ECONOMIC IMPACTS OF CLIMATE CHANGE ON FOREST RESOURCES IN OREGON

A Preliminary Analysis

Climate Leadership Initiative
Institute for a Sustainable Environment
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This report is part of an ongoing assessment of the economic impacts and opportunities associated with climate change in the Pacific Northwest by the Climate Leadership Initiative (CLI), a climate change research and technical assistance program in the Institute for a Sustainable Environment at the University of Oregon.

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Climate Leadership Initiative
Institute for a Sustainable Environment
University of Oregon
(541) 346-0786
Email: climlead@uoregon.edu
Website: http://climlead.uoregon.edu

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A Preliminary Analysis

This report offers a preliminary assessment of the economic effects of global climate change on Oregon's forest resources during the first half of the twenty-first century.

The scientific basis for this assessment, based largely on global climate scenarios prepared for the IPCC Fourth Assessment Report (2007) and downscaled to the Pacific Northwest by the Climate Impacts Group (CIG) at the University of Washington, can be summarized as follows:

- Average annual temperatures are projected to increase 2°F by the 2020s and 3°F by the 2040s compared with averages for 1970-1999. Higher temperatures will directly affect tree growth, water needs and evapotranspiration, impacts of forest insects, and wildfire.
- Average annual precipitation is not currently projected to change significantly, but more winter precipitation will fall as rain.
- Snowpack is expected to melt earlier in the spring, extending the fire season.
- Atmospheric carbon dioxide concentrations are expected to increase, a change that may increase tree growth.

This report is predicated on projections of gradual warming over the next several decades; it does not assess the possibility of abrupt climate change or consider the long-term impacts of potentially irreversible processes that may be set in motion by emissions over the next several decades.

Our key findings are as follows:

- Climate change could impact the economic contribution of Oregon's forests both directly (e.g., by affecting rates of tree growth and relative abundance of different tree species) and indirectly (e.g., by changing the magnitude of damage from fire or forest insects).
- If the same patterns and statistical relationships between temperature, precipitation, and wildfire from the 20th century continue to hold in the 21st century, an "average year" in the 2020s will be associated with a 50 percent increase in the number of acres burned relative to an average year in the 20th century, and an average year in the 2040s will be associated with a 100 percent increase in the number of acres burned relative to an average year in the 20th century.

- Acres burned strongly influence fire suppression costs and may also influence related expenditures such as costs for fire prevention programs. If suppression costs rise in proportion to acres burned—i.e., increase 50% by the 2020s and 100% by the 2040s—state expenditures by ODF could rise from $40-64 million at the turn of the century to $60-96 million by the 2020s and $80-128 million by the 2040s (with all figures in constant 2005 dollars). Federal suppression expenditures—by USFS and BLM in an area that includes both Oregon and Washington—could rise from $40-188 million at the turn of the century to $60-282 million by the 2020s and $80-376 million by the 2040s. A rough estimate allocates 50-70% of these federal expenditures to Oregon, which translates into a rise in federal expenditures in Oregon from $20-132 million at the turn of the century to $30-197 million by the 2020s and $40-$263 million by the 2040s.
- The full range of economic impacts of wildfire—including lost timber value, lost recreational expenditures, lost ecosystem services such as water purification, and health and environmental costs related to air pollution, hydrology, and other forest changes—could be many times larger than the fire preparedness and control costs described above.
- Urban forests and the urban-wildland interface may also face growing wildfire risks as temperatures rise. Fires in these areas threaten homes and businesses as well as air quality, recreation, and quality of life.
- Economic impacts unrelated to wildfires—e.g., from forest insects or changes in tree growth rates attributable to climate change—are unknown and may be either positive or negative.
- Forest management strategies such as thinning may reduce the severity of fires, but are not likely to reduce the frequency. More research is needed on the ecological effects and economic costs and benefits of thinning.
- Forest-related economic opportunities created by climate change might include carbon sequestration and biomass-based energy production. More research is needed on both of these potential opportunities to determine their economic and ecological feasibility.

