
Location: Lubrecht Experimental Forest in western Montana.

Abstract: Eight-year tree growth of western larch (*Larix occidentalis*) and Douglas-fir (*Pseudotsuga menziesii*) was measured following prescribed underburning on burned and control plots in western Montana. Western larch on burned plots had reduced radial growth in the first year following fire but increased growth in the next 7 years. Douglas-fir had similar growth on burned and unburned plots. Growth was not reduced by low levels of crown scorch or cambial injury. Stand basal area growth was less on burned plots due to high fire-caused mortality.

URL: None at this time. Please check back for updates.
Keywords: radial increment/ basal area increment/ prescribed fire/ fire effects

Reinhardt, Elizabeth D. and Ryan, Kevin C. 1989. Estimating tree mortality resulting from prescribed fire. In: Baumgartner, David M.; Breuer, David W.; Zamora, Benjamin A. and others, compilers/editors. Prescribed fire in the Intermountain Region: forest site preparation and range improvement; Pullman, WA: Washington State University: 41-44.

Groups: vegetative effects--trees.
Location: Montana, Idaho, Oregon, and Washington.

Abstract: Tree mortality resulting from prescribed fire was modeled using data on 2,356 trees from 43 prescribed fires in Montana, Idaho, Oregon, and Washington. Seven conifer species were studied: lodgepole pine, Engelmann spruce, subalpine fir, western red cedar, western hemlock, western larch, and Douglas-fir. Mortality was predicted from observed crown volume scorched (percent) and bark thickness, which was computed from d.b.h. Trees of all seven species were grouped for analysis, and a single, species-independent, logistic regression model was developed.

A graphical representation of the model was developed to aid managers in designing fire prescriptions that achieve acceptable tree survival or in predicting mortality of fire damaged trees. Using tree species, diameter, height, and crown ratio, maximum allowable flame length for a given level of mortality can be derived. Alternatively, marking criteria for salvage harvests following unplanned fires can be developed.

URL: None at this time. Please check back for updates.
Keywords: prescribed fire/Douglas-fir/western larch/western red cedar/western hemlock/Engelmann spruce/lodgepole pine/subalpine fir/tree mortality/tree survival/modeling

Ryan, K. C. and Frandsen, W. H. 1991. Basal injury from smoldering fires in mature *Pinus ponderosa* Laws. International Journal of Wildland Fire. 1(2): 107-118.

Groups: soils; vegetative effects--trees.
Location: Glacier National Park in northwestern Montana.

Abstract: Fuel accumulations were measured in duff mounds around the bases of 19 mature *Pinus ponderosa* Laws (ponderosa pine) in a 200-year-old stand in Glacier National Park, Montana. Tree diameter at breast height ranged from 50 to 114 cm (mean = 80 cm). The stand burned at intervals between 13 to 58 years prior to European settlement. This stand had not burned for 69 years. The duff depth 30 cm from the tree bole ranged from 3 to 39 cm (mean = 18 cm). Duff depth increased with tree diameter and decreased with distance from the bole. Duff depth 90 cm from the bole averaged one-half the depth 30 cm from the bole.

Duff consumption and its effect on cambium mortality were quantified following a late summer, low intensity fire. Duff moisture contents on a dry weight basis were: fermentation (20 percent) and humus (36 percent). Smoldering combustion consumed 98 percent of the duff beneath the trees. Two patterns of duff burning were documented: downward spreading and lateral spreading. Temperatures near the root crown were above 300°C for 2 to 4 hours, resulting in mortality of 45 percent of the cambium samples *(n=76)* tested at the root crown. The probability of cambium mortality increased with duff depth and tree diameter. However, cambium mortality was lower than expected from analysis of thermal diffusion through bark. Cooling by mass transport through phloem and xylem is suggested as a possible explanation for the low cambium mortality.

Additional notes: (from the authors'conclusions): Improving information of relationships between fuels and fire injury is needed to aid managers in reintroducing fire into coniferous forests. Fuel accumulation increases the potential for cambial injury while increasing bark thickness reduces it. The amount of fuel at the base of mature ponderosa pine also increases with the tree diameter. Thus the extended heating associated with the combustion of these deeper mounds results in greater cambium mortality in bigger trees. "If high survival of mature pines is a goal of a program to reintroduce fire into these ecosystems, it may be desirable to burn when the O_e (fermentation) and O_a (humus) horizons are too moist to sustain a ground fire."

URL: None at this time. Please check back for updates.
Keywords: fire ecology/mortality/heat transfer/Glacier National Park/Montana/*Pinus ponderosa*/fire effects

Ryan, K. C. and Steele, B. M. 1989. Cambium mortality resulting from broadcast burning in mixed conifer shelterwoods. In: MacIver, D. C.; Auld, H.; and Whitewood, R., editors. Proceedings of the 10th conference on fire and forest meteorology; 1989 April 17-21; Ottawa, Canada. Chalk River, Canada: Forestry Canada, Petawawa National Forestry Institute (PNFI): 108-116.

Groups: vegetative effects--trees.
Location: Priest River Experimental Forest in northern Idaho.

Abstract: Three supplemental protection methods for reducing cambium mortality resulting from prescribed burning of leave trees (n = 518) were evaluated in two shelterwood harvested areas. Treatments included: burned without supplemental protection, application of a commercial fire retardant to fuels around the base of the tree prior to burning, similar application of detergent foam, and manual removal of fuels. Species tested were: Douglas-fir, western larch, western hemlock, western red cedar, western white pine, Engelmann spruce, and grand fir. Several prefire and postfire fuel and tree morphology covariates were also observed. Fuel mass was measured on transects placed in downhill, uphill, and both sidehill positions. Cambium condition (live vs. dead) was determined at ground-line in each of the four positions. Logistic discriminant analysis (LDA) was used to select potentially useful explanatory variables. The Newton-Raphson method was used to estimate coefficients in a logistic regression analysis of deviance to evaluate important variables influence on cambium survival in a multivariate model. Models were generated to predict cambium survival from variables that can be determined before burning and from variables requiring both before and after burning observations.

The LDA indicated that bark thickness squared was the best prefire tree morphology variable for predicting cambium survival. The mass per unit area of logs greater than 7.62 cm diameter was the best prefire fuel variable. A qualitative descriptor of the depth of bark char was the best postfire predictor of cambium survival. Analysis of deviance indicated cambium survival varied with treatment (retardant > foam > manual removal = no protection). Species also strongly affected cambium survival. In the prefire model species, differences in cambium survival were western larch > Douglas-fir > grand fir > western hemlock > western white pine > Engelmann spruce = western red cedar. The same pattern occurred in the postfire model except that western white pine was not significantly different from Engelmann spruce. Diameter and either quantitative or qualitative prefire fuel descriptors also improved fit. Species and a qualitative descriptor of bark charring were the strongest postfire variables for predicting cambium condition.

Additional notes: Although this was broadcast burning of logging slash, the results on cambium survival are applicable to understory prescribed burns.

URL: None at this time. Please check back for updates.
Keywords: controlled burning/damage/cambium/shelterwood cut

Ryan, Kevin C. 2000. Effects of fire injury on water relations of ponderosa pine. In: Moser, W. Keith and Moser, Cynthia F., editors. Fire and forest ecology: innovative silviculture and vegetation management--Tall Timbers Fire Ecology Conference proceedings; Tallahassee, FL: Tall Timbers Research Station: 58-66.

Groups: vegetative effects--trees.
Location: Lubrecht Experimental Forest in western Montana.

Abstract: Heat was used to injure foliage and cambium of 36 juvenile, approximately 9-meter-tall, ponderosa pine *(Pinus ponderosa)* in western Montana. The objective was to determine the effects of crown scorch (0 percent, 40 percent, and 80 percent leaf area reduction), stem heating (0 percent, 70 percent, and 100 percent of basal circumference), and their interactions with water relations. Measurements were taken for two growing seasons following an autumn heat treatment. The first growing season was warmer and drier than normal. The second season was wetter than normal. Seasonal differences in precipitation had a relatively greater effect on water relations than did fire treatments except for 100 percent basal heating. Before August in the drought year, trees with 80 percent crown scorch had 50 percent greater stomatal conductance (g_s) than unscorched trees, whereas midday xylem pressure potential $(Psi)_m$) was 0.16 megapascal higher in undefoliated trees. In the second growing season, a low moisture stress year, g_s and transpiration (E) increased with crown scorch, but predawn xylem pressure potential (Psi_b) and Psi_m were not significantly affected. In the second season half of the trees in the 100 percent basal heating class failed to break bud. They were under severe moisture stress (in other words, Psi_b < -2.6 megapascal, and g_s and E were negligible) in early June, and died by early July.

URL: None at this time. Please check back for updates.
Keywords: fire injury/ponderosa pine/Rocky Mountains/water relations

Ryan, Kevin C. 1982. Evaluating potential tree mortality from prescribed burning. In: Baumgartner, David M., editor. Site preparation and fuels management on steep terrain; 1982 February 15-17; Spokane, WA. Pullman, WA: Washing State University Cooperative Extension: 167-179.

See Literature Reviews.

Ryan, Kevin C. and Reinhardt, Elizabeth D. 1988. Predicting postfire mortality of seven western conifers. Canadian Journal of Forest Research. 18(10): 1291-1297.

Groups: vegetative effects--trees.
Location: Idaho, Montana, Oregon, and Washington.

Abstract: We used data on 2356 trees from 43 prescribed fires in Idaho, Montana, Oregon, and Washington states to model postfire tree mortality. Data were combined for seven species of conifers to develop binary logistic regression models for predicting the probability of mortality. Probability of mortality increased with percentage of the crown killed, and decreased as bark thickness increased. Models are presented with and without species as a categorical variable. The models predicted well for trees burned in both slash fires and fires in natural fuels. The models are applicable for assessing fire-caused mortality both of individual trees and in mixed conifer stands of the Pacific Northwest.

URL: None at this time. Please check back for updates.
Keywords: prescribed fire/mortality/conifers/western/bark thickness/crown scorch/logistic regression

Scott, Donald W.; Szymoniak, John; and Rockwell, Victoria. 1996. Entomological concerns regarding burn characteristics and fire effects on tree species during prescribed landscape burns: burn severity guidelines and mitigation measures to minimize fire injuries. La Grande, OR: USDA Forest Service, Pacific Northwest Region, Wallowa-Whitman National Forest, Blue Mountains Pest Management Zone. 48 p.

See Literature Reviews.

Smith, Helen Y. 2000. Factors affecting ponderosa pine snag longevity. In: Proceedings of the Society of American Foresters 1999 convention; 1999 September 11-15; Portland, OR. Bethesda, MD: Society of American Foresters: 223-229.

Groups: vegetative effects--trees.
Location: Lolo National Forest in western Montana.

Abstract: Little is known about what factors contribute to the persistence of snags (standing dead trees), which are important ecological components of western forests. Knowledge of snag persistence, or longevity, would be useful for land managers making decisions about snag retention or recruitment. Snag management guidelines often use diameter at breast height (d.b.h.) as a decision criterion. This investigation looked at the relationships between tree age, d.b.h., wood density, and pitch content of ponderosa pine *(Pinus ponderosa)* snags and their longevity. Snags that were created 10 years earlier in a wildfire event were sampled. Longevity was classified by whether the snag was standing or had broken off below 10 ft (3 m). The one attribute measured that was positively related to snag longevity was tree age. Snags standing 10 years after tree mortality averaged 228 $\pm$ 25 years at one site (n=15) and 273 $\pm$ 19 years at another site (n=13), while those broken averaged 154 $\pm$ 24 (n=16) years and 182 $\pm$ 23 years (n=9), respectively. Pitch content and wood density in relation to snag longevity was explored but will require further research, which can benefit from the exploratory study techniques used here.

Additional notes: Concerning the last sentence in the abstract, the authors state: anecdotal evidence suggests that old fire-scarred ponderosa pine produce longer-standing snags than unscarred ponderosa pine, which might be related to higher pitch content or to greater wood density.

URL: None at this time. Please check back for updates.
Keywords: snags/ponderosa pine/longevity/age/diameter/pitch content/wood density

Smith, Helen Y. and Arno, Stephen F. 1999, editors. Eighty-eight years of change in a managed ponderosa pine forest. General Technical Report RM-GTR-23. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station. 55 p (plus photos).

See Vegetative Effects at the Stand Level.

Smith, Jane Kapler. Fire Effects Information System [Web Page]. Available at: http://www.fs.fed.us/database/feis/.

See Literature Reviews.

Sullivan, Thomas P.; Sullivan, Druscilla S.; Lindgren, Pontus M. and others. 2002. Influence of conventional and chemical thinning on stand structure and diversity of plant and mammal communities in young lodgepole pine forest. Forest Ecology and Management. 170(1-3): 173-187.

See Wildlife.

Sullivan, Thomas P.; Sullivan, Druscilla S.; and Lindgren, Pontus M. F. 2001. Stand structure and small mammals in young lodgepole pine forest: 10-year results after thinning. Ecological Applications. 11(4): 1151-1173.

See Wildlife.

Swezy, D. Michael and Agee, James K. 1991. Prescribed-fire effects on fine-root and tree mortality in old-growth ponderosa pine. Canadian Journal of Forest Research. 21(5): 626-634.

Groups: vegetative effects--trees.
Location: Crater Lake National Park, Oregon.

