

**Final report, Joint Fire Science Program  
Project: 00-2-20**

**Project Title:** Treatments that enhance the decomposition of forest fuels for use in partially harvested stands in the moist forests of the Northern Rocky Mountains (Priest River Experimental Forest)

**Project Location:** Priest River Experimental Forest, northern Idaho

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**SUMMARY OF FINDINGS TO DATE**

**The moist forests of the Rocky Mountains** typically support late seral western hemlock, moist grand fir, or western redcedar forests. In addition to these species, Douglas-fir, western white pine, western larch, ponderosa pine, and lodgepole pine can occur creating a multitude of species compositions, structures, and successional stages that can be arrayed in a variety of fine to coarse mosaics. Weather, insects and diseases are often the most frequent and persistent disturbances. Large high severity wildfires do occur but their intervals have been lengthened by successful fire suppression and fire suppression has decreased the occurrence of small mixed severity fires. White pine blister rust (an introduced disease) has decreased the presence of western white pine throughout much of northern Idaho, western Montana and eastern Washington, the heart of the moist forests of the northern Rocky Mountains. Compared to the role decomposition plays in the ponderosa pine forests, decomposition is of a regulator of biomass than is fire in the moist forests.

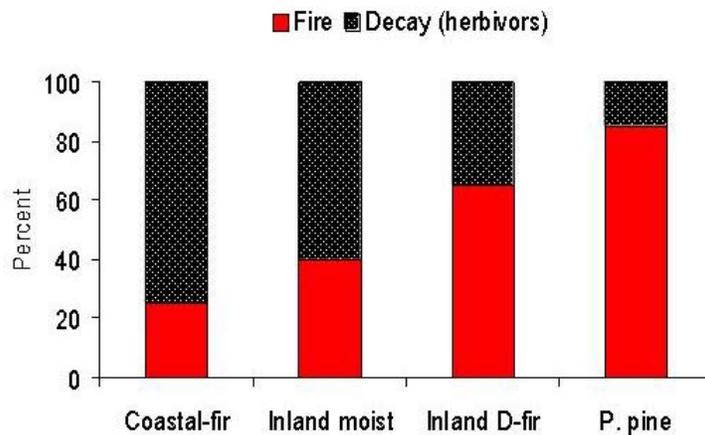


Figure 1. The relative proportions combustion and decay play in regulating the accumulation of biomass in northwestern United States forests. This graph depicts an environmental gradient from the moist Pacific Coastal fir forests to the dry inland ponderosa pine forests.

**Demonstration site**-Because decomposition is a major determinant of biomass accumulation in the moist inland forests, a demonstration was established on the Priest River Experimental Forest in northern Idaho. This demonstration site was established to see if decomposition could be enhanced and used to manage forest fuels in the wildland urban interface.

### Residue Treatments to enhance Decomposition

The compound and buildings of the Priest River Experimental Forest (PREF) were built in the 1930s by the Works Progress Administration (WPA) and the Civilian Conservation Corp (CCC) and are on the Register of Historic Buildings. As such they have high value and need to be protected from wildfire. The moist forests surrounding the buildings are similar to much of the urban interface in northern Idaho and have had fires aggressively suppressed since the 1930s.

