Abbas, D., D. Current, et al. "Guidelines for harvesting forest biomass for energy: A synthesis of environmental considerations." Biomass and Bioenergy **In Press, Corrected Proof**.

Interest in the utilization of forest biomass for energy is growing. A search into existing forest biomass harvesting and regeneration guidelines was carried out to identify how biomass energy can be environmentally sustainable. Findings have shown that there are only a few guidelines that specifically address harvesting and regenerating biomass for bioenergy or other bio-based products. Of these few, there are guidelines developed for dedicated energy plantations such as the Scottish Agricultural College guidelines, as well as some Finnish and Swedish guidelines recommending management practices for both timber and biomass extraction. Most of the existing small woody material guidelines emphasize the retention, disposal, redistribution, burning and mulching of biomass material on-site in a more detailed manner than forest and timber management guidelines. This study synthesizes and classifies existing biomass-related guidelines based on an in-depth literature review of existing guidelines in Europe and North America involved with biomass energy harvesting. Biomass guidelines are classified according to those applicable to systems producing biomass commercially for energy versus those that are applicable to systems managing this material for non-commercial purposes. Biomass guidelines are analyzed with respect to how they address issues of sustainability related to soil, water and habitat. Recommendations are offered for developing guidelines for biomass harvesting.

Baral, A. and G. S. Guha (2004). "Trees for carbon sequestration or fossil fuel substitution: the issue of cost vs. carbon benefit." Biomass and Bioenergy **27**(1): 41-55.

This study compares the costs and quantity of carbon mitigation by afforestation and fossil fuel substitution based on simple mathematical models of carbon stocks and flows assuming the growth conditions of trees in the southern US. Significant carbon benefit can be obtained by substituting biomass derived from short-rotation woody crops (SRWC) for coal or gasoline as opposed to sequestering carbon in standing trees. When biomass substitutes fossil fuel, the use of a given piece of land is not limited to just the period until the forest matures, as in the case of afforestation. At present high costs of existing biomass-based technologies and unavailability of cost-effective technologies (e.g., biomass-integrated gasifier/steam-injected gas turbine (BIG/STIG)) limits carbon sequestration to afforestation/reforestation for which the costs have been found to be modest. If growth rates of trees in afforested/reforested lands could be increased to the levels that are comparable to SRWC, more carbon benefit could be realized for a short-term horizon from afforestation than using biomass to displace fossil fuels. Carbon sequestered through afforestation projects can be used to earn carbon credits to meet carbon reduction targets through Kyoto mechanisms. As biomass-based technologies such as BIG/STIG or conversion of biomass to ethanol become commercially viable in the future, growing SRWC for substituting fossil fuels may become a cost-effective strategy to combat climate change.

Barbour, R. J., J. S. Fried, et al. (2008). "Potential biomass and logs from fire-hazard-reduction treatments in southwest Oregon and northern California." Forest Policy and Economics **10**(6): 400-407.

The FIA BioSum model was used to simulate three fire-hazard-reduction policies in an area comprising northern California, southwestern Oregon, and the east slopes ofthe Cascade Mountains in Oregon. The policy scenarios, all subject to a stand-scale fire-hazard-reduction effectiveness constraint, included maximize torching index improvement (Max TI), maximize net revenue recovery (Max NR), and minimize merchantable timber removal (Min Merch). Differences in the area treated under each scenario were considerable, ranging from 15 to 96% of the area for which effective treatments are technically feasible. For each scenario, weight, species, and source tree size of both dirty chips (hogfuel or biomass) and saw logs were estimated. The mix of species and sizes removed under each scenario was surprisingly similar, although the Min Merch scenario did remove more noncommercial species such as hardwoods and more saw logs in the midsize classes (10 to 16in. diameter at breast height (dbh); 25.4 to 40.6cm) than the other two scenarios. Saw logs accounted for 67 to 79% of the weight removed. Under all scenarios, the Douglas-fir (Pseudotsuga menziesii)liarch (Larix) and white woods (INcea spp., Tsuga spp, and Abies spp.) species groups accounted for nearly all of the saw logs removed. Tops and limbs of commercial species and noncommercial species accounted for most of the dirty chips. Stems of low value commercial conifers (7 to 16in; 17.8 to 40.6cm) were also an important source of dirty chips. Trees smaller than 7in. (17.8cm) dbh were a relatively minor component of the dirty chip mix. (c) 2008 Published by Elsevier B.V.

Barbour, R. J., X. P. Zhou, et al. (2008). "Timber product output implications of a program of mechanical fuel treatments applied on public timberland in the western United States." Forest Policy and Economics **10**(6): 373-385.

Becker, D. R., D. Larson, et al. (2009). "Financial considerations of policy options to enhance biomass utilization for reducing wildfire hazards." Forest Policy & Economics **11**(8): 628-635.