Abstract: Old-growth ponderosa pine (*Pinus ponderosa*) stands were surveyed at Crater Lake National Park, Oregon, to investigate potential accelerated mortality of large pines due to prescribed burning. Mortality of *P. ponderosa* >22 cm diameter at breast height was greater in burned areas (19.5 percent) than in unburned areas (6.6 percent), and early-season burns had >30 percent mortality. Mortality was associated with fire severity, as measured by scorch height and ground char, season of burning, and tree vigor. Pines of high, moderate, and low vigor were subjected to a prescribed burn in June; half of the trees had debris raked from tree bases as an additional treatment. Lethal heat loads (>60°C) occurred in >75 percent of samples at the soil surface and at 5 cm soil depth, with duration exceeding 5 h. Fine-root dry weight was reduced by 50-75 percent (sampled at 1 and 5 months after burning); raking and burning reduced fine-root dry weight more than burning alone after 1 month and had effects similar to burning after 5 months. A low-vigor tree that had been raked and burned died by the beginning of the fourth dry season after burning. It is concluded that fuel loads may be too high to burn during spring if old-growth *P. ponderosa* are to be protected.

URL: None at this time. Please check back for updates.
Keywords: conifers/controlled burning/damage/forest litter/seasons/mortality

USDA Forest Service. 2000. Survivability and deterioration of fire-injured trees in the northern Rocky Mountains: a review of the literature. Report 2000-13, Part 1. Missoula, MT: Northern Region, Forest Health Protection Unit, Missoula Field Office. 10 p.

See Literature Reviews.

Walstad, John D.; Radosevich, Steven R.; and Sandberg, David V. 1990. Natural and prescribed fire in Pacific Northwest forests. Corvallis, OR: Oregon State University Press. 317 p.

See Literature Reviews.

Wyant, James G.; Laven, Richard D.; and Omi, Philip N. 1983. Fire effects on shoot growth characteristics of ponderosa pine in Colorado. Canadian Journal of Forest Research. 13: 620-625.

Groups: vegetative effects--trees.
Location: front range of Colorado.

Abstract: The impact of fire damage on the shoot growth potential of 36 branches on each of nine ponderosa pine (*Pinus ponderosa* Laws.) trees was evaluated after a fall season prescribed surface fire. In the first season after burning, mean fascicle length and bud sizes (length and diameter) were greater on trees which received underburning treatment than on unburned trees. No treatment effect was observed on shoot lengths, needle numbers, or fascicle numbers, characters determined in the season of bud formation.

Additional notes: The study objective was to provide fundamental information regarding the effects of fire on crown growth and recovery of fire-damaged trees. The authors conclude that the lack of differences in shoot lengths and fascicle and needle numbers between treatment and control trees indicate that dormant season burning does not significantly affect the physiological processes of the dormant bud. They suggest that sublethal heat loadings do not apparently inhibit shoot development and that growing conditions are indicated as being superior after fire, thus enhancing the postfire recovery process of fire-damaged trees.

URL: None at this time. Please check back for updates.
Keywords: ponderosa pine/*Pinus ponderosa*/fire effects/prescribed burning/crown growth/growth

Wyant, James G.; Omi, Philip N.; and Laven, Richard D. 1986. Fire induced tree mortality in a Colorado ponderosa pine/Douglas-fir stand. Forest Science. 32(1): 49-59.

Groups: vegetative effects--trees.
Location: east slope of front range of Colorado near Rustic.

Abstract: The impact of a fall season prescribed surface fire on Douglas-fir and ponderosa pine mortality during the first 22 months following fire was evaluated using discriminant function analysis. Crown scorch, expressed as a percentage of the prefire live crown length, was the single best determinant of tree mortality. Stem charring on the least impacted quadrant is also a relevant variable in mortality determinations. Larger diameter trees of both species withstood proportionally greater stem and crown damage than smaller trees. Crown consumption indicators added substantially to the discriminating power of the functions, but prefire live crown and maximum scorch height were not important variables. Within the same size range, there was little evidence of important differences between ponderosa pine and Douglas-fir in the levels of crown and stem damage that induce mortality.

URL: None at this time. Please check back for updates.
Keywords: *Pseudotsuga menziesii*/*Pinus ponderosa*/fire effects/prescribed fire/discriminant analysis

Youngblood, Andrew. 2000. Damage to residual trees and advance regeneration from skyline and forwarder yarding in mixed-conifer stands of northeastern Oregon. Western Journal of Applied Forestry. 15(2): 101-107 .

Groups: vegetative effects--trees.
Location: Blue Mountains of northeastern Oregon.

Abstract: Reducing the risk of occurrence of wildfire and outbreaks of insects and diseases through fuel reduction is a priority management objective on federal lands within the Blue Mountains in northeastern Oregon. Optimal methods to achieve desired levels of fuel in mixed conifer stands by mechanical means are as yet unknown. One factor essential in evaluating optimal fuel reduction methods is the damage to residual trees and advance regeneration associated with specific combinations of stand condition, prescription, and harvesting system. Residual stem damage on 12,899 stems was compared after partial cutting and yarding with either skyline or ground-based forwarder in mixed conifer stands of northeastern Oregon. There were 6,092 occurrences of damage on 4,074 stems after yarding; 4.1 percent of the damaged stems had crushed foliage, 15.4 percent had a broken terminal leader, 26.5 percent had broken branches, 28.9 percent were wrenched, 35.0 percent had scraped bark, and 38.9 percent had bole scars. Fir (*Abies grandis* and *A. lasiocarpa*) seedlings were more frequently damaged than nonfir (*Larix occidentalis*, *Picea engelmannii*, and *Pinus contorta*) seedlings, and the most frequent damage to fir seedlings occurred in units treated by the forwarder. More damage occurred to residual large trees during yarding than to seedlings. Forwarder yarding resulted in slightly more damage to trees than did skyline yarding. Wrenching was generally consistent between residual seedlings and trees. Scarring occurred more frequently to residual trees than to seedlings. Mean scar area per tree on those actually scarred was generally about 40 cm^2 on seedlings and 256 cm^2 on residual trees. Despite slight differences in stand damage, both yarding methods met the silviculture prescription of reducing fuel and protecting large western larch, Engelmann spruce, Douglas-fir, and lodgepole pine stems targeted for retention. This suggests that the decision by resource managers to use one method of yarding over the other should probably be based on considerations such as availability of equipment, costs, and soil impacts.

URL: None at this time. Please check back for updates.
Keywords: costs/equipment availability/forwarder yarding/mixed conifer forest/pest outbreak risk/scar area/skyline yarding/soil-conditions/stem damage potential/wildfire risk

Vegetative Effects—Understory

This third category of treatment effects on vegetation, vegetative effects—understory, includes 36 papers that address effects of treatments on the forest understory plants. Usually, if the study mostly addressed effects on recruitment of trees, that paper went into the category on vegetative effects at the stand level. Most of these papers address the shrub component of the understory. A few address invasive weeds.

Arno, Stephen F. 1999. Effects of ecosystem-based management treatments: undergrowth response, shelterwood cutting unit. In Smith, Helen Y and Arno, Stephen F., editors. Eighty-eight years of change in a managed ponderosa pine forest. General Technical Report RMRS-GTR-23. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station: 36-37.

Groups: vegetative effects--understory.
Location: Bitterroot National Forest, Montana (Lick Creek).

Abstract: None

Additional notes: This report gives results on undergrowth response five years after a shelterwood cut in a ponderosa pine/Douglas-fir forest that reduced basal area of the overstory from an average of 117 to 52 ft^2 per acre followed by either a high fuel consumption burn, a low consumption burn, or no burn. In all three of the treatments, total plant cover one year following treatment was 15 to 20 percent lower than pretreatment cover. Undergrowth coverage surpassed pretreatment levels by the second post-burn year. Compared to preharvest levels, plant coverage increased over pretreatment levels more in both burn treatments than in the no-burn treatments. As would be expected, responses of individual plant species in relation to type of treatment followed divergent patterns. Minor changes in coverages of individual plants were associated with shelterwood cut/no-burn treatments. In contrast, the high-consumption burns often elicited major and divergent responses from different species. Responses to low-consumption burns were generally intermediate. Bitterbrush and kinnikinnick coverage decreased after high consumption burns. Rose and snowberry retained similar coverage after burn treatment. Shrubs whose coverage increased after high consumption burns were Oregon grape and spirea. Scouler's willow has increased after burn treatments in other study areas, but at Lick Creek it was severely hedged by big game and was able to grow vertically only where protected in wire mesh cages. Among grass-like plants, elk sedge often decreased in coverage with increasing severity of treatment. Conversely, pinegrass and Ross' sedge increased after the burns. None of the broadleaved herabaceous plants commonly associated with ponderosa pine forests in the Northern Rockies consistently decline in cover after treatment. Most introduced weeds that occurred decreased in coverage after year 3, except spotted knapweed continued to expand through the 4-year post-treatment period.

URL: None at this time. Please check back for updates.
Keywords: understory response/ shelterwood cut/ ponderosa pine/ Douglas-fir/ partial cutting/ prescribed burning

Arno, Stephen F.; Harrington, Michael G.; Fiedler, Carl E. and others. 1995. Restoring fire-dependent ponderosa pine forests in western Montana. Restoration and Management Notes. 13(1): 32-36.

Groups: fire behavior/fuel reduction; vegetative effects--stand level; vegetative effects--understory.
Location: Bitterroot National Forest (Lick Creek) and Lolo National Forest (Six-Mile Creek).

Abstract: None

Additional notes: In the conclusion to the paper, the authors state, “These studies demonstrate strategies for returning fire as an ecological process in ponderosa pine forests. Beginning a half-century ago several foresters and biologists presented detailed observations indicating that exclusion of fire from ponderosa pine forests

would result in severe forest-health problems. Those warnings were largely unheeded, and even today fire is not being appropriately returned to these fire-dependent forests in most commercial stands or nature reserves. Meanwhile the deleterious effects of excluding fire without substituting appropriate cultural treatments, including prescribed burning, become more obvious with the passing years. Restoring a semblance of the natural fire process in forests affected by fire exclusion requires considerable care and planning, but the technological knowledge to begin this restoration is available and should be put to use. We hope our demonstrations will help encourage this endeavor."

This paper gives preliminary results at Lick Creek on the Bitterroot National Forest, including the amount of reduction in tree density and surface fire hazards (65 percent decrease in the initial 4.5 tons per acre of litter and small woody fuels and a 60 percent reduction in the initial 5 tons per acre of large woody fuels). A further reduction of ladder fuels occurred with burning, which killed 60 percent of the seedlings and saplings. The average pre-harvest large woody-fuel loading of 5 tons per acre was increased by 2 to 3 tons with logging slash. Burning returned these fuels to approximately pre-harvest levels. Thinning and burning treatments generally resulted in improved vigor and flowering of herbacous plants in the first postburn year. Some alien herbaceous species increased. Bitterbrush suffered 25 percent mortality from injury during harvesting and an additional 40 percent mortality from burning. Scouler's willow was reduced by 9 percent from mechanical damage and 16 percent more from fire. However, the surviving plants were substantially more vigorous, with greater live biomass and better palatability than unburned plants.

URL: None at this time. Please check back for updates.
Keywords: ponderosa pine/*Pinus ponderosa*/thinning/prescribed fire

Ayers, Dayna M.; Bedunah, Donald J.; and Harrington, Michael G. 1999. Antelope bitterbrush and Scouler's willow response to a shelterwood harvest and prescribed burn in western Montana. Western Journal of Applied Forestry. 14(3): 137-143.

Groups: Vegetative effects--understory.
Location: Bitterroot National Forest in western Montana (Lick Creek).

Abstract: In many western Montana ponderosa pine (*Pinus ponderosa*) stands, fire suppression and past selective logging of large trees have resulted in conditions favoring succession to dense stands of shade-tolerant, but insect- and disease-prone Douglas-fir (*Pseudotsuga menziesii*). Stand thinning and understory prescribed burning have been proposed as surrogates for pre-Euro-American settlement ecological processes and as potential treatments to improve declining forest condition and reduce the probability of severe wildfire. To test the effectiveness of these silvicultural techniques on overstory and understory conditions, research is ongoing in the Lick Creek Demonstration Site in the Bitterroot National Forest, Montana. Our research examined the response (mortality and vigor) of the dominant browse species, antelope bitterbrush (*Purshia tridentata*) and Scouler's willow (*Salix scouleriana*), to a ponderosa pine stand restoration project utilizing four treatments: 1) a shelterwood cutthat removed 53 percent of the tree basal area; 2) a shelterwood cut with a low fuel consumption burn; 3) a shelterwood cut with a high fuel consumption burn; and 4) a control. Prior to the application of treatments, 1,856 bitterbrush and 871 willow were located, and their survival and vigor subsequently monitored for 2 yr post-treatment. The cut and burn treatments resulted in the greatest reduction in antelope bitterbrush and Scouler's willow density averaging 66 percent and 24 percent of pre-treatment density, respectively. The shelterwood cut reduced bitterbrush and Scouler's willow density by 35 percent and 14 percent , respectively. On treatments receiving a shelterwood cut (all treatments but the control), but where antelope bitterbrush and Scouler's willow did not have fire damage, mortality was 45 percent for bitterbrush and 20 percent for willow, respectively. For bitterbrush and Scouler's willow plants that received fire damage, mortality was 72 percent for bitterbrush and 19 percent for willow. Although the burn and shelterwood harvest treatments resulted in reduced density of antelope bitterbrush and Scouler's willow 2 yr post-treatment, these treatments increased vigor of both species and created mineral seedbeds that may be necessary for establishment of seedlings.

URL: None at this time. Please check back for updates.
Keywords: prescribed burning/shelterwood cut/forest condition improvement/Douglas-fir/ponderosa

pine/antelope bitterbrush/Scouler's willow/browse species/shrubs

Bedunah, Donald J.; Harrington, Michael G.; and Ayers, Dayna M. 1999. Effects of ecosystem-based management treatments: antelope bitterbrush and Scouler's willow response, shelterwood cutting unit. In Smith, Helen Y and Arno, Stephen F., editors. Eighty-eight years of change in a managed ponderosa pine forest. General Technical Report RMRS-GTR-23. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station: 40-43.