Economic Contribution of Oregon's Forest Resources

Forestland covers almost half of Oregon (30 million out of 62 million acres).[1] The state’s forests support an array of economic activities, from timber production to recreation; they also produce and protect freshwater supplies and wildlife habitat. Nearly two-thirds of the forestlands in Oregon are owned or managed by federal, state, local, and tribal governments. Most wood products, however, come from private commercial timberlands, which account for about 83 percent of the timber harvest.[2] That timber harvest is vast: according to the Western Wood Products Association, Oregon produced 7.4 billion board-feet of lumber in 2005, more than any other state.[3]

The forest sector's economic contribution can be seen in estimates of employment and Gross Domestic Product (GDP) for Oregon:[4]

Oregon, 2004	
Total GDP by state, $Billions	$134.6
Wood product manufacturing	$2.9
Paper manufacturing	$0.9
Forestry, fishing, and related activities	$1.7
Employment in wood products	32,000

Climate Change Impacts on Oregon Forests

Climate change could impact the economic contribution of Oregon's forests both directly (e.g., by affecting rates of tree growth and relative abundance of different tree species) and indirectly (e.g., by changing the magnitude of damage from fire or forest insects).

Direct impacts from climate change arise because changing levels of temperature, soil moisture, atmospheric CO_2 concentrations, and other factors affect tree growth. In the short term, vegetation growth may increase due to the effects of increased carbon dioxide in the atmosphere. However, as soil moisture decreases due to rising temperatures and earlier spring snowmelt, the quantity of forest biomass may increase beyond the levels that available moisture content can support, resulting in decreased forest growth. Quantitative estimates of this potential dynamic for forests in Oregon are not available, but studies elsewhere suggest that impacts could be significant.[5]

Climate change could affect Oregon's forests in other important ways as well. One is by changing the range of forest insects or affecting their life cycles. Very little is known about the likely impacts here, and it is worth noting that some changes could be positive, i.e., climate change might shift existing insects out of Oregon's forests instead of (or in addition to) attracting new insects to those forests. But the downside risk is likely to dominate: the state's forests have evolved to deal with existing insect species, so potential decreases in the populations of these species will probably matter less than the potential introduction of new species or potential increases in the populations of existing species. The mountain pine beetle infestation that has decimated lodgepole pine forests in British Columbia offers a sobering example of large-scale insect damage that may be linked, in part, to increasing temperatures.[6]

The most important way in which climate change affects Oregon's forests may be through fire. As the Oregon Department of Forestry puts it, "Climate and fuel interactions may increase wildfire risks… [D]rier, longer summers clearly increase fire hazards and risks. Long-term moisture stress makes trees more susceptible to pathogens such as bark beetles, which exacerbates stress and can push trees past survival thresholds, causing forest die-offs and increased fuel loadings from dead trees. Warmer winter temperatures resulting from global warming may be reducing winter snowpack and lengthening summer fire seasons."[7]

Indeed, recent research indicates that climate change has *already* affected fire in western states: Westerling et al. (2006) conclude that "large wildfire activity [in the western U.S.] increased suddenly and dramatically in the mid-1980s" and is "strongly associated with increased spring and summer temperatures and an earlier spring snowmelt."[8]

Forest fires are likely to become more prevalent in the future because summer weather is expected to get hotter and drier and snowpack is expected to melt earlier. McKenzie et al. (2004) use 20th century data for Oregon and other western states to estimate how the amount of rainfall and the average temperature in different years affected the number of acres burned in wildfires in those years.[9]

Economic Consequences

We combined the results of the study by McKenzie et al. (2004) with CIG's climate projections for the 2020s and 2040s to produce estimates of how the pattern of forest fires may change in the decades ahead in Oregon. If the statistical relationships in McKenzie et al. remain valid in the years ahead, an "average year" (in terms of rainfall and temperature in each of these states) in the 2020s will be associated with a 50 percent increase in the number of acres burned compared to an average year in the 20th century, and an average year in the 2040s will be associated with a doubling in the number of acres burned compared to an average year in the 20th century.[10]

The burden of additional firefighting responsibilities will be divided between state and federal agencies—and of course taxpayers will ultimately pay for both. Table 2 below summarizes the acres under the protection of various state and federal agencies and current and projected acres burned.[11] (Note that federal data cover both Oregon and Washington; a rough but educated estimate puts Oregon's share of acres burned at 50-70% of the total.[12]) Following the table are figures showing the relationship between acres burned and inflation-adjusted expenditures on fire suppression for state-protected lands in Oregon, for federally protected lands in Oregon and Washington, and a rough estimate for federally protected lands in Oregon alone.[13] Although there are many factors that influence expenditures, a Washington State legislative study in 2005 highlighted that "increasing costs are closely tied to the number of acres burned."[14]

Table 2. Total acres and acres burned. Sources: see footnotes 11 and 12.

