Forestry-Based Biomass Economic and Financial Information and Tools:

An Annotated Bibliography

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Abstract

This annotated bibliography is a synthesis of information products available to land managers in the western United States regarding economic and financial aspects of forestry-based woody biomass removal, a component of fire hazard and/or fuel reduction treatments. This publication contains over 200 forestry-based biomass papers, financial models, sources of biomass and log price information, and biomass utilization facility locations.

Keywords: biomass, logging residues, annotated bibliography, Joint Fire Science Program, forest management

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Introduction

Forest vegetation treatments create large quantities of forest residue biomass, and policies at many forestland management agencies encourage biomass removal to achieve fire hazard and/or fuel reduction goals. Biomass includes non-merchantable portions of a merchantable tree (that is, tops and limbs) and non-merchantable small, whole-trees that are removed to meet management objectives. Following forest vegetation treatments, the most common methods of biomass disposal are in-woods pile or broadcast burning, which degrade local air quality and produce large amounts of unhealthy particulate matter, among other drawbacks. In geographic areas that have biomass utilization infrastructure, biomass can be removed from the landing and delivered to a utilization facility to be burned in boilers with emission control devices for energy production. However, markets for biomass are underdeveloped or non-existent in many areas throughout the western United States, and managers often find it difficult to quantify the biomass that will be removed during fire hazard or fuel reduction treatments.

In 2007, the Joint Fire Sciences Program (JFSP) conducted a roundtable discussion with a group of managers and scientists from partner agencies and stakeholder groups in order to better understand the issues, problems, and research needs related to utilizing biomass removed by fuels management projects. Decision-makers and planners stated they desire easy-to-use methods to evaluate the costs and revenues of implementing treatments that involve biomass removal. They want methods to compare costs with treatments that do not remove biomass, and they need ways to better understand biomass disposal options that are locally available and what those options mean to disposing different types of biomass. Having recognized that there are scattered bodies of literature pertaining to economic and financial aspects of biomass utilization, some of which are extensive, the JFSP roundtable members chose to sponsor this effort to synthesize existing information rather than to develop new research.

The overall goal of this JFSP-funded project (07-3-3-03) is to provide a synthesis of available information products to help managers understand and deal with the economic and financial aspects of woody biomass removal as a component of fire hazard and/or fuel reduction treatments. This report is a synthesis of the body of economic and financial biomass information, literature, models, tools, databases, and other information available to land managers in the western United States. Ideally, when information about innovative operational biomass handling, removal, and/or utilization practices and techniques is documented and shared, land managers may better plan and implement biomass removal treatments. The information contained in this bibliography fills the gaps between existing information and tools and managers' awareness of and ability to use those tools and information to promote biomass utilization in place of in-woods burning. This bibliography may also help managers address the issues and problems discussed above.

This bibliography includes web-based biomass-related resources, literature from peer-reviewed journals, USDA Forest Service publications, technical reports and releases, and white papers. It also includes the location and characteristics of biomass-utilizing facilities in several western states and website links to the types, tree sizes, and volumes of wood fiber those facilities purchase; the value of wood fiber delivered to those facilities; and GIS data depicting mill locations and biomass-utilizing facilities. The first section in this report lists biomass cost and volume estimator tools, models, and related information. The second section contains an annotated bibliography of forest biomass-related literature from a wide variety of publication outlets. The third section identifies website links to regional and national sources of biomass, lumber, and log prices. The fourth section identifies biomass utilization facility locations, and the fifth section contains other forestry-based, biomass-related information. The information contained in this manuscript is also available in a searchable database format at the JFSP-sponsored Fire Research and Management Exchange System (FRAMES) website: http://frames.nbii.gov/portal/server.pt.

Section 1: Models and Tools for Estimating Economic and Financial Aspects and Quantities of Forest Biomass

BIOPAK

Means, Joseph E.; Hansen, Heather A.; Koerper, Greg J.; Alaback, Paul B.; Klopsch, Mark W. 1994. Software for computing plant biomass—BIOPAK users guide. Gen. Tech. Rep. PNW-GTR-340. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 180 p.

Means, Joseph E.; Krankina, Olga N.; Jiang, Hao; Li, Hongyan. 1996. Estimating live fuels for shrubs and herbs with BIOPAK. Gen. Tech. Rep. PNW-GTR-372. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 21 p.

Annotation: BIOPAK is a software package that contains a plant measurement library of over 1100 documented equations that estimate plant components, for example, leaf mass, leaf area, stem wood mass, bark mass, and fuel size classes. BIOPAK can choose equations from those contained in an equation library using built-in assumptions based primarily on comparisons of plant dimensions, geographic area sampled, and seral stage sampled for input data and prediction equations. Alternatively, a user can direct the program to search a specific subset of the equation library or use a particular equation for particular input data. In this manner, equations from other species may be used for species in the data for which equations are unavailable.

Available: http://www.fsl.orst.edu/lter/data/tools/software/biopak.cfm?topnav=149.

Online database of model equations: http://andrewsforest.oregonstate.edu/data/abstract.cfm?dbcode=TP072&topnav=97.

BIOPAK manual: http://andrewsforest.oregonstate.edu/pubs/webdocs/reports/pub1659.pdf.

Data requirements: Runs with DOS-type commands. Biomass estimations are made for many species based on prescribed measurements such as diameter, stem length, and cover. The independent variables are equation- and species-specific.

Contact: Don Henshaw dhenshaw@fs.fed.us, henshaw@fsl.orst.edu, don.henshaw@oregonstate.edu

Last updated: Unknown

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Biomass Site Assessment Tool (BioSAT)

Annotation: The BioSAT model is used to identify the top 20 biomass facility locations for 13 southern U.S. states. The trucking cost model of BioSAT is used with Timber Mart-South 2009 (http://www.tmart-south.com/tmart/index.html) price data to estimate the total, average, and marginal costs for biomass facilities that use mill residues for up to 1.5 million dry tons of annual consumption. Costs in south Mississippi, southeast Georgia, southeast Oklahoma, southwest Alabama, and east Texas range from $25 to $38 per dry ton for up to 1.5 million annual dry tons. Additional research on BioSAT is forthcoming for 33 U.S. states. These studies will include more types of woody and agricultural biomass (for example, logging residues, pulpwood, and corn stover). Additional cost models for transportation such as truck combinations with rail and barge will be components of BioSAT.

Available: http://www.biosat.net.

Data requirements: Unknown; contact BioSAT for more information.

Contact: James H. Purdue: jperdue@fs.fed.us, Timothy M. Young: tmyoung1@utk.edu

Last updated: October 2009

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Coordinated Resource Offering Protocol (CROP)

Annotation: The USDA Forest Service and USDOI Bureau of Land Management undertook a series of CROP pilot projects as a means of addressing the growing fuel load problem within major forest systems and the realized potential for fostering catastrophic wildfires within these systems across the United States. Focused on biomass removal (versus biomass inventory), the CROP model was initially developed in 2003 to target unlevelized, uncoordinated, and erratic resource offerings from public forest lands at landscape scale. The key tenets of CROP projects are: facilitate coordination of biomass removal between public agencies; facilitate the use of long-term, multi-agency stewardship contracts to achieve biomass removal; increase the certainty of "levelized" biomass supply offerings

from public agencies; invite investment back into a sustainable forest management landscape; and heighten public trust and support for biomass removal from public lands by operating a transparent process.

Available: http://www.forestsandrangelands.gov/Woody_Biomass/supply/CROP/index.shtml.

Data requirements: None. Summaries of CROP projects already conducted are available on the website.

Contact: Ed Gee: eagee@fs.fed.us

Last updated: March 2009

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FIA BioSum

Fried, Jeremy S.; Christensen, Glenn; Weyermann, Dale; Barbour, Jamie R.; Fight, Roger; Hiserote, Bruce; Pinjuv, Guy. 2005. Modeling opportunities and feasibility of siting wood-fired electrical generating facilities to facilitate landscape-scale fuel treatment with FIA BioSum. Systems analysis in forest resources: proceedings of the 2003 symposium: 207-216.

Annotation: FIA BioSum is a concept-based methodology that generates cost estimates, identifies opportunities, and evaluates the effectiveness of fuel treatments in region-wide forested landscapes. The BioSum modeling framework incorporates a transportation cost model, a treatment cost accounting module, a log valuation model, and a crown fire hazard evaluator with Forest Inventory and Analysis plot data.

Available: www.fs.fed.us/pnw/fia/biosum.

Data requirements: Inventory plot data with expansion factors; road network with travel time per unit distance assigned to the road segments; silvicultural treatments coded in the Forest Vegetation Simulator; and product prices. Also, a raft of assumptions, such as filters on what characteristics lead to an acre being a candidate for treatment, definitions of hazard and hazard improvement, choice of logging systems, and objectives (for example, make money, improve fuel hazard, maximize material removed, or minimize material removed).

Contact: Jeremy Fried: jsfried@fs.fed.us

Last updated: February 2009

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Forest Residue Trucking Simulator (FoRTS)

Annotation: FoRTS is a spreadsheet-based calculator that is designed to help compare alternative methods of moving biomass from the forest to a wood-using facility. The program estimates loading and hauling costs for different combinations of equipment, evaluates the best mix (numbers and types) of equipment, compares different hauling routes, and examines reloading or two-stage hauling opportunities. FoRTS does not provide actual costs because it does not include factors such as profit and overhead. It is intended to represent a relative comparison among options.

Available: http://www.srs.fs.usda.gov/forestops/biomass.htm.

Data requirements: Road travel route description; biomass materials (for example, species and moisture content); and equipment selection (in-woods, transportation, or processing).

Contact: Jason Thompson: jasonthompson@fs.fed.us

Last updated: 2006

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Fuel Reduction Cost Simulator (FRCS)

Fight, Roger D.; Hartsough, Bruce R.; Noordijk, Peter. 2006. Users guide for FRCS: Fuel reduction cost simulator software. Gen. Tech. Rep. PNW-GTR-668. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 23 p.

Annotation: FRCS is a spreadsheet application useful for estimating the cost of forest operations undertaken to reduce forest fuel loads by cutting and removing trees for solid wood products or chips. It can also be used to estimate the cost of collecting and chipping forest residues. Cost assumptions can be modified by the user. The software contains four ground-based systems, four cable systems, and two helicopter systems. Cost estimates are in U.S. dollars per 100 cubic feet, per green ton, and per acre.

Available: http://www.fs.fed.us/pnw/data/frcs/frcs.shtml.

Data requirements: System and cut type, yard/skid/forward distance, percent slope, elevation, one-way move-in costs, green wood density, residue fraction, trees per acre cut, and average volume per tree.

Contact: Dennis Dykstra: ddykstra@fs.fed.us

Last updated: 2007

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Harvest Cost-Revenue (HCR) Estimator

Becker, Dennis R.; Larson, Debra; Lowell, Eini C.; Rummer, Robert B. 2007. User guide for HCR Estimator 2.0: Software to calculate cost and revenue thresholds for harvesting small-diameter ponderosa pine. Gen. Tech. Rep. PNW-GTR-748. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 51 p.

Annotation: The HCR Estimator is engineering and financial analysis software used to evaluate stand-level financial thresholds for harvesting small-diameter ponderosa pine in the southwest United States. The HCR can help contractors and planners identify costs associated with tree selection, residual handling, transportation of raw materials, and equipment use. Costs are compared against total financial return for regionally based market opportunities to calculate potential net profit. Information is used to identify per-acre cost thresholds for contract appraisal and for prioritizing project planning for wildfire fuel reduction treatments and forest restoration efforts.

Available: http://www.fs.fed.us/pnw/publications/gtr748.

Data requirements: Cut-tree data, harvesting system, equipment information, wage and benefit rates, equipment mobilization distance, simulated log and biomass markets and distance, overhead and indirect costs, and desired profit margin.

Contact: http://www.fs.fed.us/pnw/contact/index.shtml.

Last updated: 2008

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USDA Forest Service Region 6 Forest Products Web Page: Logging Systems and Economic Programs

Annotation: This website contains information, programs, and forms used to implement forest health maintenance, restoration, and improvement projects on the 19 National Forests in Oregon and Washington. The website houses many executable programs developed by the USDA Forest Service, and the software is public domain. Programs can only be installed on IBM-compatible machines.

Available: http://www.fs.fed.us/r6/nr/fp/FPWebPage/FP70104A/Programs.htm.

Data requirements: Variable; program specific.

Contact: Rick Toupin: rtoupin@fs.fed.us

Last updated: 2008

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USDA Forest Service Southern Research Station Moisture Content Converter

Annotation: This is an Excel spreadsheet that converts wood moisture contents from either dry basis to wet basis or wet basis to dry basis. The moisture content of biomass affects the gross weight of the material that is being handled. Green material will have a higher density than drier material because of the extra water weight in the cells of the wood. In biomass markets, it is important for all parties to have a common understanding of the dry mass of material that is being sold or processed. Generally, biomass loads are sampled for moisture content and then converted to a dry-basis measure such as "bone dry tons" or "bone dry units."

Available: http://www.srs.fs.usda.gov/forestops/downloads/MC_Converter.xls.

Data requirements: Percent moisture content to convert.

Contact: Jason Thompson: jasonthompson@fs.fed.us

Last updated: 2008

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USDA Forest Service Southern Research Station Biomass Heat Values by Tree Species

Annotation: Located at this website are tables of heat of combustion (Btu per ovendry pound) of stems and branches of 6-inch diameter breast height (DBH) trees from 22 hardwood species growing on southern pine sites. Heat value, or heat of combustion, is defined as the total amount of heat obtainable from ovendry material when burned in an enclosure of constant volume, allowing no deductions for heat losses. Heat value is useful to know when dealing with biomass.

Available: http://www.srs.fs.usda.gov/forestops/biomass.htm.

Data requirements: Species.

Contact: Jason Thompson: jasonthompson@fs.fed.us

Last updated: 2007

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WEBOFIRE

Annotation: WEBOFIRE links stand inventory data and visualizations with the Fire and Fuels Extension (http://www.fs.fed.us/fmsc/fvs/description/ffe-fvs.shtml) and the Fuel Characteristic Classification System (http://www.fs.fed.us/pnw/fera/fccs) to estimate fire and fuel potentials. WEBOFIRE provides users with estimates of fire hazard associated with existing forest conditions in terms of fire behavior potential, crown fire potential, and available fuel potential; estimates of the effectiveness of the selected treatment alternative in reducing hazard; and estimates of net revenue associated with the selected treatment alternative.

Available: http://webofire.cfc.umt.edu/webofire/%28bopuyhan54dkjjuo00x2puig%29/Default.aspx.

Data Requirements: Three options: (1) select stand by visualization, (2) enter stand inventory data (species, trees per acre by diameter class, height, and crown ratio), or (3) upload existing stand data (XML file).

Contact: webofire.support@cfc.umt.edu

Last updated: June 2009

Section 2: Biomass Production, Cost, and Related Literature

Abt, Karen L.; Prestemon, Jeffrey P. 2006. Timber markets and fuel treatments in the western US. Natural Resource Modeling. 19(1): 15-43.

Abstract: This paper presents a model of interrelated timber markets in the U.S. West in order to assess the impacts of large-scale fuel reduction programs on those markets and concomitant effects of the market on the fuel reduction programs. The model maximizes area treated, given fire regime-condition class priorities, maximum increases in softwood processing capacity, maximum rates of annual treatments, prohibitions on exports of U.S. and Canadian softwood logs from public lands, and a fixed annual treatment budget. Results show that the loss to U.S. private timber producers is less than the gains for timber consumers (mills).

Keywords: wildfire, mechanical treatments, spatial equilibrium, welfare

Geographic relevance: Western United States

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Alabama Forestry Commission. 2009. Woody biomass energy opportunities in Alabama. Montgomery, AL: Alabama Forestry Commission. **Available:** http://216.226.177.78/Biomass/Woody%20Biomass%20Energy%20Opportunities%20in%20Alabama.pdf.

Abstract: This publication provides information on the woody biomass materials available in Alabama, timber harvest and price trends, and per unit cost comparisons with traditional energy sources. It also contains references to information useful to investors when deciding whether or not to install wood-using energy systems. References are provided to manufacturers of wood-using energy systems, grant sources, tax credit incentives, and case studies of others who have installed successful systems.

Keywords: biomass, harvest cost, timber price

Geographic relevance: Alabama

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Angus-Hankin, C.; Stokes, B.; Twaddle, A. 1995. The transportation of fuelwood from forest to facility. Biomass and Bioenergy. 9 (1-5): 191-203.

Abstract: In spite of its simplicity, secondary transport is typically responsible for between 20 and 40 percent of the delivered fuel cost. To achieve a full payload within maximum allowable load dimension restrictions, the transported material must have a minimum bulk density of about 250 to 280 kg/m^3. While conventional forest products generally exceed this limit, fuelwood in an unprocessed form may have a bulk density of only 120 to 150 kg/m^3. Processing fuelwood to a chip allows the use of standard transport systems that are designed to transport wood chips for the pulp sector. Major technological gains to improve the transport efficiencies of fuelwood are unlikely in the immediate future.

Keywords: wood fuel, residues, transportation, bulk density

Geographic relevance: Nondescript

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Arola, Rodger A.; Miyata, Edwin W. 1981. Harvesting wood for energy. Res. Pap. NC-200. St. Paul, MN: U.S. Deptartment of Agriculture, Forest Service, North Central Forest Experiment Station. 28 p.

Abstract: This paper illustrates the potential of harvesting wood for industrial energy, based on the results of five harvesting studies, and it presents information on harvesting operations, equipment costs, and productivity. It further discusses mechanized thinning of hardwoods, clearcutting of low-value stands, and recovery of hardwood tops and limbs and includes basic information on the physical and fuel properties of wood.

Keywords: logging, whole-tree chipping, fuelwood, mechanized thinning, clearcutting, residues

Geographic relevance: Michigan

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Arriagada, Rodrigo A.; Cubbage, Frederick W.; Abt, Karen Lee; Huggett, Robert J., Jr. 2008. Estimating harvest costs for fuel treatments in the West. Forest Products Journal. 58 (7/8): 24-30.

Abstract: The costs for harvesting timber for forest fire fuel reduction purposes were estimated for 12 states in the U.S. West. These simulation inputs

were used to estimate average costs for 12,039 Forest Inventory and Analysis plots in the West, and then that FRCS output was used develop regression equations that estimated costs as a function of small-, medium-, and large-sized trees per acre as well as slope. Ground-based, mechanical, whole-tree harvesting systems were cheapest in the areas where they could be used, with a mean cost of $620 per acre. The other three ground-based systems had mean costs that ranged from $958 to $1627 per acre. Cable yarder systems' mean costs were much more expensive at $2794 and $3535 per acre. The results indicate that fuel reduction harvests in the West are expensive, and the results provide magnitudes of these costs that can be used for planning and budgeting purposes for landowners and forestry professionals.

Keywords: fuel treatment, harvest cost

Geographic relevance: Western United States

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Ashmore, Colin; Sirois, Donald L.; Stokes, Bryce J. 1987. Evaluation of roll designs on a roll-crusher/ crusher/splitter biomass harvester: test bench results. Proceedings of the southern forest biomass workshop; 1986 June 16-19; Knoxville, TN. Muscle Shoals, AL: Tennessee Valley Authority: 113-116.

Abstract: An alternative to conventional methods of processing small-diameter trees for energy use is roll crushing/splitting. The concept involves crushing and splitting stems to expedite field drying and to facilitate handling. This method has been considered a feasible alternative for handling stems found in short-rotation harvesting. This paper reports on one of these objectives: the evaluation of roll designs by the Southern Forest Experiment Station for effectively feeding woody southern biomass into a set of crush rolls. For each of four roll designs, the specific objectives were to determine feeding efficiencies, crushing/splitting efficiencies, and operating restraints that would allow the greatest range of material to feed through the primary and secondary rolls.

Keywords: biomass, crushing, splitting

Geographic relevance: Canada

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Atkins, Dave; Rummer, Robert; Dodson, Beth; Thomas, Craig E.; Horcher, Andy; Messerlie, Ed; Rawlings, Craig; Haston, David. 2007. A report on conceptual advances in roll on/off technology in forestry. Missoula, MT: Smallwood News; 2007 October 8: 1-14.

Abstract: This report summarizes advances in forest-related roll on/off container technology. It also outlines several studies that tested the economic and environmental viability of these technologies. Hooklift-enabled trucks with roll on/off containers were found to make slash collection more efficient under certain conditions at remote landings. Also, several conceptual advances in roll on/off technology have been made, including the use of hooklift-enabled forwarders with roll on/off containers for slash and roll on/off bunks for logs. A multi-use grinder/processor boom attachment shows promise to make hooklift-enabled forwarders even more efficient for collecting slash and logs in the woods.

Keywords: biomass, roll on/off container, hooklift truck, forwarder

Geographic relevance: Montana

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Badger, Phillip C. 2002. Processing cost analysis for biomass feedstocks. Oak Ridge National Laboratory, Oak Ridge, TN. ORNL/TM-2002/199.

Abstract: The purpose of this study was to identify and characterize all the receiving, handling, storing, and processing steps required to make woody biomass feedstocks suitable for use in direct combustion and gasification applications, including in small modular biopower systems, and to estimate the capital and operating costs at each step. Since biopower applications can be varied, a number of conversion systems and feedstocks required evaluation. The boundaries of this study were from the power plant gate to the feedstock entry point into the conversion device.

Keywords: biomass, gasification, modular bioenergy, cost

Geographic relevance: United States

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Bain, Richard L.; Overend, Ralph P. 2002. Biomass for heat and power. Forest Products Journal. 52(2): 12-19.

Abstract: Bain and Overend provide a national history of biomass used for energy, a brief market and supply analysis, and a current status of technology, and they identify research needs.

Keywords: biomass, bioenergy history

Geographic relevance: United States

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Barger, Roland L. 1979. The forest residues utilization R&D program. In: Harvesting and utilization opportunities for forest residues in the northern Rocky Mountains: Symposium proceedings 1979; November 28-30; Missoula, MT. Gen. Tech. Rep. GTR-INT-110. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station: 5-16.