Groups: vegetative effects--understory.
Location: Bitterroot National Forest in western Montana (Lick Creek).

Abstract: None

Additional notes: This report gives results on response of antelope bitterbrush and Scouler's willow five years after a shelterwood cut in a ponderosa pine/Douglas-fir forest that reduced basal area of the overstory from an average of 117 to 52 ft^2 per acre followed by either a high fuel consumption burn, a low consumption burn, or no burn. The treatments resulted in modest willow mortality, substantial bitterbrush mortality, concurrent decreases in cover, but increased plant vigor. The loss of plants was greatest in the treatments associated with the combined effects of harvesting and burning. Mortality of willow (14 percent) and bitterbrush (35 percent) associated with harvesting alone was moderate and kept from being excessive by the low amount of severe ground disturbance as only 11 percent of the area had skid trails. Willow plants sustained less mechanical damage and significantly less mortality than bitterbrush, due to different morphologies. For willow and bitterbrush with burn damage, mortality was clearly associated with the degree of burn severity. Bitterbrush was notably affected by any level of fire damage, whereas willow was not markedly affected until it suffered severe charring of the root crown. For surviving bitterbrush and willow, the proportion of high vigor plants in the burn and the harvest-only treatments greatly increased compared to the control. Heavy browsing of willow in the growing season following the treatments resulted in loss of new growth and subsequently lower vigor for these plants 2 years post-treatment.

URL: None at this time. Please check back for updates.
Keywords: understory response/ shelterwood cut/ ponderosa pine/ Douglas-fir/ partial cutting/ prescribed burning/ bitterbrush/ Scouler's willow/ willow/ shrubs

Bock, Carl E. and Bock, Jane H. 1983. Responses of birds and deer mice to prescribed burning in ponderosa pine. Journal of Wildlife Management. 47(3): 836-840.

See Wildlife.

Brown, James K. and Smith, Jane Kapler. 2000. Wildland fire in ecosystems: effects of fire on flora. General Technical Report RMRS-GTR-42 Vol. 2. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station. 257 p.

See Literature Review.

Busse, M. D.; Cochran, P. H.; and Barrett, J. W. 1996. Changes in ponderosa pine site productivity following removal of understory vegetation. Soil Science Society of America Journal. 60(Nov-Dec): 1614-1621.

Groups: soils; vegetative effects--trees; vegetative effects--understory.
Location: 56 km southwest of Bend, Oregon, in the Pringle Falls Experimental Forest.

Abstract: Competition from understory vegetation for water and nutrients can limit productivity of young

forest stands. Less is known of the effect of understory vegetation on long-term stand growth or soil organic properties. The effect of understory vegetation on periodic annual increments (PAIs) of basal area, height, and volume for ponderosa pine (*Pinus ponderosa* Dougl.) in central Oregon at 4- or 5-year intervals was examined for a 35-year period. Soil C, N, and microbial biomass C (MBC) were also quantified after 32 and 35 years with and without understory vegetation on a sandy loam pumice soil (Xeric Vitricryand). Five tree spacings, ranging from 2.0 to 8.0 m (154-2469 trees per ha), in combination with two understory treatments (understory vegetation present or continuously absent) were installed in 1959. Total understory vegetation cover averaged 35% between 1959 and 1994 for treatments with understory vegetation present, and was dominated by three shrub species: antelope bitterbrush [*Purshia tridentata* (Pursh) DC.], greenleaf manzanita (*Arctostaphylos patula* Green), and snowbrush (*Ceanothus velutinus* Dougi. ex Hook.). Covariance analyses of PAIs for each successive interval were performed using appropriate stand parameters at the start of each interval as covariates. Tree growth was reduced by competing understory vegetation during the first 12 to 20 years only; understory vegetation did not reduce the adjusted PAIs during the last 15 years. Soil C and N were measured incrementally to a depth of 24 cm. Presence of understory vegetation resulted in greater C and N in the O horizon and upper 4 to 12 cm of mineral soil. Seasonal MBC, measured at 14-day intervals from May to November, was greater when understory vegetation was present. The results suggest that understory vegetation plays an important role in maintaining soil quality.

URL: None at this time. Please check back for updates.
Keywords: soils/soil nutrients/understory/ponderosa pine/competition/productivity

Busse, Matt D.; Simon, Steven A.; and Riegel, Gregg M. 2000. Tree-growth and understory responses to low-severity prescribed burning in thinned *Pinus ponderosa* forests of central Oregon. Forest Science. 46 (2): 258-268.

Groups: vegetative growth--stand level; vegetative growth--trees; vegetative growth--understory.
Location: Fremont National Forest in southcentral Oregon.

Abstract: The growth of ponderosa pine and associated understory vegetation was evaluated for a 6 yr period following spring underburning of surface fuels. Underburn and control (unburned) plots were paired at 15 replicate sites in pole-sized ponderosa pine forests of central Oregon. The burns were generally low in severity, as noted by low O horizon mass reduction (24 percent) and tree mortality (6 percent). A small but significant decline in basal area and volume growth rates of surviving trees was found in the 6 yr following underburning. The reduction in tree growth was related to a combination of crown length reduction, O horizon reduction, and site productivity. More productive stands had the highest proportional reduction in growth due to burning. By comparison, site conditions including stand density, initial basal area, elevation, parent material, and soil fertility were not related to the observed growth reduction. Understory vegetation showed a mixed response to burning. Shrub cover, dominated by *Purshia tridentata*, declined significantly following burning and remained well below preburn levels for the length of the study, even though one-fourth of all burned Purshia plants successfully resprouted. Total herbaceous vegetation cover and production were unaffected by burning, while species diversity increased slightly. With the exception of the decline in *Purshia* cover, the results indicate that low-severity prescribed burning has a relatively minor impact on tree-growth and understory response in thinned ponderosa pine stands.

URL: None at this time. Please check back for updates.
Keywords: ponderosa pine/antelope bitterbrush/crown-scorch/low-severity prescribed burning/plant diversity/root mortality/site productivity/spring underburning/thinning/tree growth/understory response

Crouch, Glenn L. 1986. Effects of thinning pole-sized lodgepole pine on understory vegetation and large herbivore activity in central Colorado. Research Paper RM-RP-268. Fort Collins, CO: Rocky Mountain Forest and Range Experiment Station. 10 p.

See Wildlife.

Harrod, Richy J. 2001. The effect of invasive and noxious plants on land management in eastern Oregon and Washington. Northwest Science. 75(Suppl.): 85-90.

See Literature Reviews.

Kauffman, J. Boone. 1992. Prescribed fire in forest vegetation management: a research synthesis. In: Workshop on forest vegetation management without herbicides; 1992 February 18-19; Corvallis, OR. Oregon State University: 25-27.

See Literature Reviews.

Kilgore, Bruce M. 1986. Evaluating direct response to understory burning in a pine-fir-larch forest in Glacier National Park. In: Lucas, R. C., compiler. National Wilderness Research Conference: current research; 1985 July 23-26; Colorado State University, Fort Collins, CO. General Technical Report INT-GTR-212. Intermountain Research Station: 26-34.

Groups: vegetative effects--stand level; vegetative effects--understory.
Location: Glacier National Park in northwestern Montana.

Abstract: An 80-acre prescribed understory burn in a pine-fir-larch forest successfully killed 60 percent of the sapling Douglas-fir and spruce with little damage to overstory ponderosa pine and larch. A more intense, stand-replacing fire in a small lodgepole pine stand resulted in nearly 8,000 lodgepole pine seedlings per acre the first year after the burn. Down woody fuels were reduced by 30 percent. No control problems were experienced. National Park Service managers need to consider whether additional such burns are appropriate in the North Fork boundary zone of Glacier National Park.

Additional notes: The numbers of larger (>6" d.b.h.) Douglas-fir, ponderosa pine, and western larch remained unchanged one year after treatments, but relative densities increased because the larger spruces decreased by about one-third and the larger lodgepole pine decreased by about two-thirds. Burning tended to decrease the cover and frequency of forbs and sub-shrubs somewhat during the first year post-treatment, but none was lost completely. Fire did not cause a major increase or decrease in most shrubs, although *Spirea betulifolia* appeared to respond favorably to fire.

URL: None at this time. Please check back for updates.
Keywords: burning/understory/forest management/Conifers/forests/Montana/Glacier National Park/forestry/environmental management/prescribed fire/lodgepole pine/Douglas-fir/Engelmann spruce/down wood

Leege Thomas A. and Hickey, William O. 1971. Sprouting of northern Idaho shrubs after prescribed burning. Journal of Wildlife Management. 35 (3): 508-515.

Groups: vegetative effects--understory; wildlife.
Location: northern Idaho.

Abstract: Most of the elk *(Cervus canadensis)* herds in northern Idaho depend upon seral brush fields created many years ago by wildfires in mature timber. Browse produced in the brush fields has decreased because of advancing plant succession and palatable shrus growing too tall to be effectively utilized. We initiated a study in 1965 to evaluate the effectivenes of spring and fall burning in reducing the height of browse. Individuals of all shrub species usually sprouted prolifically after both spring and fall burns. More sprouts generally resulted after spring burning, but the sprouts grew taller on the fall-burned plants. The physical and chemical characteristics of the sprouts are discussed. Multiple regression components are listed for predicting numbers of basal sprouts after the burn from preburn crown measurements.

URL: None at this time. Please check back for updates.
Keywords: *Cervus canadensis*/elk/browse height

Martin, Robert E. 1982. Antelope bitterbrush seedling establishment following prescribed burning in the pumice zone of the southern Cascade Mountains. In: Tiedemann, Arthur R. and Johnson, Kendall L., compilers. Proceedings--research and management of bitterbrush and cliffrose in western North America; 1982 April 13-15; Salt Lake City, UT. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station and Utah State University: 82-90.

Groups: vegetative effects--understory.
Location: Deschutes National Forest in central Oregon and Lava Beds National Monument in northeastern California.

Abstract: Antelope bitterbrush (*Purshia tridentata*) seedling establishment was surveyed on 21 units two to eight growing seasons after burning. Bitterbrush seedlings occupied from one-quarter to five times as many of the plots as did old plants, and regeneration was related to seasons since burn, site quality, and livestock grazing. Records were kept of bitterbrush seedlings, seedling groups, stems per group, and height and diameter growth.

Additional notes: The prescribed fires took place in various ponderosa pine/bitterbrush communities. Bitterbrush seedlings became established rather quickly on prescribed burn units. Sprouting of old bitterbrush was generally low.

URL: None at this time. Please check back for updates.
Keywords: bitterbrush/antelope bitterbrush/ponderosa pine/prescribed burning/fire effects

Martin, Robert E. 1982. Shrub control by burning before timber harvest. In: Baumgartner, David M., editor. Site preparation and fuels management on steep terrain: proceedings of a symposium; 1982 February 15-17; Spokane, WA. Pullman, WA: Washington State University Cooperative Extension: 35-40.

Groups: vegetative effects--understory.
Location: Pringle Falls Experimental Forest south-southwest of Bend, Oregon.

Abstract: Many shrubs do not compete well in well-stocked timber stands. Prescribed burning has the potential to kill many shrubs that would normally sprout when released and grow vigorously in the open. In addition, fires prescribed to consume a great deal of the duff can also kill many dormant but viable shrub seeds stored in the duff and upper soil.

An exploratory study was devised to burn two times before harvest. The first fire reduced fuel loads under moderate conditions, top-killed most shrubs, and caused many shrub seeds to germinate. The second fire, conducted when more duff was consumed 3 and 3 1/2 years later, killed all the new shrub seedlings and drastically reduced sprouting of shrubs. On two plots, 70.9 and 100 percent of the old snowbrush ceanothus (*Ceanothus velutinus*), 50 percent of the golden chinkapin (*Castanopsis chrysophylla*), 93.8 percent of the antelope bitterbrush (*Purshia tridentata*), and 100 percent of the greenleaf manzanita (*Arctostaphylos patula*) died.

Although the practice appears promising, it will be 10 years before its success or failure is demonstrated. The end result after harvest has not yet been measured, but the summer after logging, no new shrubs were recorded. The question of how many shrub seedlings will develop in the next several years still remains. In the meantime, forest managers might want to explore the practice on their own species and sites.

Additional notes: This study was designed to use double burning to reduce shrubs so as to decrease competition for tree regeneration. Although this isn't likely to be a goal of green fuel reduction projects, the results may apply to help understand prescribed fire's effects on shrubs.

URL: None at this time. Please check back for updates.
Keywords: prescribed burning/shrubs/scrub control/logging

Martin, Robert E. and Driver, Charles H. 1982. Factors affecting antelope bitterbrush reestablishment following fire. In: Tiedemann, Arthur R. and Johnson, Kendall L., compilers. Proceedings--research and management of bitterbrush and cliffrose in western North America; 1982 April 13-15; Salt Lake City, UT. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station and Utah State University: 266-279.

See Literature Reviews.

McConnell, Burt R. and Smith, Justin G. 1970. Response of understory vegetation to ponderosa pine thinning in eastern Washington. Journal of Range Management. 23(3): 208-212.

Groups: vegetative effects--understory.
Location: Methow Valley in northcentral Washington.

Abstract: Pine thinning caused highly significant increases in understory vegetation. After eight growing season, total understory yield increments ranged from 75 lb/acre on the unthinned plots to 417 lb under 26-foot pine spacing. The increase comprised 51 percent grasses, 37 percent forbs, and 12 percent shrubs. When pine canopy exceeded about 45 percent, forbs produced more than grasses; below 45 percent, grasses were superior producers. Shrubs were the least productive at all levels.

