Economics of Biomass Removals
Final Report to the Joint Fire Science Program
May 31, 2006

Project Title: A National Study of the Economic Impacts of Biomass Removals to Mitigate Wildfire Damages on Federal, State, and Private Lands.
Project Number: 01-1-2-09

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Project Web Page: http://www.srs.fs.usda.gov/econ/dert/biomass.htm

SUMMARY OF FINDINGS TO DATE:

We developed two different modeling systems (the EBR model and the FTM-West model) which used the same basic data. The data, including the characterization of risk and application of standard silvicultural treatments to reduce fuel hazards were developed in collaboration with Ken Skog and the Wood Utilization Opportunities Areas project. Because the two models make different assumptions, the findings differ by model. The model from which the findings emanate are noted in the findings below.

Key Finding #1: Market effects of national mechanical treatment programs vary by program size and treatment priorities when using a spatial equilibrium market model which maximizes social welfare and total acres treated (the EBR model). (Attachments 1 and 10)

- A national program to reduce fuels through mechanical treatments on government lands only and which involve product sales has small market effects when total program size is less than $300 million per year. For the western U.S., effects on producer and consumer surplus are less than 2 percent per year. Effects on prices and trade within the U.S. and across national borders are similarly small. However, the program, if sustained, could potentially go on for many decades.
- When this $300 million per year program is focused on wildland-urban interface stands, the effects are equally small on market variables, but the effect is shorter-lived, effectively completing within 1-2 decades. The western U.S. WUI stands could be completely treated within eight years, while adding southern U.S. WUI stands would add another eight years to the time to completion.
- Focusing a national-level treatment program on high-risk stands on government lands effectively shortens the time to completion of the program by about two-third. However, because stands continually grow into risky condition, accounting for growth implies that such a program would take several decades longer and require constant treatment into the far distant future (assuming that post-treated stands are not maintained through prescribed fire).

- Mechanical fuel programs for government forests, when adjusted for stand and fire risk growth extend the length to completion by about one-third. For example, a $900 million per year program could be completed within about 58 years if re-growth of stands into risky condition were assumed not to occur but, we estimate, would take nearly 75 years once re-growth were accounted for. This result depends on an assumption that mechanically treated stands are not then subject to regular prescribed fire to potentially maintain "in-condition" status in terms of fire risk. This tripling of the size of a treatment program, from $300 million per year to $900 million per year, increases the positive impacts on western timber consumers by five-fold and more than doubles the negative impacts on private producers in the western U.S. Still, the overall effect of even a $900 million per year program is to reduce western producer surplus by 3.3 percent and increase western consumer surplus by 1.4 percent (the consumer surplus absolute number is larger, however, and this figure ignores government treatment revenues). The program completes in one-third the time, compared to a $300 million annual program. This effect on time-to-completion is essentially linear.
- Government timber receipts increase with a $300 million per year program limited to the U.S. West by $5.4 billion per year, including treatment timber and regular harvests, effectively quadrupling government timber harvest receipts. This assumes that treatments are added to existing harvests. Adding the South to the program increases these revenues nearly ten-fold. A $900 million per year program more than doubles these figures.
- Accounting for growth of stands back into risky condition following treatment and into riskier condition before treatment effectively doubles the long-run cost of the treatment program. Treating all stands in the western U.S. without accounting for growth has a long-run cost, at a 7 percent discount rate, of $4.6 billion. Accounting for risk growth over time, this cost rises by $8.9 billion, nearly tripling the long run cost of the program.
- Adding the South to a national treatment program for government lands slightly increases (by less than 1 percent) the cost of the treatment program compared to one limited to the U.S. West. Addition of the South added 29 years to the total time to completion of a $300 million per year program, or about 20 percent longer. The cost, however, without accounting for stand risk growth, does not vary much because of these extra years, due to discounting of the costs of those most distant years. Such a South plus West program, however, does shift where treatments occur throughout the duration of the program, with southern condition class 3 stands treated before western risk level 2 stands.

Key Finding #2: International impacts of a mechanical fuel treatment program are small but are linearly related to the size of the treatment program using the EBR model. The effects of the program occur through at least three mechanisms. (Attachments 1 and 10)

- First, by increasing softwood removals on government lands, our exports to Canada decline because such softwood logs cannot be exported by law from the western U.S. Although private timber producers in the U.S. can make up for part of this loss in exports, they cannot make up for all of the loss. This negatively affects timber consumers in Canada.