Abstract: This publication reports the results of research conducted by the Residues R&D Program in harvesting and utilization opportunities for forest residue. It also provides a record of proceedings of the three-day symposium that explored both research and industrial experience in residues utilization and a compendium of information useful to those involved or interested in improving the recovery and utilization of forest residues.

Keywords: forest residues, wood utilization, timber harvesting, forest practices

Geographic relevance: Intermountain and Northern Rocky Mountains

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Barger, Roland L.; Benson, Robert E. 1979. Intensive utilization with conventional harvesting systems. In: Harvesting and utilization opportunities for forest residues in the northern Rocky Mountains: Symposium proceedings 1979; November 28-30; Missoula, MT. Gen. Tech. Rep. GTR-INT-110. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station: 77-95.

Abstract: Field evaluations in this study included the use of in-woods chipping systems in gentle terrain, crawler skidder systems in gentle terrain, and skyline systems in steep terrain. In each situation, utilization standards ranged from conventional saw log utilization to near-total utilization of available fiber. Intensive utilization has been achieved concurrent with saw log harvesting, rather than through postharvest salvage. The total costs of harvesting merchantable material and residue together are partitioned to derive costs of residue recovery. Costs of recovery vary significantly among the case situations studied and vary with the method by which costs are allocated. Residue recovery costs commonly run $30 to $60 per dry ton.

Keywords: forest residues, timber harvesting, wood residues, utilization, logging systems, timber harvesting productivity

Geographic relevance: Rocky Mountain Region (Montana and Wyoming)

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Barnett, Paul E.; Sirois, Donald L.; Ashmore, Colin. 1986. Reduction of biomass moisture by crushing/splitting—A concept. In: Proceedings of the southern forest biomass workshop: 1985 June 11-14; Gainesville, FL. University of Florida: 13-16.

Abstract: A biomass crusher/splitter concept is presented as a possible means of maintaining rights-of-way or harvesting energy wood plantations. The conceptual system would cut, crush, and split small woody biomass, leaving it in windrows for drying. A subsequent operation would bale and transport the dried material for use as an energy source. A survey of 20 southern power companies shows the potential applicability of a biomass harvesting system. Drying characteristics and power requirements are presented for three southern tree species.

Keywords: biomass, crusher/splitter, baler

Geographic relevance: Canada and southeastern United States

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Baughman, Ronald K.; Stokes, Bryce J.; Watson, William F. 1990. Utilizing residues from in-woods flail processing. In: Stokes, B.J., ed. Proceedings of the International Energy Agency, task VI, activity 3 workshop: Harvesting small trees and forest residues; 1990 May 28; Copenhagen, Denmark. Auburn, AL: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station: 21-30.

Abstract: A tub grinder was employed to process debris discharged by a flail. The machine successfully passed the material through a 7.62-cm screen and discharged the reduced debris into a chip van for transport. It was found that fuel production is directly dependent upon the production of clean chips by the flail/chipper portion of the system and the available biomass of the stand. Clean chips were produced at 57 green tonnes per productive machine hour (PMH) with fuel yields of 14 to 21 green tones per PMH.

Keywords: biomass, grinder, chips

Geographic relevance: Oklahoma

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Becker, Dennis R.; Abbas, Dalia; Halverson, Kathleen E.; Jakes, Pamela J.; McCaffrey, Sarah M.; Moseley, Cassandra. 2009. Characterizing lessons learned from Federal biomass removal projects. Final report submitted to Joint Fire Science Program, 07-3-2-08. Boise, Idaho.

Abstract: The purpose of this study was to identify and assess biomass utilization challenges in different parts of the United States. The information collected through case studies was used to address persistent conventional wisdoms to biomass utilization that may help land managers better accomplish project objectives through informed planning and implementation. The information may also be used to illuminate particular barriers to biomass utilization that can be addressed through policy development at the local, state, or national level.

Keywords: biomass, policy

Geographic relevance: United States

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Benson, Robert E.; Schlieter, Joyce A. 1979. Residue characteristics in the northern Rocky Mountains. In: Harvesting and utilization opportunities for forest residues in the northern Rocky Mountains: Symposium proceedings 1979; November 28-30: Missoula, MT. GTR-INT-110. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station: 33-43.

Abstract: In the northern Rocky Mountains, 350 to 450 million cubic feet of logging residue is generated each year. Up to 60 percent of the residue material is technologically suitable for wood products; but condition, size, and product potential vary among forest types. Other factors that influence residue utilization are level of harvest, trends in wood processing, industrial uses, and economic conditions.

Keywords: forest residue, logging residue, utilization

Geographic relevance: Northern Rocky Mountains

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Benson, Robert E.; Johnston, Cameron M. 1976. Logging residues under different stand and harvesting conditions, Rocky Mountains. Res. Pap. INT-181. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 15 p.

Abstract: Volume and characteristics of logging residues from 34 clearcut and partial cut harvest areas are presented. Residue volumes ranged from almost 3600 cubic feet per acre down to 550 cubic feet per acre, depending on treatment. More than 60 percent of the residues were sound.

Keywords: biomass, logging residue, timber harvest

Geographic relevance: Montana, Wyoming, and Idaho

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Bergman R.; Zerbe, J. 2008. Primer on wood biomass for energy. (Rev. January 2008). Madison, WI: U.S. Department of Agriculture, Forest Service, State and Private Forest Technology Marketing Unit, Forest Products Laboratory. Available: http://www.fpl.fs.fed.us/documnts/tmu/biomass_energy/primer_on_wood_biomass_for_energy.pdf.

Abstract: This paper explains and describes the concepts of wood energy on a residential, commercial, and industrial scale in the United States so that the USDA Forest Service can help meet the demands of communities involved in the forest-products industry. In addition, terminology associated with this field is explained so that individuals can develop a basic understanding of and familiarity with technical terms common to bioenergy. Definitions specific to wood energy are given at the end of this report.

Keywords: biomass, forest products, bioenergy

Geographic relevance: United States

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Blackard, J.A.; Finco, M.V.; Helmer, E.H.; Holden, G.R.; Hoppus, M.L.; Jacobs, D.M.; Lister, A.J.; Moisen, G.G.; Nelson, M.D.; Riemann, R.; Ruefenacht, B.; Salajanu, D.; Weyermann, D.L.; Winterberger, K.C.; Brandeis, T.J.; Czaplewski, R.L.; McRoberts, R.E.; Patterson, P.L.; Tymcio, R.P. 2008. Mapping U.S. forest biomass using nationwide forest inventory data and moderate resolution information. Remote Sensing of Environment. 112: 1658-1677.

Abstract: This paper presents a spatially explicit dataset of aboveground live forest biomass made from ground-measured inventory plots for the conterminous United States, Alaska, and Puerto Rico. The plot data are from the USDA Forest Service, Forest Inventory and Analysis program. To scale these plot data to maps, models relating field-measured response variables to plot attributes serving as the predictor variables were used. The mapping models for the United States are segmented into 65 ecologically similar mapping zones, plus Alaska and Puerto Rico. The authors found there was a tendency in all regions for the models to over-predict areas of small biomass and under-predict areas of large biomass, not capturing the full range in variability.

Keywords: forest biomass, MODIS, classification and regression trees, forest probability, carbon, FIA

Geographic relevance: United States, Alaska, and Puerto Rico

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Bolding, M. Chad; Lanford, Bobby L. 2005. Wildfire fuel harvesting and resultant biomass utilization using a cut-to-length/small chipper system. Forest Products Journal. 55 (12): 181-189.

Abstract: This study examined and measured the feasibility of ground-based mechanical harvesting to reduce forest fuel buildup and produce energywood. This study shows that a cut-to-length harvesting system coupled with a small, in-woods chipper provided a low impact way to harvest pre-commercial trees and tops along with merchantable logs. A smaller, less expensive chipper allowed operations to stay small and more efficient when compared to a larger operation and grinder. Productivity and cost results showed that the system was capable of harvesting non-merchantable trees and utilizing non-merchantable portions of merchantable-sized trees as energywood chips.

Keywords: biomass, chipper, timber harvest

Geographic relevance: Alabama

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Brinker, Richard W.; Tufts, Robert A. 1989. Whole-tree chipping in the southern United States. In: Stokes, B.J., ed. Proceedings of the International Energy Agency, task VI, activity 3 symposium: Harvesting small trees and forest residues; 1989 June 5-7; Auburn, AL: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station: 140-149.

Abstract: This paper provides a general overview of chipping wood for pulp and energy wood including fuel chip production costs, problems, innovations, and system designs.

Keywords: biomass, chipper, harvest cost

Geographic relevance: Southern United States

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Brown, James K. 1978. Weight and density of crowns of Rocky Mountain Conifers. Res. Pap. INT-197. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 56 p.

Abstract: Relationships between live and dead crown weight and DBH, crown length, tree height, and crown ratio are presented for 11 Rocky Mountain conifers. Also included are partitioned estimates of crown foliage and branchwood. This study shows a high correlation between DBH and crown weight.

Keywords: tree biomass, crown sampling, crown weights, forest fuels

Geographic relevance: Northern Rocky Mountains (Idaho and Montana)

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Brown, James K. 1976. Predicting crown weights for 11 Rocky Mountain conifers. Working part on forest biomass, International Union of Forest Research Organizations congress; 1976 June 22; Oslo, Norway. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station: 103-115.

Abstract: For 11 conifer species in the Rocky Mountains, the best-fitting regression relationships between live and dead crown weight and DBH, crown length, tree height, and crown ratio were determined. Also determined were fractions of crown weight in foliage and branchwood diameter classes.

Keywords: tree biomass, crown sampling, crown weights, forest fuels

Geographic relevance: Northern Rocky Mountains (Idaho and Montana)

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Brown, James K.; Kendall Snell, J.A.; Bunnell, David L. 1977. Handbook for predicting slash weight of western conifers. Gen. Tech. Rep. INT-GTR-37. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 35 p.

Abstract: Procedures are provided for predicting weights of slash using tables of either slash weight per tree by DBH or slash weight per square foot of tree basal area by DBH. Slash weights include crowns and non-merchantable bole tips to 3- to 6-inch diameters. Slash can be predicted for material less than and greater than 3-inch diameters.

Keywords: tree biomass, slash, forest fuels

Geographic relevance: Northern Rocky Mountains (Idaho and Montana)

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Calkin, David; Gebert, Krista. 2006. Modeling fuel treatment costs on Forest Service lands in the western United States. Western Journal of Applied Forestry. 21(4): 217-221.

Abstract: This report was intended to increase the accuracy of cost data available for planning and prioritizing fuel management in National Forests. A survey of fire management officers was used to develop regression models that may be used to estimate the cost of hazardous fuel

reduction treatments. The model is based on USDA Forest Service Region, biophysical setting, treatment type, and design. The authors found that treatment size described the largest amount of variation in cost per acre, with increased size reducing cost per acre, on average.

Keywords: fuel treatments, prescribed burning, economics

Geographic relevance: Continental United States

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Cleaves, David; Martinez, Jorge; Haines, Terry. 2000. Influences on prescribed burning activity and costs in the National Forest system. Gen. Tech. Rep. SRS-GTR-37. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 34 p.

Abstract: This study covers the results of survey concerning National Forest System prescribed burning activity and costs from 1985 to 1995. Four types of prescribed fire were looked at, including slash reduction; management-ignited fires; prescribed natural fires; and brush, grass, and rangeland burns. Ninety-five of 114 national forests responded to the survey, providing rankings of importance for 9 resource enhancement targets, 14 possible barriers to burning, and 12 factors that influence burning costs. Furthermore, respondents were asked to anticipate burning levels over the next 10 years and what burning levels would be needed to achieve the desired management goals on National Forest System lands.

Keywords: ecosystem management, environmental laws, hazard reduction, management ignited fire, national forests, prescribed natural fire

Geographic relevance: United States

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Clark, A.; Saucier, J.R. 1990. Table for estimating total-tree weights, stem weights, and volumes of planted and natural southern pine in the southeast. Georgia Forestry Commission, Forest Research Paper 79. 23 p.

Abstract: This article has tables and equations that can be used to estimate total-tree weights, stem weights, and volumes of plantation-grown loblolly and slash when DBH and height to a 4-inch top or total height are known.

Keywords: tree biomass, tree weight, stem weight, forest fuels

Geographic relevance: Mid-Atlantic and Southeast United States

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Clark, A.; Saucier, J.R.; McNab, W.H. 1986. Total-tree weight, stem weight, and volume tables for hardwood species in the Southeast. Georgia Forestry Commission, Forest Research Paper 60. 44 p.

Abstract: This paper is a summary of the cooperative research with the USDA Forest Service, Southeastern Experiment Station and the Georgia Forestry Commission. Together, members of the agency conducted a study to develop reliable weight and volume equations and tables for the hardwoods in the Southeast that are commercially important. The tables and equations can be used to estimate the green weight of wood and bark and volume of wood excluding bark in the total tree, stem to a 4-inch top, and stem to sawlog top. The tables and equations contain estimates for numerous commercially viable southeastern hardwood species.

Keywords: tree biomass, tree weight, stem weight, forest fuels

Geographic relevance: Southeast United States

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Conner, Roger C.; Adams, Tim O.; Johnson, Tony G. 2009. Assessing the potential for biomass energy development in South Carolina. Res. Pap. SRS-46. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 19 p.

Abstract: This paper provides an assessment of the potential for developing a sustainable biomass energy industry in South Carolina. Several possible sources of biomass were analyzed: unutilized logging residue and standing residual inventory trees on acres with tree harvesting, commercial thinning, precommercial thinning on overstocked natural sapling/seedling stands, mill residue, and urban wood waste. A range of prices from $20 to $30 per ton was established using surveys sent to South Carolina's timber producers (2008 market conditions). The estimates of potential biomass distributed across these price points rose from 4.8 million tons to a total of 16.5 million tons annually. Nearly 7.7 million tons are being utilized. New facilities that use wood to produce energy could capitalize on the 8.8 million annual tons of unutilized biomass and operate without overly impacting existing forest industries or increasing harvest levels above 2006 estimates.

Keywords: biofuel, biomass markets, FIA, forest landowner, green tons, hardwood poletimber, haul distance, softwood poletimber, timberland

Geographic relevance: South Carolina

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Daugherty, Peter J.; Fried, Jeremy S. 2007. Jointly optimizing selection of fuel treatments and siting of forest biomass-based energy production facilities for landscape-scale fire hazard reduction. INFOR. 45(1): 17-30.

Abstract: This study was conducted to look into landscape-scale fuel treatments for forest fire hazard reduction that can potentially produce large quantities of material suitable for biomass energy production. The analytic framework FIA BioSum addresses this situation by developing detailed data on forest conditions and production under alternative fuel treatment prescriptions and by computing haul costs to alternative sites where forest biomass-based energy production facilities could be constructed. This research presents a joint-optimization approach that simultaneously selects acres to be treated by fuel treatment prescription and assigns bioenergy production facility locations and capacities. Effects of alternative fuel treatment policies on fuel treatment effectiveness, economic feasibility, material produced, generating capacity supported, and the location and capacity of assigned facilities are evaluated.

Keywords: joint optimization, spatially explicit facility siting, forest biomass energy

Geographic relevance: Central Oregon and northern California

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Demchik, Michael C.; Abbas, Dalia; Current, Dean; Arnosti, Don; Theimer, Myra; Johnson, Patty. 2009. Combining biomass harvest and forest fuel reduction in the Superior National Forest, Minnesota. Journal of Forestry. 107 (5): 235-241.

Abstract: The impact of combined biomass/fuel reduction harvests on the pools of forest fuels was analyzed in this paper to determine whether biomass harvest reduced the cost of mechanical fuel treatments. Two potential biomass harvest systems were tested in wildland-urban interface areas on the Superior National Forest in Minnesota. Both systems performed similarly in terms of cost and efficiency at harvesting biomass. It was found that the cost of biomass harvest was impacted by site conditions, forwarding distance, number of units harvested with one machine haul, number of machines that were hauled, acres harvested, and roundwood inclusion. Income from the sale of biomass did not cover the costs of harvest and delivery.

Keywords: energy, harvesting, cost assessment

Geographic relevance: Minnesota

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Dwivedi, Puneet; Alavalapati, Janaki R.R. 2009. Stakeholders' perceptions on forest biomass-based bioenergy development in the southern US. Energy Policy. 37 (5): 1999-2007.

Abstract: This study analyzes perceptions of four stakeholder groups regarding forest biomass-based bioenergy development in the southern United States. Results suggest that non-governmental organization representatives perceived rural development as an important opportunity. The government stakeholder group noted that less or no competition with food production and promoting energy security were major strength factors. Conversion technologies that are still under trial were identified as a major weakness by industry representatives. Representatives of academia felt that the competition from other renewable energy sources could be a major threat. Overall, all stakeholder groups were in favor of forest biomass-based bioenergy development in the southern United States.

Keywords: southern United States, forest biomass-based bioenergy development, stakeholders' perceptions

Geographic relevance: Southern United States

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Edman, F. Talmage. 1989. Small stem thinning in the Pacific Northwest with barking and chipping in the woods. In: Stokes, B.J., ed. Proceedings of the International Energy Agency, task VI, activity 3 symposium: Harvesting small trees and forest residues; 1989 June 5-7; Auburn, AL: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station: 126-130.

Abstract: This paper provides a brief history of the development of a system to economically thin overstocked, naturally seeded stands in the Pacific Northwest. It also provides a comparison of flail debarking efficiency in the woods with small alder systems with a pulp log debarker in a satellite yard.

Keywords: thinning, harvest cost

Geographic relevance: Puget Sound and Washington

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Emergent Solutions, Christopher Allen and Associates. 2003. Pre-feasibility assessment: Small diameter under (SDU) wood feedstock for a 10 MW co-generation facility at the Milltown dam site. Submitted to U.S. Department of Agriculture, Forest Service, State and Private Forestry, Montana Community Development Corporation, Bonner

Development Group. Available: http://www.mtcdc.org/news-events/reportspublications.html.

Abstract: This pre-feasibility assessment was conducted to explore the potential of using SDU wood from local forests as the feedstock for a 10 MW cogen plant concept at the Milltown Dam site. The assessment indicates that with green tags and Federal tax credit for renewable energy production, the highest likely price for the sale of electricity from the facility would be approximately $.077 per kWh. Typical generation costs in large-scale direct-fired biomass plants are $.09 per kWh. The assessment also indicates that sufficient woody biomass is physically available from local forests to meet the 84,000 BDT per year feedstock requirement of a 10 MW facility.

Keywords: biomass, biomass power, bioenergy, cogeneration

Geographic relevance: Montana

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Evans, Alexander M. 2008. Synthesis of knowledge from woody biomass removal case studies. Santa Fe, NM: The Forest Guild. 39 p.

Abstract: Woody biomass—usually logging slash, tops and limbs, or trees that cannot be sold as timber—is the lowest valued material removed from the forest and presents economic and logistic challenges. This report brings together 45 case studies of how biomass is removed from forests and used across the country to demonstrate the wide variety of successful strategies, funding sources, harvesting operations, utilization outlets, and silvicultural prescriptions.

Keywords: biomass, harvest cost, silviculture

Geographic relevance: United States

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Evans, Alexander M.; Perschel, Robert T. 2009. An assessment of biomass harvesting guidelines. Santa Fe, NM: The Forest Guild. 20 p.

Abstract: This report compares the guidelines for harvesting woody biomass from various states including Maine, Minnesota, Missouri, Pennsylvania, and Wisconsin. The biomass harvesting guidelines as well as this paper cover topics such as dead wood, wildlife, water quality, soil productivity, silviculture, and disturbance as it pertains to biomass removal.

Keywords: biomass, timber harvest

Geographic relevance: Northeast United States and Canada

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Eza, Douglas A.; McMinn, James W.; Dress, Peter E. 1984. Wood Residue Distribution Simulator (WORDS). Gen. Tech. Rep. SE-28. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station. 6 p.

Abstract: WORDS attempts to find a least-cost allocation of residues from local sources of supply to local sources of demand, given the cost of the materials, their distribution, and the distribution of demand. The results are useful in evaluating the feasibility of developing wood energy either for a sub-region in general or for specific locales. This paper gives an example of WORDS application to mill residues in the State of Georgia.

Keywords: energy, supply, demand, Georgia

Geographic relevance: United States

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Fahey, Thomas D. 1979. Value ranking for utilizing lodgepole pine residues. In: Harvesting and utilization opportunities for forest residues in the northern Rocky Mountains: Symposium proceedings 1979; November 28-30; Missoula, MT. Gen. Tech. Rep. GTR-INT-110. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station: 239-250.

Abstract: Relative values per ton of log input are developed for poles, corral poles, house logs, lumber, studs, veneer, chips, and fuel on a current market basis. The techniques to reevaluate on different markets are demonstrated. Product specifications, demand, and potential to salvage significant volumes are also addressed.

Keywords: residues, forest products, lodgepole pine, poles, house logs, lumber, veneer, chips

Geographic relevance: Rocky Mountain Region

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Faurot, James L. 1977. Estimating merchantable volume and stem residue in four timber species: ponderosa pine, lodgepole pine, western larch, Douglas fir. Res. Pap. INT-196. Ogden UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 55 p.

Abstract: This report presents tables and equations for estimating total cubic volumes of wood, wood residue, and bark for ponderosa pine, western larch, and Douglas-fir. The equations and tables provide a means for estimating wood and bark residue volumes from tops, bole sections, and smaller sub-merchantable

stems. Tables and equations can also be used to estimate total cubic volume for the size classes, species, and locales sampled.

Keywords: tree biomass, residue, bark, forest fuels

Geographic relevance: Montana

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

Abstract: This study evaluated restoration prescriptions for three widely occurring ponderosa pine stand conditions, and researchers determined to what level the value of product removal could finance the treatment costs. The article compares the cost in both terrain suitable for ground-based harvesting systems as well as in cable systems and with or without a roundwood/pulpwood market.