Additional notes: This is a joint pine spacing/growth increment study initiated in 1959. This report describes changes that occurred in understory vegetation during the eight growing seasons between 1959 and 1966. Prethinning vegetation consisted of thick pine regeneration (48 years old) with a sparce understory of poorly growing shrubs and scattered grasses and forbs. Treatments consisted of thinning trees to the following spacings: 253 trees/ac (13.2 X 13.2 ft), 134 trees/ac (18.7 X 18.7 ft), 67 trees/acre (26.4 X 26.4 ft), and unthinned (approximately 2,800 trees/acre).

URL: None at this time. Please check back for updates.
Keywords: *Pinus ponderosa*/thinning/understory/vegetation/Washington

Messier, Christian and Mitchell, A. K. 1994. Effects of thinning in a 43-year-old Douglas-fir stand on above- and below-ground biomass allocation and leaf structure of understory *Gaultheria shallon*. Forest Ecology and Management. 68(2-3): 263-271.

Groups: vegetative effects--understory.
Location: Vancouver Island.

Abstract: The above- and below-ground biomass allocation and leaf structure of understory salal (*Gaultheria shallon*) were compared between an unthinned and a heavily thinned (two-thirds of basal area removed) 43-year-old Douglas-fir (*Pseudotsuga menziesii*) plot 6 years after thinning at Shawnigan Lake on southern Vancouver Island, British Columbia. The increase in both above- and below-ground resources caused by thinning resulted in a smaller fine-root/leaf biomass ratio in the thinned (1.2) than the unthinned (2.0) plot. The balance between the production of fine-roots to acquire limited water and of foliage to acquire limited light is suggested as an explanation for this shift in carbon allocation from fine-root to leaf biomass between the two plots. The responses of *G. shallon* to thinning are discussed in relation to its role as a competitor for below-ground resources.

Additional notes: This is a different habitat than what was targeted for this publication, but it provides an interesting discussion on carbon allocation.

URL: None at this time. Please check back for updates.
Keywords: *Pseudotsuga menziesii*/*Gaultheria shallon*/biomass/understory/thinning/Douglas-fir/silvicultural implications/rhizome biomass/fine-root biomass/competition

Miller, Melanie. 1977. Response of blue huckleberry to prescribed fires in a western Montana larch/fir forest. Research Paper INT-RP-188. USDA Forest Service, Intermountain Forest and Range Experimental Station. 33 p.

Groups: vegetative effects--understory.
Location: Lubrecht Experimental Forest in western Montana.

Abstract: In a western larch/Douglas-fir forest type in western Montana, 9 spring and 11 fall understory burns were conducted. Multiple regression equations related the number of *Vaccinium globulare* (blue huckleberry) stems present 1 and 2 years after fire to the number present before fire, pre-fire fuel loadings, moisture content of fuel, duff and soil, environmental conditions, fuel reduction, fire intensity, and temperatures reached at duff and soil surfaces during the fires. Post-fire *Vaccinium* numbers were most closely related to the number of *Vaccinium* present before fire. The number of sprouts depended upon the fire treatment received by stems and rhizomes. There was no evidence of any seasonal variation in the physiological ability of *Vaccinium* to produce sprouts.

In the spring, mostly fine fuels burned; in the fall, dry large fuels and duff layers often burned. All spring fires increased *Vaccinium* stem numbers. Plants were pruned but high duff and soil moisture protected rhizomes from heat. Many more rhizomes were killed during fall fires than spring fires. Soil moisture was too low to protect rhizomes from the great amounts of heat released.

Additional notes: Recommendations given were to use spring burning to increase the density of *Vaccinium globulare* in Douglas-fir/western larch, but not if lower duff and soil are dry. If decreased *V. globulare* density is desired, burning should be done in the fall.

URL: None at this time. Please check back for updates.
Keywords: fire/ fire effects/ broadleaves/ *Vaccinium globulare*/ blue huckleberry/ prescribed fire

Noste, Nonan V. 1984. Influence of fire severity on response of evergreen ceanothus. In: Lotan, James E. and Brown, James K., compilers. Fire's effects on wildlife habitat--symposium proceedings; 1984 March 21; Missoula, MT. 91-96.

See Literature Reviews.

Noste, Nonan V. 1982. Vegetation response to spring and fall burning for wildlife habitat improvement. In: Baumgartner, David M., editor. Site preparation and fuels management on steep terrain: proceedings of a symposium; 1982 February 15-17; Spokane, WA. Pullman, WA: Washington State University Cooperative Extension: 125-132.

Groups: vegetative effects--understory.
Location: western Montana.

Abstract: Early spring burning is a common and accepted practice to rejuvenate seral shrub fields. The time when spring burning can be accomplished is limited by the onset of spring rains. The effects of spring and fall burning are being compared. An evaluation is made of the idea that more intense fall fires will result in slower initial vegetal recovery, but better shrub regeneration and long-term recovery.

Initial results show that more evergreen ceanothus (*Ceanothus velutinus*) plants survived by sprouting on the

spring burn, and seedlings are becoming established on the fall burn. After two growing seasons, shrub crown volume is greater than herb crown volume on both the spring and fall burns. Fuel conditions and fire behavior were well documented to develop prescriptions and guidelines for burning.

Additional notes: The fall treatment set succession back to an herb stage for one season. Shrubs recovered faster on the spring burn, and herbaceous cover recovered faster on the fall burn. Established evergreen ceanothus plants were reduced by 60 percent on the fall burn, while ceanothus seeds germinated and seedlings are becoming established. Grass species increased on the spring burn, while nongraminoid herbceous species increased on the fall burn.

URL: None at this time. Please check back for updates.
Keywords: prescribed burning/fire effects/plant succession/habitat/wildlife

Noste, Nonan V. and Bushey, Charles L. 1987. Fire response of shrubs of dry forest habitat types in Montana and Idaho. General Technical Report INT-GTR-239. Ogden, UT: USDA Forest Service, Intermountain Research Station. 22 p.

See Literature Reviews.

Riegel, Gregg M.; Miller, Richard F.; and Krueger, William C. 1992. Competition for resources between understory vegetation and overstory *Pinus ponderosa* in northeastern Oregon. Ecological Applications. 2(1): 71-85.

Groups: vegetative effects--understory.
Location: Wallowa Mountains of northeastern Montana.

Abstract: The objective of this research was to determine which environmental resources, light, water, and/or nutrients, control understory plant production in a *Pinus ponderosa* forest in northeastern Oregon. A split-plot experimental design, with three 5.0-ha blocks, four treatments, and 44 plots, was established in the summer of 1985. Twenty plots (4 x 4 m) were trenched (root-reduction treatment) approximately 1 m in depth, and 24 non-trenched plots (root-control treatment) were used to assess the effects of root competition of overstory trees on understory plants. Trees were commercially thinned (canopy-reduction treatment) in half of each block (2.5 ha) during the winter and early spring of 1986, from a density of 345 to 148 trees/ha to increase light levels to the understory. Thinning significantly increased photosynthetically active radiation, decreased midday relative humidity, and increased midday air temperatures. Xylem potential of the dominant graminoid (*Carex geyeri*), soil water potential, mineralizable nitrogen, and pH were increased within the root-reduction vs. the root-control treatments. Micro- and macronutrients in *C. geyeri* and *Symphoricarpos albus*, the dominant shrub, were influenced in both treatments. Increasing light did not increase understory biomass production. Reducing root competition for soil water and nutrients increased understory aboveground biomass by 53 and 94 percent in 1986 and 1987, respectively. This research demonstrated that belowground resources were the primary controlling factors of understory production in *P. ponderosa* forests in northeastern Oregon.

URL: None at this time. Please check back for updates.
Keywords: production/resource utilization/understory/forests/*Pinus ponderosa*/Oregon/competition/resources/thinning/trenching/*Carex geyeri*

Riegel, Gregg M.; Miller, Richard F.; and Krueger, William C. 1995. The effects of aboveground and belowground competition on understory species composition in a *Pinus ponderosa* forest. Forest Science. 41(4): 864-889.

Groups: vegetative effects--understory.
Location: Wallow Mountains of northeastern Oregon.

Abstract: The objective of this research was to test the hypothesis that water and nutrients, and not light, control understory plant species composition in a *Pinus ponderosa* forest in northeastern Oregon. The experiment was conducted as a split-plot experimental design with a 2 X 2 factorial analysis. To assess the effects of root competition of overstory trees on understory species composition, 20 plots (4 X 4 m) were trenched approximately 1.0 m in depth, and compared to 24 nontrenched plots. To increase light levels to understory vegetation, trees were thinned from 345 to 148 trees/ha in half of each block (2.5 ha) during the winter and early spring of 1986. Canonical discriminant analysis indicated that light accounted for the greatest environmental resource response among the treatments. The number of species (8) that increased in cover and density was 60 percent greater when tree root competition was reduced in the root-reduction treatment, versus 5 when tree canopy influences were reduced in the canopy-reduction treatment. Simple correlation showed that changes in species composition were significantly ($P \leq 0.05$) related to both changes in aboveground attributes (light, midday air temperature, and soil temperature) and belowground attributes (soil water potential, pH, and nitrogen). Competition for limited resources, light, water, and nutrients, does affect understory species composition as evidenced by the response of individual species to increasing availability of these resources.

URL: None at this time. Please check back for updates.
Keywords: Oregon/nitrogen/light/midday air temperature/nutrients/pH/resource availability/soil temperature/soil water potential/thinning/trenching

Rose, Jeffrey A. and Eddleman, Lee E. 1994. Ponderosa pine and understory growth following western juniper removal. Northwest Science. 68(2): 79-85.

Groups: vegetative effects--stand level; vegetative effects--understory.
Location: Crook County in central Oregon.

Abstract: Recent expansions of western juniper are of great concern to land managers throughout the drier regions of the Pacific Northwest. While removal of western juniper has been found to significantly increase understory plant biomass, little information is available on the effect of western juniper removal on the tree species. This research evaluated response of understory plant biomass and cover, and ponderosa pine growth following removal of western juniper. Study sites were established in the ponderosa pine/western juniper ecotone of central Oregon. Total understory plant biomass and cover increased in response to western juniper removal. However, thinning ponderosa pine and leaving western juniper reduced biomass and cover of understory groups below control levels. Ponderosa pine under 5 cm d.b.h. (diameter at breast height) had greater percent growth in the control, where no trees were removed, than trees in treatments where competing trees were removed. Removal of western juniper appears to benefit understory vegetation, but may depress growth of small ponderosa pine trees for the first few years following tree removal.

Additional notes: This study gathered data for 2 years post-treatment.

URL: None at this time. Please check back for updates.
Keywords: *Pinus ponderosa*/growth/understory/*Juniperus occidentalis*/eradication/Oregon

Ruha, T. L. A.; Landsberg, J. D.; and Martin, R. E. 1996. Influence of fire on understory shrub vegetation in ponderosa pine stands. In: Barrow, J. R.; McArthur, E. D.; Sosebee, R. E. and others, compilers. Proceedings: shrubland ecosystem dynamics in a changing environment; General Technical Report INT-GTR-338. Ogden, UT: USDA Forest Service, Intermountain Research Station: 108-113.

Groups: vegetative effects--understory.
Location: Deschutes and Mount Hood National Forests in Oregon.

Abstract: The effect of prescribed fire on understory shrub vegetation revealed that postfire development of understory shrubs is characterized by many factors including prefire composition of the stand, fire intensity, and regeneration characteristics of the different species. Recovery speed of understory vegetation is highly variable. Young shrubs of burned stands are mostly alive and vital compared to shrubs in unburned stands that have

become old and decadent. Early results from two Oregon ponderosa pine *(Pinus ponderosa* Dougl. ex Laws.) sites indicate that the number of understory shrub species did not change significantly after prescribed underburning. The number of shrubs increased in a ponderosa pine/bitterbrush-greenleaf manzanita/needlegrass *(P. ponderosa/Purshia tridentata (*Pursh}*--Arctostaphylos patula* Greene/*Stipa occidentalis* Thurb. ex Wats) community, but did not change in a ponderosa pine/snowberry *(P. ponderosa/Symphoricarpos* spp.) community. The percentage of live individual shrubs increased, and the percentages of standing-dead and dead-and-down decreased.

Additional notes: In the conclusions, the authors state, "The number of understory shrub species did not increase markedly after prescribed underburning in the two ponderosa pine communities. Where bitterbrush had been the dominant understory shrub species prior to burning, it retained dominance although it decreased to some extent. The number of snowbrush ceanothus and greenleaf manzanita, which are fire-adapted, increased. At Lava Butte, which had a low initial understory shrub density, the number of shrubs increased after burning; at Bear Springs which had a high initial understory shrub density, the number of shrubs per hectare did not increase. At both sites, the percentage of standing-dead shrubs decreased after the underburns and the percentage of live shrubs increased. More information is needed, however, to determine shrub crown cover and biomass response to prescribed underburning across a range of site conditions."

URL: None at this time. Please check back for updates.
Keywords: ponderosa pine/shrubs/prescribed fire/understory burning/fire effects/bitterbrush/ceanothus/snowberry/manzanita

Saveland, James M. and Bunting, Stephen C. 1987. Fire effects in ponderosa pine forests. In: Ponderosa pine--the species and its management: symposium proceedings; 1987 September 29-October 1; Spokane, WA. Pullman, WA: Washington State University, Cooperative Extension: 125-131.

See Literature Reviews.

Smith, Helen Y. and Arno, Stephen F., editors. 1999. Eighty-eight years of change in a managed ponderosa pine forest. General Technical Report RM-GTR-23. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station. 55 p (plus photos).

See Vegetative Effects at the Stand Level.

Smith, Jane Kapler. Fire Effects Information System [Web Page]. Available at: http://www.fs.fed.us/database/feis/.

See Literature Reviews.