	Oregon Dept. of Forestry	USFS, BLM, other federal agencies
Total acres	15,800,000	15,300,000 in OR, 9,500,000 in WA
1988-99 average acres burned	11,300	209,800 in OR and WA (an estimated 104,900-146,900 in OR)
2020s projected	17,000	314,700 in OR and WA (an estimated 157,400-220,300 in OR)
2040s projected	22,600	419,600 in OR and WA (an estimated 209,800-293,700 in OR)

Figure 1. Acres burned and inflation-adjusted costs of fire suppression for lands protected by the Oregon Department of Forestry. Note that costs are annual averages based on biennial figures. Sources: see footnote 13.

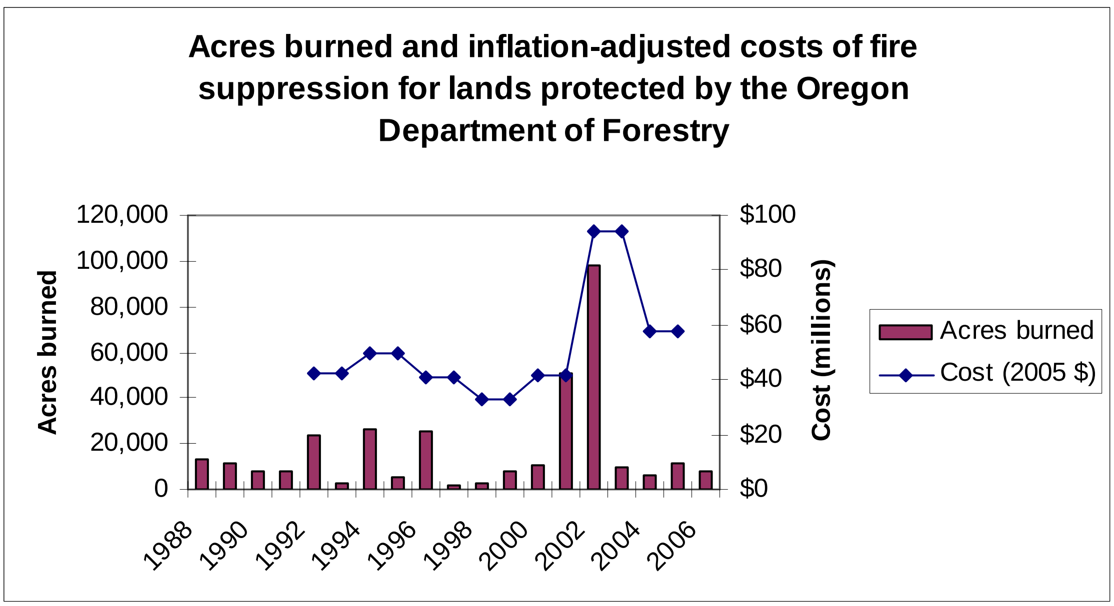


Figure 2. Acres burned and inflation-adjusted costs of fire suppression for federal lands in Oregon and Washington protected by the US Forest Service (USFS) and the Bureau of Land Management (BLM). Sources: see footnote 13.