Keywords: biomass, harvest cost, pulp market

Geographic relevance: Northern Rocky Mountains

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Fiedler, Carl E.; Keegan, Charles E.; Morgan, Todd A.; Woodall, Christopher W. 2003. Fire hazard and potential treatment effectiveness: a statewide assessment in Montana. Journal of Forestry. 101(2): 7.

Abstract: This assessment of Montana used data collected from Forest Inventory and Analysis plots across Montana and is summarized by forest type, density, and structure. The focus of the analysis was ponderosa pine/Douglas-fir/dry mixed conifer forests that had historically seen low-intensity fires. Applying the Fire and Fuels Extension to the Forest Vegetation Simulator, crown fire hazard was modeled and two fire hazard reduction approaches, a thin from below approach and a comprehensive ecologically based treatment, were evaluated.

Keywords: fuel treatment, fire hazard, silviculture

Geographic relevance: Montana

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Fight, Roger D.; Barbour, James R. 2005. Financial analysis of fuel treatments. Gen. Tech. Rep. PNW-GTR-662. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 20 p.

Abstract: This paper discusses the My Fuel Treatment Planner software to show the effect treatment variables have on the cost and net revenue from fire hazard reduction treatments in dry forest types of the western United States. The study was meant to help design a hazard reduction treatment with cost estimation of four ground-based systems, four cable systems, and two helicopter systems.

Keywords: financial analysis, silviculture, fire, prescriptions, economics, fuel treatments

Geographic relevance: Western United States

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Fire Science Digest. 2009. Making biomass pay: obstacles and opportunities. Joint Fire Science Program, issue 6. Available: http://www.firescience.gov/Digest/FSdigest6.pdf.

Abstract: Getting woody biomass from the forest to the consumer is economically and logistically difficult, and efforts to make biomass utilization profitable have been disappointing so far. Joint Fire Science Program-funded researchers have found that, while there is no recipe for building a successful economy around forest biomass, certain elements are essential: commitment and budget support from land-management agency leaders, processing and transportation infrastructure, developed or potential markets, and the ability of community members to work together. The researchers' findings give land managers and community leaders a basis for assessing whether biomass utilization can be successful in their communities.

Keywords: biomass, bioenergy market, land management

Geographic relevance: United States

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Forest Guild. 2008. Woody biomass removal case studies. Santa Fe, NM: Forest Guild. Available: http://biomass.forestguild.org.

Abstract: These case studies show that all aspects of woody biomass removals, from markets to mechanization, are evolving. This report identifies the building blocks for successful biomass projects–including public involvement, partnerships with contractors, and judicious mechanization of harvesting operations–that are present in the management of many forests across the country.

Keywords: biomass, bioenergy market, timber harvest

Geographic relevance: United States and Alaska

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Forest Resources Association. 2007a. Adding a chipper to a treelength system for biomass collection. Technical Release 07-R-3. Rockville, MD. Available: http://www.forestresources.org.

Abstract: Forest Resources Association partnered with Langdale Industries of Valdosta, Georgia, to evaluate the performance of a tree-length Southern pine operation that added a small Conehead 565 chipper to chip material otherwise left in the woods. Three treatments were evaluated: in one treatment there was no attempt to harvest and chip unmerchantable material, but the other two treatments included unmerchantable material chipping. The crew produced an average of 8 loads of roundwood per day in the chipper treatments and 9 loads per day in the conventional treatments. A load of chips was produced for every 5 and 18 loads of roundwood in chipper treatments.

Keywords: biomass, chipper

Geographic relevance: Georgia

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Forest Resources Association. 2007b. Chipping biomass: a challenge in first thinnings. Technical Release 07-R-32. Rockville, MD. Available: http://www.forestresources.org.

Abstract: Forest Resources Association partnered with Langdale Industries of Valdosta, Georgia, to evaluate the performance of a tree-length Southern pine operation that added a small Conehead 570 chipper to chip material otherwise left in the woods. Two treatments were evaluated: a clearcut and a first thinning. The clearcut removed around 65 tons per acre of roundwood compared to 20 tons per acre in the first thinning. If only limbs and tops were chipped, the volumes per acre of biomass chips were similar: 3.8 tons per acre in the clearcut and 3.0 tons per acre in the thinning. When understory was also chipped, the volumes of biomass chips differed significantly. The clearcut produced 10.8 tons per acre when limbs, tops, and understory were chipped, compared to 20.0 tons per acre with this treatment in the first thinning.

Keywords: biomass, chipper

Geographic relevance: Georgia

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Forest Resources Association. 2008a. Gathering and transporting hogfuel from logging slash. Technical Release 08-R-28. Rockville, MD. Available: http://www.forestresources.org.

Abstract: This paper provides a brief description of how an Idaho logging contractor has developed an innovative collection and transportation method for gathering scattered logging slash and then processing and concentrating it into volumes more easily accessed by chip vans. Maneuverable, high-sided farm trucks with modified, easily latched rear gates collect the processed slash as the grinder moves along the road and then transport the material to a nearby road intersection or other location where typical 53-foot quad-axle chip vans can more efficiently turn themselves around and be loaded. A front-end loader fills each van with 8 to 12 loads.

Keywords: biomass, grinder, chip van

Geographic relevance: Idaho

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Forest Resources Association. 2008b. New sizing head for processing slash piles. Technical Release 08-R-29. Rockville, MD. Available: http://www.forestresources.org.

Abstract: Working with neighboring industrial forest landowners, Grays Harbor Paper in Hoquiam, Washington, has developed a new processor head to help secure additional hogfuel from existing logging slash piles. The processing head consists of a brush grapple with one chain saw mounted on each side, configured so that an operator can control each independently. When the operator picks up a full grapple of slash, he or she can trim the material sticking out at either side, creating shorter length stems and, ultimately, a denser material that is ready to transport.

Keywords: biomass, forest engineering, processor

Geographic relevance: Washington

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Fresco, Nancy; Chapin, Stuart F., III. 2009. Assessing the potential for conversion to biomass fuels in interior Alaska. Res. Pap. PNW-RP-579. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 56 p.

Abstract: The feasibility of switching from fossil fuels to wood energy in rural Alaskan villages in forested regions of interior Alaska were assessed in this study. This analysis demonstrated that conversion to biomass fuels is economically viable and socially beneficial for many villages across interior Alaska. Modeling results based on recent data on rural energy use, demographics, economics, and forest dynamics indicated that the installation costs of biomass systems would be recouped within 10 years for at least 21 communities in the region. In addition, results showed that all but the largest remote communities could meet all their electrical demand and some heating needs with a sustainable

harvest of biomass within a radius of 10 km of the village. Biomass conversion also offers potential social benefits of providing local employment, retaining money locally, and reducing the risk of catastrophic wildfire near human habitation.

Keywords: biomass fuel, carbon offset, interior Alaska, wood energy

Geographic relevance: Alaska

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Fried, J.S.; Christensen, G.; Weyermann, D.; Barbour, R.J.; Fight, R.; Hiserote, B.; Pinjuv, G. 2005. Modeling opportunities and feasibility of siting wood-fired electrical generating facilities to facilitate landscape-scale fuel treatment with FIA BioSum. In: Bevers, Michael; Barrett, Tara M., comps. Systems analysis in forest resources: Proceedings of the 2003 Symposium; 2003 October 7-9; Stevenson, WA. Gen. Tech. Rep. PNW-GTR-656. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 195-204.

Abstract: The FIA BioSum modeling framework that incorporates Forest Inventory and Analysis plot data, a transportation cost model, a treatment cost accounting module, a log valuation model, and a crown fire hazard evaluator was applied to a 28 million-acre study area of western Oregon and northern California. It was shown that with four 50 MW biomass-fueled power plants strategically distributed over the study area, up to 5.3 million acres could be effectively treated with net revenue of $2.6 billion, a merchantable yield of 9.5 billion cubic feet, and a biomass yield of 79 million green tons if net-revenue maximizing fuel treatments are selected.

Keywords: FIA, biomass, bioenergy

Geographic relevance: Western Oregon and northern California

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Gan, Jianbang; Smith, C.T. 2007. Co-benefits of utilizing logging residues for bioenergy production: The case for East Texas, USA. Biomass and Bioenergy. 31(9): 623-630.

Abstract: This study evaluated the co-benefits associated with utilizing logging residues for electricity production in East Texas, USA. The benefits evaluated included the value of carbon dioxide emissions displaced due to substituting logging residues for coal in power generation, reductions in site preparation costs during forest regeneration, and creation of jobs and income in local communities. Based on the 2004 Forest Inventory Analysis data and a 70 percent biomass recovery rate, annual recoverable logging residues in East Texas were estimated at 1.3 megatons (dry). These residues, if used for electricity production, would displace about 2.44 megatons of carbon dioxide. Removing logging residues would also save $200 to $250 per hectare in site preparation costs. Input-output modeling revealed that logging residue procurement results in about 1340 new jobs created and $215 million in value-added generated annually.

Keywords: forest residues, carbon value, site preparation costs, community impact, electricity

Geographic relevance: Texas

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Gibson, L. 2007. WMSP economic assessment. Conducted for WMSP multi-party monitoring FAO 2001. Global forest resources assessment. Forestry Paper 140. Rome, Italy: 75-80.

Abstract: The goal of this paper was to look into the Healthy Forests Initiative to find the economic impacts on the timber harvesting and processing industry in Arizona's White Mountain Region. The goal of the study was to obtain a factual and critical baseline that quantitatively describes changes in firms in the forest industries in the Region and that point out new ways that the area might capitalize on current and potential industry for more economic benefit from the forest cluster.

Keywords: HFRI, biomass

Geographic relevance: Arizona

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Gingras, J-F. 1995. Harvesting small trees and forest residues. Biomass and Bioenergy. 9 (1-5): 153-160.

Abstract: This report summarizes the progress achieved under the auspices of the activity "Harvesting small trees and forest residues" during 1992 to 1994. The work included literature reviews to assess potentially recoverable material as a function of harvesting system, analysis of factors affecting chipping quality and productivity, a comparison of firewood processing technologies, small tree and residue harvesting method reviews, a description of some prototype combination machines for recovering roundwood and forest biomass, and an update on multiple-tree handling harvester head development in the Nordic countries.

Keywords: harvesting, residues, forest biomass, firewood, multiple-tree handling

Geographic relevance: Canada, Finland, Norway, United Kingdom, and Sweden

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Gonsior, Michael J. 1979. Outlook for new harvesting technology. In: Harvesting and utilization opportunities for forest residues in the northern Rocky Mountains: Symposium proceedings 1979; November 28-30; Missoula, MT. Gen. Tech. Rep. GTR-INT-110. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station: 113-146.

Abstract: This paper analyzes harvesting as well as its role in the total forest management picture. Models are presented for testing the sensitivity of total management cost and the harvesting components of cost to alternative silvicultural, utilization, and other forest management objectives. These models were used to discern opportunities for new harvesting technology.

Keywords: logging systems, timber harvesting, forest management, cost modeling, new technology

Geographic relevance: Northern Rocky Mountains

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Grushecky, Shawn T.; Wang, Jingxin; McGill, David W. 2007. Influence of site characteristics and costs of extraction and trucking on logging residue utilization in southern West Virginia. Forest Products Journal. 57 (7/8): 63-67.

Abstract: In this study, the authors investigated the relationship between logging residue accumulations and site characteristics on 70 timber harvests in southern West Virginia. The average overall weight of wood residue remaining after timber harvest in the 14-county region was 10.4 tons per acre. Scenarios of residue extraction and trucking indicated a cost range of $58.20 per cunit or $94.30 per million board feet (MBF) to $193.10 per cunit ($312.80 per MBF). These results suggest that extracting residues to the landing during harvesting would be most cost-effective. Likewise, the use of grapple skidders and appropriate loading and trucking equipment would be more economical than other systems modeled.

Keywords: biomass, logging residue, timber harvest

Geographic relevance: West Virginia

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Hall, Richard B. 2008. Woody bioenergy systems in the United States. In: Zalesny, Ronald S., Jr.; Mitchell, Rob; Richardson, Jim, eds. Biofuels, bioenergy, and bioproducts from sustainable agricultural and forest crops: Proceedings of the short rotation crops international conference; 2008 August 19-20; Bloomington, MN. Gen. Tech. Rep. NRS-P-31. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station: 18.

Abstract: This paper describes how most wood bioenergy crop systems in the United States are still in the early stages of development, with a wide variety of approaches under test in different regions of the country. In the United States, dedicated wood biomass cropland is expected to increase to more than 2 million hectares with an average production rate of 18 tons per hectare. Another 334 million dry tons per year can come from forest residues and wood wastes. This short paper provides a few examples.

Keywords: adoption impediments, cultural systems, Populus, Salix, yields

Geographic relevance: United States (New York, Pacific Northwest, and Minnesota)

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Hampton, H.M.; Sesnie, S.E.; Dickson, B.G.; Rundall, J.M.; Sisk, T.D; Snider, G.B.; Bailey, J.D. 2008. Analysis of small-diameter wood supply in northern Arizona. Forest Ecosystem Restoration Analysis Project, Center for Environmental Sciences and Education. Flagstaff, AZ: Northern Arizona University. 210 p.

Abstract: This report describes how forest products businesses are likely to play a key role in achieving forest management activities to restore fire-adapted ponderosa pine ecosystems in northern Arizona by reducing treatment costs and providing economic opportunities through harvesting, processing, and selling wood products. A 20-member working group was put together to identify a level of forest thinning treatments as well as potential wood supply from restoration byproducts in northern Arizona. Study participants developed up-to-date, remote sensing-based forest structure data layers to inform the development of treatment scenarios and to estimate wood volume. If mechanical thinning occurred on 41 percent of the landscape analyzed, a total of 850 million cubic feet of wood byproducts from tree boles alone and an additional 8 million green tons from branches and other tree crown biomass would be available.

Keywords: biomass, treatment cost, GIS

Geographic relevance: Northern Arizona

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Han, H.; Halbrook, J.; Pan, F. 2008. Economic evaluation of a roll-off trucking system removing forest biomass resulting from shaded fuelbreak treatments. Submitted to U.S. Department of Agriculture, Forest Service, Eureka, CA. Arcata, CA: Humboldt State University. 28 p.

Abstract: This study shows that mechanical removal of slash has not been successfully implemented in many areas due to limited accessibility to sites and the high costs associated with slash collection and transportation. To address these issues, a roll-off truck paired with a small skid-steer loader was used to collect and transport slash to a centralized processing site where slash was ground as hogfuel for energy production. Financial analysis indicated that contractors can receive high rates of return on their invested capital after accounting for inflation and income taxes, but limited work opportunities are a concern for contractors.

Keywords: biomass, bioenergy, fuel treatment, forest fires, roll-off containers

Geographic relevance: Northern California

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Han, Han-Sup; Lee, Harry W.; Johnson, Leonard R.; Folk, Richard L.; Gorman, Thomas M. 2002. Economic feasibility of small wood harvesting and utilization on the Boise National Forest—Cascade, Idaho City, Emmett Ranger Districts. Moscow, ID: University of Idaho, College of Natural Resources, Department of Forest Products. 61 p.

Abstract: This report discusses opportunities for biomass energy in southwest Idaho, looking at the amount of biomass available and potential costs and economic feasibility of harvesting small-diameter trees. Biomass in this report is classified into three different potential sources: tops, limbs, and small stems (slash) generated from harvesting larger commercial timber; the volume generated from thinning younger stands; and chips, shavings, and sawdust generated from traditional manufacturing processes.

Keywords: biomass, timber harvest

Geographic relevance: Idaho

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Han, Han-Sup; Lee, Harry W.; Johnson, Leonard. 2004. Economic feasibility of an integrated harvesting system for small-diameter trees in southwest Idaho. Forest Products Journal. 54 (2): 21-27.

Abstract: Considered in this article is the economic feasibility of small wood thinning and utilization in order to reduce the risk of wildfire in the Interior Northwest of the United States. The major factors influencing economic feasibility were forest harvesting methods used, road accessibility and conditions, hauling distances to processing facilities, and the market price of thinning materials. This article also includes a detailed discussion of tree volume and potential product recovery in (roundwood/sawlog, clean chip, biomass fuel) with respect to a variety of harvesting methods (stump-to-truck, skyline, helicopter, and mechanized whole-tree) and their associated economic considerations.

Keywords: biomass, timber harvest, transportation

Geographic relevance: Idaho

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Hardy, Colin C. 1998. Guidelines for estimating volume, biomass, and smoke production for piled slash. Gen. Tech. Rep. PNW-GTR-364. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 28 p.

Abstract: Guidelines in the form of a six-step approach are provided for estimating volumes, oven-dry mass, consumption, and particulate matter emissions for piled logging debris. Seven stylized pile shapes and their associated geometric volume formulae are used to estimate gross pile volumes. The gross volumes are then reduced to net wood volume by applying an appropriate wood-to-pile volume packing ratio. Next, the oven-dry mass of the pile is determined by using the wood density, or a weighted-average of two wood densities, for any of 14 tree species commonly piled and burned in the western United States. Finally, the percentage of biomass consumed is multiplied by an appropriate emission factor to determine the mass of particulate matter (PM; PM10 and PM2.5) produced from the burned pile. These estimates can be extended to represent multiple piles, or multiple groups of similar piles, to estimate the particulate emissions from an entire burn project.

Keywords: fuel, emissions, piled slash, smoke management

Geographic relevance: Western United States

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Hartsough, Bruce R. 1989. Harvesting small stems and forest residues in the pacific southwestern United States. In: Stokes, B.J., ed. Proceedings of the International Energy Agency, task VI, activity 3 symposium: Harvesting small trees and forest residues; 1989 June 5-7; Auburn, AL: U.S. Department of Agriculture,

Forest Service, Southern Forest Experiment Station: 100-107.

Abstract: At the time of this paper, most forest residues were too expensive to recover but some materials were being chipped at the roadside. This paper describes biomass-powered generating facilities and the sources of materials for the plants in California at the time it was produced.

Keywords: biomass, bioenergy power plant, chipper

Geographic relevance: California

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Hartsough, Bruce R.; Stokes, Bryce J. 1990. Comparison and feasibility of North American methods for harvesting small trees and residues for energy. In: Stokes, B.J., ed. Proceedings of the International Energy Agency, task VI, activity 3 workshop: Harvesting small trees and forest residues; 1990 May 28; Copenhagen, Denmark. Auburn, AL: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station: 31-40.

Abstract: In this study, a database of North American harvesting systems was developed. Parameters for each system were site, material and product characteristics, equipment mix, and production rate. Onto-truck and delivered costs per green tonne and breakeven oil prices were developed using standard costing methods. Systems costs were compared over the ranges of piece size, volume per unit area removed, capital/labor ratio, and other variables. Feasibilities of various systems were also compared.

Keywords: biomass, bioenergy, timber harvest

Geographic location: North America

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Hartsough, Bruce R.; Drews, Erik S.; McNell, Joseph F.; Durston, Thomas A.; Stokes, Bryce J. 1997. Comparison of mechanized systems for thinning ponderosa pine stands and mixed conifer stands. Forest Products Journal. 47(11/12): 59-68.

Abstract: This article presents a comparative study of three systems used for thinning pine plantations and mixed conifer stands: whole-tree methods, cut-to-length systems, and hybrid systems. All three produced small sawlogs and fuel chips. Time-motion data were collected to predict cost per unit volume.

Keywords: biomass, time-and-motion

Geographic relevance: California

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Hartsough, Bruce R.; Zhang, Xiaoshan; Fight, Roger D. 2001. Harvesting cost model for small trees in natural stands in the interior northwest. Forest Products Journal. 51(4): 54-70.

Abstract: Data from numerous published studies were combined to estimate the costs of harvesting small trees in natural stands in the Interior Northwest of North America. This article discusses cost estimates for harvesting small trees in natural stands. The cost relationships for six harvesting systems were modeled. Specifically, four harvesting methods for gentle terrain were discussed (manual log-length, manual whole-tree, mechanized whole-tree, mechanized cut-to-length systems), and two harvesting methods for steeper terrain were discussed (manual log-length and mechanized cut-to-length systems).

Keywords: biomass, harvest costs

Geographic relevance: Inland Northwest United States

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Hazel, Dennis W.; Bardon, Robert E. 2008. Evaluating wood energy users in North Carolina and the potential for using logging chips to expand wood fuel use. Forest Products Journal. 58(5): 34-39.

Abstract: A survey to characterize the extent and nature of commercial-scale wood energy in North Carolina was sent to 200 primary wood-processing, secondary wood-manufacturing, and nonwood-processing facilities known to have used wood fuels in 2004. Ninety-four percent of responding facilities estimated their energy savings were 40 percent or greater after using wood energy instead of fossil fuels. Twelve percent of facilities were generating electricity and 22 percent expressed interest in exploring the feasibility of generating electricity. Results suggest most wood residues produced by wood-processing facilities in North Carolina are being used as fuel. Thus, expansion of wood energy must be based on use of logging chips or municipal woodwastes. The main constraints found for using logging chips as a fuel were price, moisture, dirt, and chip size. Facilities that purchase wood residues for fuel indicated a willingness to purchase logging chips at similar prices in the future.

Keywords: biomass, wood energy

Geographic relevance: North Carolina

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Henley, John W. 1979. Technical and economic aspects of harvesting dead lodgepole pine for energy. In: Harvesting and utilization opportunities for forest residues in the northern Rocky Mountains: Symposium proceedings 1979; November 28-30; Missoula, MT. Gen. Tech. Rep. GTR-INT-110. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station: 213-215.

Abstract: This study highlights the results of a study of the economic feasibility of harvesting dead lodgepole pine for fuel and products. Costs, production rates, and recoverable wood volumes were obtained from a three-month study of a whole-tree logging operation in which dead lodgepole was harvested for fuel and products.

Keywords: lodgepole pine, harvesting, energy, residues

Geographic relevance: Oregon

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Host, John R. 1979. Low capital investment logging systems. In: Harvesting and utilization opportunities for forest residues in the northern Rocky Mountains: Symposium proceedings 1979; November 28-30; Missoula, MT. Gen. Tech. Rep. GTR-INT-110. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station: 97-111.