Abstract: The Harvest Costâ€“Revenue Estimator, a financial model, was used to examine the cost sensitivity of forest biomass harvesting scenarios to targeted policies designed to stimulate wildfire hazardous fuel reduction projects. The policies selected represent actual policies enacted by federal and state governments to provide incentive to biomass utilization and are aimed at addressing particular challenges in the production lifecycle of trees to final product. Policies were modeled to compare financial impacts on a per-acre project basis for three scenarios of harvest intensity in southwestern ponderosa pine stands classified as being at high risk of wildfire. This allowed for identification of key cost nodes and how particular policies might better allocate limited resources. Effects of limiting the size of trees harvested and access to biomass markets were also modeled. This analysis showed that the co-location of processing facilities that results in shorter distances traveled is the single most important strategy for reducing costs for all three scenarios modeled. Per acre subsidies and certified product premiums were the next highest ranked in providing economic incentive, followed by production tax credits and cost-share programs. Fuel surcharge waivers and transport tax credits provided the least gains.

Becker, D. R., M. Nechodom, et al. (2009). "Assessing the role of federal community assistance programs to develop biomass utilization capacity in the western United States." Forest Policy and Economics **11**(2): 141-148.

As forest biomass utilization becomes cost effective to harvest, more areas at risk of catastrophic wildfire can be thinned of dense brush and small diameter trees. In an effort to increase biomass utilization, the USDA Forest Service granted more than $36 million in National Fire Plan-Economic Action Program funds in the western United States during fiscal years 2001 to 2003. Interviews with program coordinators and grant recipients were used to characterize the types of investment strategies used and to assess accomplishments relative to national fuels reduction objectives. Findings include a strong emphasis on grants leveraging other funding sources, coordination of resources to increase utilization capacity, and the need for technical assistance to facilitate project design and implementation. We conclude that community assistance programs may help to create the type of utilization capacity necessary to reduce hazardous fuels. but that sustained progress will depend on synergistic activities on multiple fronts and improved demonstration of program accomplishments. (c) 2008 Elsevier B.V. All rights reserved.

Broadhead, J. K. W. C. M. C. A. F. and N. Agriculture Organization of the United (2008). Forests and energy : key issues. Rome, Food and Agriculture Organization of the United Nations.

Forest and energy are at the center of the global debate on climate change. Soaring energy consumption and prices, and increasing greenhouse gas emission, represent a major opportunity and challenge for the forestry sector to find a new role in energy supply, climate change and sustainable development. This publication is aimed at both specialized and general audiences interested in learning more about the role of forests in energy production.

California Energy Commission (2006). A Roadmap for the Development of Biomass in California P. C. Report. Davis California Biomass Collaborative 156.

California Energy Commission, C. D. o. F. a. F. P. (2005). Biomass Potentials from California Forest and Shrublands Including Fuel Reduction Potentials to Lessen Wildfire Threat. G. S. Prab Sethi. Sacramento 47.

Collins, L. (1998). "Renewable energy from wood and paper: technological and cultural implications." Technology in Society **20**(2): 157-177.

Renewable energy from biomass, especially from wood and paper, has great potential as a substitute for burning fossil fuels, the main agents of global warming. There are, however, strong economic, political and cultural constraints to achieving full potential. Baark and Jamison's hypothesis that the developmental trajectory of technological innovation will be influenced by the political and cultural frameworks has strong relevance in this context. It is shown in this paper that government environmental policies, which are strongly guided by public acceptability in many Western countries, seem to be in conflict with scientific arguments and evidence concerning the immediate need to address the world's major environmental problem of global warming. Policies encouraging the development of renewable energy, for example, are predicated on the need to reduce global emissions of carbon dioxide, whereas concurrent government strategies for encouraging higher rates for recycling wastepaper are alleged to do the opposite, that is, such government strategies lead to greater reliance on fossil fuels. The discussion of these issues here reinforces arguments made in an earlier paper that during the first half of the new millennium (which is expected to encompass the fifth Kondratieff cycle) a much greater reliance will be placed on the adoption of innovations relating to further development of biotechnology.

Daily, S. (2011). "Production of biofuel from forests will increase greenhouse gas emissions, study finds.". Retrieved November 8, 2011, 2011.

Domac, J., L. K. Richards, et al. (2005). "Socio-economic drivers in implementing bioenergy projects." Biomass & Bioenergy **28**(2): 97-106.