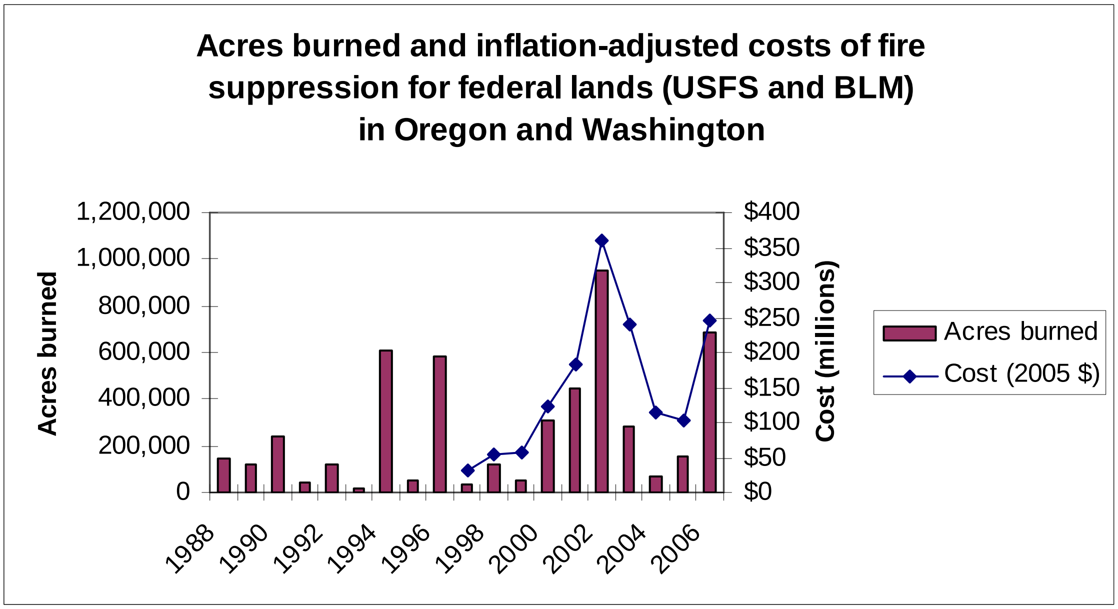
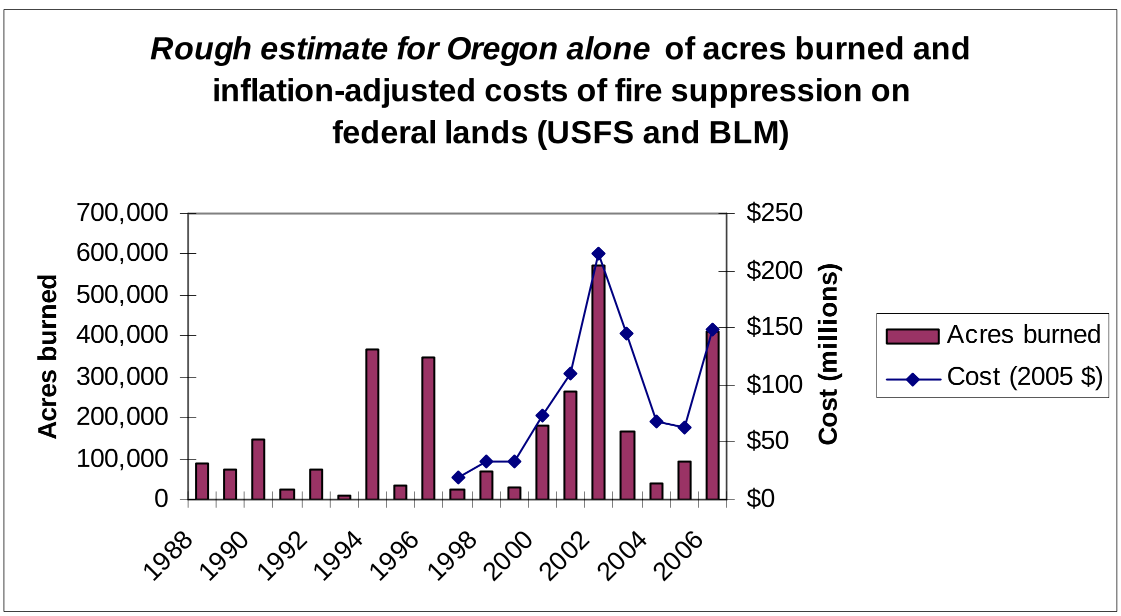


Figure 3. *Rough estimate* for acres burned and inflation-adjusted costs of fire suppression for federal lands in Oregon protected by the US Forest Service (USFS) and the Bureau of Land Management (BLM). Oregon accounts for roughly 50-70% of the totals for Oregon and Washington combined; the figure shows an Oregon estimate of 60%. Sources: see footnotes 12 and 13.