Stark, N. and Steele, R. 1977. Nutrient content of forest shrubs following burning. American Journal of Botany. 64(10): 1218-1224.

Groups: soils; vegetative effects--understory.
Location: Lubrecht Experimental Forest in western Montana.

Abstract: Prescribed burning under mature larch/Douglas-fir forests produced changes in elemental uptake. Elemental analyses of individual species and existing biomass three years post-burn from hot, medium, and lightly burned sites and unburned controls showed a significant shift in species composition with burn intensity. Few species from hotly burned sites had elevated levels of ions, except phosphorus and iron, but the aboveground shrub and herb biomass did have greater total cations, percent ash, and individual cations (except Ca and Mg) on hotly burned sites. Although the hotly burned sites had the greatest total biomass, only iron,

manganese, total nitrogen, sodium, and phosphorus were significantly higher (5 percent level) in biomass from hot burns compared to control biomass (g/m^2 basis). Hot burns alter the soil pH to the alkaline range making some elements like iron less soluble and available. Some species growing on hotly burned sites appeared able to alter nutrient uptake making more iron, phosphorus, and other elements available for growth, even with low available levels, compared to control sites. Three-year-old western larch *(Larix occidentalis* Nutt.) seedlings were able to accumulate high levels of Fe, K, and P relative to controls. *Marchantia polymorpha* L. concentrated some ions on hotly burned soils, but it was not possible to locate this plant on unburned areas for comparison.

Additional notes: When controlled burning is done with the objective of stimulating tree growth, the treatment often fails to produce a growth of trees. Many shrub species in fire-adapted forests sprout readily after fire. This rapid flush of growth is a logical reservoir for some of the nutrients released into the soil from burning. There is a question whether higher soil nutrient loading from hot burns of heavy fuels will result in more shrub biomass, and hence in greater total nutrient storage in the shrub component. The purpose of this study was to examine that question.

URL: None at this time. Please check back for updates.
Keywords: *Larix occidentalis*/*Pseudotsuga menziesii*/Douglas-fir/western larch/prescribed burning/shrubs/nutrient cycling/nutrients

Sullivan, Thomas P.; Sullivan, Druscilla S.; Lindgren, Pontus M. and others. 2002. Influence of conventional and chemical thinning on stand structure and diversity of plant and mammal communities in young lodgepole pine forest. Forest Ecology and Management. 170(1-3): 173-187.

See Wildlife.

Sullivan, Thomas P.; Sullivan, Druscilla S.; and Lindgren, Pontus M. F. 2001. Stand structure and small mammals in young lodgepole pine forest: 10-year results after thinning. Ecological Applications. 11(4): 1151-1173.

See Wildlife.

Tiedemann, Arthur R. and Woodard, Paul M. 2002. Multiresource effects of a stand-replacement prescribed fire in the *Pinus contorta-Abies lasiocarpa* vegetation zone of central Washington. General Technical Report PNW-GTR-535. La Grande, OR: U.S. Forest Service, Pacific Northwest Research Station. 26 p.

See Wildlife.

Walstad, John D.; Radosevich, Steven R.; and Sandberg, David V. 1990. Natural and prescribed fire in Pacific Northwest forests. Corvallis, OR: Oregon State University Press. 317 p.

See Literature Reviews.

Youngblood, Andrew and Riegel, Gregg. 1999. Reintroducing fire in eastside ponderosa pine forests: a long-term test of fuel treatments. In: Proceedings from the Joint Fire Science conference and workshop; 1999 June 15-17; Boise, ID. University of Idaho and the International Association of Wildland Fire: 142-150.

See Vegetative Effects at the Stand Level.

Zabinski, Catherine. 1998. Knapweed response to disturbance in ponderosa pine/Douglas-fir forests. Final Report, INT-97059-RJVA. Missoula, MT: Division of Biological Services, University of Montana. 16 p.

Groups: vegetative effects--understory.
Location: Bitterroot National Forest in western Montana (Lick Creek).

Abstract: None.

Additional notes: This report summarizes a preliminary study (with only one replicate in each of the burn treatments), designed to test the effects of two kinds of disturbance--skid trails and fire--on spotted knapweed (*Centaurea maculosa*) distribution in ponderosa pine (*Pinus ponderosa*)/Douglas-fir (*Pseudotsuga menziesii*) forests. This study took place at Lick Creek on the Bitterroot National Forest in western Montana in 1997. In 1991, a study was established at Lick Creek to evaluate the efficacy of shelterwood cutting and prescribed burning to enhance second-growth ponderosa pine stands. Within the shelterwood cut, three burn treatments were established: no burn, moist burn, and dry burn. Knapweed occurs on slopes ranging from 3 percent to 31 percent (out of possible 0-41 percent), with the most dense occurrence on 31 percent slope. Knapweed occurred more commonly on southeast aspects. Canopy cover ranged from 48-80 percent. Knapweed occurred on plots with canopy cover ranging from 52-77 percent, indicating that canopy cover did not appear to be a significant environmental variable in determining density of knapweed. Knapweed density was higher in the burn treatments than in the no-burn treatment, but there was no difference between the two types of burn treatments. Five of the twenty native and non-native plant species had a higher number of occurrences on skid trails than off, including knapweed and thistle (non-natives), and buffaloberry, lupine, and penstemon. Knapweed showed the strongest response, and lupine the weakest. An additional five species, all native, showed a negative response to skid trails (ponderosa pine seedlings, Oregon grape, rose, snowberry, and elk sedge).

URL: None at this time. Please check back for updates.
Keywords: spotted knapweed/ *Centaurea maculosa*/ ponderosa pine/ *Pinus ponderosa*/ Douglas-fir/ *Pseudotsuga menziesii*/ prescribed fire/ skid trails/ invasive species

Wildlife

There were 45 papers that studied effects of fuel reduction treatments on wildlife. Birds, small mammals, and big game species were the most frequently studied. For this category more than others, the bibliography included papers outside of the targeted region, especially for understudied fauna such as amphibians and soil mesofauna.

Adam, Michael; Hayes, John P.; and Weeks, Jennifer. 1996. Effects of commercial thinning on bird abundance and diversity in the Oregon Coast Range: a preliminary report. Coastal Oregon Productivity Enhancement Project (COPE) Report. 9(1): 4-6.

Groups: wildlife.
Location: Oregon coast range

Abstract: None

Additional notes: This study took place on the Oregon Coast range in early seral Douglas-fir, western hemlock, and noble fir forest and presents preliminary results one year post-treatment. No age was given for the studied stands. Three treatments included control (no thinning), a moderate thin (relative density of 35, 100-120 trees per acre), and a heavy thin (relative density of 20, 60-75 trees per acre). Bird counts were conducted before thinning and in the first year post-thinning. The thinning stands had greater increases in bird detections than did the control stands. There was a slight increase in species richness in the moderately thinned stands. Species richness appeared to increase most dramatically in the heavily thinned stands (24 and 38 species in 1994 and 1995, respectively). Of the 13 species they observed at least 50 times in either year, the American robin, dark-eyed junco, red-breasted nuthatch, warbling vireo, and winter wren appeared to have increased in abundance in response to thinning. The species that decreased were the black-throated blue warbler, varied thrush, and Pacific-slope flycatcher. Abundance of hairy woodpeckers, Hammond's flycatcher, and Townsend's solitaire increased significantly after thinning, but sample sizes for these species were relatively small.

URL: None at this time. Please check back for updates.
Keywords: wild birds/thinning/forest management/habitat/stand density/coast ranges/Oregon/bird populations/bird habitat/birds

Alexander, Robert R. 1986. Silvicultural systems and cutting methods for old-growth lodgepole pine forests in the Central Rocky Mountains. General Technical Report RM-GTR-127. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 31 p.

See Literature Reviews.

Armleder, H. M.; Waterhouse, M. J.; Dawson, R. J. and others. 1998. Mule deer response to low-volume partial cutting on winter ranges in central interior British Columbia. Research Report. Victoria, BC: Research Branch, British Columbia Ministry of Forestry. 11 p.

Groups: wildlife.
Location: central interior British Columbia.

Abstract: A specialized low-volume removal (20 percent) single-tree selection silvicultural system was designed to integrate timber harvesting with the needs of mule deer (*Odocoileus hemionus hemionus*) on interior Douglas-fir (*Pseudotsuga menziesii* var. *glauca*) winter ranges in central interior British Columbia, Canada (Armleder and others 1986). The impact of this harvesting was assessed on mule deer during winter by counting mule deer tracks 2-3 days after snowfalls of 6 cm or greater. The assessment was made during the winters of 1984-1991 in paired unlogged and partially cut blocks on two winter ranges. To test the effect of

snow depth on mule deer use of partially cut logged stands, snow depth for each track assessment date was characterized as shallow (0-25 cm), moderate (26-40 cm), or deep (>40 cm) by measuring snow depth in the open. The mean number of tracks per 50 m per week did not differ significantly between control and logged blocks for either winter range. Increased snow depths did not significantly affect the number of tracks in either partially cut or unharvested areas. This single-tree selection silvicultural system can be used to harvest portions of Douglas-fir winter ranges in central interior British Columbia while maintaining winter habitat requirements of mule deer.

Additional notes: The concern here was that removing too much overstory in this mule deer winter range would increase snow depth within the stands. The silviculture system had long cutting cycles (approximately 40 years) and a recognition of micro-habitat values. The used partial cutting of small groups of two to six trees through a range of merchantable diameter classes, with an emphasis on leaving more of the larger, older Douglas-fir trees. Volume removal was lighter on micro-habitats most important to deer (such as warm aspects and ridges).

URL: None at this time. Please check back for updates.
Keywords: mule deer/ deer/ wildlife/ thinning/ partial cutting/ Douglas-fir/ selection cutting

Artman, Vanessa L. 2003. Effects of commercial thinning on breeding bird populations in western hemlock forests. American Midland Naturalist. 149(1): 225-232.

Groups: wildlife.
Location: western hemlock habitat on the westside of the Cascades in Washington.

Abstract: Bird populations and habitat structure were compared between three commercially thinned and three unthinned western hemlock (*Tsuga heterophylla*) stands to assess short-term effects of commercial thinning on breeding bird communities. Thinning reduced the density of small trees and snags (30 cm d.b.h.), but did not affect the density of large trees or snags (>30 cm d.b.h.). The overstory canopy was more open and cover of forbs, grasses and seedlings was higher in thinned than unthinned stands. Winter wrens (*Troglodytes troglodytes*), dark-eyed juncos (*Junco hyemalis*), chestnut-backed chickadees (*Parus rufescens*), and red-breasted nuthatches (*Sitta canadensis*) were more abundant in thinned than unthinned stands, but total bird density did not differ between thinned and unthinned stands. Commercial thinning thus enhances habitat conditions for some bird species while having minimal effects on other bird species.

URL: None at this time. Please check back for updates.
Keywords: *Tsuga heterophylla*/thinning/population density/forest management/habitat/ *Troglodytes troglodytes*/*Junco hyemalis*/*Parus rufescens*/*Sitta canadensis*

Beringer, Elizabeth A.; Hejl, Sallie J.; and Bacon, Lynn. 1999. Effects of ecosystem-based management treatments: effects of logging and burning on birds during the nonbreeding season, shelterwood cutting units. In Smith, Helen Y and Arno, Stephen F., editors. Eighty-eight years of change in a managed ponderosa pine forest. General Technical Report RMRS-GTR-23. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station: 43.

Groups: wildlife.
Location: Bitterroot National Forest in western Montana (Lick Creek).

Abstract: None

Additional notes: This report gives results on avian response during the nonbreeding season during the two years after a shelterwood cut in a ponderosa pine/Douglas-fir forest that that reduced basal area of the overstory from an average of 117 to 52 ft^2 per acre followed by either a high fuel consumption burn, a low consumption burn, or no burn. The other site was not treated. They noted 29 species on these sites during the three falls seasons, and 20 of these were found on both control and treatments. Treatment effects varied among species.

Some species (such as red-breasted nuthatch and golden-crowned kinglet) were more abundant at the untreated site, which potentially indicates negative effects of logging or logging and burning. Other species (such as downy woodpecker) were not obviously affected by logging and seem to be positively affected by burning following logging. Woodpeckers as a group were more abundant in the low-consumption burn areas, as compared to the unlogged/unburned areas or logged/unburned and logged/high consumption burned areas, particularly in the second year after the burns.

URL: None at this time. Please check back for updates.
Keywords: bird response/ shelterwood cut/ ponderosa pine/ Douglas-fir/ partial cutting/ prescribed burning/ birds

Bock, Carl E. and Bock, Jane H. 1983. Responses of birds and deer mice to prescribed burning in ponderosa pine. Journal of Wildlife Management. 47(3): 836-840.

Groups: vegetative effects--stand level; vegetative effects--understory; wildlife.
Location: Black Hills of South Dakota.

Abstract: None

Additional notes: This study looked at the short-term effects of two cool-season prescribed burns on vegetation, breeding birds, and the deer mouse (*Peromyscus maniculatus*) in ponderosa pine forests and savannahs in the Black Hills of South Dakota. The prescribed burns reduced fuels, slowed pine invasion and recruitment, and temporarily improved habitat for 1 rodent and 7 songbird species. Prescribed burning reduced litter depth through two post-fire growing seasons, with litter depth averaging 4.02 cm before burning and 1.89 cm after. Pine canopy, trunks, and saplings were reduced through two years and herbaceous vegetation increased relative to controls. Ground cover of shrubs was reduced through the first but not the second post-fire year. Collectively, graminoid cover was not affected although changes in some species did occur. Total breeding birds were more abundant on burned than on paired control transects in three of four instances during the first post-fire summer. In the second summer, one of four burn lines had fewer birds than its control, whereas the others did not differ. Species composition of burned vs. control areas remained nearly the same through both years. However, seven species were more abundant on the burns than in controls during the first post-fire nesting season, whereas none was more common on control plots. In the second summer, only one species was more abundant on the burns, whereas two were more common on the controls. Deer mice were more abundant on the burn in the first summer. During the second summer, the April burn had fewer deer mice than the control, but the other two burns did not differ from their controls.