Within the international community there is considerable interest in the socio-economic implications of moving society towards the more widespread use of renewable energy resources. Such change is seen to be very necessary but is often poorly communicated to people and communities who need to accept such changes. There are pockets of activity across the world looking at various approaches to understand this fundamental matter. Typically. socio-economic implications are measured in terms of economic indices, such as employment and monetary gains. but in effect the analysis relates to a number of aspects which include social. cultural, institutional, and environmental issues. The extremely complex nature of bioenergy, many different technologies involved and a number of different, associated aspects (socio-economics, greenhouse gas mitigation potential, environment....) make this whole topic a complex subject. This paper is primarily a descriptive research and review of literature on employment and other socio-economic aspects of bioenergy systems as drivers for implementing bioenergy projects. Due to the limited information, this paper does not provide absolute quantification on the multiplier effects of local and or national incomes of any particular country or region. The paper intends to trigger a more in-depth discussion of data gaps. potentials. opportunities and challenges. An encouraging trend is that in many countries policy makers are beginning to perceive the potential economic benefits of commercial biomass e.g. employment/earnings, regional economic gram, contribution to security of energy supply and all others. (C) 2004 Elsevier Ltd. All rights reserved.

Donovan, G. H. B., Thomas C. (2008). "Estimating the Avoided Fuel-Treatment Costs of Wildfire." Western Journal of Applied Forestry **23**: 197-201.

Although the importance of wildfire to fire-adapted ecosystems is widely recognized, wildfire management has historically placed less emphasis on the beneficial effects of wildfire. We estimate the avoided fuel treatment cost for 10 ponderosa pine (Pinus ponderosa) stands on the Umatilla National Forest in the Pacific Northwest. Results show that fires in stands that show the greatest divergence from the archetypical ponderosa pine stand structure (large trees in an open, parklike stand) tend to have higher avoided costs. This is a reflection of the higher cost of fuel treatments in these stands: treatments designed to restore a stand to a desired condition are normally more expensive than treatments to maintain a stand in a desired condition.

Evans, A., V. Strezov, et al. (2010). "Sustainability considerations for electricity generation from biomass." Renewable and Sustainable Energy Reviews **14**(5): 1419-1427.

The sustainability of electricity generation from biomass has been assessed in this work according to the key indicators of price, efficiency, greenhouse gas emissions, availability, limitations, land use, water use and social impacts. Biomass produced electricity generally provides favourable price, efficiency, emissions, availability and limitations but often has unfavorably high land and water usage as well as social impacts. The type and growing location of the biomass source are paramount to its sustainability. Hardy crops grown on unused or marginal land and waste products are more sustainable than dedicated energy crops grown on food producing land using high rates of fertilisers.

Farr, A. K. and D. Atkins (2010). "Fuel supply planning for small-scale biomass heating systems." West J Appl Forestry Western Journal of Applied Forestry **25**(1): 18-21.

G.C, S. and S. R. Mehmood (2010). "Factors influencing nonindustrial private forest landowners' policy preference for promoting bioenergy." Forest Policy and Economics **12**(8): 581-588.

Woody biomass has gained considerable attention in the U.S. as a feedstock for producing renewable bioenergy. Though these resources are generally not cost competitive with fossil fuels under current technology and market conditions, they are likely to generate numerous socioeconomic and environmental benefits to the entire nation. Since the positive externalities associated with wood-based bioenergy production are not fully accounted for in the market place, policy incentives could play an important role in its promotion in the future. Nonindustrial private forests (NIPFs) of the southern United States, representing a large percentage of timberlands in the nation, are often viewed as potential sources of woody biomass for future bioenergy production. It is therefore critical

to understand landowners' policy preferences for promoting wood-based bioenergy. This study examines policy alternatives preferred by landowners for promoting wood-based bioenergy and utilizes binary logit models to identify the factors influencing these policy preferences. The results indicate that landowners in general prefer tax based policies over direct subsidy support. A significant relationship was observed between landowners' decision to support or not to support different policy instruments and their income, age, distance of residence from the forest, size of the forest owned, size of trees in the forests, forest management objectives, and previous experience of using government cost-share programs.

Gan, J. B. and C. T. Smith (2006). "Availability of logging residues and potential for electricity production and carbon displacement in the USA." Biomass & Bioenergy **30**(12): 1011-1020.

This study assessed the abundance and regional distribution of logging residues and their potential for electricity generation and CO2 emission displacement in the USA. Based on the 1997 Forest Inventory and Analysis (FIA) data, a 70% residue recovery rate, and a minimum viable power plant capacity of 10 MW, annually recoverable logging residues in the USA were estimated at 13.9 million dry t from growing stock and 36.2 million dry t from both growing stock and other sources. Most logging residues were located in the eastern USA; the Southeast and South Central regions accounted for approximately two-thirds of the national total from growing stock and about 50% of that from both growing stock and other sources. The recoverable residues from both growing stock and other sources could generate 67.5 TWh electricity annually. This would displace 17.6 million t carbon emitted from coal-fueled power plants (about 3% of total carbon emissions from the US electricity sector in 1997) at a cost ranging from US$60 to 80 t(-1) C. (c) 2006 Elsevier Ltd. All rights reserved.