- Second, by lowering the domestic price of timber in the U.S. such treatment programs would tend to substitute western logs for logs used in the eastern U.S. (by small amounts), which would lower export opportunities for Canadian lumber producers (not directly modeled in the timber market modeling chapter but modeled in FTM-West, discussed below and in Attachments 2,5 and 6).
- Third, Canadian consuming mills would experience some lower wood input prices and hence benefit, because of the slightly lower Canadian export opportunities.

Key Finding #3: Increased wood demand capacity in the western U.S. alters the gains and losses to consumers and producers using the EBR model. (Attachment 10)

- Allowing for gradually expanding wood demand capacity in the western U.S., a treatment program would primarily benefit western U.S. consumers (mills).
- On the other hand, private timber producers would be more negatively affected, as a higher feasible rate of government harvests substitutes for private harvests in the market, and prices drop.
- Consumers in the rest of the world are also very slightly harmed, as more timber processing is concentrated in the western U.S. Similar effects occur after allowing for expanded southern U.S. capacity.

Key Finding #4: Approximately 46 million acres of timberland did not meet the established hazard criteria and were treatable: 30 million in low-severity forest types and 16 million in high-severity forest types (lodgepole and fir-spruce). Federal land comprised 59% of the total treatable area. (Attachments 7, 8 and 9)

- Using available FIA inventory data, treatment was simulated in twelve Western states on plots that did not meet the hazard criteria of: torching index and crowning index ≥ 25 mph or crowning index ≥ 40 mph. A suite of even- and uneven-aged mechanical treatments were applied to plots not meeting hazard criteria.
- Based on our hazard assessment
    - On low-severity forest types across all ownerships 31% of treatable land is high hazard.
    - On high-severity forest types across all ownerships 49% of treatable land is high hazard.
- When limits on the amount of basal area removed on low-severity forest types were imposed at the plot level, the even-aged treatments placed more acres above our hazard targets while the uneven-aged treatments removed more sawlog volume.
    - Across all ownerships, the uneven-aged treatment that removed the most large trees produced just under 30 billion ft^3 of sawlog volume. The uneven-aged treatment produced 7 billion ft^3 of sawlog volume.

    - Across all ownerships, the uneven-aged treatment that removed the most large trees placed 62% of treatable acres above our hazard targets. The uneven-aged treatment placed 91% of treatable acres above our hazard targets.
- Without limits on the amount of basal area removed on low-severity forest types at the plot level, all treatment alternatives placed virtually every treatable acre above our hazard targets.
    - Across all ownerships, the uneven-aged treatment that removed the most large trees produced 35 billion ft^3 of sawlog volume. The even-aged treatments produced 8 billion ft^3 of sawlog volume.
    - Across all ownerships, the simulation algorithm was able to find the optimal prescription for each plot for each treatment in almost every instance. Since there was no constraint on removals, over 99.5% of treatable acres were able to achieve our hazard targets.
- A West-wide comprehensive program for mechanical fuel treatments, combining an uneven-aged removal-limited treatment for low-severity forest types and an even-aged removal-limited treatment for high-severity forest types
    - Balances feasibility, hazard reduction, and removal volume.
    - Produced 31 billion ft^3 of sawlog volume across all ownerships and 19 billion ft^3 of sawlog volume on federal ownership.
    - Placed 58% of treatable acres on all ownerships above our hazard targets.
- The correlation between Fire Regime Condition Class and our hazard classifications was very low. This suggests that caution should be used in applying coarse-scale ratings at the plot level and/or that our assignment of hazard does not reflect the departure from historical conditions.

Key Finding #5: Mean fuel harvesting costs ranged from $620 per acre to $3,535 per acre. This large range was due mostly to the very expensive cases where cable yarding systems were required. Median costs were lower. (Attachments 3 and 4)

- Two harvest cost models, STharvest and the Fuel Reduction Cost Simulator (FRCS), were used to generate treatment costs with data from simulated removals on Forest Inventory and Analysis (FIA) plots in twelve Western states. These cost outputs and a set of predictor variables from the FIA plots enabled the estimation of a series of regression equations for harvest cost per acre.
- Variations in cost estimates were partly explained by the type of harvesting system employed, plot location and slope, stem density, and removal intensity across the diameter classes.
- Mechanical whole-tree harvesting operations were much cheaper on average than the other systems, followed by cut-to-length and manual-whole tree.
- Plot slope was statistically significant for all harvesting systems. For ground-based systems, each 1% increase in slope added $6 to $14 per acre. The contribution of slope to cost was smaller, or even slightly negative in some cases, for cable yarder systems.