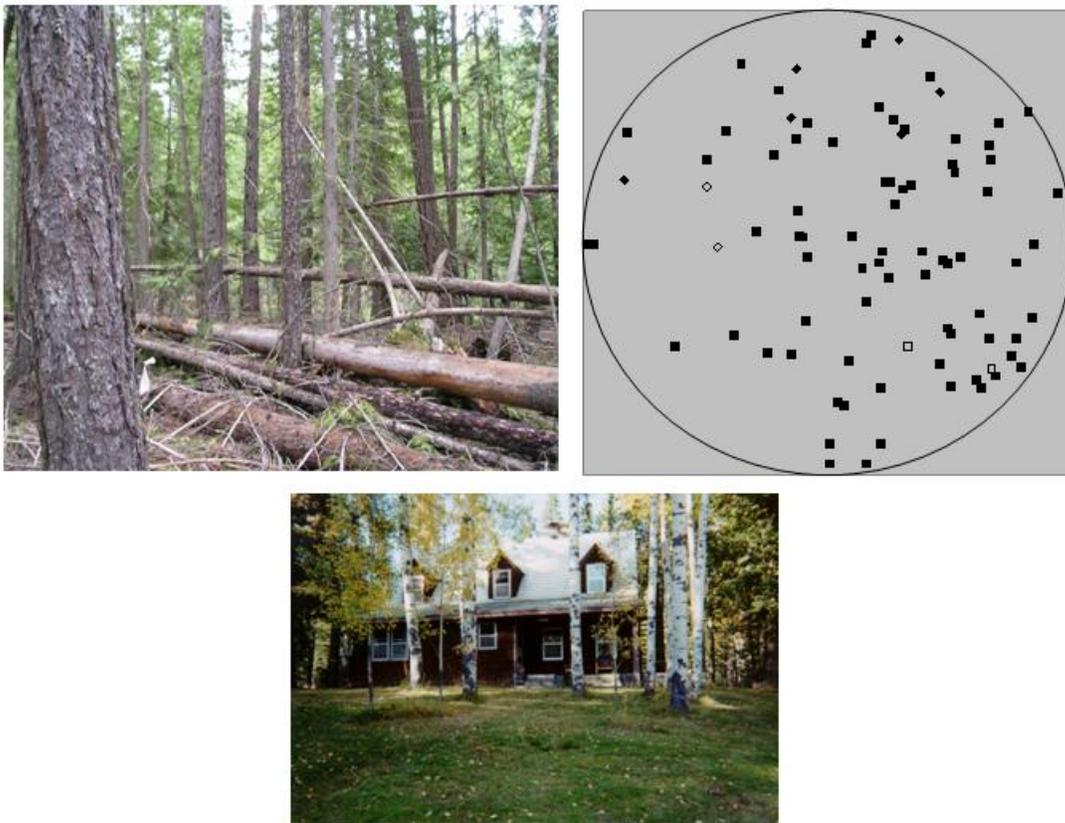


Figure 2. This figure shows the condition of the forest immediately behind the lodge on the experimental forest before it was treated. The forest contained on the average 33.8 tons of coarse woody debris per acre, 179 trees per acre and 121 ft<sup>2</sup> of basal area per acre. The stand map in the upper right depicts the tree locations on a typical half-acre.

**Decomposers**-There are a multitude of fungi that decompose wood. Some fungi thrive on dead material and others prefer live material. Some prefer conditions typified by those occurring close to the soil surface while others prefer conditions such as those occurring on top of logs. However, warm and moist conditions usually facilitate the decomposition of woody material. With this understanding we decided to compare mastication, machine grapple piling, and lopping and scattering of slash with a control after harvest and decreasing the canopy and ladder fuels around the historic buildings. Mastication is shredding or breaking of wood residue into chunks through mechanical means (Figure 4). Lopping and scattering is the process of cutting fuels into various lengths and removing their limbs to encourage the material to be in contact with the soil surface. We randomly located 12 one-acre plots. To these randomly located areas within the PREF compound we randomly chose three one-acre plots to masticate, three plots to grapple pile, and three plots to lopp and scatter the surface fuels and the slash in three plots remained as controls.

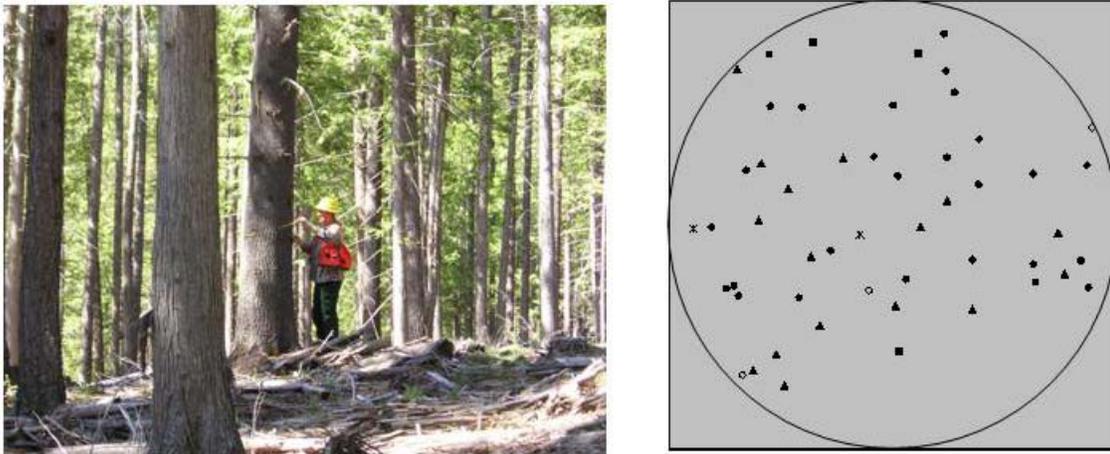


Figure 3. After removing house logs, saw logs, and trees capable of falling on the buildings, the 100 acre area around the compound contained on the average 117 trees per acre and 118 ft<sup>2</sup> per acre of basal area. The trees were dispersed relatively unevenly as the half-acre stand map on the right shows.