In addition to deer mice, the American robin, mountain bluebird, solitary vireo, yellow-rumped warbler, western tanager, dark-eyed junco, and chipping sparrow were positively affected by the burns in the first post-fire year. Overall effects of the two cool-season burns on vegetation were modest. The fires resulted in dramatic increases in deer mice and nesting birds during the first post-fire year, an effect that disappeared or even reversed itself by the second year.

URL: None at this time. Please check back for updates.
Keywords: prescribed fire/ponderosa pine/birds/mice/fire effects/Black Hills

Brown, Rick. 2000. Thinning, fire and forest restoration: a science-based approach for National Forests in the Interior Northwest. Washington, D.C.: Defenders of Wildlife. 25 p.

See Literature Reviews.

Bull, Evelyn L.; Aubry, Keith B.; and Wales, Barbara C. 2001. Effects of disturbance on forest carnivores of conservation concern in eastern Oregon and Washington. Northwest Science. 75(Suppl.): 180-184.

See Literature Reviews.

Bull, Evelyn L. and Blumton, Arlene K. 1999. Effect of fuel reduction on American martens and their prey. Research Note PNW-RN-539. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 9 p.

Groups: wildlife.
Location: northeastern Oregon (Limber Jim southwest of LaGrande).

Abstract: The effect of a fuels-reduction treatment on small mammals was investigated in lodgepole pine (*Pinus contorta* Dougl. ex Loud.) and mixed-conifer stands by trapping and track surveys in northeastern Oregon. The number of red squirrel (*Tamiasciurus hudsonicus*) and snowshoe hare (*Lepus americanus*) tracks decreased in lodgepole pine treatments after harvest. Only two snowshoe hare tracks were detected in harvested stands of mixed conifer, compared with 46 tracks in unharvested stands. In most treatments, the number of red-backed voles (*Clethrionomys gapperi*) decreased and chipmunks (*Tamius* spp.) increased after harvesting.

Additional notes: They studied several treatments. They found less of a decline in the number of snowshoe hares, no decline in squirrels, and an increase in red-backed voles in the island treatment compared to the scatter treatment in lodgepole pine. Declines in voles, squirrels, and hares in the harvested stands would be detrimental to martens because these species are primary prey items. Treatments that didn't provide subnivean habitat, such as provided by logs, would be unsuitable for martens. Although it appeared the island treatment provided better habitat for small mammals than the scatter treatment, the authors don't recommend extrapolating the data beyond this study because of low sample size and short sampling period.

URL: http://www.fs.fed.us/pnw/pubs/rn_539.pdf
Keywords: fuel reduction/ martens/ northeastern Oregon/ small mammals/ track surveys/ squirrels/ snowshoe hares/ chipmunks/ red-backed voles

Bull, Evelyn L.; Torgersen, Torolf R.; Blumton, Arlene K. and others. 1995. Treatment of an old-growth stand and its effects on birds, ants, and large woody debris: a case study. General Technical Report PNW-GTR-353. Portland, OR: USDA Forest Service, Pacific Northwest Research Station . 12 p.

Groups: wildlife.
Location: Wallowa-Whitman National Forest, Oregon.

Abstract: An old-structure stand with large amounts of tree mortality was treated to accelerate regeneration and reduce fuel loads but still maintain its function as old growth for selected bird species. The small-diameter (<15 inches in diameter at breast height [d.b.h.]), dead trees were removed as was some of the down wood <15 inches in diameter at the large end. All live trees of any size and all dead trees ≥15 inches d.b.h. were retained. Vaux's swifts (*Chaetura vauxi*) and pileated woodpeckers (*Dryocopus pileatus*) continued to use the stand after harvest for nesting and roosting. Brown-headed cowbirds (*Molothrus ater*) were more than twice as common in the treated stand as in an adjacent unlogged, control stand. In a comparison before and after harvest in the treated stand, the number of logs increased, the number of logs with ants increased, but the percentage of logs with ants decreased.

URL: http://www.fs.fed.us/pnw/pubs/gtr353.pdf
Keywords: forest ecology/ forest fires/ forest management/ forest pests/ forest trees/ forests/ logs/ old-growth/ regeneration/ silviculture/ trees/ ants/ down wood/ restoration/ pileated woodpecker/ wildlife/ Vaux's swift

Bull, Evelyn L.and Wales, Barbara C. 2001. Effects of disturbance on amphibians of conservation concern in eastern Oregon and Washington. Northwest Science. 75(Suppl.): 174-179.

See Literature Reviews.

Bull, Evelyn L.and Wales, Barbara C. 2001. Effects of disturbance on birds of conservation concern in eastern Oregon and Washington. Northwest Science. 75(Suppl.): 166-173.

See Literature Reviews.

Bury, R. Bruce. 2004. Wildfire, fuel reduction, and herptofaunas across diverse landscape mosaics in northwestern forests. Conservation Biology. 18(4): 968-975.

See Literature Reviews.

Bury, R. Bruce; Major, Donald J.; and Pilliod, David. 2002. Responses of amphibians to fire disturbance in Pacific Northwest forests: A review. In: Ford, W. M.; Russell, K.R. and others, editors. The role of fire in nongame wildlife management and community restoration: traditional uses and new directions, proceedings of a special workshop; 2000 September 15; Nashville, TN. General Technical Report NE-GTR-288. Newton Square, PA: USDA Forest Service, Northeastern Experiment Station: 34-42.

See Literature Reviews.

Carey, Andrew B. and Wilson, Suzanne M. 2001. Induced spatial heterogeneity in forest canopies: responses of small mammals. Journal of Wildlife Management. 65(4): 1014-1027.

Groups: wildlife.
Location: Puget Sound area

Abstract: We hypothesized that creating a mosaic of interspersed patches of different densities of canopy trees in a second-growth Douglas-fir (*Pseudotsuga menziesii*) forest would accelerate development of biocomplexity (diversity in ecosystem structure, composition, and processes) by promoting spatial heterogeneity in understory, midstory, and canopy, compared to typical managed forests. In turn, increased spatial heterogeneity was expected to promote variety in fine-scale plant associations, foliage height diversity, and abundance of small mammals. Three years following treatment, understory species richness and herb cover were greater with variable-density thinning than without. Midstory and canopy species did not have time to develop significant differences between treatments. Variable-density thinning resulted in larger populations of deer mice (*Peromyscus maniculatus*), a species associated with understory shrubs; creeping voles (*Microtus oregoni*), a species associated with herbaceous vegetation, and vagrant shrews (*Sorex vagrans*), a species usually associated with openings but common in old growth. No forest floor small-mammal species, including those associated with old-growth forest, declined in abundance following variable-density thinning. Annual variation in population size was not related to treatment. Variable-density thinning may accelerate the development of biocomplexity in second-growth forest by promoting spatial heterogeneity and compositional diversity in the plant community, increasing diversity and abundance of small mammals, and similarly affecting other vertebrate communities. When combined with long rotations, legacy retention, and management for snags and coarse woody debris, variable-density thinning has broad applicability to enhance biodiversity in managed Douglas-fir forests across the Pacific Northwest.

URL: None at this time. Please check back for updates.
Keywords: forest management/biodiversity/thinning/heterogeneity/understory/species composition/herbs/wildlife management/*Pseudotsuga menziesii*/*Peromyscus maniculatus*/*Microtus oregoni*/*Sorex vagrans*/Douglas-fir/deer mouse/creeping vole/vagrant shrew

Crouch, Glenn L. 1986. Effects of thinning pole-sized lodgepole pine on understory vegetation and large herbivore activity in central Colorado. Research Paper RM-RP-268. Fort Collins, CO: Rocky Mountain Forest and Range Experiment Station. 10 p.

Groups: vegetative effects--understory; wildlife.
Location: Fraser Experimental Forest near Fraser, Colorado.

Abstract: Thinning treatments to control growing stock levels (GSL) in a stand of 65-year-old logepole pine enhanced understory plant production, cover, and forage quality 5 years after treatment. Plant use and large herbivore activity also increased in the more heavily thinned blocks.

Additional notes: Thinning treatments provided basal areas of 40, 80, and 120 square feet per acre when the average tree diameter (d.b.h.) was 10 inches in each stocking level.

URL: None at this time. Please check back for updates.
Keywords: lodgepole pine/ thinning/ understory growth/ wildlife

Finch, Deborah M.; Ganey, Joseph L.; Youg, Wang and others. 1997. Effects and interactions of fire, logging, and grazing. General Technical Report RM-GTR-292. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station. p. 103-136

See Literature Reviews.

Graham, Russell T.; Jain, Theresa B.; Reynolds, Richard T. and others. 1995. The role of fire in sustaining northern goshawk habitat in Rocky Mountain forests. In: Proceedings: fire effects on rare and endangered species and habitats conference; 1995 November 13-16; Coeur d'Alene, ID; International Association of Wildland Fire.

See Literature Reviews.

Harrington, Michael. 1999. Effects of ecosystem-based management treatments: wildlife snag production, commercial thinning, and shelterwood cutting units. In Smith, Helen Y and Arno, Stephen F., editors. Eighty-eight years of change in a managed ponderosa pine forest. General Technical Report RMRS-GTR-23. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station: 43-44.

See Vegetative Effects—Trees.

Koncerak, William F. 1996. Determining the effects of fire restoration on elk winter range and hiding cover. Missoula, MT: University of Montana. 70 p. Thesis.

Groups: wildlife.
Location: Bitterroot Valley, western Montana.

Abstract: Hiding cover for elk and forage on winter range was evaluated following prescribed burning in the Bitterroot valley of western Montana. Underburn sites were identified and paired with representative control sites. Stands were sampled by measuring trees per acre, tree diameters at breast height, shrubs per acre, shrub diameters at breast height, percent cover of selected species on winter range, height of selected species, and general stand characteristics. Between July and November 1995, 400 plots across 25 prescribed fire stands and 15 representative control stands were sampled.

Stands were classified based on years since the prescribed burn, 0.5 to 2 (1993-1995), 3 to 7 (1988-1992), and 8 to 19 years old (1976-1987). Field values were entered in the HIDE2 program to calculate mean stand values for hiding cover.

Changes to hiding cover and quantity of forage on winter range resulting from prescribed fire were detected.

Hiding cover values dropped immediately following the burn and, based on a regression of percent hiding cover by time for treatment areas, returned to pre-burn levels after 25 to 30 years. A significant difference was found between control and treatment hiding cover values ($t = 8.90$; $df = 24$; $p \leq 0.000$). The mean was 8 percent for ages 0.5 to 2 years, 16 percent for ages 3 to 7 years, and 23 percent for ages 8 to 19 years. The mean hiding cover value across controls was 52 percent. Total cover of winter range forage species increased after the burn and remained above the pre-burn levels for approximately 15 years. Treatment percent cover of grasses increased over that of the controls after the prescribed underburn ($t = 5.83$; $df = 24$; $p \leq 0.000$). The mean for cover of grasses on control sites was 24 percent and for treatment grass cover it was 43 percent. No overall difference in the cover of shrubs between the treatment and control plots was detected ($t = 0.56$; $df = 24$; $p \leq 0.584$). Study results were applied to the elk use potential model (cover/forage function) to examine possible effects of landscape scale treatments.

URL: None at this time. Please check back for updates.
Keywords: elk/ hiding cover/ prescribed fire/ understory burning/ winter range/ elk use potential model/ cover/ forage

Kotliar, Natasha B.; Hejl, Sallie J.; Hutto, Richard L. and others. 2002. Effects of fire and post-fire salvage logging on avian communities in conifer-dominated forests of the western United States. Studies in Avian Biology. 25: 49-64.

See Literature Reviews.

Leege Thomas A. and Hickey, William O. 1971. Sprouting of northern Idaho shrubs after prescribed burning. Journal of Wildlife Management. 35 (3): 508-515.

See Vegetative Effects—Understory.

Mannan, R. W. and Meslow, E. C. 1984. Bird populations and vegetation characteristics in managed and old-growth forests, northeastern Oregon. Journal of Wildlife Management. 48(4): 1219-1238.

Groups: wildlife.
Location: Wallowa-Whitman National Forest in northeastern Oregon.

Abstract: Populations of breeding birds and structure and composition of vegetation were examined in managed and old-growth mixed-coniferous forests in northeastern Oregon. Forest stands were about 85 and over 200 years of age and were dominated by Douglas-fir (*Pseudotsuga menziesii*) and ponderosa pine (*Pinus ponderosa*). Components of vegetation that distinguished old-growth forests from managed forests included the numbers of large trees (51+ cm d.b.h.) and snags (31+ cm d.b.h.), small understory grand fir (*Abies grandis*) trees (2.5-10 cm d.b.h.), and tree height diversity; mean values of all of these components were greater in old-growth forests. Three of these variables could be associated, either directly or indirectly, with major differences in bird populations between managed and old-growth forests. The abundance of large snags in old-growth forests was probably responsible, in part, for the relatively high numbers of red-breasted nuthatches (*Sitta canadensis*), and most other hole-nesting birds, observed in this habitat. Large trees were indirectly important to hole-nesting birds because they provided a source of large snags. Grand fir trees were used by Townsend's warblers (*Dendroica townsendi*) and golden-crowned kinglets (*Regulus satrapa*) when foraging and nesting, and we attributed the abundance of these two bird species in old-growth forests to the presence of this understory tree component. Species of birds that were more abundant in managed forests than in old-growth forests appeared to be attracted to the open structure of the managed stands. We discuss the effects of replacing old-growth forests with managed forests on bird species in northeastern Oregon. Methods of maintaining habitat for those species that will decline in density following removal of old-growth forests are suggested.