- Harvesting costs increased as more trees were harvested and as larger trees were harvested. For ground-based systems, average per acre cost increased by \$2 to \$5 for each additional tree under 7” dbh that was removed and by \$14 to \$16 for each additional tree 13” dbh and larger that was removed. The relationship between tree size and average cost was not as clear for the cable yarder systems.
- Overall the results confirm that removing a large number of small stems, often on steep terrain, is far less economically efficient than removing fewer large trees with much more volume.

Key Finding #6: Reentry into treated stands for additional management may be necessary to maintain conditions within acceptable bounds. (Attachment 13)

- Projecting growth and regeneration following treatment allowed us to include long-term projections of fuel hazard after treatment. Projections were made for ponderosa pine and Douglas fir plots in Colorado in 5 year steps for a total of 25 years.
- Frequency distributions of treated area moving from one hazard category to another over the projection period permitted the creation of a set of transition matrices for each 5 year growth step. These transitions can be used in Markov chain analysis to understand the probability that a stand will attain an ending hazard condition given a starting hazard condition.
- With limits on basal area removed the even-aged treatments initially place more acres above our hazard targets. The gap between the treatments is quickly closed after only 5 years. After 25 years, there is little difference in the amount of treated area meeting our targets across the treatments.
- Without limits on basal area removed all treatment alternatives were able to place every treatable acre above our hazard targets. From +5 to +25 years post-treatment the uneven-aged treatments retain more treated area in condition. Average basal area per acre returns to pre-treatment levels within 15 to 25 years.
- Because all eligible land will not be treated at the same time, the return of treated stands into hazardous condition raises equity issues. If the program requires that all stands be treated once, then plots that grow into higher risk stands may be left untreated for many years. Alternatively, if the program requires that the highest risk be treated each year, some plots may receive multiple treatments, while others never get treated.

Key finding #7: Timber product output varies by state and forest type for all treatable government land in the western states. (Attachment 11)

- About 30 percent of the treatable government timberland in the Western states could be treated in first five years with annual subsidy (payments for treatments) of 1.5 billion U.S. dollars.
- Lodgepole pine, ponderosa pine and fir-spruce are projected to be major forest types treated in the West.

- Idaho, Montana, Oregon, Colorado are the states having large projected treatment areas on public timberland during the first five years.
- About 59% of the potential volume removals are sawtimber for all the public timberland treated.
- Among the projected total biomass removals from treatment, about 20% of the total biomass are trees less than 5-inch, and another 20% of the biomass is expected from trees 20-inch and above.
- The thinning methods using for fuel reduction treatment will significantly affect the composition of the timber product output.

Key finding #8: Requiring that all treatments be accomplished within 16 years significantly increases the welfare impacts and reduces the revenues to the government when modeled using FTM-West. (Attachments 2, 5 and 6)

- A partial equilibrium market model was developed which assumed (1) all treatments are accomplished within 16 years, (2) all treatments are either thin from below (TFB) or to specified level of stand density index (SDI) using the Fuel Treatment Evaluator, and (3) no subsidy, an administrative fee of $500/acre, and a harvest subsidy of $200/mcf were evaluated.
- The SDI scenarios had larger effects than the TFB scenarios on volume, prices and producer and consumer surplus. TFB treatments had larger (negative) effects on overall welfare because decreases in producer surplus outweighed the increases in consumer surplus. Subsidy made little difference to the TFB scenarios.
- The harvest subsidy alternatives had larger effects than the administrative fee alternatives.
- Subsidies seem unnecessary to achieve treatments in the coastal region, yet crucial to achieve goals in the interior region.

Key finding #9: The USDA Forest Service and the Department of Interior Bureau of Land Management have the authorities they need to address fire hazard reduction problem using existing policies. (Attachment 12)