Pieces of wood that do not dry and wet readily and allow oxygen and heat to penetrate are the preferred substrate for decomposing fungi. Because these conditions foster decomposition, sawdust piles and chip piles generally do not readily decompose. In addition these fungi utilize large amounts of nitrogen as anyone can attest who has added fresh sawdust to a lawn and the grass turns yellow. Therefore, for the mastication treatment, we tried to create chunks of material rather than small chips or shavings so that the fungi species or its preferred environmental conditions favoring its growth and consumption of woody biomass would be encountered within the treated area.



Figure 4. The machine we used to masticate the surface fuels had a horizontal rotating head that could articulate, reach 25 feet horizontally, and reach approximately 15 feet vertically.

We avoided grinding the material into small pieces and kept the pieces in the range of football size if possible, making them as conducive as possible for decomposition (lower right photo). With minimal guidance the machine operator was able to create the desired piece size.

### **Treatment comparison**

Immediately after the treatments were completed we estimated the amount of fine and coarse woody fuels left by the treatments. We also estimated the nutrient properties of the litter, buried rotten wood (soil wood), humus, and the shallow mineral soil down to a depth of 10 cm. Twelve 50-foot fuel transects were randomly located within each treatment replicate (1-acre plot) and 3 soil samples were randomly placed along half of the transects results in taking 9 soil samples in each of the one-acre treatment units. The soil samples were extracted using a slide hammer core sampler (9 cm by 30 cm).

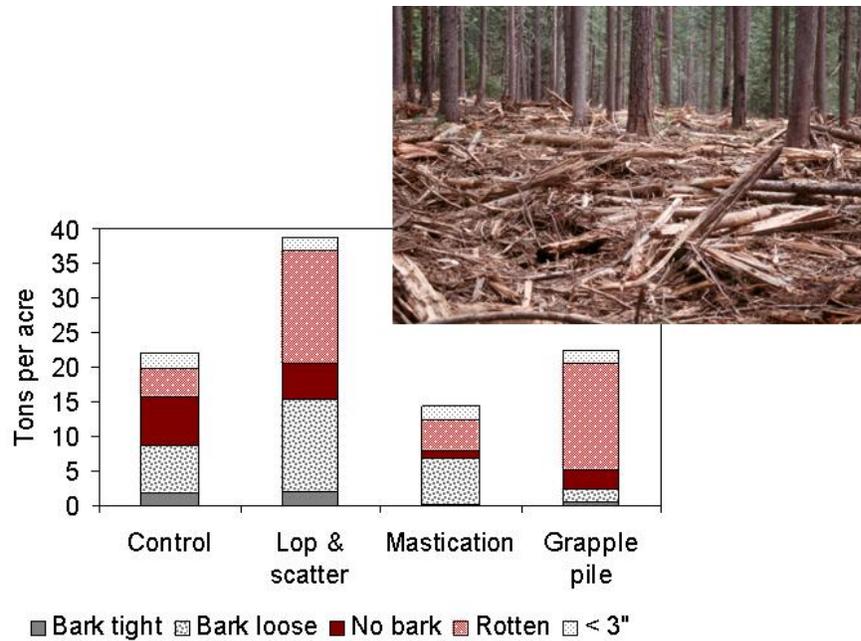


Figure 5. After the surface fuel treatments were applied the total fuel in the area that was masticated averaged 14.3 tons per acre with the most fuel remaining in the areas in which the fuels were lopped and scattered.

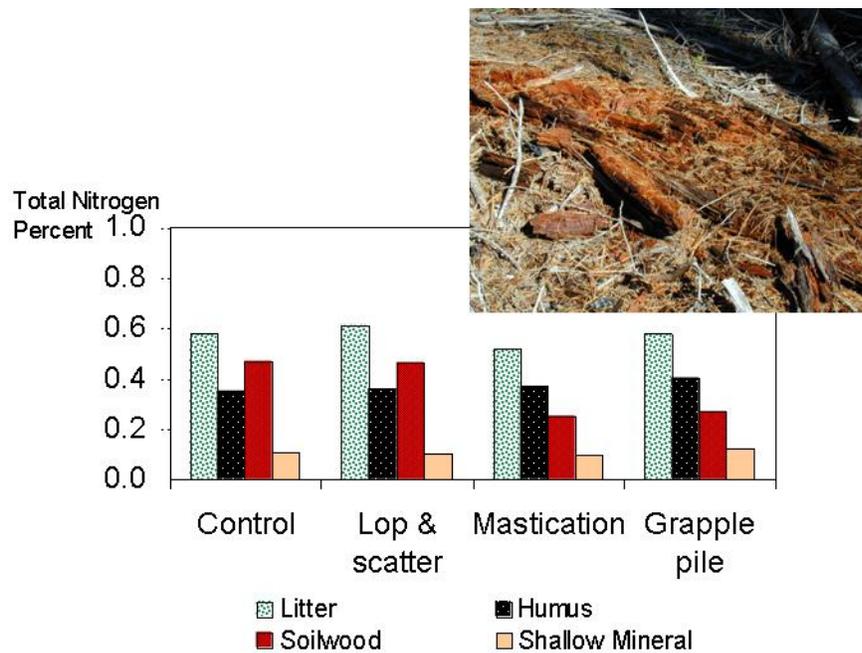


Figure 6. We tested different soil substrates for nitrogen content to see if the fuel treatments affected their chemical properties. As the graph indicates, the nitrogen concentration in the soil components was not appreciably affected by the fuel treatments.