Additional notes: Managed forests were near or at rotation age. The 85-year-old stands were thinned in 1971 from about 10,000 to 330 stems/ha (5.5-m spacing). The study took place in 1978-1980.

URL: None at this time. Please check back for updates.
Keywords: grand fir/Douglas-fir/ponderosa pine/thinning/old-growth/birds/wildlife

Maxell, Bryce A. 2000. Management of Montana's amphibians: a review of factors that may present a risk to population viability and accounts on the identification, distribution, taxonomy, habitat use, natural history, and the status and conservation of individual species. Missoula, MT: University of Montana, Wildlife Biology Program. 161 p.

See Literature Reviews.

Medin, Dean E. 1986. Small mammal responses to diameter-cut logging in an Idaho Douglas-fir forest. Research Note INT-RN-362. Ogden, UT: USDA Forest Service, Intermountain Research Station. 6 p.

Groups: wildlife.
Location: Valley County in Idaho.

Abstract: Relative small mammal populations were estimated on logged and unlogged plots from 1975 (first year prelogging) through 1979 (third year post-logging) by using live-trapping and mark-recapture methods. Three species made up 93 percent of 698 individual animals caught: deer mice *(Peromyscus maniculatus),* yellow-pine chipmunks *(Tamias amoenus),* and Gapper's red-backed voles *(Clethrionomys gapperi).* Deer mice populations were similar on both logged and unlogged plots. Numbers of yellow-pine chipmunks increased on logged sites. Red-backed voles disappeared from the small mammal community after logging. Other species including the golden-mantled ground squirrel *(Spermophilus lateralis)* and shrews *(Sorex* spp.) were trapped irregularly and in smaller numbers.

Additional notes: Logging was diameter-limit cutting, with a minimum diameter of 10" d.b.h. Basal area declined from 90 ft^2/acre to 22 ft^2, trees >10 inches d.b.h. decreased from 29.3/acre to 1.9/acre, and poles (3-10 inches) decreased from 96/acre to 71/acre. Percent canopy cover of shrubs and forbs decreased while cover for graminoids and annuals increased. In addition to the results above, the total number of small mammals captured each year on logged sites was about the same as the number caught on unlogged sites, but there was a pronounced compositional change in the community.

URL: None at this time. Please check back for updates.
Keywords: composition changes/ diameter-cut logging/ population changes/ small mammals

Medin, Dean E. and Booth, Gordon D. 1989. Responses of birds and small mammals to single-tree selection logging in Idaho. Research Paper INT-RP-408. Ogden, UT: USDA Forest Service, Intermountain Research Station. 11 p.

Groups: wildlife.
Location: Valley County in Idaho.

Abstract: Responses of birds and small mammals to logging depends on the cutting methods used and the degree to which forest stands are altered. This study examined short-term changes in the composition and abundance of small mammals and breeding birds following single-tree selection logging in an Idaho Douglas-fir forest. Populations of birds and mammals were estimated on a logged plot and on a nearby unlogged plot from 1975 (two years prelogging) to 1979 (three years post-logging).

Total numbers of breeding birds were relatively stable between years and between logged and unlogged plots. More pronounced patterns of response occurred in the populations making up the breeding bird communities. Species with positive numerical responses to the selection cut were olive-sided flycatcher, Swainson's thrush, yellow-rumped warbler, and chipping sparrow. Species with negative numerical responses to logging were red-

breasted nuthatch and brown creeper. Fourteen other species showed little numerical response to the timber harvest.

Birds that forage by gleaning the surface of the bark (timber gleaners) declined in number after logging. Foliage feeders, aerial-sally feeders, and timber drillers were about equally abundant before and after logging. The ground gleaning guild showed a slightly positive pattern of response. Of six nesting guilds represented only the secondary cavity nesters were adversely affected by logging. Bush and small tree nesters tended to increase after timber harvest.

Deer mice, yellow-pine chipmunks, and boreal redback voles accounted for 93 percent of 815 individual animals trapped during the study. Postlogging estimates of deer mice density were generally similar on both the logged and the unlogged plots. But when results were expressed as the mean number of individual animals trapped each year, significantly fewer deer mice were trapped on the logged plot. Numbers of yellow-pine chipmunks increased on logged sites; it was the most commonly trapped small mammal in postlogging environments. No significant difference was found in the number of red-backed voles trapped in the cut and uncut forest. Other species were trapped irregularly and in smaller numbers.

Additional notes: There were 47 trees/acre (>9" d.b.h.) on the watershed before cutting and 38 trees/acre after.

URL: None at this time. Please check back for updates.
Keywords: composition changes/ population changes/ single-tree selection/ small mammals

Metz, Louis J. and Farrier, M. H. 1973. Prescribed burning and populations of soil mesofuana. Environmental Entomology. 2(3): 433-440.

See Soils.

Naughton, George P.; Henderson, Colin B.; Foresman, Kerry R. and others. 2000. Long-toed salamanders in harvested and intact Douglas-fir forests of western Montana. Ecological Applications. 16(6): 1681-1689.

Groups: wildlife.
Location: Swan Valley of western Montana.

Abstract: There is little known about how timber harvest practices have affected terrestrial amphibians in the northern Rocky Mountains. Especially lacking is information on the effects of revised harvest methods that fall within the framework of environmental or New Forestry. We estimated the relative abundance of a common forest amphibian, the long-toed salamander (*Ambystoma macrodactylum*) captured in pitfall arrays on intact, environmentally harvested, and overstory-removal harvested sites in mixed-conifer forests of western Montana. Pitfall data from 1994 through 1996 showed that previously logged sites contained significantly fewer long-toed salamanders regardless of harvest method used. The number of salamanders captured on intact sites (3.1 salamanders/[array]/[100d]) was nearly three times the number captured on logged sites (1.2 salamanders/[array]/[100d]). Habitat conditions measured in conjunction with trapping efforts indicated that lower amphibian abundance was associated with decreased numbers of large live trees. Declines in amphibian abundance occurred in the absence of changes in understory vegetation that typically occur when forest canopy is reduced. Our findings suggest that long-toed salamanders responded to changes in the physical environment, probably increased temperatures and decreased moisture. That salamanders should respond so dramatically indicates that immediate changes in physical conditions may profoundly alter habitat quality even when other components of the habitat are unaffected.

Additional notes: The study sites were in Douglas-fir dominated mixed coniferous forests at approximatley 1200 m elevation. Overstory-removal harvests removed all trees >25 cm diameter. Logging debris was piled and burned on the periphery of harvest plots. On the New Forestry plots, all trees >25 cm diameter were removed except for 10-15 dominant or codominant trees per ha. Left trees were selected without respect to species in order to retain preharvest proportions in affected plots. Harvested trees were limbed at felling sites,

and branches were scattered. All nonmerchantable trees and snags were retained on both overstory-removal and New Forestry plots.

URL: None at this time. Please check back for updates.
Keywords: *Ambystoma macrodactylum*/amphibian/disturbance/environmental forestry/forest management/habitat associations/long-toed salamander/Montana/New Forestry/overstory removal/Rocky Mountains/salamander

Pearson, Dean E. 1999. Small mammals of the Bitterroot National Forest: a literature review and annotated bibliography. General Technical Report RMRS-GTR-25. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station. 63 p.

See Literature Reviews.

Pilliod, David S.; Bury, R. Bruce; Hyde, Erin J. and others. 2003. Fire and amphibians in North America. Forest Ecology and Management. 178(2003): 163-181.

See Literature Reviews.

Ream, Catherine H. 1981. The effects of fire and other disturbances on small mammals and their predators: an annotated bibliography. General Technical Report INT-GTR-106. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station. 55 p.

See Literature Reviews.

Russell, Kevin R.; Van Lear, David H.; and Guynn, David C., Jr. 1999. Prescribed fire effects on herpetofauna: review and management implications. Wildlife Society Bulletin. 27(2): 374-384.

See Literature Reviews.

Shepherd, J. F. 1994. Initial response of small mammals to new forestry and overstory removal timber harvests. Missoula, MT: University of Montana. 84 p. Thesis.

Groups: wildlife.
Location: Swan Valley of western Montana.

Abstract: I examined the initial response of small mammals to new forestry and overstory removal timber harvest methods as part of a larger biodiversity project. Four sets of experimental plots were located within 13 km of each other in the Swan Valley of western Montana. Each set of plots contained an uncut control and two treatment types: new forestry and overstory removal.

Small mammals were trapped on all 12 experimental plots during June and August of the pre- and post-harvest field seasons. Vegetation was sampled on each trapping grid in August of each field season. Analysis of pretreatment vegetation showed no significant difference among understory or overstory variables.

No significant change in vegetative cover or density of small trees was found in the post-treatment season. Density of large trees was significantly different between the controls and treatments in the post-treatment season. Although no significant treatment effect on the abundance of any small mammal species was found, trends in abundance were apparent. The red-tailed chipmunk (*Tamias ruficaudus*) appeared to decline in response to harvest while the yellow pine chipmunk (*Tamias amoenus*) and the red-backed vole (*Clethrionomys*

gapperi) increased. Further analysis was conducted to determine habitat associations for the most numerous small mammal species in the pre- and post-harvest seasons.

Small mammal trapping in riparian buffers examined the initial response of small mammals to overstory removal timber harvest adjacent to riparian areas. Differences in small mammal abundances for riparian trap rows (A and B) versus upland trap rows (C through E) and harvested versus unharvested plots were statistically tested. Numbers of individuals caught for all species combined and for the red-backed vole (*Clethrionomys gapperi*) were significantly higher than expected in riparian rows of the overstory removal grids and upland rows of the control grids. Distribution of the meadow vole (*Microtus pennsylvanicus*) was not significantly different from random.

Additional notes: The underlying principle of "new forestry" as referred to in this paper is to leave forest structure intact to a greater degree than traditional forestry methods. New forestry practices leave some dominant living trees, some standing dead trees, downed trees, and smaller coarse woody debris and attempt to imitate the complexity in young unmanaged forest stands after natural disturbances. Specific prescriptions are provided in the paper.

URL: None at this time. Please check back for updates.
Keywords: habitat selection/ new forestry/ over-story removal/ small mammal abundance/ timber management

Smith, Helen Y. and Arno, Stephen F., editors. 1999. Eighty-eight years of change in a managed ponderosa pine forest. General Technical Report RM-GTR-23. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station. 55 p (plus photos).

Groups: soils; vegetative effects--stand level; vegetative effects--trees; vegetative effects—understory, wildlife.
Location: Bitterroot National Forest in western Montana (Lick Creek).

Abstract: This publication gives an overview of structural and other ecological changes associated with forest management and fire suppression since the early 1900s in a ponderosa pine forest, the most widespread forest type in the western United States. Three sources of information are presented: 1) changes seen in a series of repeat photographs taken between 1909 and 1997 at 13 camera points; 2) knowledge from 19 authors who have investigated effects of recent ecosystem-based management treatments; integrated with 3) findings of forest changes related to earlier treatments and to succession. The contributing authors discuss effects of historical silviculture and recent ecosystem-based management treatments, including an evaluation of various burning prescriptions in terms of tree response, undergrowth, soils, wildlife habitat, and esthetics and public acceptance.

Additional notes: This is a compilation of papers and the individual papers are listed within this bibliography.

URL: None at this time. Please check back for updates.
Keywords: ecosystem-based management/ forest succession/ prescribed fire/ ponderosa pine/ *Pinus ponderosa*

Smith, Jane Kapler. Fire Effects Information System [Web Page]. Available at: http://www.fs.fed.us/database/feis/.

See Literature Reviews.

---. 2000. Wildland fire in ecosystems: effects of fire on fauna. General Technical Report RM-GTR-42 Vol. 1. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station. 83 p.

See Literature Reviews.

Strohmaier, David J. 2000. The ethics of prescribed fire: a notable silence. Ecological Restoration. 18(1): 5-9.

See Social and Human Dimensions, and Esthetics.

Sullivan, Thomas P.; Sullivan, Druscilla S.; and Lindgren, Pontus M. F. 2001. Stand structure and small mammals in young lodgepole pine forest: 10-year results after thinning. Ecological Applications. 11(4): 1151-1173.

Groups: vegetative effects--stand level; vegetative effects--trees; vegetative effects--understory; wildlife.
Location: near Penticton, Kamloops, and Prince George in south-central British Columbia, Canada.

Abstract: Management of forested landscapes for biological diversity is a major objective across North America. Perhaps the greatest potential to diversify future forests lies in the vast areas of young second-growth stands which may be managed silviculturally to accelerate ecosystem development. This study was designed to test the hypotheses that large-scale precommercial thinning, at ages 17-27 yr, to various stand densities would, over the 10-yr period since treatment, enhance: 1) productivity of lodgepole pine (*Pinus contorta*) crop trees, 2) stand structure attributes, and 3) species richness and diversity of forest floor small-mammal communities. Study areas were located near Penticton, Kamloops, and Prince George in south-central British Columbia, Canada, in three forest ecological zones. Each study area had three stands thinned to densities of approximately 500 (low), approximately 1000 (medium), and approximately 2000 (high) stems/ha, with an unthinned juvenile pine and old-growth pine stand for comparison. Understory vegetation was measured in all stands in 1990, 1993, and 1998, and coniferous tree layers were measured in 1998. Small-mammal populations were sampled intensively in 1990, 1991, and 1998.