DELIVERABLES

Proposed	Accomplished/Planned
Annual reports	Completed.
Mill distribution and demand surfaces for the western and southern U.S., by product	Completed. The mill maps and capacity information for all mill types and locations in the USA are available for download at http://www.srs.usda.gov/econ/mills/mill2005.htm.
Manuscripts that describe the methods and results of the research.	Completed: Abt, K.L. and J.P. Prestemon. 2006. Timber markets and fuel treatments in the Western U.S. Natural Resource Modeling 19(1):15-43. (Attachment 1) Ince, P.J., A. Kramp, H. Spelter, K. Skog, D. Dykstra. 2006. FTM-West: Fuel treatment market model for the U.S. West. In Proceedings of the Annual Southern Forest Economics Workshop. Baton Rouge, LA. April 20, 2005. In press. Available soon at http://sofew.cfr.msstate.edu/papers.html (Attachment 2) Arriagada, R., F.W. Cubbage and K.L. Abt. 2006. Estimating timber harvesting costs for fuel treatment in the West: Preliminary results. In Proceedings of the Annual Southern Forest Economics Workshop. Baton Rouge, LA. April 20, 2005. In press. Available soon at http://sofew.cfr.msstate.edu/papers.html (Attachment 3) Cubbage, F.W., R. Arriagada and G. Frey. 2006. Estimating harvest costs for applying fuel treatments to FIA plots. Final Report for Cooperative Agreement with North Carolina State University. (Attachment 4) Ince, P. and H. Spelter. 2006. Design and objectives of FTM-West model. In Proceedings of First Fire Behavior and Fuels Conference. March 28-30 2006. Portland, OR. (Attachment 5) Kramp, A. and P.J. Ince. 2006. FTM-West model results for selected fuel treatment scenarios. In Proceedings of First Fire Behavior and Fuels Conference. March 28-30 2006. Portland, OR. (Attachment 6) Skog, K.E. and R.J. Barbour. 2006. Estimating woody biomass supply from thinning treatments to reduce fire hazard in the U.S. west. In Proceedings of First Fire Behavior and Fuels Conference.

	March 28-30 2006. Portland, OR. (Attachment 7) Rummer, B.; Prestemon, J.P.; May, D.; Miles, P.; Vissage, J.S.; McRoberts, R.E.; Liknes, G.; Shepperd, W.D.; Ferguson, D.; Elliot, W.; Miller, S.; Reutebuch, S.E.; Barbour, J.; Fried, J.; Stokes, B.; Bilek, E.; Skog, K. and Hartsough, B. 2003. A strategic assessment of forest biomass and fuel reduction treatments in western states. http://www.fs.fed.us/research/pdf/Western_final.pdf Skog, K.E.; Barbour, R.J.; Abt, K.L.; Bilek, E.M.(Ted); Burch, F.; Fight, R.D.; Huggett, R.J.; Miles, P.D.; Reinhardt, E.D.; Shepperd, W.D. Evaluation of silvicultural treatments and biomass use for reducing fire hazard in western states. Research Paper FPL-RP-634. Madison, WI. USDA Forest Service, Forest Products Laboratory. 29p. Shepperd, W., K.L. Abt, R.J. Barbour, R. Fight, R.J. Huggett, P. Miles, E. Reinhardt, K. Skog. 2006. The fuel treatment evaluator – a silvicultural approach to reducing fire hazard. In Proceedings of Annual Society of American Foresters Meeting. October 19-23, 2005. Fort Worth, TX. Attachment 8.
	Planned: Forest Policy and Economics: Special Issue. Anticipated 2007. Articles include: • Huggett, R.J., Jr., W. Shepperd and K.L. Abt. The Spatial and Temporal Impacts of Mechanical Fuel Treatments on Wildfire Hazard Ratings in Colorado (Draft as Attachment 9) • Rummer, R. Costs of Technological Alternatives in Forest Operations for Fuel Reduction Treatment. • Prestemon, J.P., K. L. Abt, and R.J. Huggett, Jr. Spatio-temporal allocation and market impacts of subsidies for mechanical fuel treatments. (Draft as Attachment 10) • Ince, P. and others. The impacts of a national program of wildfire related fuel treatments on the wood processing sector of the western U.S. • Zhou, X. and R.J. Barbour. Timber Product Output Implications of a National Program of Mechanical Fuel Treatments Applied on Government Lands in the U.S. (Draft as Attachment 11) Arriagada, R. Chapter in PhD dissertation. Anticipated 2007. Barbour, R.J. and others. A discussion of policy issues with respect to mechanical fuel treatments. Anticipated for submission to a journal in 2007. (Draft as Attachment 12)

	Huggett, R.J. and K.L. Abt. Mechanical Fuel Treatments on Timberland in the Western United States and Their Impact on Wildfire Hazard Ratings. Anticipated for Southern Research Station publication as a general technical report in 2007. (Draft as Attachment 13)
Note: Additional publications will be forwarded to JFSP in both electronic and print format and acknowledgement of funding for this initial project will be included.	