Estimated Future Costs for Fire Suppression

Data limitations and the variability of the historic record make it difficult to pick a definitive baseline for establishing historic costs for fire suppression. This analysis uses the inflation-adjusted average for the available years through 1999. (Table 3 on the following page summarizes the paragraphs below.)

For the Oregon Department of Forestry (ODF), inflation-adjusted expenditures on fire suppression for 1992-99 averaged $40 million.[15] If these expenditures increase in proportion to projections for acres burned, this figure would rise to $60 million by the 2020s and to $80 million by the 2040s. Recent expenditures strongly suggest that these estimates are conservative: inflation-adjusted expenditures on fire suppression for 2000-2005 already average $64 million. (In particular, 2001 and 2002 were two of the three costliest fire seasons in 35 years, with annual expenditures nearing $100 million.[16]) With a less conservative estimate, then, ODF costs could rise from about $64 million at the turn of the century to $96 million by the 2020s and $128 million by the 2040s.

There are also federal government expenditures on wildfires. For U.S. Forest Service (USFS) and the Bureau of Land Management (BLM) lands in Oregon and Washington combined, inflation-adjusted expenditures on fire suppression for 1997-99 averaged $40 million.[17] (USFS and BLM lands account for about 85% of acres burned on federal lands in Oregon and Washington.) If these expenditures increase in proportion to projections for acres burned, this figure would rise to $60 million by the 2020s and to $80 million by the 2040s. This figure is extremely conservative: inflation-adjusted expenditures on fire suppression for 2000-2005 averaged $188 million. With a less conservative estimate, then, federal costs could rise from about $188 million at the turn of the century to $282 million by the 2020s and $376 million by the 2040s.

As noted previously, these federal data cover both Oregon and Washington, and a rough but educated estimate puts Oregon’s share of acres burned at 50-70% of the total for the two states. For Oregon, then, inflation-adjusted expenditures by USFS and BLM on fire suppression for 1997-99 averaged an estimated $20-28 million. If these expenditures increase in proportion to projections for acres burned, this figure would rise to $30-42 million by the 2020s and to $40-56 million by the 2040s. Using the less conservative estimate based on recent expenditures, federal costs in Oregon could rise from $94-132 million at the turn of the century to $141-197 million by the 2020s and $188-263 million by the 2040s.

Table 3. Annual costs for fire suppression and related activities, historic and projected, in constant (2005) dollars. The conservative estimate of historic costs uses the inflation-adjusted average for the available years through 1999; the less conservative estimate of historic costs uses the inflation-adjusted average for 2000-2005. For USFS and BLM lands, Oregon is estimated to be 50-70% of the total amount for Washington and Oregon. Sources: see footnotes 12 and 13.

	Oregon Dept. of Forestry	USFS and BLM (in Oregon and Washington)	USFS and BLM (in Oregon alone, estimated)
Conservative estimate			
Conservative estimate of historic costs	$40 million	$40 million	$20-28 million
2020s projected (conservative estimate)	$60 million	$60 million	$30 million
2040s projected (conservative estimate)	$80 million	$80 million	$40 million
Less conservative estimate			
Less conservative estimate of historic costs	$64 million	$188 million	$94-132 million
2020s projected (less conservative estimate)	$96 million	$282 million	$141-197 million
2040s projected (less conservative estimate)	$128 million	$376 million	$188-263 million

Additional Costs

Forest fires also impose other costs. These include the foregone value of timber harvest, recreation and tourism spending foregone due to forest closures and smoke impacts, and health and other environmental costs associated with air pollution. A 2003 analysis of Oregon's Fremont National Forest and Washington's Okanogan National Forest estimated such indirect costs to be 4-5 times larger than the direct costs of fire control.[18] Including these costs could bring total costs for ODF-protected lands up from a historic estimate of $200-$384 million per year to $300-$576 million per year by the 2020s and $400-$768 million per year by the 2040s.[19] For the USFS and BLM forestlands in Oregon, including indirect costs could bring total costs up from a historic estimate of $100-

792 million per year to $150 million - $1.2 billion per year by the 2020s and $200 million - $1.6 billion per year by the 2040s.[20] These are very rough estimates, and additional research in these areas, and on the differences in costs between state, federal, and private lands, would make valuable contributions to understanding the full economic effects of wildfires.