We also evaluated the same soil components for carbon and magnesium and like the nitrogen concentrations the fuel treatments had no differential effect on either carbon or magnesium.

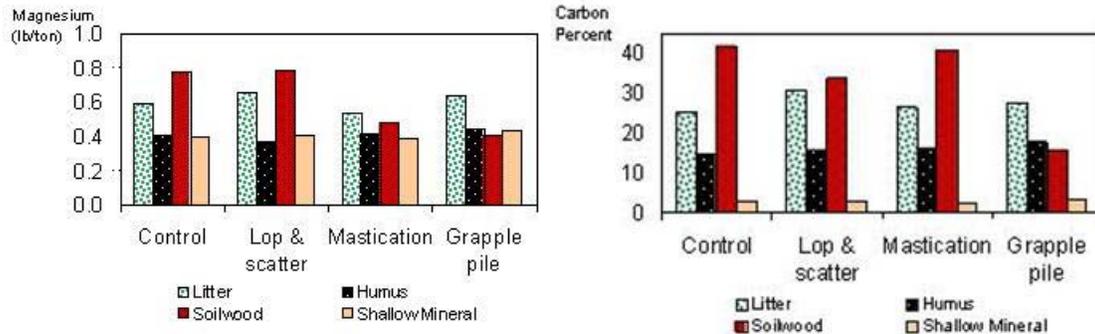


Figure 7. Similar to nitrogen, the different fuel treatments appeared to have little impact on soil carbon and magnesium.

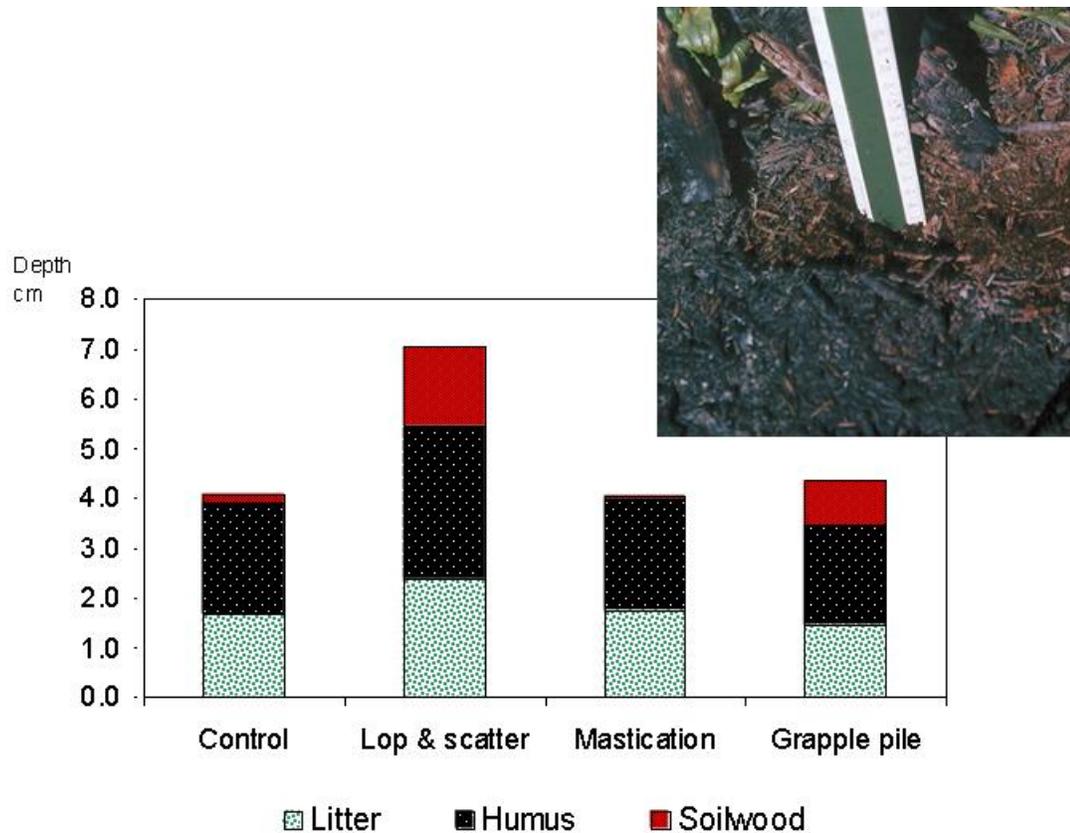


Figure 8. After the treatments were applied the greatest duff depth occurred in the areas in which the fuels were lopped and scattered and the duff depths occurring in the areas masticated and grapple piled were similar to those found in the control areas.