Abstract: This report, part of a larger study of factors affecting the utilization of small trees, deals with the impact of capital investment on logging productivity. Equipment selling price is not an indicator of machine productivity. Translated into machine production costs, which do not include any wages, supervision, or overhead; it cost 12 to 48 cents to skid each piece, with higher costs associated with higher priced skidders. Ten skidders and 15 yarders were studied. The selling price of these machines ranged from $72,000 to $240,000. Yarding costs varied directly with selling price and ranged from $1.10 to $4.30 per piece and $5.77 to $23.90 per cunit.

Keywords: capital productivity, logging production, logging costs, yarding, skidding

Geographic relevance: Northern Rocky Mountains

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Howard, James. 1978. A technique for predicting logging residue volumes in the Douglas-fir region. Res. Pap. PNW-235. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 14 p.

Abstract: This report presents the findings of a study for determining the feasibility of predicting the volume of logging residue on clearcuts prior to harvesting. Data were collected from 160 clearcuts on USDOI Bureau of Land Management and USDA National Forest lands in western Oregon and western Washington. Multiple regression techniques were used to develop equations relating preharvest stand and economic characteristics to measured residue volumes. The regression procedure resulted in the development of individual equations for each of four Bureau of Land Management Districts in western Oregon. Separate equations were also derived for the National Forests in Oregon and Washington.

Keywords: residue measurements, clearcutting systems, computation, Oregon, Washington

Geographic relevance: Pacific Northwest (Oregon and Washington)

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Howard, James O. 1979. Wood for energy in the Pacific Northwest: An overview. Gen. Tech. Rep. PNW-GTR-094. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 28 p.

Abstract: The first section describes fuel values and significant processes used to generate various energy products from wood. Physical, technical, and economic availability of the wood resource is discussed in the second section. The paper concludes with an outline of some critical problems in handling wood and some socioeconomic factors that impact the production of energy from wood.

Keywords: biomass, bioenergy, wood utilization, Pacific Northwest

Geographic relevance: Pacific Northwest

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Hunter, M.E.; Shepperd, W.D.; Lentile, J.E.; Lundquist, J.E.; Andreu, M.G.; Butler, J.L.; Smith, F.W. 2007. A comprehensive guide to fuels treatment practices for ponderosa pine in the Black Hills, Colorado Front Range, and Southwest. Gen. Tech. Rep. RMRS-GTR-198. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 93 p.

Abstract: This paper presents recommendations for fuels treatments in ponderosa pine forests in the Southwest, Colorado Front Range, and Black Hills of

South Dakota stemming from a synthesis of existing knowledge in the peer-reviewed literature and discussions with fuels treatment practitioners. Specific treatments; the circumstances under which they can be applied; treatment effects; and recommendations related to where, how, and how often fuels treatments may be prescribed to achieve desired outcomes are described.

Keywords: southwest, Black Hills, ponderosa pine, wildfire, forest thinning, prescribed fire

Geographic relevance: Southwest United States, Colorado Front Range, and South Dakota Black Hills

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Hurteau, M.D.; Koch, G.W.; Hungate, B.A. 2008. Carbon protection and fire risk reduction: toward a full accounting of forest carbon offsets. Frontiers in Ecology and the Environment. 6(9): 493-498.

Abstract: This study looked into the carbon sequestering abilities of forests, and researchers found that policies in place promoted avoidable carbon releases and discouraged actions that would actually increase long-term carbon storage. After stand-replacing catastrophic fires moved through an area, the study found that thinning the area and implementing prescribed burns would have reduced the carbon dioxide release from live tree biomass by as much as 98 percent.

Keywords: biomass, carbon, prescribed fire

Geographic relevance: Western United States

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Hurteau, Matthew; North, Malcolm. 2009. Fuel treatment effects on tree-based forest carbon storage and emissions under modeled wildfire scenarios. Frontiers in Ecology and the Environment. 7(8): 409-414.

Abstract: This paper provides results of modeling the effects of eight different fuel treatments on tree-based carbon (C) storage and release over a century, with and without wildfire. Model runs show that after a century of growth without wildfire, the control stored the most C. However, when wildfire was included in the model, the control had the largest total C emission and largest reduction in live-tree-based C stocks. In model runs including wildfire, the final amount of tree-based C sequestered was most affected by the stand structure initially produced by the different fuel treatments. In wildfire-prone forests, tree-based C stocks were best protected by fuel treatments that produced a low-density stand structure dominated by large, fire resistant pines.

Keywords: carbon, wildfire, fuel treatments

Geographic relevance: Sierra Nevada (California)

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Ince, Peter J.; Henley, John W.; Grantham, John B.; Hunt, Douglas L. 1984. Costs of harvesting beetle-milled lodgepole pine in eastern Oregon. Gen. Tech. Rep. PNW-GTR-165. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 32 p.

Abstract: The cost of harvesting and recovering roundwood logs and whole-tree chips from small-diameter lodgepole pine infested by mountain pine beetle was studied in the Blue Mountains of eastern Oregon in 1979. The average cost of producing chips was $31.30 per ton, wet, delivered 50 miles from harvest sites. A gross energy balance indicates that energy required by harvesting was about 3.4 percent of the gross energy content of the delivered products.

Keywords: logging enterprise costs, lodgepole pine, wood utilization, energy, insect damage, forest products, mountain pine beetle

Geographic relevance: Oregon

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Jenkins, Jennifer C.; Chojnacky, David C.; Heath, Linda S.; Birdsey, Richard A. 2003. National scale biomass estimators for United States tree species. Forest Science. 49: 12-35.

Abstract: This report compiled all available diameter-based allometric regression equations for estimating total aboveground and component biomass, defined in dry weight terms, for trees in the United States. A modified meta-analysis based on the published equations to develop a set of consistent, national-scale, aboveground biomass regression equations for U.S. species was implemented. Equations for predicting biomass of tree components were developed as proportions of total aboveground biomass for hardwood and softwood groups. This analysis represents the first major effort to compile and analyze all available biomass literature in a consistent, national-scale framework.

Keywords: allometric equations, forest biomass, forest inventory, global carbon cycle

Geographic relevance: United States

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Johansson, J.; Liss, J.; Gullberg, T.; Bjorheden, R. 2006. Transport and handling of forest energy bundles—advantages and problems. Biomass and Bioenergy. 30(4): 334-341.

Abstract: This study shows that bundles (especially if dry) are cheaper to transport than fuel chips in road transport bins. The useful cargo space is the limiting factor for trucks when transporting dry material. Transport cost decreased until the moisture content reached the critical levels: below 40.9 percent for chips in road transport bins and below 44.7 percent for bundles on timber truck. However, there are also other advantages with a dryer material.

Keywords: bundle, forest fuel, main hauling, terminal, timber truck, road transport, road transport bins, transport cost, wood chips

Geographic location: Sweden

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Johnson, Leonard R. 1989. Recovery of woods residues in the Intermountain Region. In: Stokes, B.J., ed. Proceedings of the International Energy Agency, task VI, activity 3 symposium: Harvesting small trees and forest residues; 1989 June 5-7; Auburn, AL: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station: 11-31.

Abstract: At the time of this paper, it was found that residue recovery operations in the Intermountain Region were mostly experimental, as mill residue supplies were adequate for hogfuel demand. However, it was recognized that future wood fiber supplies and environmental concerns would provide incentives and markets for more residue recovery from the woods. This paper summarizes residue recovery research projects using a variety of equipment. Cost results are provided.

Keywords: biomass, residues, timber harvest

Geographic relevance: Montana, Idaho, Oregon, and Washington

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Johnson, L. 2002. Adapting conventional harvesting equipment to small diameter stands—The Fritz Experiments. In: Baumgartner, D.M.; Johnson, L.R.; DePuit, E.J., comps. and eds. Small diameter timber: resource management, manufacturing, and markets; 2002 February 25-27; Spokane, WA. Pullman, WA: Washington State University Cooperative Extension. MISC0509. 268 p.

Abstract: In this study, two units (one on steep slopes and one on gentle slopes) were harvested using variations to conventional harvesting systems in northeastern Washington. On the steep slope unit, cut-to-length processing and forwarding were observed in small-diameter timber. Adjacent stands were harvested using the cut-to-length processor and a feller-buncher but were transported to the landing with a cable yarder. On the gentle slope units, cut-to-length harvesting at 40-foot trail spacing was compared to whole-tree harvesting. Harvesting costs on the gentle slope units were significantly less than on the steep slopes. Whole-tree harvesting was the least costly system. On steep slopes, the lowest costs were observed with the cut-to-length processor and forwarder, followed by the costs of cable yarding and bunched logs uphill. The processing and bunching provided by the cut-to-length processor appeared to improve production of the cable yarder when handling small timber.

Keywords: cable-yarding, cut-to-length, whole-tree harvesting, small timber harvesting

Geographic relevance: Washington

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Johnson, Maxine C. 1979. Residue utilization and the regional economy. In: Harvesting and utilization opportunities for forest residues in the northern Rocky Mountains: Symposium proceedings 1979; November 28-30; Missoula, MT. Gen. Tech. Rep. GTR-INT-110. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station: 289-292.

Abstract: This paper describes the state of the wood products industry and the economy of western Montana in the late 1970s. Forty to 45 percent of the earnings in western Montana's basic or export industries at the time came from the wood products and paper industries. The author believed the future of forest industries in Montana depended mostly upon Montana's ability to compete in the national market and upon the availability of raw materials. The author also believed that increased residue use may be Montana's only chance of maintaining the forest industry at or near the level at the time this report was published.

Keywords: residues utilization, timber availability, Montana

Geographic relevance: Rocky Mountain Region and Montana

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Johnson, Morris C.; Peterson, David L. 2005. Forest fuel treatments in western North America: Merging silvicultural and fire management. The Forestry Chronicle. 81(3): 365-368.

Abstract: In order to accomplish complex and multiple management objectives related to forest structure, fuels, and fire disturbance, silviculture and fire management must be effectively integrated in science and practice. The authors linked scientific and management tools to develop an analytical approach that allows resource managers to quantify and evaluate the effectiveness of alternative fuel treatments in dry interior forests of western North America.

Keywords: fire behavior, fire hazard, fuel treatments, silviculture

Geographic relevance: Western United States

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Keegan, Charles E., III. 1979. The economic availability of forest residue in the northern Rocky Mountains: a preliminary analysis. In: Harvesting and utilization opportunities for forest residues in the northern Rocky Mountains: Symposium proceedings 1979; November 28-30; Missoula, MT. Gen. Tech. Rep. GTR-INT-110. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station: 55-63.

Abstract: The goal of this project was to estimate the cost of harvesting and transporting forest residues to processing centers in the northern Rocky Mountains. Regionwide estimates were to be made based on the detailed analyses of the volumes and types of forest residues available to selected individual manufacturing centers. The results of the analysis of the first manufacturing center are presented in this paper. The initial study area selected was Lincoln County, Montana, with Libby, Montana, as the processing center. It appears from the analysis that substantial volumes of logging residue material would be available at a cost that would allow for its use in fuel and reconstituted wood fiber products as well as solid wood products.

Keywords: residue availability, residue utilization, residue cost

Geographic relevance: Montana

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Keegan, C.E.; Niccolucci, M.J.; Fiedler, C.E.; Jones, J.G.; Regel, R.W. 2002. Harvest cost collection approaches and associated equations for restoration treatments on National Forests. Forest Products Journal. 52(7/8): 96-99.

Abstract: This article provides several harvest cost estimation methods for forest managers. Methods discussed include elements of stump-to-truck timber harvest cost estimation methods in ecosystem restoration prescriptions. Particular attention is given to cost estimation models for tractor and skyline systems in Montana with additional focus on cost variances incurred at different tree diameters and skidding/yarding distances.

Keywords: fuel treatments, harvest costs

Geographic relevance: Montana

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

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, mature ponderosa pine/Douglas-fir, second-growth pine/fir, and mixed conifer). Average harvest costs for New Forestry prescriptions ranged from no increase to 48 percent ($72 per million board feet [MBF]) higher. In light of stumpage price increases of >$200 per MBF since 1991, these increased costs should be a minor factor in determining the feasibility of future timber harvest.

Keywords: silviculture, harvest costs, logging systems

Geographic relevance: Montana

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Kellogg, L.D.; Bettinger, P. 1994. Thinning productivity and cost for a mechanized cut-to-length system in the Northwest Pacific coast region of the USA. Journal of Forest Engineering. 5(2): 43-54.

Abstract: This production study of the single-grip harvester and forwarder combination focused on delay-free productive machine hour rates in a second growth thinning operation in western Oregon. Rates of production of "marked by forester trees" and trees "selected by machine operator" are discussed as well as specific

techniques of forwarder operation in relation to site conditions.

Keywords: mechanized logging, single-grip harvester, forwarder, logging cost, thinning productivity

Geographic relevance: Pacific Northwest (Oregon)

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Kelsey, Rick G.; Shafizadeh, Fred. 1979. Chemical characteristics of wood residues and implications for utilization. In: Harvesting and utilization opportunities for forest residues in the northern Rocky Mountains: Symposium proceedings 1979; November 28-30; Missoula, MT. Gen. Tech. Rep. GTR-INT-110. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station: 203-221.

Abstract: In the Northern Rocky Mountains, where dry or cold conditions predominate, woody residues remain sound without visual signs of decomposition for many years. The chemical composition of this weathered material does not change significantly and it can be utilized like greenwood. Since wood and woody residues are heterogeneous, there are two basic approaches to its chemical utilization: (1) whole wood processing and (2) separation of the heterogeneous components followed by processing. The chemical utilization of woody residues is almost limitless, the major barrier being economics rather than technology.

Keywords: residue utilization, wood composition

Geographic relevance: Northern Rocky Mountains

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Kerstetter, James D. 1979. Review of biomass gasification. In: Harvesting and utilization opportunities for forest residues in the northern Rocky Mountains: Symposium proceedings 1979; November 28-30; Missoula, MT. Gen. Tech. Rep. GTR-INT-110. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station: 223-236.

Abstract: This paper reviews the topic of biomass air gasifiers. The gasification process chemistry is outlined and the operating characteristics of two types of gasifiers are presented. A few typical applications are discussed and the economics for a particular system are presented in comparison with the costs of natural gas. Finally, the appendix gives a list of biomass research, demonstration projects and manufacturers.

Keywords: gasification, biomass fuel

Geographic relevance: United States

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Kirkland, Larry A.; Steinhagen, H. Peter; Campbell, Alton G. 1991. The University of Idaho wood-fired boiler: A case study. Forest Products Journal. 41(6): 54-56.

Abstract: The University of Idaho converted its campus steam generating plant from natural gas to wood residue fuel. The combustion system typically burned chipped or hogged wood fuel 2 inches or less at 35 to 50 percent moisture content (wet basis). Pre-dried fuel was used initially but the fraction of fines caused operating and emissions problems. High quality, low moisture content fuel purchased in the summer was blended with wet hogfuel during the winter when steam loads were high. The wood-fired unit net fuel cost savings of several hundred thousand dollars a year.

Keywords: biomass, hogfuel, biomass boiler

Geographic relevance: Idaho

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Klepac, John; Rummer, Bob; Thompson, Jason. 2006. Evaluation of a cut-to-length system implementing fuel reduction treatments on the Coconino National Forest in Arizona. In: Chung, W.; Han, H.S., eds. The 29th council on forest engineering conference, Coer d'Alene, ID: U.S. Department of Agriculture, Forest Service, Southern Research Station: 405-414.

Abstract: Time-and-motion-derived production and costs were estimated for a cut-to-length system while implementing fuel reduction treatments in two stands on the Coconino National Forest in Arizona. Product recovery and fire behavior within each stand were also examined. Time-and-motion data collected revealed the harvester produced 33 cubic feet per productive machine hour while harvesting biomass. Biomass unit costs were $9.62 per cubic foot while harvesting biomass.

Keywords: fuel reduction, time-and-motion, timber harvest

Geographic relevance: Arizona

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Lambert, Michael B. 1989. Harvesting small stems and forest residues in the Pacific Northwestern United States. In: Stokes, B.J., ed. Proceedings of the International Energy Agency, task VI, activity 3 symposium: Harvesting small trees and forest residues; 1989

June 5-7; Auburn, AL: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station: 90-99.

Abstract: This paper addresses the imbalance of unused resources, costs of onsite fuel treatment, electrical power demands, technology and economic deficiencies in harvesting and transportation, and the shrinking average size of trees being harvested. In this paper, two examples of integrated harvesting systems that produce energy wood and emphasize decisive allocation of the entire above-ground tree biomass are discussed. The processing systems and reasons for their approach are also discussed.

Keywords: biomass, harvesting systems, wood energy

Geographic relevance: Pacific Northwest

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Leenhouts, Bill. 1998. Assessment of biomass burning in the conterminous United States. [Online]. Conservation Ecology. 2(1). Available: http://www.consecol.org/vol2/iss1/art1.

Abstract: Wildland fire has been an integral part of the landscape of the conterminous United States for millennia. Analysis of contemporary and pre-industrial conditions, using potential natural vegetation, satellite imagery, and ecological fire regime information, shows that wildland fires burned 35 to 86 by 106 Mha annually in the pre-industrial era, consuming 530 to 1230 Tg of biomass. At present, in comparison, 5 to 7 Mha per year burn, consuming 77 to 189 Tg of biomass annually. For each era, 11 biomass (wildland and agricultural) burning emissions were estimated and differences of similar magnitude were found. Estimates of contemporary fossil fuel emissions are also provided for comparison. Atmospheric, climatic, social, and ecological system effects from the decrease in area burned, biomass consumed, and emissions produced are discussed.

Keywords: air quality, biomass burning, climate change, conterminous United States, emission estimates, fire regimes, pre-industrial conditions, prescribed burning, wildland fire.

Geographic relevance: Continental United States

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Leicht, Richard E. 1979. Intermountain Region wood utilization and wood energy application program. In: Harvesting and utilization opportunities for forest residues in the northern Rocky Mountains: Symposium proceedings 1979; November 28-30; Missoula, MT. Gen. Tech. Rep. GTR-INT-110. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station: 217-221.

Abstract: In 1978, the USDA Forest Service initiated a National Wood Utilization and Wood Energy Application Program to focus attention on application of existing and developing technology. In this paper, the mission and goals of this program are discussed. Additionally, problems such as access, economic feasibility, and long-term guarantees are discussed. The benefits and hazards of utilizing forest residues are summarized and the paper closes with mention of the USDA Forest Service and Regional commitment and the future opportunities (at the time the paper was written) for wood energy.

Keywords: wood energy, wood residues, firewood, wood utilization

Geographic relevance: Northern Rocky Mountains

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Loeffler, Dan; Calkin, David E.; Silverstein, Robin P. 2006. Estimating volumes and costs of forest biomass in western Montana using forest inventory and geospatial data. Forest Products Journal. 56(6): 31-37.

Abstract: This report studied the feasibility of using biomass for renewable energy production as an alternative to onsite burning. Due to the relatively low value of biomass, accurate estimates of volumes and costs of collection and transport are necessary if investment in this type of renewable energy production will be possible. Through the use of forest inventory data, remotely sensed data, and spatial data of Ravalli County in Western Montana, it was determined that 12 to 14 green tons per acre of biomass are potentially available for biomass energy production at a reasonable delivered cost. A spatial framework for estimating biomass volumes and costs is established in this article utilizing publicly available forest inventory and remotely sensed data for Ravalli County, Montana. This study identified 67,000 acres of forestland where a fuel reduction treatment could potentially deliver renewable biomass to the county at reasonable delivered costs.

Keywords: biomass, harvest costs, biomass availability

Geographic relevance: Montana

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Lowell, Eini; Larson, Debra; Rummer, Robert; Becker, Dennis. 2005. In-woods decision making of utilization opportunities to lower costs of fire hazard reduction treatments. Joint Fire Science Program: Project #01-1-2-03. Boise, ID. Available: http://www.firescience.gov.

Abstract: The result of this research is an accumulation of information on harvest costs and product values necessary for identifying economic thresholds of fuels reduction projects. This information was used to develop a Windows-based, public domain financial/engineering software program called the Harvest Cost-Revenue (HCR) Estimator that can be used to evaluate stand-level economic thresholds for harvesting small-diameter ponderosa pine in the southwestern United States. The HCR Estimator was developed for a variety of users including logging contractors and forest planners. Its purpose is to identify costs of fuel reduction treatments and evaluate in-woods decisionmaking regarding tree selection, residuals left onsite, and product suitability for regionally based wood markets.

Keywords: biomass, harvest costs, logging

Geographic relevance: Arizona

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Lowell, E.C.; Becker, D.R.; Rummer, R.; Larson, D.; Wadleigh L. 2008. An integrated approach to evaluating the economic costs of wildfire hazard reduction through wood utilization opportunities in the southwestern United States. Forest Science. 54(3): 273-283.

Abstract: This paper describes the development of an integrated wildfire fuels reduction system from silvicultural prescription through tree selection, harvesting, in-woods processing, transport, and market selection. Data on harvest equipment productivity, lumber recovery, and net profit (loss) for different levels of fuels reduction treatments in small-diameter ponderosa pine were collected from four 20-acre sites in northern Arizona. These data were used in the development of the Harvest Cost-Revenue Estimator, a financial and engineering software program.

Keywords: ponderosa pine, wildfire fuel reduction, financial analysis, harvest cost-revenue estimator

Geographic relevance: Northern Arizona

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Lowery, David P. 1979. Extended use of residue for conventional solid wood products. In: Harvesting and utilization opportunities for forest residues in the northern Rocky Mountains: Symposium proceedings 1979; November 28-30; Missoula, MT. Gen. Tech. Rep. GTR-INT-110. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station: 181-189.