Our research has primarily focused on the consequences of increased wildland fires. Although we found no studies that looked at other types of fires, it seems likely that similar risks exist for the urban-wildland interface and for forests and parklands in urban areas of the state (such as Portland's Forest Park and others).[21] Higher temperatures are likely to increase the potential for fires in urban forests, just as they may increase the damage from insects and diseases in these forests. Increased fire in urban areas would threaten homes and businesses and the associated smoke would affect air quality and public health. Urban forests also provide essential services. From recreational opportunities to moderating temperatures and sequestering carbon, “green infrastructure” enhances the quality of life in urban areas. The risks and consequences of wildfire must be considered in these areas.

Management Strategies

One of the logical questions resulting from our analysis concerns forest management. It appears unlikely that better (or different) management alone will be sufficient to prevent the projected increase in fire frequency. For example, Westerling et al. (2006) conclude that the increase in western wildfires measured since the mid-1980s is more strongly correlated with increased spring and summer temperatures and an earlier spring snowmelt than with past or current management activities.[22] However, it is possible that management strategies such as thinning may help reduce the extent of fire damage. The economic and ecological feasibility of such strategies are open questions that would benefit from additional research.

Economic Opportunities

Also worthy of additional research are two potential economic opportunities. One is carbon sequestration: because forests store carbon, forestlands could become a potential revenue source under a cap-and-trade system or other system involving carbon offsets. One study suggests that carbon sequestration in Pacific Northwest forests could be worth hundreds of millions of dollars—indeed, private landowners in California and a Native American tribe in Washington State have already found buyers for carbon credits from forestland—so this could be an important area for future research and evaluation.[23]

The second potential economic opportunity involves biomass energy generation, i.e., the use of woody debris and other forest products to generate electricity or to supply raw material for production of cellulosic ethanol or other biofuels. Such activities could aid with both *adaptation to* climate change (by removing woody fuels that increase fire risk) and *mitigation of* climate change (by producing electricity and biofuels from forest products—with zero net carbon emissions—instead of from fossil fuels). Biomass is already a significant source of energy for at least one firm in the forest products industry, generating 51% of the energy used in Weyerhaeuser's wood product facilities and 72% of the energy used in Weyerhaeuser's pulp and paper mills.[24] One recent study suggests that biomass energy could produce 150 MW of electricity per year in Oregon at a cost of about 8-9 cents per kWh (compared to current generating costs of 6.5 to 7.5 cents per kWh).[25]

Because many economic and ecological questions about biomass energy production remain unanswered, this area (like carbon sequestration) remains a promising topic for future research and evaluation.

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[1] *Oregon Forests Report 2005*, Oregon Dept of Forestry, p. 22. Online at http://www.oregon.gov/ODF/PUBS/docs/Oregon_Forests_Reports/05OFR.pdf, linked from http://www.oregon.gov/ODF/PUBS/publications.shtml.

[2] Timber shares for Oregon (2003) from p.9 of *Oregon Forests Report 2005*. Caution should be used before combining state figures with the WWPA figures cited below because of potential data inconsistencies.

[3] Western Wood Products Association, "Another record year for demand pushes western lumber production higher in 2005," Sept. 12, 2006. Online: http://www.wwpa.org/press/r-2005%20production.doc, linked from http://www.wwpa.org/newsroom.htm. Caution should be used before combining these figures with the state figures cited above because of potential data inconsistencies.

[4] GDP figures for 2004 from Bureau of Economic Analysis, "Gross Domestic Product by State," online at http://www.bea.gov/regional/gsp/. Oregon employment from Office of Economic Analysis, *Oregon Economic and Revenue Forecast*, March 2007, Table A.1, online at http://www.oregon.gov/DAS/OEA/economic.shtml.