TECHNOLOGY TRANSFER and COLLABORATION

Proposed	Accomplished
Collaboration not originally proposed	We collaborated with the Wood Utilization Opportunity Area analysis, including the development of the Fuel Treatment Evaluator, the designation of risk and the design of fire hazard reduction treatments. Several of our deliverables and presentations derive from this collaborative work.
Presentations	Completed: • Prestemon, J.P., K.L. Abt, and T.P. Holmes. 2002. The Economic impacts of fire risk-related biomass reductions on government lands. Symposium on Small Diameter Timber: Resource Management, Manufacturing, and Markets. February 25 - 27, 2002, Spokane, WA. • Prestemon, J.P. and K.L. Abt. 2003. The market economics of mechanical fuel treatments. Second International Wildland Fire Ecology and Fire Management Congress and Fifth Symposium on Fire and Forest Meteorology, November 16-20, 2003. Orlando, FL. • Huggett, R.J. Jr., J.P. Prestemon, K.L. Abt. 2005. Timber market impacts resulting from mechanical fuel treatments. IFORS. June 2005. Honolulu, Hawaii. • Ince, P. and H. Spelter. 2006. Design and objectives of FTM-West model. First Fire Behavior and Fuels Conference. March 28-30 2006. Portland, OR. • Kramp, A. and P.J. Ince. 2006. FTM-West model results for selected fuel treatment scenarios. First Fire Behavior and Fuels Conference. March 28-30 2006. Portland, OR. • Skog, K.E. and R.J. Barbour. 2006. Estimating woody biomass supply from thinning treatments to reduce fire hazard in the U.S. west. First Fire Behavior and Fuels Conference. March 28-30 2006. Portland, OR.

	• Ince, P.J., H.N. Spelter, M. Alderman, J. Ronca, I. Durbak, J.P. Prestemon. 2005. Economics of biomass removals-West model. Annual Southern Forest Economic Workshop. Baton Rouge, LA. April 20, 2005. • Prestemon, J.P., R.J. Huggett, Jr., K.L. Abt. 2005. The market economics of mechanical fuel treatments. Annual Southern Forest Economic Workshop. Baton Rouge, LA. April 20, 2005. • Huggett, R.J. Jr., K.L. Abt, K.E. Skog, W.D, Shepperd, E. Reihhardt, J. Barbour, P. Miles. 2005. Mechanical fuel treatments in the Western United States and their Impact on wildfire hazard ratings. Annual Southern Forest Economic Workshop. Baton Rouge, LA. April 20, 2005. • Abt, K.L., J.P. Prestemon and R.J. Huggett, Jr. 2005. Market impact of fuel treatment subsidies for fire hazard reduction in the Southern and Western US. Annual Southern Forest Economic Workshop. Baton Rouge, LA. April 20, 2005. • Arriagada, R., F.W. Cubbage, and K.L. Abt. 2005. Estimating timber harvesting costs for forest fuel reduction treatments in the west. Annual Southern Forest Economic Workshop. Baton Rouge, LA. April 20, 2005.
	Planned: Abt, K.L., Prestemon, J.P, and R.J. Huggett, Jr. Evaluating financial trade-offs between mechanical fuel reduction and prescribed fire treatment programs on national forests of the US West and South. Third International Fire Ecology and Management Congress, November 13-17, 2006. San Diego, CA Prestemon, J.P. K.L. Abt and R.J. Huggett, Jr. Balancing wildfire risk and markets in the design of cost effective mechanical fuel treatment programs. Society of American Foresters Annual Meeting, October 25-29, 2006. Pittsburgh, PA.
Small group meetings and consultations	USFS Northern Region Barry Bollenbacher, Mike Niccolucci, Dan Loeffler, Dave Calkin, David Atkins, Catherine Stewart Missoula, Montana May 10, 2006
	USFS Pacific Southwest Region and Station, Mark Nechodom and Bernie Bahro May 9, 2006
	USFS Fire and Aviation Management and Rocky Mountain Research Station, Rich Lasko, Greg Jones, Dave Calkin May 17 ,2006
Link to Fire and Fire Surrogates	This linkage was accomplished through Jamie Barbour who is an investigator on both projects. In addition, because our needs were for

program	broader scale models of costs and operations, we also developed a collaboration with Ken Skog, USFS Forests Products Lab.
Note: Abstracts of additional presentations and summaries of meetings and consultations will be forwarded to JFSP in both print and electronic format and acknowledgement of funding for this initial project will be included.	

CONTINUATION OF WORK

Proposed	**Anticipated**
Not part of the proposal.	Possible additional modeling may result from consultations and meetings including replacing our fire risk priorities with regionally defined priorities for fuel treatment.
	A feasibility assessment of a methodology to evaluate the costs and benefits of large scale treatment programs under conditions approximating real-world fire, climate vegetation and economic conditions. JFSP Proposal 06-3-2-24. This work will greatly expand the landscape detail for small areas and link to the market model for evaluation of long term economic costs and benefits of fuel treatment programs.
Note: Information on continuation of work funded originally by JFSP will be forwarded to JFSP in both print and electronic format, and acknowledgement of funding for this initial project will be included.	