Abstract: There is no inherent difference between the wood from dead trees and green trees. Solid wood product studies have indicated that dead trees can be used for lumber, house logs, and posts and poles, although the amount of usable lumber is usually lower for dead trees than for green trees. Dead trees may be preferred for house logs, posts, and poles; however, extra care is required in selecting and processing these products.

Keywords: dead tree utilization, dead tree lumber, posts and poles, lodgepole pine, western white pine

Geographic relevance: Northern Rocky Mountains

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MacDonald, A.J. 2009. Assessment of economically accessible biomass. FP Innovations Technical Report, Quebec. 2 p.

Abstract: FP Innovations calculated the amount of forest biomass generated by timber harvesting operations on Vancouver Island and the south coast mainland. Field measurements related the volume of roadside residues to the volume of harvested merchantable logs in a factor called the biomass ratio. Roadside residue volumes for the entire study area were calculated by applying the biomass ratio. Comminution and transportation costs were calculated, and volume reductions were made to account for accessibility and transportation costs.

Keywords: biomass, inventory, residue, cost, roadside, dispersed

Geographic relevance: Vancouver Island and southwestern Canada

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Maloney, T.M. 1979. Particle and fiber building products from residue raw material. In: Harvesting and utilization opportunities for forest residues in the northern Rocky Mountains: Symposium proceedings 1979; November 28-30; Missoula, MT. Gen. Tech. Rep. GTR-INT-110. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station: 171-179.

Abstract: This paper covers the definitions of the composition and composite materials, provides a brief history of this segment of the forest products industry, describes types of building materials that have been produced or are possible to produce, discusses past developments, and presents the role of forest residue raw materials. Considerable research has been conducted on the use of dead standing trees of western white pine and lodgepole pine for use in various composition board materials. Economic analyses have shown that there is no particular cost penalties associated with the use of the dead material in comparison with standard green material after the raw material has been delivered to the plant site.

Keywords: residue utilization, building materials

Geographic relevance: Northern Rocky Mountains

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Manfredo, Michael J.; Fishbein, Martin; Hass, Glenn E.; Watson, Alan E. 1990. Attitudes toward prescribed fire policies. Journal of Forestry 88(7): 19-23.

Abstract: This article discusses social considerations with respect to public wildland forest fire policy. Social attitudes, beliefs, and behavioral intentions of wildland fire are described as well as the public's knowledge of the effects of fire. This study details those social issues with regard to the "let burn" policy and the 1988 fires in Yellowstone National Park.

Keywords: biomass, prescribed fire, wildland fire, social science

Geographic relevance: United States

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Mason, C.L.; Lippke, B.R.; Zobrist, K.W.; Bloxton, T.D., Jr.; Ceder, K.R.; Comnick, J.M.; McCarter, J.B.; Rogers, H.K. 2006. Investments in fuel removals to avoid forest fires result in substantial benefits. Journal of Forestry. 104(1): 27.

Abstract: Although large trees can be removed for valuable products, the market value for the smaller logs may be less than the harvest and hauling charges, resulting in a net cost for thinning operations. However, failure to remove these small logs results in the retention of ladder fuels that support crown fires with destructive impacts to the forest landscape. A cost/benefit analysis broadened to include market and non-market considerations indicates that the negative impacts of crown fires are underestimated and that the benefits of government investments in fuel reductions are substantial.

Keywords: forest fuels, non-market values, small-diameter logs, cost/benefit analysis, forest fires

Geographic relevance: United States

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McIver, J.D.; Adams, P.W.; Doyal, J.A.; Drews, E.S.; Hartsough, B.R.; Kellogg, L.D.; Niwa, C.G.; Ottmar, R.; Peck, R.; Taratoot, M.; Torgersen, T.; Youngblood, A. 2003. Environmental effects and economics of mechanized logging for fuel reduction in northeastern Oregon mixed-conifer stands. Western Journal of Applied Forestry. 18(4): 238-249.

Abstract: Fuel reduction by mechanical thinning and removal was studied in mixed-conifer stands in northeastern Oregon. A single-grip harvester was coupled with either a forwarder or a skyline yarding system; and operational economics, fuel reduction, stand damage, soil disturbance, effects on soil biota, and downwoody material were measured.

Keywords: fire risk reduction, soil compaction, skyline yarding, forwarder, single-grip harvester

Geographic relevance: Oregon

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McMichael, Marvin. 1979. Utilizing residue material in pulping. In: Harvesting and utilization opportunities for forest residues in the northern Rocky Mountains: Symposium proceedings 1979; November 28-30; Missoula, MT. Gen. Tech. Rep. GTR-INT-110. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station: 194-196.

Abstract: The pulp raw material shortage in 1973 and 1974 provided incentives for using whole-tree chips at a number of pulp mills in the United States. From 1974 to the time of this paper, pulp raw materials supplies returned to more acceptable levels, and as a result, whole-tree chips were being used only on a limited basis. However, at the time of this paper, energy shortages provided incentives for the utilization of whole-tree chips, and projects were underway in Montana, Idaho, and Washington to increase the demand for waste fuel.

Keywords: residue utilization, pulping

Geographic relevance: Montana, Idaho, and Washington

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McMinn, James C.; Clark, Alexander, III. 1988. Predicting residuals by stand condition and type of harvest. Southern Journal of Applied Forestry. 12(3): 190-193.

Abstract: This paper describes how in mixed pine-hardwood stands in central Georgia, the tonnage of all trees not designated for harvest accounted for 89 percent of the variation in tonnage of standing residuals after conventional harvesting. Standing residuals weighed 5.4 to 29.3 tons per acre after conventional harvests, but an additional 2 to 13 tons of broken and uprooted material and 1 to 8 tons of hardwood tops hindered recovery. A whole-tree system, for which small stems were harvested first, recovered 16 to 43 tons per acre, which was 56 to 94 percent more material than would have been left standing after conventional harvest of the same areas.

Keywords: biomass, logging, whole-tree harvest

Geographic relevance: Central Georgia

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McMinn, James C.; Clark, Alexander, III. 1989. Influence of whole-tree versus conventional harvesting on recoverable biomass in pine-hardwood mixtures. In: Stokes, B.J., ed. Proceedings of the International Energy Agency, task VI, activity 3 symposium: Harvesting small trees and forest residues; 1989 June 5-7; Auburn, AL: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station: 32-43.

Abstract: Seven areas in Georgia were harvested with a conventional system and three with a whole-tree system. Pre- and post-harvest sampling of all standing woody biomass provided base data for estimating standing and downed residuals by initial stand conditions and harvest system. Relationships were developed to permit estimation of recoverable stand components.

Keywords: biomass, hardwood, timber harvest

Geographic relevance: Central Georgia

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Meyer, Vernon W. 1979. Harvesting efficiency: A historical perspective. In: Harvesting and utilization opportunities for forest residues in the northern Rocky Mountains: Symposium proceedings 1979; November 28-30; Missoula, MT. Gen. Tech. Rep. GTR-INT-110. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station: 67-76.

Abstract: This paper briefly describes the history of the logging industry in the United States. Specifically, harvesting technology and methods are discussed. Many significant and far-reaching changes have taken place in the logging industry since its inception in the mid-seventeenth century. But technological advances aimed at improved timber utilization have not come about quickly. It has been an incremental and continuous process.

Keywords: logging, harvesting, history

Geographic relevance: United States

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Miller, D.; Straka, T.; Stokes, B.; Watson, W. 1987. Productivity and cost of conventional understory biomass harvesting systems. Forest Products Journal. 37(5): 39-43.

Abstract: In this study, conventional harvesting equipment was tested for removing forest understory biomass for use as fuel. Two types of systems were tested: a one-pass system and a two-pass system. In the one-pass system, the energywood and pulpwood were harvested simultaneously. In the two-pass system, the energywood was harvested in a first pass through the stand, and the pulpwood was harvested in a second pass. Equations were developed to estimate the cost per green ton of energywood. The two-pass system exhibited high harvesting costs when biomass amounts were low, but costs moderated as biomass amounts increased. The one-pass system harvesting costs were not sensitive to the amount of energywood present.

Keywords: biomass, logging, harvest cost

Geographic relevance: Southern United States (Alabama)

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Mitchell, Dana L. 2005. Assessment of current technologies for communition of forest residues. ASAE Paper 05-8024. St. Joseph, MI: American Society of Agricultural Engineers. 9 p.

Abstract: This paper provides an overview of existing literature related to the harvest, communition, and transport of forest residues. Past studies have investigated the systems associated with biomass harvesting. Researchers have explored whether to incorporate the biomass component with other forest product removals or to harvest it in a separate entry. Land managers do not have the tools to adequately assess the cost of biomass processing prior to treatments. Handling residue can be awkward due to the size and arrangement of the material. Dirt and rocks can contaminate residues and cause equipment repair problems or reduced utilization of the resource. These issues

coupled with the problems of comparing existing production studies lead to some of the reasons why land managers have difficulty assessing communition processing costs.

Keywords: biomass, chippers, grinders, production, communition, forest residues, fuel, chunks

Geographic relevance: Nondescript

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Mitchell, Dana. 2008. Felling small trees with a drive-to-tree feller-buncher. Technical Release 08-R-16. Rockville, MD: Forest Resources Association, Inc. 2 p.

Abstract: Conventional forestry equipment is often used to harvest small-diameter trees. The typical ground-based logging operation is highly mechanized, with the most common operation using feller-bunchers, grapple skidders, and a chipper or grinder. But these machines may not be economical when used in precommercial or unmerchantable thinning operations in which the number of trees to be removed per acre is high but volume per tree is low. Published studies commonly find that feller-buncher productivity (tons per productive machine hour) is directly proportional to tree diameter. As tree diameters increase, the tons produced per hour increase, resulting in a lower cost per unit of wood produced.

Keywords: biomass, logging, harvest cost

Geographic relevance: Alabama

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Mitchell, Dana; Ayala, Renee, comps. 2005. Biomass publications of the forest operations research unit: a synthesis. [CD-ROM]. Auburn, AL: U.S. Department of Agriculture, Forest Service, Southern Research Station. Available: http://www.treesearch.fs.fed.us/pubs/20138.

Abstract: The authors of this synthesis have implemented several studies over the years, and this CD-ROM is a compilation of these data into a usable format. The Executive Summary contains 10 primary research topic areas related to biomass: baling/bundling; biomass harvesting systems; biomass inventory' chipping systems; drying, storing, transporting, and roll splitting; economic analysis; environmental effects; individual machines; proto-type machines; short rotation woody crop production.

Keywords: biomass, Southern Research Station, harvest cost

Geographic relevance: United States

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Mitchell, Dana; Gallagher, Tom. 2007. Chipping whole trees for fuel chips: A production study. Southern Journal of Applied Forestry. 31(4): 176-180.

Abstract: This time-and-motion study determined the productivity and costs of an in-woods chipping operation to create biomass fuel from processing whole small-diameter trees. It was found that the cost of biomass chipping was comparable to other existing treatments such as cut-and-pile or mulching. Two different overstocked stands were studied with the same harvesting and chipping method.

Keywords: biomass, hogfuel, harvesting, production

Geographic relevance: Alabama

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Mitchell, Dana; Klepac, John. 2008. Processing woody biomass with a modified horizontal grinder. In: Proceedings of the 31st annual meeting of the council on forest engineering: Addressing forest engineering challenges for the future. 7 p.

Abstract: This study documents the production rate and cost of producing woody biomass chips for use in a power plant that has specific raw material handling requirements. None of the samples from machines met the specifications needed. A horizontal grinder was modified to replace the teeth on the drum with chipping blades in order to process whole-trees into biomass chips that met the power plant's size specification. The time-and-motion study gathered data on whole-tree processing for short and long fiber chips. The average production rate ranged from 24.9 to 38.2 green tons per productive machine hour. A machine rate of $161.20 per productive machine hour was calculated, resulting in a cost of $4.22 per green ton for producing the long fiber biomass chips.

Keywords: biomass, grinder, harvest cost

Geographic relevance: Alabama

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Mitchell, Dana; Rummer, Bob. 2007. Processing woody debris biomass for co-milling with pulverized coal. In: American Society Agricultural and Biological Engineers 2007 annual international meeting; 2007 June 17-20; Minneapolis, MN. Paper No. 078049. 6 p.

Abstract: This project proposed removing small-diameter stems and unmerchantable woody material from National Forest lands and delivering it to a coal-fired power plant in Alabama for energy conversion. The biomass fuel that was created in this project needed to

meet unique criteria that differentiate fuel chips created for the power plant from typical fuel chips. The wood fuel was to be created from whole-tree chips and co-milled with coal. After further review, it was determined that a cutting action, as opposed to a shearing action, was needed to meet the raw material handling requirements within the plant. A specially equipped horizontal grinder was the final equipment choice.

Keywords: biomass, forest engineering, harvesting, logging, chipper, grinder

Geographic relevance: Alabama

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Mitchell, Dana; Seixas, Fernando; Klepac, John. 2008. Modified Precision-Husky progrind H-3045 for chipping biomass. Forest Operations Review. 10(4): 1-5.

Abstract: A specific size of whole-tree chip was needed to co-mill wood chips with coal. The specifications are stringent because chips must be mixed with coal, as opposed to a co-firing process. In a partnership involving several entities, a trial was conducted to determine if wood chips could be created in a one-step, in-woods process that would meet the stringent requirements of the power plant. Precision-Husky of Leeds, Alabama, volunteered to work with the partnership to manufacture a machine that would create the chips to the stringent specifications.

Keywords: biomass, grinder, logging cost

Geographic relevance: Alabama

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Morris, G. 1999. The value of the benefits of U.S. biomass power. NREL/SR-570 27541. Golden, CO: National Renewable Energy Laboratory. 24 p.

Abstract: This report estimates the value of ancillary services provided by the U.S. biomass industry in order to inform policy makers on the viability of the biomass industry. Specifically, criteria air pollutants, greenhouse gas emissions, landfill capacity use, forest and watershed improvement, rural employment and economic development and energy diversity and security of the biomass industry are discussed in detail.

Keywords: biomass, greenhouse gas, forestry

Geographic relevance: United States

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Nicholls, David. 2009. Wood energy in Alaska—Case study evaluations of selected facilities. Gen. Tech. Rep. PNW-GTR-793. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 33 p.

Abstract: This case study review considers successes and lessons learned from current wood energy systems in Alaska, and it also considers opportunities for future bioenergy development. Biomass resources in Alaska are extensive and diverse, comprising millions of acres of standing small-diameter trees, diseased or dead trees, and trees that have low-grade timber. Biomass products in Alaska that have potential for development are as diverse as wood pellets, cordwood (firewood), compost, wood-plastic composite products, and liquid fuels.

Keywords: Alaska, biomass, bioenergy, wood energy, renewable, cordwood, sawmill residues

Geographic relevance: Alaska

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Nicholls, David L.; Monserud, Robert A.; Dykstra, Dennis P. 2008. A synthesis of biomass utilization for bioenergy production in the western United States. Gen. Tech. Rep. PNW-GTR-753. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 48 p.

Abstract: This study examines the use of woody residues, primarily from forest harvesting or wood products manufacturing operations, as a feedstock for direct-combustion bioenergy systems for electrical or thermal power applications. Opportunities for utilizing biomass for energy at several scales, with an emphasis on larger scale electrical power generation at stand-alone facilities and on smaller scale facilities such as governmental, educational, or other institutional facilities, are examined. Barriers that tend to inhibit bioenergy applications, including accessibility, terrain, harvesting costs, and capital costs, are identified and an evaluation of the role of government as a catalyst in stimulating new technologies and new uses of biomass material is conducted.

Keywords: biomass, bioenergy, fuel hazard reduction, renewable energy, harvesting, forest products

Geographic relevance: Western United States

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Nicholls, D.; Monserud, R.; Dykstra, D. 2008. Biomass utilization for bioenergy in the western United States. Forest Products Journal. 58(1/2): 6-16.

Abstract: This study examines the use of woody residues, primarily from forest harvesting or wood products manufacturing operations (and to a limited

degree from urban wood wastes), as a feedstock for direct-combustion bioenergy systems for electrical or thermal power applications. Opportunities for utilizing biomass for energy at several different scales, with an emphasis on larger scale electrical power generation at stand-alone facilities and on smaller scale facilities (thermal heating only) such as governmental, educational, or other institutional facilities, are examined.

Keywords: biomass, forest products, timber harvest

Geographic relevance: Western United States

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NREL. 1998. International and domestic market opportunities for biomass power, volumes I and II. NREL/SR-570-25492. Golden, CO: National Renewable Energy Laboratory. 155 p.

Abstract: This report examines the domestic and international markets for biopower. Domestic and foreign markets present fundamentally different challenges to private power developers. The domestic challenge lies in finding economically viable opportunities for biopower. These volumes contain an outline of the state of the U.S. biomass industry (at the time this report was written), a discussion of the policies affecting biomass development, a description of some demonstration projects, and a discussion of the future direction of the industry. The volumes then explore the relationship between biopower and the impending restructuring of the electric power industry. The U.S. market assessment concludes with a discussion of various technological applications of biomass power.

Keywords: biomass, bioenergy, emerging market

Geographic relevance: United States

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Page-Dumroese, Deborah S.; Jurgensen, Martin; Terry, Thomas. 2010. Maintaining soil productivity during forest or biomass-to-energy thinning harvests in the western United States. Western Journal of Applied Forestry. 25(1): 5-11.

Abstract: Forest biomass thinnings can potentially impact soil resources by altering soil physical, chemical, and/or biological properties. This paper provides basic recommendations and findings derived from stand-removal studies to guide biomass thinnings for forest health, fuel reduction, or energy production. The focus of these recommendations is to reduce the impact of thinning operations on soil productivity and subsequent stand growth.

Keywords: thinning, best management practices (BMP), site productivity, soil management

Geographic relevance: Western United States

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Pan, F.; Han, H.-S.; Johnson, L.R.; Elliot, W.J. 2008. Net energy output from harvesting small-diameter trees using a mechanized system. Forest Products Journal. 58(1/2): 25-30.

Abstract: This paper examines the efficiency of forest biomass used for energy. The study used net energy ratios to compare how much energy was consumed by mechanized harvesting systems of small-diameter trees that were transported and used for forest biomass energy to the amount of energy (in BTUs) the forest biomass produced. The overall conclusion showed that forest biomass energy had an encouraging net energy ratio compared to other biomass sources, however increases in miles traveled and diesel fuel costs can inhibit the use of forest biomass for energy.

Keywords: biomass, energy ratio, timber harvest, carbon

Geographic relevance: Arizona

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Parhizkar, Omid; Smith, Robert L. 2008. Application of GIS to estimate the availability of Virginia's biomass residues for bioenergy production. Forest Products Journal. 58(3): 71-76.

Abstract: Forest residues are widely dispersed across large geographical areas in Virginia, and there is little information on the location and the quantity of these materials. Geographic Information System (GIS) was used in this study to identify the availability of residues from wood manufacturers, landfills, and loggers. A graphical-mapping GIS program allowed for the location of biomass residue from those facilities and estimated the available biomass residue in each county in Virginia. Residue information was collected through a survey of primary and secondary wood manufacturers, landfills, and loggers in Virginia. It was then incorporated into a GIS so that locations and quantities of various residues could be plotted.

Keywords: biomass, forest residues, GIS

Geographic relevance: Virginia

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Patterson, David W.; Pelkki, Matthew H.; Steele, Phillip H. 2008. Productivity of the John Deere slash bundler in removing in-forest residues from pine harvest sites in the mid-South: Four case studies. Forest Products Journal. 58(7/8): 31-36.

Abstract: In the summer of 2006, the John Deere 1490D slash bundler was brought to Arkansas so that four independent case studies could be conducted where no previous studies on the machine had been conducted in the South. The study sites were: a clear cut, a second thinning, and a first thinning harvested with conventional equipment. The fourth site was a thinning by cut-to-length equipment. The productivity rate of the machine ranged from 60 to 78 percent. Delays (for example, saw binding, materials handling, and twine spools collapse) were the main problem of the first three sites and movement was the major nonproductive element at the fourth site. The bundles can be economically produced (based on current markets) and they can be stored for seven to eight months.

Keywords: biomass, slash bundler

Geographic relevance: Arkansas

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Patton-Mallory, Marcia; Nelson, Richard; Skog, Ken; Jenkins, Bryan; Parker, Nathan; Tittmann, Peter; Hart, Quinn; Gray, Ed; Schmidt, Anneliese; Gordon, Gayle. 2008. Strategic assessment of biofuels potential for the western U.S. In: Zalesny, Ronald S., Jr.; Mitchell, Rob; Richardson, Jim, eds. Biofuels, bioenergy, and bioproducts from sustainable agricultural and forest crops: Proceedings of the short rotation crops international conference; 2008 August 19-20; Bloomington, MN. Gen. Tech. Rep. NRS-P-31. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station: 42.

Abstract: This is a short summary of an effort to address the technical feasibility of producing biofuels in the western United States. This paper contains spatially explicit biomass resource supply curves, a detailed transportation network model for the region, and costs for converting biomass to refined biofuels. This paper also presents biofuel supply curves that estimate potential future supplies of liquid fuels from biomass in the western United States as a function of market price.

Keywords: biofuels, agriculture residues, wood residues, thinnings, grease, herbaceous energy crops, biomass supply estimates, network analysis

Geographic relevance: Western United States

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Perez-Verdin, Gustavo; Grebner, Donald L.; Sun, Changyou; Munn, Ian A.; Schultz, Emily B.; Matney, Thomas G. 2009. Woody biomass availability for bioethanol conversion in Mississippi. Biomass and Bioenergy. 33(3): 492-503.

Abstract: This study evaluated woody biomass from logging residues, small-diameter trees, mill residues, and urban waste as a feedstock for cellulosic ethanol conversion in Mississippi. Supply and cost of four woody biomass sources were derived from Forest Inventory Analysis information, a recent forest inventory conducted by the Mississippi Institute for Forest Inventory, and primary production costs. According to the authors' analysis, about 4.0 million dry tons of woody biomass are available for production of up to 1.2 billion liters of ethanol each year in Mississippi. The feedstock consists of 69 percent logging residues, 21 percent small-diameter trees, 7 percent urban waste, and 3 percent mill residues. Of the total, 3.1 million dry tons (930 million liters of ethanol) can be produced for $34 per dry ton or less. Woody biomass from small-diameter trees is more expensive than other sources of biomass. Transportation costs accounted for the majority of total production costs.