[5] According to a study of the Sierra mixed conifer timberlands in El Dorado County, California, climate change could reduce timber yields by 18-31 percent by the end of the 21st century, primarily because of increased summer temperatures. (Note that these timberlands are different from those in the Pacific Northwest.) John J. Battles et al., "Climate Change Impact on Forest Resources" (California Climate Change Center). March 2006.Online: http://www.energy.ca.gov/2005publications/CEC-500-2005-193/CEC-500-2005-193-SF.PDF. See also Chapter 3 of *Forests, Carbon and Climate Change: A Synthesis of Science Findings*, Oregon Forest Resources Institute, 2006. Online: http://www.oregonforests.org/.

[6] It is important to note that the mountain pine beetle is not an invasive species but rather is native to these forests. For additional information on the connection to climate change, see for example, "Climate Change and Mountain Pine Beetle Range Expansion in British Columbia," *Information Forestry* (newsletter of the Pacific Forestry Centre, Victoria, B.C.), August 2003. Online: http://www.pfc.cfs.nrcan.gc.ca/news/InfoForestry/Aug2003/ifclimate_mpb_e.html.

[7] Oregon Department of Forestry, *Protection from Fire Program Review: Final Report*, March 28, 2005, online at http://www.oregon.gov/ODF/FIRE/FireProgramReview.shtml#Final_Report. Because fire risk is mostly associated with "fine fuels" such as needles and leaves, the risk from

dead trees is likely to be short-term rather than long-term. (Personal communications with Anthony Westerling, UC Merced, and Jeremy Littell, University of Washington, April 2007.)

[8] Anthony Leroy Westerling et al.. 2006. "Warming and Earlier Spring Increases Western U.S. Wildfire Activity ," *Science Express*, July 6. Online: http://www.sciencemag.org/cgi/content/abstract/1128834v1. See also Steven W. Running. 2006 "Is Global Warming Causing More, Larger Wildfires?" *Science Express*, July 6. Online: http://www.sciencemag.org/cgi/content/abstract/1130370v1.

[9] Donald McKenzie et al. 2004. "Climatic change, wildfire, and conservation," *Conservation Biology* 18(4): 890-902. Note that this is an active area of scientific research, with improved analyses likely forthcoming from researchers including Donald McKenzie and Jeremy Littell of the University of Washington and Anthony Westerling of UC Merced. (As part of California's climate policy initiative, Westerling will be leading an effort in 2007 to model wildfire changes under different climate scenarios for all of California, Oregon, and other western states.)

[10] Although there are a number of caveats that apply to these projections—e.g., that the relationship between temperature, precipitation, and acres burned is likely be non-linear because of factors such as the Pacific Decadal Oscillation (PDO) and the cumulative effect of increased fires—conversations with experts in the field who are conducting on-going research in this area (see comments in the previous footnote) suggest that these projections are as likely to be underestimates as overestimates.

[11] Acres protected from p. 22 of *Oregon Forests Report 2005* and p. 11 of *Protection from Fire Program Review: Final Report*, Oregon Department of Forestry, March 28, 2005, online: http://www.oregon.gov/ODF/FIRE/FireProgramReview.shtml#Final_Report. Acres burned for 1988-99 is from the Northwest Interagency Coordination Center (NWCC), online: http://www.nwccweb.us/content/products/Intelligence/PNW_Historical_Fire.mht.

[12] James Agee, University of Washington College of Forest Resources, personal communication, March 2007.

[13] Source: Acres burned is from the Northwest Interagency Coordination Center (NWCC), online: http://www.nwccweb.us/content/products/Intelligence/PNW_Historical_Fire.mht. ODF expenditures are based on biennial expenditures from Michelle Remmy, Protection Business Manager, ODF, personal communication, February 28, 2007. USFS and BLM expenditures are from Tom Knappenberger, Public Affairs Officer, Gifford Pinchot National Forest, Personal communications, Feb. 13 and 16, 2007. Expenditure figures are adjusted for inflation using the BLS Inflation Calculator (http://www.bls.gov/cpi/). Note that USFS and BLM lands account for about 85% of acres burned on federal lands in Oregon and Washington.