Mean diameter increments of trees in the low-density stands were significantly higher than those in the medium- and high-density stands at all study areas. Mean height increments of trees were similar in the medium- and high-density stands and significantly higher than that in the low-density stands at Penticton and Prince George. Crown volume index (biomass) of herbs was highest in the thinned stands by 1998, but there was no difference among stands for shrubs and trees; volume of mosses was highest in the old-growth stands. Mean species richness and diversity of herbs, shrubs, and trees were similar among stands at 2, 5, and 10 yr after thinning. However, mean species diversity and structural diversity of coniferous trees were significantly higher in the low- and medium-density stands than in the high-density and unthinned stands 10 yr after thinning. Total structural diversity of all vegetation in the low-density stands was significantly greater than that of the medium-density, unthinned, and old-growth stands in 1998.

Mean total abundance of all small mammals was similar among stands in 1990-1991, but the low-density and old-growth stands had the most mammals in 1998. Mean abundance of southern red-backed voles (*Clethrionomys gapperi*) was consistently higher (2.1-3.3 times) in the old-growth stands than in unthinned stands. In seven of nine cases, mean abundance of red-backed voles was similar among old-growth and thinned stands. Mean species richness and species diversity of small mammals were highest in the low-density and medium-density stands. Heavily thinned lodgepole pine stands developed structural attributes such as large diameter trees, large crowns, and structurally diverse vegetative understories. Forest floor small-mammal communities reflected the compositional and structural diversity of these managed stands.

URL: None at this time. Please check back for updates.
Keywords: stand structure/thinning/forest management/species richness/abundance/*Pinus contorta*/Canada, British Columbia/lodgepole pine/mammals/biodiversity/crop trees/old-growth/precommercial thinning/silviculture/small mammals/species diversity/stand density/tree growth/wildlife habitat

Sullivan, Thomas P.; Sullivan, Druscilla S.; Lindgren, Pontus M. and others. 2002. Influence of conventional and chemical thinning on stand structure and diversity of plant and mammal communities in young lodgepole pine forest. Forest Ecology and Management. 170(1-3): 173-187.

Groups: vegetative effects--stand level; vegetative effects--trees; vegetative effects--understory; wildlife.

Location: Summerland, Kelowna and Williams Lake in south-central British Columbia, Canada.

Abstract: Silvicultural practices that provide a wide variety of vegetative composition and structure (habitats) in young stands should help manage for biological diversity across forested landscapes. This study was designed to test the hypotheses that: i) abundance and diversity of stand structure attributes (species diversity and structural diversity of herb, shrub and tree layers) and forest floor small mammal communities, and ii) relative habitat use by large herbivores, will increase from unthinned to conventionally thinned to chemically thinned stands of young lodgepole pine (*Pinus contorta*) forest. Replicate study areas were located near Summerland, Kelowna and Williams Lake in south-central British Columbia, Canada. Each study area had three treatments: a conventionally thinned, a chemically thinned, and an unthinned stand. Pre-commercial thinning was conducted in 1993. Coniferous stand structure and understory vegetation were measured prior to thinning in 1993 and 5 years later in 1998. Small mammal populations were sampled intensively from 1993 to 1998. Relative habitat use by large herbivores was sampled in 1998.

Our results indicate that chemical thinning of young lodgepole pine stands produced an aggregated pattern of crop trees compared with stands subjected to conventional thinning. Diameter growth of crop trees in the chemically thinned stands was similar to that in the conventionally thinned, but also to that in unthinned stands. Although horizontal stratification (aggregates of trees) was enhanced, vertical stratification (structural diversity of vegetation) was less in the chemically than conventionally thinned stands. Abundance and diversity of understory vegetation and small mammal communities were generally unaffected by stand thinning in these particular installations. Relative habitat use by mule deer (*Odocoileus hemionus*) occurred in a gradient from highest in the conventionally thinned stand to lowest in the unthinned stand. Habitat use by snowshoe hares (*Lepus americanus*) tended to have the opposite trend. Moose (*Alces alces*) exhibited no difference in habitat use among stands. Thus, although there were few differences among treatment stands, chemical thinning could be used to develop an aggregated pattern of crop trees in pre-commercially thinned stands to maintain habitat for herbivores such as snowshoe hares and mule deer. Understory plant and forest floor small mammal communities would be maintained in these stands as well.

URL: None at this time. Please check back for updates.
Keywords: stand structure/herbs/shrubs/trees/community composition/plants/thinning/forest management/mammals/*Pinus contorta*/Canada, British Columbia/mammals/lodgepole pine/precommercial thinning/understory vegetation/small mammal communities/species diversity/glyphosphate herbicide

Suzuki, Nobuya and Hayes, John P. 2003. Effects of thinning on small mammals in Oregon coastal forests. Journal of Wildlife Management. 67(2): 352-371.

Groups: wildlife.
Location: coastal Oregon.

Abstract: Because of fires and intensive logging practices, young forest stands dominate much of the landscape of the Pacific Northwest. Most young stands were reforested with Douglas-fir *(Pseudotsuga menzeisi*i) trees at high densities. Researchers have proposed thinning of the densely stocked young stands as a means to improve habitats for vertebrates. However, effects of thinning intensity on forest-floor small mammals are not well understood. During 1994–1996, we conducted experimental and retrospective studies using pitfall trapping to assess effects of thinning intensity on abundance and reproduction of small mammals in Douglas-fir forests of the Oregon Coast Range, USA. In the experimental study, we assessed the short-term effects of thinning stands to moderate and to low tree densities on small mammals during the first 2 years following thinning. In the retrospective study, we assessed potential long-term effects of thinning by comparing relative abundance and reproductive performance of small mammals in previously thinned (7–24 years prior to the study) and unthinned stands. Among the 12 species of small mammals we examined in the experimental study, number of captures increased for 4 species and decreased for 1 within 2 years of thinning. However, responses were similar between moderately and heavily thinned stands. Among the 9 species we examined in the retrospective study, number of captures was greater for 5 species and lower for none in previously thinned than in unthinned stands. Furthermore, total number of small mammals captured was higher in previously thinned than in unthinned stands. Effects of thinning on 2 species, creeping voles (*Microtus oregoni*) and Pacific jumping mice

(*Zapus trinotatus*), were consistent in the short and long term. The number of captures for both species increased in the first 2 years following thinning and was greater in stands thinned 7–24 years previously than unthinned stands. Number of western red-backed voles (*Clethrionomys californicus*) captured decreased within 2 years of thinning but was similar in stands thinned 7–24 years previously and in unthinned stands. Reproductive performances of deer mice (*Peromyscus maniculatus*) and creeping voles improved following thinning in the short term. In the retrospective study, reproductive performance of western red-backed voles was higher in thinned than in unthinned stands. Overall, thinning did not have substantial detrimental effects on any of the species we investigated and had positive effects on several. We suggest that thinning is a viable option to enhance habitat quality for several species of forest-floor small mammals in densely stocked, young Douglas-fir stands.

URL: http://www.cof.orst.edu/cof/teach/fs453/Suzuki_and_Hayes.pdf
Keywords: abundance/creeping vole/deer mouse/Douglas-fir/forest management/habitat/Oregon/Pacific jumping mouse/reproduction/small mammals/thinning/western red-backed vole

Tiedemann, Arthur R.; Klemmedson, James O.; and Bull, Evelyn L. 2000. Solution of forest health problems with prescribed fire: Are forest productivity and wildlife at risk? Forest Ecology and Management. 127(1-3): 1-18.

See Literature Reviews.

Tiedemann, Arthur R. and Woodard, Paul M. 2002. Multiresource effects of a stand-replacement prescribed fire in the *Pinus contorta-Abies lasiocarpa* vegetation zone of central Washington. General Technical Report PNW-GTR-535. La Grande, OR: U.S. Forest Service, Pacific Northwest Research Station. 26 p.

Groups: soils; vegetative effects--stand level; vegetative effects--understory; wildlife.
Location: eastern slope of the Cascade Range in central Washington.

Abstract: A stand-replacement prescribed fire in an over-mature lodgepole pine (*Pinus contorta* Dougl. ex Loud.)-subalpine fir (*Abies lasiocarpa* (Hook.) Nutt.) stand (snag area) and in a mature lodgepole pine thicket (thicket area) resulted in lower plant diversity within the first year after burning, and as fire energy outputs increased, postburn plant cover and diversity decreased. There was no reestablishment of the original plant cover where total heat output exceeded 100,000 kcal/m^2. Apparently, most plants in this habitat were not fire resistant. Postfire recovery appears to depend on immigration of seeds from adjacent unburned areas or on seeds and rhizomes that survive on unburned microsites (refugia) within the burn. After fire, temperatures increased in the forest floor fermentative layer (FL) (10 to 19^o C) and upper 10 cm of the soil layer (SL) (3 to 7^o C) on several dates in summer 1976. Increased pH levels in FL (about 2 units) and SL (about 0.5 unit) after burning provided an improved environment for bacterial development, and counts of total bacteria and proteolytic bacteria both increased. Both nitrogen fixation and nitrification were increased after burning. Despite the apparent increase in microbiological activity, microbial respiration declined after burning--apparently because of reduced forest floor organic carbon energy reservoir. Diversity of birds increased the year after burning. New species of birds included hairy woodpecker (*Picoides villosus*), black-backed woodpecker (*Picoides arcticus*), three-toed woodpecker (*Picoides tridactylus*), common flicker (*Colaptes auratus*), and mountain bluebird (*Sialia currucoides*). Numbers of needle-foraging species, such as Townsend's warbler (*Dendroica townsendi*), hermit thrush (*Catharus guttatus*), golden-crowned kinglet (*Regulus satrapa*), and western tanager (*Piranga ludoviciana*), declined or were absent after fire. Responses of small mammals to fire were not definitive, but there was a marked decline in Townsend's chipmunk (*Tamias townsendii*) after burning. In the first year after burning, forage for elk (*Cervus elaphus*) in the burned area was higher in crude protein than in unburned areas, but low productivity and distance from water diminished the value of the burned area for elk.

URL: http://www.fs.fed.us/pnw/pubs/gtr535.pdf
Keywords: prescribed burning/ post-fire recovery/ seed sources/ sprouting/ unburned microsites/ wildlife/ birds/ small mammals/ elk/ soil

Walstad, John D.; Radosevich, Steven R.; and Sandberg, David V. 1990. Natural and prescribed fire in Pacific Northwest forests. Corvallis, OR: Oregon State University Press. 317 p.

See Literature Reviews.

Weikel, Jennifer M. and Hayes, John P. 1997. Habitat use by cavity-nesting birds in young commercially thinned and unthinned forests. Coastal Oregon Productivity Enhancement Program (COPE) Report. 10(3): 2-6.

Groups: wildlife.
Location: Oregon Coast Range.

Abstract: None.

Additional notes: This study took place on the Oregon Coast range in 30-45 year-old Douglas-fir forest within the Tillamook Burn, and presents results of bird counts conducted before thinning and in the first two years post-thinning. Three treatments included control (no thinning), a moderate thin (relative density of 35, 100-120 trees per acre), and a heavy thin (relative density of 20, 60-75 trees per acre). The response to commercial thinning varied by species. Commercial thinning did not appear to influence abundance of chestnut-backed chickadees or red-breasted nuthatches. Thinning resulted in an increased abundance of hairy woodpeckers. Brown creepers did not apear to be affected by moderate thinning, but they were absent in heavily thinned stands after treatment. Foraging and nesting habitat preferences are presented. Recommendations include thinning, retaining hardwood patches, retaining large-diameter snags and logs, and (when necessary) creating snags.

URL: None at this time. Please check back for updates.
Keywords: cavities in trees/forest plantations/wild birds/birds/nesting/coast ranges/Oregon/cavity nesting birds/commercial thinning

Young, Jock S.; Hoffland, John R.; and Hutto, Richard L. 2002? Northern Region Landbird Monitoring Program ponderosa pine dry forest restoration (2001). Unpublished report on first year of data collection. Missoula, MT: Division of Biological Sciences, University of Montana. 24 p.

Groups: wildlife.
Location: USFS Northern Region, mostly in northern Idaho and western Montana.

Abstract: None.

Additional notes: In 2001, the goal was to collect and develop information on avian species' response to logging and/or understory burning treatments on dry forest habitat types in the west-side forests of the Northern Region. The objectives were to: 1) determine the effects on bird populations from vegetative changes due to restoration logging and prescribed burning in ponderosa pine/Douglas-fir and ponderosa pine/grand fir stands; 2) compare the effects on bird populations of dry-forest restoration treatments and naturally caused low to moderate severity fires they are intended to mimic; 3) determine the relationship of vegetation structure, components, and plant species composition to bird populations within and among untreated, treated, and naturally burned sites; and 4) compare vegetation structure, components, and plant species composition among treatment types. In 2003, they returned to the forest restoration transects.

The following came from the discussion section of the report, referring only to the 2001 study: "Preliminary results showed that the responses of most species were similar to those found in other data from the NRLMP [Landbird Monitoring Program] (Hutto and Young 1999). There was some indication that the restoration treatments provided similar habitat to the natural underburns that they are intended to mimic. This indicates that the restoration treatment may be at least superficially successful as a management practice. The canopy cover was similar on the two treatments. The main vegetative difference between the two treatments was the lower

coverages of understory shrubs in the natural underburns. This may have accounted for most of the differences in bird populations between the treatments. As the understory recovers, the differences between the treatments (both birds and vegetation) may lessen. On the other hand, the open understory in the first couple of years after a natural underburn may be critical for such ground-foraging species as the Townsend's solitaire, and perhaps bluebirds as well. Any conclusions should wait for the completion of the study, however."

URL: http://biology.dbs.umt.edu/landbird/effects/Restoration/DryForestReport.htm
Keywords: ponderosa pine/ Douglas-fir/ thinning/ prescribed fire/ birds/ forest restoration/ prescribed fire/ thinning