Keywords: logging residues, mill residues, Mississippi, production costs, small-diameter trees, urban waste

Geographic relevance: Mississippi

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Perez-Verdin, Gustavo; Grebner, Donald L.; Munn, Ian A.; Sun, Changyou; Grado, Stephen C. 2008. Economic impacts of woody biomass utilization for bioenergy in Mississippi. Forest Products Journal. 58(11): 75-83.

Abstract: This study examined the economic impacts of woody biomass utilization for bioenergy conversion in Mississippi. Analysis of economic impacts was organized around three groups of events: (1) recovery of logging and thinning residues, (2) electricity generation from co-firing systems, and (3) construction and operation of biofuel facilities. Results showed that the single activity of recovery of all available logging and thinning residues would create a considerable number of jobs and stimulate the rural economy with more resources coming to local industries and households. Due to construction and operation costs, economic impacts of biofuels were higher than biopower. However, biofuels reported the lowest employment and value-added multipliers of all three groups.

Keywords: biomass, slash, bioenergy, economic development

Geographic relevance: Mississippi

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Peterson, David L.; Johnson, Morris C.; Agee, James K.; Jain, Theresa B.; McKenzie, Donald; Reinhardt, Elizabeth D. 2005. Forest structure and fire hazard in dry forests of the western United States. Gen. Tech. Rep. PNW-GTR-628. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 30 p.

Abstract: This document synthesizes the relevant scientific knowledge that can assist fuel-treatment projects on national forests and other public lands and contribute to National Environmental Policy Act analyses and other assessments. It was intended to support science-based decisionmaking for fuel management in dry forests of the western United States at the scale of forest stands (about 1 to 200 acres). It highlights ecological principles that need to be considered when managing forest fuel and vegetation for specific conditions related to forest structure and fire hazard. It also provides quantitative and qualitative guidelines for planning and implementing fuel treatments through various silvicultural prescriptions and surface fuel treatments.

Keywords: crown fire, fire hazard, forest structure, fuel treatments, prescribed burning, silviculture, thinning

Geographic relevance: Western United States

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Prestemon, Jeffrey P.; Abt, Karen Lee; Holmes, Thomas P. 2002. The economic impacts of fire-related biomass reduction on government lands. In: Baumgartner, D.M.; Johnson, L.R.; DePuit, E.J., comps. and eds. Proceedings: Small diameter timber: Resource management, manufacturing, and markets; 2002 February 25-27; Spokane, WA. MISC0509. Pullman, WA: Washington State University Cooperative Extension. 268 p.

Abstract: This paper outlines a Joint Fire Science Program (JFSP) funded study *A national study of the economic impacts of biomass removals to mitigate wildfire damages on Federal, State, and private lands*. The study involves the treatment-product and cost information provided by the *Fire and fire surrogates* study, another JFSP-funded research effort. This information is combined with timber inventory information across fire-prone regions of the United States to develop treatment supply schedules for fire-prone regions. Using GIS and other modeling techniques, this approach quantifies the small region and broad region supply responses to alternative scales of fire risk-related biomass reduction programs. Concurrently, information on timber product output was to be assembled to identify product demand relationships.

Keywords: biomass, JFSP, GIS

Geographic relevance: United States

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Puttock, G. 1995. Estimating costs for integrated harvesting and related forest management activities. Biomass and Bioenergy. 8(2): 73-79.

Abstract: Often, the deciding factor in the economical recovery of wood fuel is its relationship with some other objective such as stand establishment, stand improvement, or forest access. The costs and benefits arising from these related management activities are discussed in this article. Two different approaches to estimating the cost of producing conventional products and fuel wood with integrated harvesting systems are also examined.

Keywords: forest energy, biomass, integrated harvesting, marginal cost, joint product cost

Geographic relevance: Canada, United Kingdom, northern Europe, and United States

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Puttock, G. 1987. The economics of collecting and processing whole-tree chips and logging residues for energy. Forest Products Journal. 37(8): 15-20.

Abstract: In this study, the economics of collecting and processing whole-tree chips and logging residues (slash and residual timber) for energy use have been compared using data collected from four timber harvesting operations. Fuel produced from whole-tree chips is competitive with natural gas when hauling distances are 80 km or less. Whole-tree chips are a feasible substitute for oil when distances are less than 200 km. Logging residues are an attractive alternative to oil at hauling distances of less than 100 km but cannot be competitive with the lower priced fossil fuels such as natural gas and coal.

Keywords: forest energy, biomass, integrated harvesting, marginal cost, joint product cost

Geographic relevance: United States

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Raymond, Crystal L.; Peterson, David L. 2005. Fuel treatments alter the effects of wildfire in a mixed-evergreen forest, Oregon, USA. Canadian Journal of Forest Research. 35: 2981-2995.

Abstract: The authors quantify the relationship between fuels and fire severity using pre-fire surface and canopy fuel data and fire severity data after a wildfire. Modeled fire behavior showed that thinning reduced canopy fuels, thereby decreasing the potential for crown fire spread. The potential for crown fire initiation remained fairly constant despite reductions in ladder fuels because thinning increased surface fuels, which contributed to greater surface fire intensity. Thinning followed by underburning reduced canopy, ladder, and surface fuels, thereby decreasing surface fire intensity and crown fire potential. However, crown fire is not a prerequisite for high fire severity; damage to and mortality of overstory trees in the wildfire were extensive despite the absence of crown fire. Mortality was most severe in thinned treatments (80 to l00 percent), moderate in untreated stands (53 to 54 percent), and least severe in the thinned and underburned treatment (5 percent). Thinned treatments had higher fine-fuel loading and more extensive crown scorch, suggesting that greater consumption of fine fuels contributed to higher tree mortality.

Keywords: biomass, fuel treatments, wildfire

Geographic relevance: Oregon

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Rawlings, C.; Rummer, R.; Seeley, C.; Thomas, C.; Morrison, D.; Han, H.; Cheff, L.; Atkins, D.; Graham, D.; Windell, K. 2004. A study of how to decrease the costs of collecting, processing, and transporting slash. Montana Community Development Corporation. Missoula, MT. 21 p.

Abstract: This study compares the costs of various slash transportation systems and found a roll on/off container system is not competitive with a regular highway chip van unless part of that distance is inaccessible to the chip van. The roll on/off container system allows for recovery of residue from difficult-to-access locations. There are many variables to consider when determining the cost of hogfuel production, and a simple spreadsheet model has been developed to help evaluate those variables as users choose the best combination of options.

Keywords: biomass, roll on/off container, hooklift truck, chip van

Geographic relevance: Western Montana

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Robatcek, John G. 1979. The implications of improved residue utilization on timber sale activities. In: Harvesting and utilization opportunities for forest residues in the northern Rocky Mountains: Symposium proceedings 1979; November 28-30; Missoula, MT. Gen. Tech. Rep. GTR-INT-110. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station: 269-272.

Abstract: The purpose of the paper is to discuss some of the implications of improved residue utilization on timber sales activities. Improved residue utilization on timber sales requires new and innovative economic and practical approaches on timber sales. Varying uses, resource needs, and economic limitations complicate the land manager's task of salvaging this material.

Keywords: residues, utilization, economics, complicate

Geographic relevance: United States

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Roos, Anders; Graham, Robin L.; Hektor, Bo; Rakos, Christian. 1999. Critical factors to bioenergy implementation. Biomass and Bioenergy. 17: 113-126.

Abstract: This paper contributes to the identification and analysis of barriers and drivers behind bioenergy market growth. It presents a framework for the analysis of both existing and projected bioenergy market potential using economic concepts and models from transaction cost theory and industrial organization. The framework can be used for assessments of the potential for market growth of different bioenergy systems by decision-makers in administration and industry. The framework is demonstrated with five cases of real bioenergy markets: pellet residential heating in the United States, bioenergy power in the United States, pellet residential heating in Sweden, biomass district heating in Sweden, and biomass district heating in Austria.

Keywords: bioenergy market, nontechnical barriers, energy policy

Geographic relevance: United States, Sweden and Austria

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Rummer, Robert. 2004. Forest residues bundling project: new technology for residue removal. [CD-ROM]. 0451-2M25-MTDC. Missoula, MT: U.S. Department of Agriculture, Forest Service, Missoula Technology Development Center.

Abstract: This CD-ROM provides an overview of biomass issues, a determination of where bundling works and does not, productivity and cost estimates, and an assessment of properties and quality of bundled biomass for energy production. The objective of this project was to examine the operational performance of the Timberjack 1490D Slash Bundler across a wide range of conditions found on typical western United States forests. The bundler operated for approximately two weeks at each location to develop a productive operating environment. Stand conditions were assessed pre and post-biomass collection. In addition, detailed data about productivity, soil disturbance, residual stand impacts, and bundle quality were recorded.

Keywords: biomass, slash bundler

Geographic relevance: Western United States

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Rummer, Bob; Klepac, John. 2003. Evaluation of roll-off trailers in small-diameter applications. In: Proceedings of the 2003 council of forest engineering 26th annual conference. Bar Harbor, ME: University of Maine, New England Regional Council on Forest Engineering. 5 p.

Abstract: This project studied the performance and costs of an innovative wood transport system using roll-off pallet racks to facilitate handling of small-diameter thinning material. Elemental studies defined the transport cycles, and cost analysis compared the economics of the new system with conventional transport technology–a conventional five-axle logging truck with a shortwood trailer operating at 85 percent utilization and a conventional shortwood trailer system operating at 30 percent utilization.

Keywords: biomass, harvest cost

Geographic relevance: New Mexico

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Sampson, George R. 1979. Evaluating in-woods chipping feasibility. In: Harvesting and utilization opportunities for forest residues in the northern Rocky Mountains: Symposium proceedings 1979; November 28-30; Missoula, MT. Gen. Tech. Rep. GTR-INT-110. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station: 159-167.

Abstract: This paper presents an evaluation of the test results and uses the results to predict the future of in-woods chipping. Economic analysis of data from a demonstration test showed that in-woods debarking-chipping was only marginally competitive with conventional methods of harvesting roundwood for pulp chips. The future for in-woods chipping appears to be whole-tree chipping. Cost of delivered chips may not be much different from conventional roundwood systems unless credits are taken for increased utilization and slash disposal.

Keywords: chipping machines, logging economics

Geographic relevance: Arizona and Colorado

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Samson, R. Neil; Smith, Megan S.; Gann, Sara B. 2001. Western forest health and biomass energy potential. Submitted to the Oregon Office of Energy. Alexandria, VA: The Samson Group, Inc. 53 p.

Abstract: This article discusses the need for a reduction of fuels in forest ecosystems in order to mitigate the risk of catastrophic wildfire and the ability of the biomass industry to play a role in managing this risk. Generally, this article concludes that significant opportunities exist to link forest health treatments and biomass energy production. Several obstacles to this are discussed, including the feasibility of biomass fuel delivery, the availability of viable biomass markets to forest managers at a reasonable distance, and security assurances for the initial investment in biomass production facilities. The coordination of land management and energy policy is discussed.

Keywords: biomass, biomass markets, harvest cost

Geographic relevance: Western United States (Oregon)

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Schnepf, Chris; Graham, Russell T.; Kegley, Sandy; Jain, Theresa B. 2009. Managing organic debris for forest health: Reconciling fire hazard, bark beetles, wildfire, and forest nutrition needs. Pacific Northwest Extension Publication 609. Moscow, ID: University of Idaho. 66 p.

Abstract: This publication outlines the role of forest organic debris (biomass) in inland northwest forests and provides general management strategies. It helps forest owners and those who work with them ask more effective questions in order to plan the best treatments strategy for each site and keep forests and wildlife more healthy and sustainable while keeping risks from fire and insects within acceptable limits.

Keywords: biomass, land management, wildfire, bark beetles

Geographic relevance: Western United States

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Schweitzer, Dennis L. 1979. An economist's perspective of residues. In: Harvesting and utilization opportunities for forest residues in the northern Rocky Mountains: Symposium proceedings 1979; November 28-30; Missoula, MT. Gen. Tech. Rep. GTR-INT-110. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station: 273-279.

Abstract: As the values of wood products increase, there are more economic opportunities to utilize residues. This is true both for dead-and-down materials and for previously unharvested stands, which together make up the potential economic residues resource. This report describes how a variety of research efforts were developing the information and technology necessary to utilize these opportunities at the time of this report. The authors note that the key to minimizing future residues problems is to integrate residues considerations with overall forest resource planning.

Keywords: biomass, harvest, integrated harvest

Geographic relevance: United States

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Scott, D. Andrew; Tiarks, Allan. 2008. Dual-cropping loblolly pine for biomass energy and conventional wood products. Southern Journal of Applied Forestry. 32(1): 33-37.

Abstract: This study explores a dual-cropping system for southern pine bioenergy and solidwood products that began in 1982 in Louisiana. Direct-seeding pine in the interrows of a traditional pine plantation produced about 10.2 Mg per ha of biomass for energy at the age of five years but had no lasting effect on the planted pine height, diameter, or standing volume. The system is a viable method to produce both bioenergy and solidwood products. Herbaceous competition control and nitrogen fertilization likely would make the system even more productive and profitable.

Keywords: fertilization, phosphorus, competition, stand development

Geographic relevance: Louisiana

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Sedjo, Roger A. 1997. The economics of forest-based biomass supply. Energy Policy. 25(6): 559-566.

Abstract: This paper undertakes a preliminary exploration into the economics of generating energy from forest-based biomass. The study assesses the feasibility of greatly expanding the share of total energy consumption in developed countries that could be economically satisfied by biomass without fiscal subsidy support given the technologies at the time of this report and with plausible potential technologies 10 years into the future. The study briefly considers the environmental effects of biomass usage compared with fossil fuels. Since wood has uses both as fuelwood for energy and as industrial wood for wood products, the comparative economics of these alternative uses are examined.

Keywords: forest economics, forest-based energy competitiveness of forest-based biomass

Geographic relevance: Worldwide

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Silverstein, Robin P.; Loeffler, Dan; Jones, J. Greg; Calkin, Dave E.; Zuuring, Hans R.; Twer, Martin. 2006. Biomass utilization modeling on the Bitterroot National Forest. In: Andrews, Patricia L.; Butler, Bret W., comps. Fuels management—How to measure success: conference proceedings. 2006 March 28-30; Portland, OR. Proc. RMRS-P-41. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station: 673-688.

Abstract: The potential for biomass utilization to enhance the economics of treating hazardous forest fuels was examined on the Bitterroot National Forest and surrounding areas. Initial forest stand conditions were identified from Forest Inventory and Analysis data, and the Forest Vegetation Simulator was used to simulate stand growth and development and to estimate removed volumes. Harvest and haul cost models were used to estimate stump to mill costs. Temporal and spatial implications of utilization were examined to identify sustainable quantities and associated costs based on accessibility, haul distance, flow, and quantity of small-diameter material.

Keywords: biomass, harvest cost, GIS

Geographic relevance: Western Montana

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Sirois, Donald L.; Ashmore, Colin. 1986. Design considerations for a roll crusher/splitter for woody biomass. In: Program and abstracts: Fourth southern biomass energy research conference; 1986 October 7-9; Athens, GA. Research University of Georgia and TVA/Southeastern Regional Biomass Energy Program: 33.

Abstract: The principal focus of biomass harvesting in the past has been the use of chipping systems to reduce a wide variety of woody materials down to small pieces for easier handling and transporting. However, chipping systems have several shortcomings that limit their

operational environments. For example, a conventional chipping system might not be applicable for harvesting small-diameter trees growing in powerline rights-of-ways and energywood plantations. An alternative to conventional methods of harvesting small-diameter trees for energy use is roll crushing/splitting. The concept involves the crushing and splitting of small-diameter stems to expedite field drying and to facilitate handling by producing a uniform material for baling or modulating.

Keywords: biomass, forest engineering

Geographic relevance: Nondescript

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Sirois, Donald L.; Stokes, Bryce J. 1985. Preparation of wood for energy use. In: Proceedings of the 5th annual solar and biomass energy workshop; 1985 April 23-25; Atlanta, GA. Tifton, GA: U.S. Department of Agriculture, Research Service: 173-174.

Abstract: This paper presents an overview of sources and forms of raw materials for wood energy use and the types of machines available to convert them to the desired form for boiler fuel. Both the fuel source, or raw material, and the combustion furnace dictate the requirements for the processing system. Because of the wide range of processing equipment available, systems can be designed to meet most wood burning boiler requirements.

Keywords: biomass, boiler, harvest system

Geographic relevance: United States

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Skog, Kenneth E.; Barbour, James. 2006. Estimating woody biomass supply from thinning treatments to reduce fire hazard in the U.S. West. In: Andrews, Patricia L.; Butler, Bret W., comps. Fuels management—How to measure success: conference proceedings. 2006 March 28-30; Portland, OR. Proc. RMRS-P-41. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station: 657-672.

Abstract: This paper identifies timberland areas in 12 western states where thinning treatments (1) are judged to be needed to reduce fire hazard and (2) may "pay for themselves" at a scale to make investment in forest product processing a realistic option. A web-based tool, Fuel Treatment Evaluator 3.0, is used to select high-fire-hazard timberland plots from the Forest Service Forest Inventory and Analysis Program database and provide results of simulated thinning treatments.

Keywords: fire, fire ecology, fuels management, woody biomass supply, thinning treatments, fire hazard, Fuel Treatment Evaluator 3.0, Forest Service Forest Inventory and Analysis Program (FIA), fuel treatment market model, FTM-West

Geographic relevance: Western United States

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Skog, Kenneth E., Barbour, R. James; Abt, Karen L.; Bilek, E.M. (Ted); Burch, Frank; Fight, Roger D.; Hugget, Robert J.; Miles, Patrick D.; Reinhardt, Elizabeth D.; Shepperd, Wayne D. 2006. Evaluation of silvicultural treatments and biomass use for reducing fire hazard in western states. Res. Pap. FPL-RP-634. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. 29 p.

Abstract: The purpose of this report was to begin to identify locations in the West where fire hazard reduction treatments have a potential to "pay for themselves" at a scale in order to, over a long enough time, make investment in additional forest product processing infrastructure a reality. Treatments analyzed would treat 7.2 to 18.0 million acres, including 0.8 to 1.2 million acres of wildland urban interface area, and would provide 169 to 640 million oven-dry tons of woody biomass (about 55 percent of biomass would be from sawlogs). Sixty to 70 percent of acres that were to be treated are in California, Idaho, and Montana.

Keywords: Hazardous fuel reduction, simulation, FIA data, biomass utilization, harvesting costs, western states

Geographic relevance: Western United States

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Skog, Kenneth E.; Rummer, Robert; Jenkins, Bryan; Parker, Nathan; Tittman, Peter; Hart, Quinn; Nelson, Richard; Gray, Ed; Schmidt, Anneliese; Patton-Mallory, Marcia; Gayle, Gordon. 2009. A strategic assessment of biofuels development in the Western States. In: McWilliams, Will; Moisen, Gretchen; Czaplewski, Ray, comps. Forest Inventory and Analysis (FIA) symposium 2008; October 21-23 2008; Park City, UT. Proc. RMRS-P-56CD. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 13 p.

Abstract: This paper describes the methods used to estimate forest biomass supply curves and selected overall results of the analysis, including information on all forest and agricultural supply sources and maps that indicate the estimated location of biofuels plants using cellulosic feedstocks that would include forest biomass

feedstocks. The model developed here included information on forest biomass supply curves by county (developed using USDA Forest Service FIA data), agricultural biomass supply curves, transportation networks, and capital and operating costs of selected conversion technologies. Results indicate biofuels could potentially provide between 5 and 10 percent of projected transportation fuel demand in western states with fuel price between $2.40 and $3.00 per gasoline gallon equivalence (GGE), excluding local distribution costs and taxes. At a target price of $2.40 per GGE, forest biomass could supply an estimated 11 million oven dry tons per year, or about 9 percent of total feedstock supplied.

Keywords: biofuels, agriculture residues, wood residues, thinnings, grease, herbaceous energy crops, biomass supply estimates, network analysis

Geographic relevance: Western United States

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Smith, Douglas S. 1979. Legislation and policy influencing wood resource utilization. In: Harvesting and utilization opportunities for forest residues in the northern Rocky Mountains: Symposium proceedings 1979; November 28-30; Missoula, MT. Gen. Tech. Rep. GTR-INT-110. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station: 281-284.

Abstract: The framework for harvesting and utilization opportunities for forest residues includes a number of long standing as well as recently enacted statutes. Air and water quality standards set forth in legislation also have an effect on utilization opportunities. A further emerging factor pertaining to the harvesting and utilization of the forest biomass is our land base and its availability. Around the time of this publication, the Senate enacted a number of bills dealing with timber economics.

Keywords: residues utilization, forest policy, legislation

Geographic relevance: United States

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Snell, J.A. Kendall; Brown; James K. 1980. Handbook for predicting residue weights of Pacific Northwest conifers. Gen. Tech. Rep. PNW-GTR-103. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 51 p.

Abstract: Procedures are given for estimating weights of potential residue from Douglas-fir and western hemlock. Preliminary estimates are given for six other species. Estimates are provided in pounds per tree and pounds per square foot of basal area for a 6- or 8-inch top. Estimates are also separated into less than 3 inches DBH and greater than or equal to 3 inches DBH. Tabular weigths include foliage, live and dead branchwood, and non-merchantable top.

Keywords: biomass, residue weights, conifers, weight tables

Geographic relevance: Western Oregon and Western Washington

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Snider, G.; Daugherty, P.J.; Wood, D. 2006. The irrationality of continued fire suppression: An avoided cost analysis of fire hazard reduction treatments verses no treatment. Journal of Forestry. 104(8): 431-437.