Two years after the treatments were applied the character of the masticated material had changed remarkably with the mastication areas similar in nature to the areas in which the fuels were grapple piled.

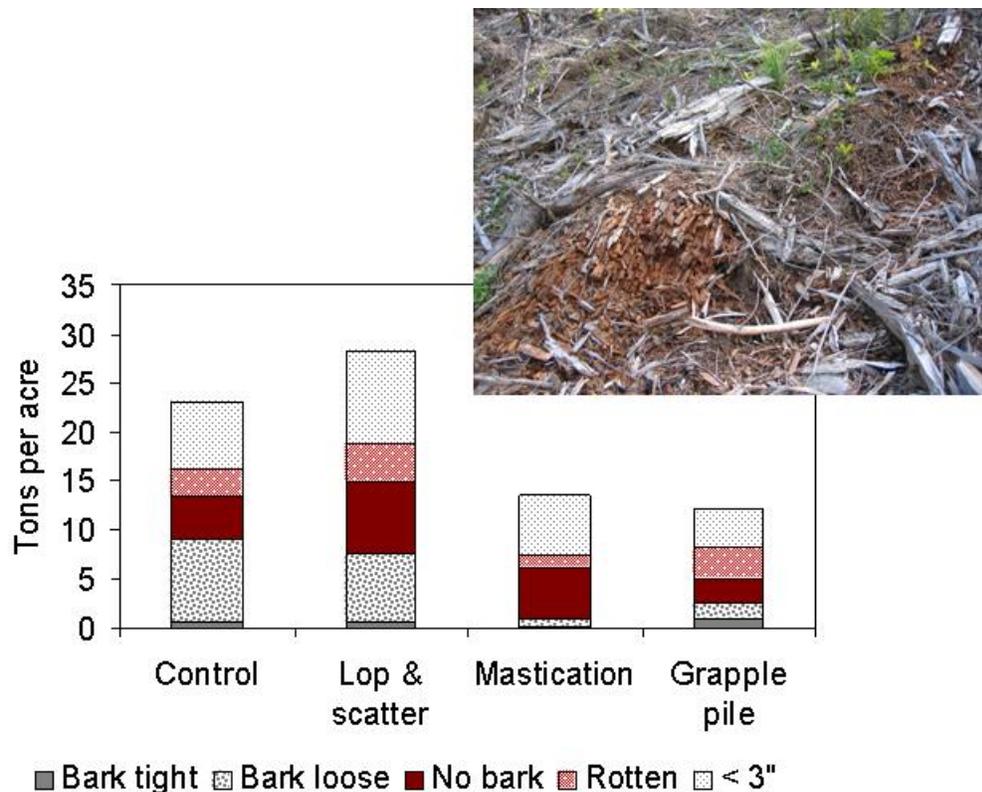


Figure 9. Two years after treatment the structure and character of the masticated fuels was such that these areas resembled those that had the fuels piled.

### Key Points

- Decay is a major process influencing biomass accumulation in the moist forests of the inland northwestern United States.
- A variety of fungi decompose wood in various states and in a variety of environmental conditions.
- Opening the high forest canopy through tree removal and the reduction of ladder fuels increases heat and moisture reaching the forest floor which facilitates wood decomposition.
- Small chips, shavings, and sawdust pieces individually, wet and dry and warm and cool readily, slowing or preventing their decomposition. Deep layers or piles of these materials prevent air circulation which also retards their decomposition.
- “Chunks” (figure 4) offer a variety of substrate (wood) conditions and moisture and temperature conditions that encourage decomposition.
- Two years after treatment, masticating fuels created forest floor conditions similar to those created by machine piling the fuels.