[14] Joint Legislative Audit and Review Committee (JLARC), State of Washington. 2005. *Department of Natural Resources Fire Suppression Study*, Report 05-11. http://www1.leg.wa.gov/reports/05-11.pdf.

[15] Sources given in footnote 13.

[16] See p. 25 of *Protection from Fire Program Review: Final Report*, Oregon Department of Forestry, March 28, 2005. Online: http://www.oregon.gov/ODF/FIRE/FireProgramReview.shtml#Final_Report.

[17] Sources given in footnote 13.

[18] University of Washington Rural Technology Initiative. 2003. *Investigation of Alternative Strategies for Design, Layout, and Administration of Fuel Removal Projects*, http://www.ruraltech.org/pubs/reports/fuel%5Fremoval/. See also Sandra Hines, September 26, 2003. "Without thinning the worst is yet to come for fire-prone forests," http://www.washington.edu/newsroom/news/2003archive/09-03archive/k092603.html. Some scientists advocate selective thinning of forests as one way to reduce fire risks. But this would also be costly: RTI estimates place the cost of selective thinning at $580 per acre.

[19] The low end of the historic estimate of $200-$384 million per year comes from direct ODF costs of $40 million (conservative estimate) plus 4 times that amount in indirect costs. The high end comes from direct ODF costs of $64 million (less conservative estimate) plus 5 times that amount in indirect costs. The 2020 and 2040 projections are 1.5 times and 2.0 times these amounts, respectively.

[20] The low end of the historic estimate of $100-$792 million per year comes from direct federal costs in Oregon of $20 million (low end of conservative estimate) plus 4 times that amount in indirect costs. The high end comes from direct federal costs in Oregon of $132 million (high end of less conservative estimate) plus 5 times that amount in indirect costs. The 2020 and 2040 projections are 1.5 times and 2.0 times these amounts, respectively.

[21] This subject was the lead story in the May 11, 2007, *USA Today*: Brad Heath, "Wildfire areas get influx of residents," online: http://www.usatoday.com/printedition/news/20070511/1a_lede11.art.htm. See also Roger G. Kennedy, *Wildfire and Americans* (New York: Hill & Wang, 2006).

[22] Note that this conclusion is for the west as a whole, and may not be valid for individual states or other sub-regions (Anthony Westerling, personal communication, May 2007).

[23] See, for example, John Perez-Garcia et al., "Economic Incentives for Carbon Storage in Western Washington's Forested Riparian Management Areas," in Climate Change, Carbon, and Forestry in Northwestern North America:
Proceedings of a Workshop, November 14 - 15, 2001, Orcas Island, Washington, online: http://www.fs.fed.us/pnw/pubs/pnw_gtr614.pdf; Jim Robbins, "Sale of Carbon Credits Helping Land-Rich, but Cash-Poor, Tribes," *New York Times*, May 8, 2007, online: http://www.nytimes.com/2007/05/08/science/earth/08carb.html?_r=2; "Preservation of a Native Northwest Forest: The Lummi Nation," online: http://www.carboncounter.org/60/section.aspx/8.

[24] Weyerhaeuser has pledged that by 2020 its greenhouse emissions will be 40% below its emissions in 2000, and substitution of biomass for fossil fuels appears to be central to their strategy. See "Weyerhaeuser to cut greenhouse gas emissions by 40 percent," press release, June 21, 2006; online: http://www.weyerhaeuser.com/popups/_frameset.asp?bodyFrame=/popups/pressReleases.asp?id=06-06-21_WeyerhaeuserToCutGreenhouseGasEmissions; "2005 Sustainability Report"; online: http://www.wy.com/environment/sustainability/; and "2004 Roadmap for Sustainability: Conserving Natural Resources"; online: http://www.weyerhaeuser.com/environment/sustainability/2004/conservingresources/energyconservation.asp.

[25] Oregon Forest Resources Institute, "Biomass Energy and Biofuels from Oregon's Forests," June 30, 2006. Online: http://oregonforests.org/content/researchResources.asp?section=20&content=57.