Abstract: This study shows that without large-scale implementation of fire hazard reduction treatments, the costs of uncharacteristic crown fires in southwest United States forests will continue to increase. The authors examined the economic rationality of continuing this policy of emphasizing fire suppression activities over restoration-based fire hazard reduction treatments. They also compared treatment plus fire suppression costs to the cost of fire suppression without treatments over 40 years for southwestern forests. This avoided-cost analysis estimates the amount one could invest in treatments to avoid the future cost of fire suppression.

Keywords: economics, restoration, avoided cost, fire, fire hazard reduction

Geographic relevance: Southwest United States

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Stephenson, Everett H. 1989. Flail debarking: a historical perspective and review of current technology. In: Stokes, B.J., ed. Proceedings of the International Energy Agency, task VI, activity 3 symposium: Harvesting small trees and forest residues; 1989 June 5-7; Auburn, AL: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station: 162-169.

Abstract: This paper provides an overview of the concept, development, and technology of flail debarkers.

Keywords: biomass, debarker

Geographic relevance: United States

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Stokes, Bryce J. 1992. Harvesting small trees and forest residues. Biomass and Bioenergy. 2(1-6): 131-147.

Abstract: Eight countries collaborated and shared technical information on the harvesting of small trees and forest residues in a three-year program. Proceedings and reports from workshops and reviews are summarized in a review of activities and harvesting systems of the participating countries. Four databases were developed for harvesting and transportation of these materials.

Keywords: harvesting, residues, forest biomass, transportation, databases

Geographic relevance: Canada, Italy, New Zealand, Norway, Sweden, Switzerland, United Kingdom, and United States

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Stokes, Bryce J.; Frederick, Douglas J.; Curtin, Dennis T. 1986. Field trials of a short-rotation biomass feller buncher and selected harvesting systems. Biomass. 11(3): 185-204. Great Britain: Elsevier Applied Science Publishers, Ltd.

Abstract: Sycamore has high promise as a short-rotation fiber and energy species on better quality sites in the southeastern United States. There have been few studies on operational harvesting systems for hardwood plantations. A continuous-speed felling and bunching prototype machine was evaluated in harvesting a three-year-old, short-rotation sycamore plantation. A small tractor, grapple skidder, and large chipper were evaluated along with the prototype machine as complete harvesting systems. Prediction equations, production rates, and costs were developed for each component of the systems.

Keywords: biomass, yield, production, harvesting

Geographic relevance: Southeast United States

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Stokes, Bryce J.; McDonald, Timothy P.; Kelley, Tyrone. 1993. Transpirational drying and costs for transporting woody biomass—A preliminary review. In: Proceedings of IEA/BA task IX, activity 6: Transport and handling; 1994 May 16-25; New Brunswick, Canada. Aberdeen, United Kingdom: Aberdeen University: 76-91.

Abstract: High transport costs are a factor to consider in the use of forest residues for fuel. Costs can be reduced by increasing haul capacities, reducing high moisture contents, and improving trucking efficiency. The literature for transpirational drying and the economics of hauling woody biomass is summarized here. Some additional, unpublished roundwood and chip drying test results are also included.

Keywords: biomass, forest fuel, transportation

Geographic relevance: Worldwide

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Stokes, Bryce J.; Sirois, Donald L. 1989. Recovery of forest residues in the southern United States. In: Stokes, B.J., ed. Proceedings of the International Energy Agency, task VI, activity 3 symposium: Harvesting small trees and forest residues; 1989 June 5-7; Auburn, AL: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station: 32-43.

Abstract: This paper describes how in the mid-1970s, accelerated price increases for petroleum products forced rapid exploration into and adoption of alternative energy sources. A viable option for the forest industry was the recovery of woody biomass from unmerchantable trees and logging residues. The authors note that several studies estimated that an abundance of such forest materials existed in the southeastern United States and how other research concentrated on economical methods of converting forest residues into energy for industrial uses.

Keywords: biomass, forest products

Geographic relevance: Southern United States

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Stokes, Bryce J.; Sirois, D.L. 1986. Evaluation of chipper-forwarder biomass harvesting concept. In: Proceedings of the southern forest biomass workshop; 1985 June 11-14; Gainesville, FL: University of Florida: 62-67.

Abstract: A chipper-forwarder system offers an alternative for biomass harvesting. Components are a small feller buncher for felling and bunching, and a chipper-forwarder that chips at the pile and transports the chips to roadside. In a case study on a mixed pine and hardwood site in Georgia after conventional harvesting, production rates and cost estimates for a prototype chipper-forwarder were developed. At forwarding distance of 153 meters, the cost of chipping and forwarding was estimated to be between $15 and $25 per dry tone, depending on initial investment assumptions.

Keywords: biomass, timber harvest, chipper

Geographic relevance: Georgia

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Stokes, B.J.; Sirois, D.L.; Woodfin, S.L. 1987. Preliminary evaluation of steel-roller round baler for woody biomass baling. In: Proceedings of the 9th annual meeting of the southern forest biomass workshop; 1987 June 8-11; Biloxi, MS. Mississippi State, MS: Mississippi State University, Department of Forestry: 167-174.

Abstract: A round hay baler with little modification was used to bale small-diameter, crushed trees. The trees had been crushed using a series of compression rollers. Bale cores had to be developed by hand before the baler became self-feeding. Windrowed material was packed off the ground by the baler system after a core had been developed.

Keywords: biomass, baler

Geographic relevance: Southeast United States

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Stokes, Bryce J.; Watson, William F.; Savelle, I. Winston. 1985. Alternate biomass harvesting systems using conventional equipment. In: Saucier, Joseph R., ed. Proceedings of the 1984 southern forest biomass workshop; June 5-7; Athens, GA. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station: 111-114.

Abstract: Three harvesting methods were field tested in two stand types. Costs and stand utilization rates were developed for a conventional harvesting system without energywood recovery, a two-pass roundwood and energywood system, and a one-pass system that harvests roundwood and energywood. The systems harvested 20-acre test blocks in two pine pulpwood plantations and in a natural pine sawtimber stand. The one-pass method resulted in the least cost and better utilization of biomass residue.

Keywords: biomass, timber harvest, harvest cost

Geographic relevance: Alabama

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Stokes, Bryce J.; Watson, William F.; Sirois, Donald L. 1987. Factors affecting power requirements for chipping whole trees. ASAE Paper 87-6012. St. Joseph, MI: American Society of Agricultural Engineers. 10 p.

Abstract: This study was performed to evaluate some of the factors that affect the power requirements for chipping whole-trees in the South for energywood. Results are presented for the effects of tree size, moisture content, and species on power requirements. Large and small in-woods disk chippers were used in field tests to determine the power requirements for chipping whole-trees. Hardwood and softwood species were evaluated over a range of diameter classes and moisture contents.

Keywords: power, chipper, whole-tree

Geographic relevance: Southern United States

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Sturos, John A. 1979. Outlook and opportunity for whole-tree chip quality improvement. In: Harvesting and utilization opportunities for forest residues in the northern Rocky Mountains: Symposium proceedings 1979; November 28-30; Missoula, MT. Gen. Tech. Rep. GTR-INT-110. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station: 147-158.

Abstract: Three processes were developed in the United States, one in Canada, and one in Finland for improving the quality of whole-tree and forest residue chips. They had potential application individually or in combination. Two of them were applied commercially by the pulp and paper industry. The author believed at the time of this report that application of these processes, coupled with integrated utilization of the various output wood, bark, and foliage fractions for fiber and energy products, would promote the recovery of more forest residues.

Keywords: bark removal, residues, biomass, utilization, foliage removal

Geographic relevance: United States, Canada, and Finland

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Sturos, John A.; Thompson, Michael A. 1989. Harvesting small stems and residues in the Lake States. In: Stokes, B.J., ed. Proceedings of the International Energy Agency, task VI, activity 3 symposium: Harvesting small trees and forest residues; 1989 June 5-7; Auburn, AL: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station: 108-117.

Abstract: This paper presents an overview of several harvesting machines and systems considered new at the time this paper was produced. The systems were being applied in the hopes of improving profitability from harvesting small stems and residues. Productivities and costs typical to the Lake States Region are also discussed.

Keywords: biomass, timber harvest

Geographic relevance: Michigan, Wisconsin, and Minnesota

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Ter-Mikaelian, Michael T.; Korzukhin, Michael D. 1997. Biomass equations for sixty-five North American tree species. Forest Ecology and Management. 97: 1-24.

Abstract: The paper presents a comprehensive review of the biomass equations for 65 North American tree species. All equations are of the form M = aDb, where M is the oven-dry weight of the biomass component of a tree (kg), D is DBH (cm), and a and b are parameters. Equations for the following tree components were included in the review: total aboveground biomass, stem wood, stem bark, total stem (wood and bark), foliage, and branches (wood and bark). A total of 803 equations are presented with the range of DBH values of the sample, sample size, coefficient of determination R2, standard error of the estimate, fitting method used to estimate the parameters a and b, correction factor for a bias introduced by logarithmic transformation of the data, site index and geographic location of the sampled stand(s), and a reference to the paper in which the equation (or the data) was published. The review is a unique source of equations that can be used to estimate tree biomass and/or to study the variation of biomass components for a tree species.

Keywords: above-ground biomass, stemwood biomass, bark biomass, foliage biomass, branch biomass, dry weight

Geographic relevance: North America

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Thompson, Jason. 2003. Productivity of a tree length harvesting system thinning ponderosa pine in Northern Arizona. In: Proceedings of the 2003 Council of Forest Engineering 26th annual conference. Bar Harbor, Maine: University of Maine, New England Regional Council on Forest Engineering. 5 p.

Abstract: A productivity study was performed on a tree length harvesting system thinning of a ponderosa pine stand in Flagstaff, Arizona, to investigate opportunities to lower the costs of fire hazard reduction treatments in overstocked stands. The harvesting system consisted of a Hydro-Ax 421 E rubber tired feller-buncher with a shear head, a Caterpillar 528 grapple skidder, and a Denharco 4400 stroke delimber mounted on a Caterpillar 320C base. Detailed time study was used to gather productivity data for all machines in the harvesting system. This paper presents the results of the study, including a description of the stand, study methods, and productivity equations for each machine.

Keywords: biomass, thinning, timber harvest

Geographic relevance: Arizona

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USDA Forest Service. 2005. A strategic assessment of forest biomass and fuel reduction treatments in western states. Gen. Tech. Rep. RMRS-GTR-149. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 17 p.

Abstract: This article assesses how forest biomass can be utilized with implementation of fuel reduction and ecosystem restoration objectives of the National Fire Plan in the western United States. Variables of both public and private forests are assessed in the West, including standing tree volume with additional data on stem, limb, and top volumes. Operational systems to conduct the treatments and their effects on the ecosystem as well as utilization opportunities and market implications are also discussed.

Keywords: assessment, biomass, fuel reduction, inventory

Geographic relevance: Western United States

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Van Hooser, Dwane D. 1979. Resources evaluation and residue: where we've been and where we're going. In: Harvesting and utilization opportunities for forest residues in the northern Rocky Mountains: Symposium proceedings 1979; November 28-30; Missoula, MT. Gen. Tech. Rep. GTR-INT-110. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station: 27-32.

Abstract: This paper outlines how Resources Evaluation has treated forest residue in the past and what changes were made at the time this paper was produced to more adequately address forest residue. This paper also presents a consideration of what changes will have to be made in to provide basic input into a forest residue decision model.

Keywords: forest inventory, utilization, residues

Geographic relevance: Rocky Mountain Region

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Van Rees, Ken C.J. 2008. Wood bioenergy systems in Canada. In: Zalesny, Ronald S., Jr.; Mitchell, Rob; Richardson, Jim, eds. Biofuels, bioenergy, and bioproducts from sustainable agricultural and forest crops: Proceedings of the short rotation crops international conference; 2008 August 19-20; Bloomington, MN. Proc. NRS-P-31. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station: 62.

Abstract: This paper discusses obstacles to woody biomass production in Canadian prairies. One of the firest obstacles for producer involvement in bioenergy systems is changing the farmer mindset that growing a crop for longer than one year is not an impediment to earning money. At one time or another, most farmers in the prairies have removed woody biomass on their farms to increase their capacity for growing crops and are reluctant to go back into "woody" systems. However, the newer generation of farmers may be less reluctant to do so because of an ability to take more risks, greater environmental consciousness, and better education.

Keywords: woody biomass, farmer perceptions, sustainability

Geographic relevance: Canada

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Wade, Dale D. 1969. Estimating slash quantity from standing loblolly pine. Res. Note. SE-125. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station. 4 p.

Abstract: No significant differences were found between variances of two prediction equations for estimating loblolly pine crown weight from DBH. One equation was developed from trees on the Georgia Piedmont and the other from trees on the South Carolina Coastal Plain. An equation and table are presented for estimating loblolly pine slash weights from either cruise data or harvested cords per acre.

Keywords: biomass, slash quantity, loblolly pine

Geographic relevance: Southeast United States (Georgia and South Carolina)

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Watson, W.F.; Miller, D.E.; Stokes, B.J.; Broussard, M.L. 1987. Energy budget for an energywood harvesting system. Proceedings of the southern forest biomass workshop; 1986 June 16-19; Knoxville, TN. Muscle Shoals, AL: Tennessee Valley Authority: 113-116.

Abstract: The fuel and energy requirements for alternative energywood harvesting operations were determined from field operations. Comparisons were made among the total energy requirements, including transportation for conventional operation and one- and two-pass energywood operations. The two-pass energywood operation required more energy per green ton than the other operations. Transportation required twice the energy as did the woods operations.

Keywords: biomass, bioenergy, fuel consumption, transportation

Geographic relevance: Alabama

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Watson, W.F.; Ragan, J.R.; Straka, T.J.; Stokes, B.J. 1987. Economic analysis of potential fuelwood sources. In: Proceedings of the 1986 Society of American Foresters national convention; 1986 October 5-8; Birmingham, AL. Bethesda, MD: Society of American Foresters: 339-342.

Abstract: This paper compares fuelwood produced from logging residues and energy plantations on the basis of potential for production and expected costs at the various levels of production. Prospects for improving the production of fuelwood for each source are also examined.

Keywords: biomass, logging residue, bioenergy

Geographic relevance: Southern United States

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Watson, W.F.; Sabo, Robert F.; Stokes, B.J. 1986. Productivity of in-woods chippers processing understory biomass. Proceedings of the council on forest engineering; 1986 September 29-October 2; Mobile, AL. Auburn, AL: Auburn University: 69-72.

Abstract: This paper presents productivity and cost per ton predictions for two in-woods chippers (Norbark 20 and 27) where DBH, species groups, and moisture content were varied.

Keywords: transpirational drying, chipper

Geographic relevance: Alabama

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Watson, Billy; Stokes, Bryce. 1994. Cost and utilization of above ground biomass in thinning systems. In: Proceedings of the meeting on advanced technology in forest operations: Applied technology in action; 1994 July 24-29; Portland/Corvallis, OR. Corvallis, OR: Oregon State University: 192-201.

Abstract: Cost and utilization were compared for a thinning operation that removed the stems as roundwood with a flail chipper operation. The flail chipper operation recovered an additional 4.2 tons of acceptable chips per acre, which resulted in a higher return to the site. There was little difference in the cost of acceptable chips delivered to the digester between the two methods of thinning.

Keywords: flail delimbing, debarking, woodlands chipping, logging costs, thinning

Geographic relevance: Louisiana

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Watson, William F.; Stokes, Bryce J. 1989. Harvesting small stems—A southern USA perspective. In: Stokes, B.J., ed. Proceedings of the International Energy Agency, task VI, activity 3 symposium: Harvesting small trees and forest residues; 1989 June 5-7; Auburn, AL: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station: 131-139.

Abstract: Operations that harvest small stems using conventional equipment are discussed. A typical operation consisted of rubber-tired feller-bunchers with shear heads, rubber-tired grapple skidders, and in-woods chippers. The systems harvested the small stems either in a pre-harvest, post-harvest, or integrated-harvest method. The unused forest biomass offered forest products firms an easy substitute for the fossil fuels being utilized at that time.

Keywords: biomass, timber harvest, logging system

Geographic relevance: Southern United States (Alabama)

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Watson, W.F.; Stokes, B.J.; Savelle, I.W. 1986. Comparisons of two methods of harvesting biomass for energy. Forest Products Journal. 36(4): 63-68.

Abstract: This study focused on two harvesting methods for utilizing understory biomass that were tested against a conventional harvesting method to determine relative costs. The conventional harvesting method removed all pine 6 inches DBH and larger and hardwood sawlogs as tree length logs. The two intensive harvesting methods were a one-pass and a two-pass method. In the one-pass method, all material 1 inch DBH and larger was simultaneously harvested. With the two-pass method, the energywood (same description as in the one-pass) was harvested in a first pass through the stand, and the commercial-sized wood being removed as tree length logs was harvested in a second pass.

Keywords: biomass, timber harvest

Geographic relevance: Alabama

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Windell, Keith; Bradshaw, Sunni. 2000. Understory biomass reduction methods and equipment catalog. Tech. Rep. 0051-2826-MTDC. Missoula, MT: U.S. Department of Agriculture, Forest Service, Missoula Technology and Development Center. 156 p.

Abstract: This report contains the results of numerous interviews, a field survey, and a literature search and discusses fuel reduction equipment and methods that have been tried in the past, those that are currently being used, and those that may warrant consideration in the future. There is also a catalog of equipment suitable to treat landscape areas before prescribed burns.

Keywords: biomass, collection, disposal, Douglas-fir, fuel treatment, handling, management, ponderosa pine, prescribed fire, residues, thinning

Geographic relevance: United States

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Withycombe, Richard. 1979. Applications of a cost model to northern Rocky Mountain residues. In: Harvesting and utilization opportunities for forest residues in the northern Rocky Mountains: Symposium proceedings 1979; November 28-30; Missoula, MT. Gen. Tech. Rep. GTR-INT-110. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station: 45-54.

Abstract: Whatever decisions are to be made concerning the possible use of forest residues, questions always arise about the costs of collecting and transporting them to a place where they might be used. The residue cost model consists of a series of seven tables, which allow the estimation of the collection costs of the types of residues common to the northern Rocky Mountains. The cost tables were developed from published studies of both conventional logging and residue collection.

Keywords: biomass, residue collection, residue utilization

Geographic relevance: Northern Rocky Mountains

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Withycombe, Richard. 1979. Wood product and market trends influencing residue utilization. In: Harvesting and utilization opportunities for forest residues in the northern Rocky Mountains: Symposium proceedings 1979; November 28-30; Missoula, MT. Gen. Tech. Rep. GTR-INT-110. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station: 285-288.

Abstract: The potential markets for forest residues can be classified into four primary categories. This paper deals with each of these categories separately, and attempts to indicate some of the major influences that are expected to change the trend of forest residue utilization for each of the potential uses. Of the four major potential uses for forest residues, none offer any immediate prospects for large scale use. We can expect cyclical demand for residues to supplement the material supply to the pulp and paper industry. The rising cost of energy could generate the greatest potential demand for residues.

Keywords: biomass, residues utilization, residue markets

Geographic relevance: Northern Rocky Mountains

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Woodfin, Sammy; Frederick, Doug; Stokes, Bryce. 1987. Selected harvesting machines for short rotation intensive culture biomass plantations. ASAE Paper 87-1567. St. Joseph, MI: American Society of Agricultural Engineers. 18 p.

Abstract: Numerous harvesting machines were evaluated in a series of annual tests on stands of different ages. Several different machines were used to harvest sycamore research plots in south Alabama. The machines varied from manually operated devices and conventional forestry equipment to sophisticated prototypes. This paper documents the results of these evaluations as well as a rationale for the evolving development of short rotation intensive culture harvesting equipment. Field tests showed a system consisting of the Hyd-Mech FB-7 and extraction machines to be the least costly.

Keywords: forest engineering, harvesting machinery, woodlots

Geographic relevance: Alabama

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Wright, Clinton S.; Vihnanek, Robert E. 2009. Estimating the biomass of hand-piled fuels for smoke management planning. Joint Fire Science Program: Project #07-2-1-57. Boise, Idaho. Available: http://www.firescience.gov.

Abstract: Dimensions, volume, and biomass were measured for 121 hand-constructed piles composed primarily of coniferous and shrub/hardwood material at sites in Washington and California. Equations using pile dimensions, shape, and type allow users to accurately estimate the biomass of hand piles. Equations for estimating true pile volume from simple geometric shapes and measurements of pile dimensions were also developed to assist users who require estimates of pile volume for regulatory reporting. Biomass and volume estimation equations are being programmed into a web-based calculator to allow users to estimate either value from pile dimensions.

Keywords: biomass, smoke management, pile-burn

Geographic relevance: Washington and California

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Wynsma, B.; Aubuchon, R.; Len, D.; Daugherty, M.; Gee, E. 2007. Woody biomass utilization desk guide. 2400-Forest Management. Washington, DC: U.S. Department of Agriculture, Forest Service, National Technology and Development Program. 84 p.

Abstract: This paper was intended to be a reference guide to local land managers regarding locating and collaborating with biomass stakeholders. This document offers suggestions on how to use current National Environmental Policy Act planning tools to start up and maintain a biomass-utilization program and how to use cost-effective sale preparation techniques, including the preparation of timber sale, stewardship, and service contracts to provide increased supplies of biomass. The viability of offsetting the costs of hazardous fuels and restoration treatments by utilizing small-diameter trees and other biomass is also discussed.

Keywords: biomass, NEPA, land management, timber sale

Geographic relevance: United States

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Yepsen, Rhodes. 2008. Forest thinning strategies for biomass utilization. BioCycle. 49(12): 32-36.

Abstract: This study looks at several projects that are testing new equipment and management practices that treat slash as a marketable commodity. Projects are often combined with research on profitability and best practices to educate loggers to utilize slash from their operations and to promote use of woody biomass.