## Deliverables

A 100-acre site surrounding the historic buildings was established demonstrating and providing comparison opportunities of treating canopy, ladder, and surface fuels in the wildland urban interface. The methods of treating fuels included lopping and scattering fuels which is a common method aimed at encouraging decomposition, piling fuels using a grapple machine so they could be burned, and “chunking” using a mastication machine. Because the demonstration site was in such close proximity of the buildings where visitors stay and meetings and short-courses are held, the area is used frequently. The following is a sample of **more than 25** field visits we have hosted since the demonstration site was established:

1. Graham, Russell T.; Jain, Theresa B. 2000. Silviculture of the moist forests. University of Idaho silviculture class, Priest River Experimental Forest, Priest River, ID, April 29, 2000.
2. Graham, Russell T.; Jain, Theresa B. 2000. Coarse woody debris its role and management in western forests. University of Idaho Extension Forestry coarse woody debris workshop, Priest River Experimental Forest, Priest River, ID, July 13, 2000.
3. Graham, Russell T.; Jain, Theresa B. 2001. Moist forest restoration in the Priest Lake Basin. Selkirk Conservation Alliance, Priest River, ID, March 16, 2001.
5. Graham, Russell T.; Jain, Theresa B. 2001. Silviculture of the moist forests. Long-term soil productivity meeting, Priest River Experimental Forest, Priest River, ID, August 20-21, 2001.
7. Graham, Russell T.; Jain, Theresa B. 2002. Coarse woody debris its role and management in western forests. University of Idaho Extension Forestry coarse woody debris workshop, Priest River Experimental Forest, Priest River, ID, June 29, 2002.
8. Graham, Russell T.; Jain, Theresa B. 2003. Silviculture of the moist forests. Inland Empire Tree Improvement Coop Meeting, Priest River Experimental Forest, Priest River, ID, June 18, 2003.
10. Graham, Russell T.; Jain, Theresa B. 2004. Silviculture of the moist forests. Inland Empire Society of American Foresters Field Tour, Priest River Experimental Forest, Priest River, ID, May 4-5, 2004.
11. Graham, Russell T.; Jain, Theresa B. 2005. Treatments Within the Wildland/Urban Interface. Project Learning Tree: Teacher continuing education, Priest River Experimental Forest, May 20, 2005.

12. Graham, Russell T.; Jain, Theresa B. 2005. Coarse woody debris its role and management in western forests. University of Idaho Extension Forestry coarse woody debris workshop, Priest River Experimental Forest, Priest River, ID, July 22, 2005.
13. Graham, Russell T.; Jain, Theresa B. 2005. Selection silvicultural systems. Forest Service, Idaho Panhandle National Forests Fuels Management Meeting, Priest River Experimental Forest Priest River, ID, August 30, 2005.
14. Graham, Russell T.; Jain, Theresa B. 2005. Fuel Management Decisions. Forest Service, Idaho Panhandle National Forests Fuels Management Meeting, Priest River Experimental Forest Priest River, ID, August 30, 2005.
15. Graham, Russell T.; Jain, Theresa B. 2002. Coarse woody debris its role and management in western forests. University of Idaho Extension Forestry coarse woody debris workshop, Priest River Experimental Forest, Priest River, ID, July 13, 2006.

In addition to the on-site use of the demonstration area results from this work has been presented at over **93 local, regional, national and international scientific meetings and workshops** and this is a sampling of those presentations:

1. Graham, Russell T.; Jain, Theresa B. 2000. Forest treatments for meeting multiple objectives. Forest Service, Clearwater National Forest, Planning workshop, Orofino, ID, January 13, 2000.
2. Graham, Russell T.; Jain, Theresa B. 2000. Coarse woody debris and soil management. Idaho Panhandle National Forests, Soils and Silviculture workshop, Coeur d' Alene, ID, Mar. 15-16, 2000.
3. Graham, Russell T.; Jain, Theresa B. 2000. Silviculture of the moist forests. University of Idaho silviculture class, Priest River Experimental Forest, Priest River, ID, April 29, 2000.
4. Graham, Russell T.; Jain, Theresa B. 2000. Coarse woody debris its role and management in western forests. Southwestern Idaho Forest Planning Meeting, McCall, ID, December 5-6, 2000.
5. Graham, Russell T.; Jain, Theresa B. 2001. How silvicultural treatments affect fire behavior. Forest Service, Region 4 silviculture/fire workshop. Ogden, UT, March 6-8, 2001.
6. Graham, Russell T.; Jain, Theresa B. 2001. Physically and biologically enhancing forest residue decomposition. Inland Reforestation Council Meeting, Coeur d'Alene, ID, March 13-14, 2001.

7. Jain, Theresa B.; Graham, Russell T. 2001. Coarse woody debris its role and management in the Black Hills. Forest Service, Black Hills National Forest silviculture, fire, and wildlife meeting, Custer, SD, May 21-24, 2001.
8. Graham, Russell T.; Jain, Theresa B. 2001. Silvicultural treatments and fire behavior and severity. Great Basin Fuels Committee, Cedar City, Utah, October 22-26, 2001.
9. Graham, Russell T. 2002. Silviculture and fuel treatments. Forest Service, Region 2 silviculture and fuels workshop, Denver, CO, March 4-6, 2002.
10. Graham, Russell T. 2002. How can management effectively restore/recreate/maintain important features required to conserve biodiversity. BorNet International Conference on biodiversity conservation in boreal forests, Uppsala, Sweden, May 27 - 28, 2002.
11. Graham, Russell T. 2002. Silvicultural options for producing diverse forest structures. Oregon State University, Extension Forestry, Diverse forest structure management, Sisters, OR, June 24-27, 2002.
12. Graham, Russell T.; Jain, Theresa B. 2002. Experimental Forests of Idaho. National Experimental Forest Meeting, H. J. Andrews Experimental Forest, Eugene, OR, October 22, 2002.
13. Graham, Russell T.; Jain, Theresa B. 2003. Integrating silviculture into mechanical and fire fuel treatments. Interregional Fuel Treatment Training, Albuquerque, NM, January 28, 2003.
14. Graham, Russell T. 2003. Science for informing fuel treatment decisions. Deputy Under-Secretary of Agriculture Briefing, Washington, DC, April 24, 2003.
15. Jain, Theresa B.; Graham, Russell T. 2003. Coarse woody debris and fuel treatments. Agenda 2020 annual meeting, Kelso, WA, May 1, 2003.
16. Graham, Russell T. 2003. Science for informing fuel treatment decisions in the forests of Idaho. Idaho Conservation League Annual Meeting, Red Fish Lake, ID, May 17-18, 2003.
17. Graham, Russell T.; Jain, Theresa B. 2004. Mechanical and fire fuel treatments and their effects. Bureau of Land Management Fuel Treatments Workshop, Miles City, MT, February 17, 2004.
18. Graham, Russell T.; Jain, Theresa B. 2004. Integrating silviculture into mechanical and fire fuel treatments. Interregional Fuel Treatment Training, Denver, CO, February 24, 2004.

19. Graham, Russell T.; Jain, Theresa B. 2004. Coarse Woody Debris Management. Forest Service, southwest ecogroup coarse woody debris, snags, and fuels management, Boise, ID, September 8-9, 2004.
20. Graham, Russell T.; Jain, Theresa B. 2004. Silviculture to Mimic Fire and Natural Disturbances. Western Forestry and Conservation Association Annual meeting, Coeur d'Alene, ID, December 7, 2004.
21. Graham, Russell T. 2005. New tools for hazardous fuel management. Incorporating new science into hazardous fuels and vegetation treatment planning, Portland, OR, May 17-18, 2005.
22. Graham, Russell T.; Jain, Theresa B. 2006. Mastication for site preparation & fuels reduction. Inland Empire Reforestation Council Meeting: creating conditions for early survival, Coeur d'Alene, ID, February 14, 2006.
23. Jain, Theresa B.; Graham, Russell T. 2002. Restoring moist forests of the inland northwestern United States. IUFRO Conference on restoration of boreal and temperate forests, Billund/Vejle, Denmark, May 2, 2002.
24. Graham, Russell T.; Jain, Theresa B. 2004. Application of free selection in mixed forests of the inland northwestern United States. IUFRO Meeting the challenge: silvicultural research in a changing world, La Grande Motte, Montpellier, France, June 14-18, 2004.
25. Graham, Russell T.; Jain, Theresa B. 2005. Free selection: a silvicultural option. Forest Service, Restoring fire -adapted forested ecosystems. 2005 National Silviculture workshop, Lake Tahoe, CA, June 6-10, 2005.
26. Graham, Russell T.; McCaffrey, Sarah; Barbour, Jamie; Johnson, Morris. 2005. Integration of science: informing fuel treatments: fuel synthesis. Forest Service, Restoring fire -adapted forested ecosystems. 2005 National Silviculture workshop, Lake Tahoe, CA, June 6-10, 2005.

## **Publications**

The following publications contain references to or data from the demonstration site:

1. Harvey, Alan E.; Graham, Russell T.; McDonald, GERAL I. 2000. Fire/decay: managing codependent processes across the landscape. in: Neuenschwander, Leon F.; Ryan, Kevin C. Tech. Eds. Crossing the Millennium: Integrating spatial technologies and ecological principles for a new age in fire management, Joint fire science conference and workshop. Boise, ID. Spokane, WA: International Association of Wildland Fire. 179-189.