Keywords: biomass, timber harvest, bioenergy, slash

Geographic relevance: Montana

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Young, T.M.; Ostermeier, D.M.; Mulach, R.W.; Thomas, J.D.; Brooks, R.T., Jr. 1989. A simulation of harvesting systems for economic supply models. In: Stokes, B.J., ed. Proceedings of the International Energy Agency, task VI, activity 3 symposium: Harvesting small trees and forest residues; 1989 June 5-7; Auburn, AL: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station: 170-183.

Abstract: A harvesting simulation model was developed to estimate average total costs of whole-tree chip harvesting as a function of equipment configurations and stand characteristics. The harvesting simulation model was part of a larger economic model used to estimate the economic availability of whole-tree chips for 62 potential energy plants in southeastern United States. The harvesting model described in this paper was used to select a balanced harvesting system for 45 possible stand types.

Keywords: biomass, timber harvest, harvest cost

Geographic relevance: Southeast United States

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Young, Timothy M.; Ostermeier, David M.; Thomas, J. Daniel; Brooks, Robert T. 1991. The economic availability of woody biomass for the southeastern United States. Bioresource Technology. 37: 7-15.

Abstract: In this paper, a deterministic model was developed to estimate the average total cost of producing whole-tree chips for energy production. The model estimated harvest, transportation, stumpage costs, and total costs for 62 potential plant sites in southeast United States. The model used a spatial analytical component and GIS to locate potential sites.

Keywords: woody biomass, energy production, deterministic model, economic availability, average total cost.

Geographic relevance: Southeast United States

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Young, Timothy M.; Perdue, James H.; Hartsell, Andy; Abt, Robert C.; Hodges, Donald; Rials, Timothy G. 2009. A real-time web-based optimal Biomass Site Assessment Tool (BioSAT): Module 1. An economic assessment of mill residues for the southern U.S. In: McWilliams, Will; Moisen, Gretchen; Czaplewski, Ray, comps. Forest Inventory and Analysis (FIA) symposium 2008; October 21-23; Park City, UT. Proc. RMRS-P-56CD. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 22 p.

Abstract: In this paper, optimal locations for biomass facilities that use mill residues are identified for 13 southern U.S. states using the Biomass Site Assessment Tool (BioSAT) model. The top 20 areas identified in the study region are located in south Mississippi, southeast Georgia, southeast Oklahoma, southwest Alabama, and east Texas. Costs in these areas range from $25 to $38 per dry ton for up to 1.5 million annual dry tons. Additional research on BioSAT is forthcoming for 33 U.S. states. These studies will include more types of woody and agricultural biomass (for example, logging residues, pulpwood, and corn stover). Additional cost models for transportation such as truck combinations with rail and barge will be components of BioSAT.

Keywords: biomass, economic availability, siting model, BioSAT, mill residues

Geographic relevance: Southern and eastern United States

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Zalesny, Ronald S., Jr.; Mitchell, Rob; Richardson, Jim, eds. 2008. Biofuels, bioenergy, and bioproducts from sustainable agricultural and forest crops: Proceedings of the short rotation crops international conference. Proc. NRS-P-31. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 76 p.

Abstract: There is a substantial global need for development of biofuels, bioenergy, and bioproducts systems and technologies that can economically and sustainably produce short rotation crops across multiple temporal and spatial scales. Topic areas in these proceedings were biological and environmental; and economic and policy implications of sustainable biofuels, bioenergy, and bioproducts. Presentations addressed anatomy, breeding, genetics, physiology, ecosystem services, phytotechnologies, and production systems, as well as conversion technologies, costs and operational feasibility, environmental impacts and review, social factors, policy issues, and regional logistics.

Keywords: biodiesel, biodiversity, biomass, conservation, crop improvement, ethanol, lignocellulosics, productivity, sustainability, yield

Geographic relevance: United States

Section 3: Log and Mill Residue Price Information

Forest Products Industry Research Program, Bureau of Business and Economic Research, The University of Montana—Missoula

Annotation: The Forest Products Industry Research Program monitors industry operations in Montana, Idaho, Arizona, Colorado, New Mexico, Utah, and Wyoming, as well as the Pacific Coast states of Alaska, California, Oregon, and Washington. Research focuses on the forest products industry's size, diversity, and economic impacts, providing quantitative evaluations of timber sources and use as raw material. Additionally, mill production and sales; utilization of mill residues; associated employment and payrolls; and the industry's role in regional, State, and local economies are evaluated.

Available: http://www.bber.umt.edu.

Contact: Todd Morgan: todd.morgan@business.umt.edu

Last updated: Continuous

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National Forestry Association and National Woodland Owners Association (LogPrice.com)

Annotation: This website provides internet links to log prices for all 50 states.

Available: http://www.logprice.com.

Contact: info@logprice.com

Last updated: February 2009

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Oregon Department of Forestry

Annotation: This website provides species-specific sawlog prices by quarter for Oregon.

Available: http://oregon.gov/ODF/STATE_FORESTS/TIMBER_SALES/logpage.shtml.

Contact: Dan Corgan: dcorgan@odf.state.or.us

Last updated: January 2009

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Timber Mart-South

Annotation: Timber Mart-South publishes quarterly and annual reports used by private companies, consultants, landowners, and others to assess market prices in the southern United States. Timber Mart-South has been surveying and reporting timber prices since 1976 and market news since 1996. Quarterly news and prices are available by subscription or by individual issue to provide information on timber market changes in the southern United States as well as average prices in 22 areas of the southeastern timber markets.

Available: http://www.tmart-south.com/tmart/index.html.

Contact: Tom Harris: harris@warnell.uga.edu, tmart@uga.edu

Last updated: Quarterly

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USDA Forest Service Northern Region, Forest and Rangeland Appraisal Information

Annotation: The Northern Region timber sale summary reports and regional accomplishments are available on this website. Many of the reports are available on a quarterly basis and are usually posted 20 working days after quarter end.

Available: http://www.fs.fed.us/r1/forest_range/timber_reports/timbersales.shtml.

Contact: USFS Northern Region: 406-329-3511

Last updated: Continuous

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USDA Forest Service Southern Research Station Timber Prices on the Web

Annotation: This website contains internet links to timber prices, timber selling guidelines, stumpage prices, and/or delivered log prices for many states.

Available: http://www.srs.fs.usda.gov/econ/data/prices.

Contact: Jeff Prestemon: jprestemon@fs.fed.us

Last updated: July 2008

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WoodPlanet

Annotation: WoodPlanet helps buyers find suppliers and get price quotes and at the same time allows sellers to move inventory and develop new relationships with buyers. Sourcing Service is a free service that allows buyers to locate suppliers and get price quotes quickly and efficiently. Suppliers may take advantage of a range of free and paid services. WoodPlanet gives sellers of wood products new opportunities to move inventory and develop relationships with buyers.

Available: http://www.woodplanet.com/woodplanet_home.cfm.

Contact: info@woodplanet.com, marketing@woodplanet.com, support@woodplanet.com

Last updated: Continuous

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Wood Industry Sourcebook Website

Annotation: This website provides information and tools to forestry entrepreneurs to help them develop new businesses, sustain existing enterprises, and develop business skills that will be necessary to become sustainable enterprises in southwest United States forests. The site also serves as a reference to community collaborative organizations that are striving to develop new economic development strategies revolving around forestry resources in their area. Similarly, economic development agencies may use this site as a decisionmaking tool. It may also be used to provide technical transfer opportunities that promote the science of healthy forest ecosystems and acceptable practices for reducing hazardous forest fuels.

Available: http://www.littlecolorado.net/EntSourcebook/WoodIndustry.htm.

Contact: Herb Hopper: herbert.hopper@rcdnet.net

Last updated: Continuous

Section 4: Biomass Utilization Facility Locations

Biomass Power Association (BPA)

Annotation: BPA is a member-driven organization with the goal of increasing the use of biomass power and creating new jobs and opportunities in the biomass industry. BPA works to expand and advance the use of clean, renewable biomass power and represents 80 biomass power plants in 20 states across the United States. Members include: local owners and operators of existing biomass facilities, suppliers, and plant developers. The BPA website contains links to biomass-related news, maps of biomass facility locations, biomass power projects, and biomass-related policy news and updates.

Available: http://www.usabiomass.org/index.php.

Contact: media@biomasspowerassociation.com

Last updated: 2009

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California Biomass Energy Alliance

Annotation: This website provides internet links to location and contact information for 29 biomass-fueled power plant facilities in California as well as information related to the approximately 80 biomass power plants located in 19 states.

Available: http://www.calbiomass.org/index.html.

Contact: calbiomass@reesechambers.com

Last updated: Unknown

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Database of State Incentives for Renewable Energy (DSIRE)

Annotation: The DSIRE website provides a fast and convenient method for accessing a wide variety of information about renewable energy and energy efficiency incentives as well as regulatory policies administered by Federal and State agencies, utilities, and local organizations. DSIRE tracks financial incentives for energy efficiency upgrades, purchases of energy efficient products and systems, and construction of new energy efficient buildings.

Available: http://www.dsireusa.org.

Contact: http://www.dsireusa.org/library/includes/GenericContacts.cfm?CurrentPageID=13

Last updated: February 2009

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Fuels for Schools

Annotation: Fuels for Schools is a collaboration of USDA Forest Service and Idaho, Montana, Nevada, North Dakota, Wyoming, and Utah State Foresters. It is a Federal and State partnership to promote and encourage the use of wood biomass as renewable energy in public and private buildings to facilitate the removal of hazardous fuels from forest lands. This website contains links to financing, funding opportunities, and contacts.

Available: http://www.fuelsforschools.info.

Contacts:

Idaho: ffsidaho@adelphia.net,

Nevada: jperock@forestry.nv.gov,

Utah: geoffmcnaughton@utah.gov,

Bitterroot Resource Conservation and Development program: bitterrootrcd@cybernet1.com,

Montana: afarr@mt.gov,

North Dakota: thomas.claeys@ndsu.edu,

Wyoming: dperko@state.wy.us,

Other states: http://www.fuelsforschools.info/pdf/National_State_Forest_Biomass_Contacts.pdf

Last updated: Continuous

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Montana Manufacturers Information System (MMIS)

Annotation: The MMIS brings Montana Manufacturers electronically closer to each other by providing detailed and up-to-date information about each manufacturer's products, processes, and capabilities. Manufacturers and decision-makers can use the MMIS to potentially identify new markets, sources of materials, supplies, and services; pursue opportunities to supply products and services now being purchased out of state; locate

potential partners for cooperative production, marketing, buying, and shipping; and analyze the condition and outlook of Montana's manufacturing industries.

Available: http://www.mmis.umt.edu.

GIS shapefile of Montana mill locations available at: http://www.mmis.umt.edu/IndList.asp?indcode=1000&Name=Wood,%20paper,%20furniture.

Contact: MMIS@business.umt.edu

Last updated: Continuous

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National Renewable Energy Laboratory Biomass Maps

Annotation: These maps illustrate the biomass resources available in the United States by county. Biomass feedstock data are analyzed both statistically and graphically using GIS. The following feedstock categories are evaluated: crop residues; forest residues; primary and secondary mill residues; urban wood waste; and methane emissions from manure management, landfills, and domestic wastewater treatment.

Available: http://www.nrel.gov/gis/biomass.html.

Contact: http://www.nrel.gov/gis/webmaster.html

Last updated: October 2009

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USDA Forest Service Southern Research Station, U.S. Wood-Using Mill Locations

Annotation: This dataset is based on information collected by mill data managers in Forest Inventory and Analysis Units as well as collaborators in the Texas Forest Service, the Forest Products Laboratory, and the Focused Science Delivery Program of the Pacific Northwest Research Station. The data describe wood-demanding mills of the Continental United States. Data are restricted to primary wood processors–those that purchase logs or chips. Secondary processors of wood such as paper mills that buy market pulp or rely entirely on recycled fiber are excluded.

Available: http://www.srs.fs.usda.gov/econ/data/mills.

Contact: Jeffrey Prestemon: jprestemon@fs.fed.us

Last updated: October 2008

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Wood Supply Research Institute (WSRI)

Annotation: The WSRI is a joint project of professional loggers, forest landowners, wood consuming mills, educators, and manufacturers that facilitates and funds research to promote and improve efficiency in the wood supply system. WSRI identifies and documents the structure and performance of the wood supply system and identifies opportunities for improvement; investigates ways to operate more efficiently and cost-effectively; communicates research findings directly to WSRI members; and publishes key findings to benefit the entire forest products industry.

Available: http://www.forestresources.org/WSRI.

Contact: Tom Reed: tom.reed@plumcreek.com

Last updated: Continuous

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Wood2Energy

Annotation: This project accomplishes two primary objectives related to the state of the science in wood to energy research and industry: providing a complete literature review on the state of the science and developing a database of wood to energy related industries in the United States and Canada. The database is an important tool for the further development and expansion of wood to energy markets. The development of this knowledge base enables stakeholders from a variety of backgrounds to understand the current demand of wood for use as an energy source. This information also allows stakeholders to conduct analyses for a variety of purposes, including new market development.

Available: http://www.wood2energy.org.

Contact: Sam Jackson: bioenergy@utk.edu

Last updated: Continuous

Section 5: Ancillary Biomass Information

Biomass Energy Resource Center (BERC)

Annotation: The BERC mission is to assist communities, colleges and universities, State and local governments, businesses, utilities, schools, and others in making the most of their local energy resources. BERC further strives to achieve a healthier environment, strengthen local economies, and increase energy security across the United States through the development of sustainable biomass energy systems at the community scale. BERC's particular focus is on the use of woody biomass and other pelletizable biomass fuels.

Available: http://www.biomasscenter.org.

Contact: http://www.biomasscenter.org/contact.html

Last updated: Unknown

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Biomass Energy Foundation

Annotation: This website contains discussions of new developments in liquid fuels from biomass (especially Biodiesel and methanol), WoodGas stoves, and now BioChar and Charcoal. Site sponsors are interested in and knowledgeable about all aspects of biomass energy but particularly in high temperature conversion and pyrolysis and gasification that can produce heat, power, and fuels. The site is used for research, consulting, publishing, and travel activities in the field of biomass and gasification, and the Foundation is able and willing to sponsor projects related to these purposes.

Available: http://www.woodgas.com/index.htm.

Contact: Tom Reed: TomBReed@comcast.net

Last updated: September 2005

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Forest Guild

Annotation: The Forest Guild website contains a substantial library of biomass-related publications. Research publications include syntheses of existing literature that were written in order to answer policy questions. The Forest Guild practices and promotes ecologically, economically, and socially responsible forestry as a means of sustaining the integrity of forest ecosystems and the human communities dependent upon them. The Guild engages in education, training, policy analysis, research, and advocacy to foster excellence in stewardship, support practicing foresters and allied professionals, and engage a broader community in the challenges of forest conservation and management.

Available: http://www.forestguild.org.

Contact: info@forestguild.org; Howard Gross: howard@forestguild.org

Last updated: Continuous

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Fire Research and Management Exchange System (FRAMES)

Annotation: FRAMES is an Internet-based database that contains a library of data, documents, projects, tools, and web pages to support fire management and research. The goal of FRAMES is to provide a systematic method of exchanging information and transferring technology among wildland fire researchers, managers, and other stakeholders in order to make wildland fire documents, data, tools, and other information resources easy to find, access, distribute, compare, and use.

Available: http://frames.nbii.gov/portal/server.pt.

Data Requirements: Vary by selection

Contact: Greg Gollberg: gollberg@uidaho.edu

Last updated: Continuous

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Landscape Fire and Resource Management Planning Tools Project (LANDFIRE)

Annotation: LANDFIRE is an ongoing research project and database that contains geospatial data products that describe existing vegetation composition and structure, potential vegetation, surface and canopy fuel characteristics, historical fire regimes, and fire regime condition class. LANDFIRE provides fire and land managers with the information required to identify lands with wildland fuel build-up and to facilitate the prioritization, implementation, reporting, and monitoring of landscape fuel treatments. These data may be used during specific wildland fire incidents to increase firefighter safety, pre-position

resources, and evaluate fire behavior under a variety of weather conditions.

Available: http://www.landfire.gov/index.php.

Data requirements: Extensive. LANDFIRE is creating spatial data layers that include: all layers required to run fire modeling applications such as FARSITE and FlamMap, Existing Vegetation Type, Canopy Height, Biophysical Setting, Environmental Site Potential, Fire Regime Condition Class, and fire effects layers.

Contact: helpdesk@landfire.gov

Last updated: Continuous

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National Association of Conservation Districts Woody Biomass Utilization Desk Guide

Annotation: This Guide is designed for use by Resource Conservation and Development and Extension professionals throughout the United States. The Woody Biomass Desk Guide and Toolkit provides an overview of woody biomass production and utilization in the United States, tips on how to provide effective outreach for clientele, and educational handouts to share with audiences. The purpose of this guide is to equip natural resource professionals and outreach specialists with the information and tools needed to increase awareness of the use of woody biomass for energy in the United States.

Available: http://nacdnet.org/resources/guides/biomass.

Contact: Sarah Ashton: sashton@warnell.uga.edu

Last updated: Online publication

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National Biofuels Action Plan

Annotation: This document describes current United States national fuel challenges in the context of increased renewable energy production. The following is the Congressionally created Biomass Research and Development Board's mandate: "to coordinate programs within and among departments and agencies of the Federal Government for the purpose of promoting the use of bio-based fuels and bio-based products by (1) maximizing the benefits deriving from Federal grants and assistance; and (2) bringing coherence to Federal strategic planning." The Board's Action Plan is described in seven topical areas: sustainability, feedstock production, feedstock logistics, conversion science and technology, distribution infrastructure, blending, and environment, health and safety.

Available: http://www1.eere.energy.gov/biomass/pdfs/nbap.pdf.

Contact: Department of Energy: (202) 586-9220; USDA Rural Development: (202) 720-4581

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State Bioenergy Primer

Annotation: This State Bioenergy Primer is designed to bring many resources together that discuss biomass/bioenergy and provide useful, targeted information that will enable a state decision-maker to determine if he/she wants or needs more details. The primer offers succinct descriptions of biomass feedstocks, conversion technologies, and benefits/challenges of promoting bioenergy. It includes a step-wise framework, resources, and tools for determining the availability of feedstocks, assessing potential markets for biomass, and identifying opportunities for action at the state level. The primer also describes financial, policy, regulatory, technology, and informational strategies for encouraging investment in bioenergy projects and advancing bioenergy goals.

Available: http://www.epa.gov/cleanenergy/documents/bioenergy.pdf.

Contact: U.S. Environmental Protection Agency, EPA 430-R-09-024, National Renewable Energy Laboratory, NREL/TP-6A2-44688

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USDA Forest Service Southern Research Station Biomass Publications from the Forest Operations Research Unit: A Synthesis

Annotation: The Forest Operations Research Unit at the Southern Research Station has been studying biomass-related topics since 1977. This CD-ROM aids the reader by organizing these publications in one easy-to-use CD-ROM. Included on the CD-ROM are an executive summary, two bibliographies, individual publications, and a keyword listing. The types of publications on the CD-ROM consist of presentation reports, published reports, portions of books, and master's theses.

Available: http://www.srs.fs.usda.gv/pubs/biomass_cd.

Data requirements: Vary by selection

Contact: Dana Mitchell: danamitchell@fs.fed.us

Last updated: 2008

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USDA Forest Service Woody Biomass Utilization Website

Annotation: The Woody Biomass Utilization Team is an interdisciplinary team that promotes and facilitates the planning and delivery of an integrated, interdisciplinary approach to the recovery and utilization of woody biomass from ecological restoration and hazardous fuels reduction work. Field coordinators have been designated at each of the National Forest Regions and Research Stations to coordinate woody biomass utilization efforts throughout the Forest Service.

Available: http://www.fs.fed.us/woodybiomass/index.shtml.

State biomass supply links: http://www.fs.fed.us/woodybiomass/strategy/supply.shtml

Contact: woody_biomass@fs.fed.us

Forest Service Woody Biomass and Bioenergy Contacts: http://www.fs.fed.us/woodybiomass/contact/fscontacts.shtml

Last updated: June 2009

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U.S. Department of Energy, Energy Efficiency and Renewable Energy Biomass Program

Annotation: The Biomass Program primarily facilitates out-of-state and regional partnerships through cooperation with the National Biomass State and Regional Partnerships, which consists of five regional organizations: Coalition of Northeastern Governors Policy Research Center, Council of Great Lakes Governors, Southern States Energy Board, Western Governors' Association, and U.S. Department of Energy's Western Regional Office. Information resources include listings and links to United States state and regional biomass energy programs and information for industry, consumers, researchers, policy-makers, and students.

Available: http://www1.eere.energy.gov/biomass/state_regional.html.

Contacts:

Great Lakes Regional Biomass Energy Program: http://www.cglg.org/biomass,

Northeast Regional Biomass Energy Program: http://www.nrbp.org,

Pacific Regional Biomass Energy Program: http://www.pacificbiomass.org,

Southeast Regional Biomass Energy Program: http://www.serbep.org,

Western Regional Biomass Energy Program: http://www.westgov.org/wga/initiatives/biomass

Last updated: February 2009

Rocky Mountain Research Station

The Rocky Mountain Research Station develops scientific information and technology to improve management, protection, and use of the forests and rangelands. Research is designed to meet the needs of the National Forest managers, Federal and State agencies, public and private organizations, academic institutions, industry, and individuals. Studies accelerate solutions to problems involving ecosystems, range, forests, water recreation, fire, resource inventory, land reclamation, community sustainability, forest engineering technology, multiple use economics, wildlife and fish habitat, and forest insects and diseases. Studies are conducted cooperatively, and applications may be found worldwide.

Station Headquarters
Rocky Mountain Research Station
240 W Prospect Road
Fort Collins, CO 80526
(970)498-1100

Research Locations

Flagstaff, Arizona	Reno, Nevada
Fort Collins, Colorado	Albuquerque, New Mexico
Boise, Idaho	Rapid City, South Dakota
Moscow, Idaho	Logan, Utah
Bozeman, Montana	Ogden, Utah
Missoula, Montana	Provo, Utah

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