2. Graham, Russell T. 2002. Historical landscapes and forest structures. in: Baumgartner, David M.; Johnson, Leonard R.; Deput, Edward J. Comp. Small diameter timber: Resource management, manufacturing, and markets. February 25-27, 2002, Spokane, WA. Pullman, WA: Washington State University. 25-31.
3. Graham, Russell T. 2002. How can management effectively restore/recreate/maintain important features required to conserve biodiversity. in: Leech, Susan; Whitaker, Carolyn; Innes, John. Eds. BorNet International Conference on biodiversity conservation in boreal forests. May 27 - 28, 2002, Uppsala, Sweden. Vancouver, British Columbia: University of British Columbia. 32-33.
4. Jain, Theresa B.; Graham, Russell T. 2002. Restoring moist forests of the Inland Northwestern United States. in: Gardiner, Emile S.; Breland, Lynne J. Comps. Proceedings of the IUFRO conference on restoration of boreal and temperate forests-documenting forest restoration knowledge and practices in boreal and temperate ecosystems. Vejle, Denmark. Fredeniksberg, Denmark: Danish Centre for Forest, Landscape and Planning. 157-158.
5. Graham, Russell T. 2004. Burn severity and vegetation (fuels) management. In: Ruth Harrison. Ed. Wildland Fire Impacts on Watersheds Understanding, Planning and Response. October 21-23, 2003, Denver, CO. Boulder, CO: The Geological Society of America. CD.
6. Graham, Russell T.; Jain, Theresa B. 2004. Priest River Experimental Forest. in : Adams, Mary Beth; Loughry, Linda; Plaughter, Linda. Comps. Experimental Forests and Ranges of the USDA Forest Service. Gen. Tech. Rep. NE-321. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northeastern Research Station. 128-129.
7. Graham, Russell T. McCaffrey Sarah Jain Theresa B. Tech. Eds. 2004. Science basis for changing forest structure to modify wildfire behavior and severity. Gen. Tech. Rep. RMRS-GTR-120. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 43 p.
8. Jain, Theresa B.; Graham, Russell T. 2004. Enhancing moist forest restoration opportunities in riparian systems. In: Shepperd, Wayne D.; Eskew, Lane G. compilers. Silviculture in special places: proceedings of the National Silviculture Workshop. Granby, CO. Proceedings. RMRS-P-34. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 49-63.
9. Graham, R. T.; Jain, T. B. 2005. Application of free selection in mixed forests of the inland northwestern United States. in: Parrotta , John A.; Auclair, Daniel. Eds. Meeting the challenge: silvicultural research in a changing world. June 14-18, 2004, La Grande Motte, Montpellier, France. Vienna, Austria: IUFRO Headquarters. 49-52.

10. Graham, Russell T.; Jain, Theresa B. 2005. Application of free selection in mixed forests of the inland northwestern United States. *Forest Ecology and Management* 209(1-2): 131-145.
11. Graham, Russell T.; Jain, Theresa B. 2005. Silvicultural treatments in forests burned by mixed fires. In: Lagnene, Taylor; Zelnik, Jessica; Cadwallader, Sara; Hughes, Brian. Compilers and Editors. *Mixed severity fire regimes*. November 17-19, 2004, Spokane, WA. Pullman, WA: Washington State University Extension, Washington State University. 45-58.
12. Graham, Russell T.; Jain, Theresa B.; Cannon, Phil. 2005. Stand establishment and tending in Rocky Mountain Forests. in : Harrington, Constance A.; Schoenholtz. Tech. Eds. *Productivity of western forests: A forest products focus*. September 20-23, 2004, Kamiche, WA. Gen. Tech. Rep. PNW-GTR-642. Portland, OR: Pacific Northwest Research Station. 47-78.
13. Jain, Theresa B.; Graham, Russell T. 2005. Restoring dry and moist forests of the inland northwestern U.S. in : Stanturf, John A.; Madsen, Palle. Eds. *Restoration of boreal and temperate forests*. Boca Raton, FL: CRC Press. 463-480.
14. Graham, Russell T.; Jain, Theresa B. 2006. Free selection: a silvicultural option. In: Powers, Robert. Ed. *Restoring fire -adapted forested ecosystems*. 2005 National Silviculture workshop. June 6-10, 2005, Lake Tahoe, CA. Gen. Tech. Rep. PSW-GTR-203. Albany, CA: U. S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 121-156.
15. Halbrook, Jeff; Han, Han-Sup; Graham, Russell T.; Jain, Theresa B.; Denner, Robert. 2006. Mastication: A fuel reduction and site preparation alternative. in: Chung, W.; Han, H. S. Eds. *The 29th Council on Forest Engineering Conference*. July 30-August 2, 2006, Coeur d' Alene, Idaho. Moscow, ID: University of Idaho. 137-146.
16. Graham, Russell T.; Jain, Theresa B.; Mathews, Susan J. In Press. Fuel Management in Forests of the Inland Western United States . In: Audin, Lisa; Elliot, William. Eds. *Cumulative watershed effects of fuel treatments*. Gen. Tech. Rep. U. S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.