Gan, J. B. and C. T. Smith (2006). "A comparative analysis of woody biomass and coal for electricity generation under various CO2 emission reductions and taxes." Biomass & Bioenergy **30**(4): 296-303.

Mitigating global climate change via CO2 emission control and taxation is likely to enhance the economic potential of bioenergy production and utilization. This study investigated the cost competitiveness of woody biomass for electricity production in the US under alternative CO2 emission reductions and taxes. We first simulated changes in the price of coal for electricity production due to CO2 emission reductions and taxation using a computable general equilibrium model. Then, the costs of electricity generation fueled by energy crops (hybrid poplar), logging residues, and coal were estimated using the capital budgeting method. Our results indicate that logging residues would be competitive with coal if emissions were taxed at about US$25 Mg-1 CO2, while an emission tax US$100Mg(-1) CO2 or higher would be needed for hybrid poplar plantations at a yield of 11.21 dry Mg ha(-1)yr(-1) (5 dry tons ac(-1)yr(-1)) to compete with coal in electricity production. Reaching the CO2 emission targets committed under the Kyoto Protocol would only slightly increase the price of fossil fuels, generating little impact on the competitiveness of woody biomass. However, the price of coal used for electricity production would significantly increase if global CO2 emissions were curtailed by 20% or more. Logging residues would become a competitive fuel source for electricity production if current global CO2 emissions were cut by 20-30%. Hybrid poplar plantations would not be able to compete with coal until emissions were reduced by 40% or more. (c) 2005 Elsevier Ltd. All rights reserved.

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

This study evaluated the co-benefits associated with the utilization of logging residues for electricity production in East Texas, USA. The benefits evaluated included the value Of CO2 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% biomass recovery rate, annual recoverable logging residues in East Texas were estimated at 1.3 Mt (dry). These residues, if used for electricity production, would displace about 2.44 Mt Of CO2, valued at some 9MS at the current CO2 price traded at the Chicago Climate Exchange (accounting for about 2% of the stumpage value). Removing logging residues would also save $200-250 ha(-1) in site preparation costs. In addition, input-output modeling revealed that logging residue procurement and electricity generation together would have a stronger ripple effect on employment than on output or value-added, with about 1340 new jobs created and 215MS in value-added generated annually. These results offer new insights into the cost-competitiveness of forest biomass and bioenergy production. (C) 2007 Elsevier Ltd. All rights reserved.

Gasparatos, A., P. Stromberg, et al. (2011). "Biofuels, ecosystem services and human wellbeing: Putting biofuels in the ecosystem services narrative." Agriculture Ecosystems & Environment **142**(3-4): 111-128.

First generation biofuels provide a number of ecosystem services (e.g., fuel, climate regulation) but they also compromise other ecosystem services (e.g., food, freshwater services) which are of paramount value to human wellbeing. However, this knowledge is fragmented and little is known about how the ecosystem services provided and/or compromised by biofuels link to human wellbeing. In fact, whether biofuels production and use can have a negative or positive impact on the environment and society depends on several interconnected factors. This paper provides a critical review of the drivers, impacts and tradeoffs of biofuel production and use. In particular, it rationalizes the evidence coming from diverse academic disciplines and puts it into perspective by employing the ecosystem services framework popularized by the Millennium Ecosystem Assessment (MA). An outcome of this systematic review is a simplified conceptual framework that illustrates the main trade-offs of biofuel production and use by employing a consistent language grounded on the

concepts of ecosystem services. Given the almost complete lack of literature explicitly linking biofuels and ecosystem services, our review concludes by identifying priority research areas on the interface of biofuels, ecosystem services and human wellbeing. (C) 2011 Elsevier B.V. All rights reserved.

Gold, S. and S. Seuring (2011). "Supply chain and logistics issues of bio-energy production." Journal of Cleaner Production **19**(1): 32-42.
Within the concert of renewable energy technologies, bio-energy can play a decisive role during the next decades, when smartly designed and applied under favorable conditions. In this respect, efficient and effective supply chain and logistics management represent one key parameter. This paper presents a literature review of articles published in English-speaking peer-reviewed journals from 2000 to 2009, which cover the interface of bio-energy production and issues of logistics and supply chain management. First, the articles are assessed according to descriptive criteria such as journal, year of publication and research design applied. Then, issues and challenges of designing and operating biomass chains that secure stable and competitively-priced feedstock supply for bio-energy plants have been classified (1) into the operations harvesting and collection, storage, transport, and pre-treatment techniques as well as (2) into overall supply system design. Although biomass supply chains for energy use are manifold in terms of size, design, and functioning, most relevant issues regarding supply chain management and logistics of bio-energy production are identified. The findings are discussed against the backdrop of bio-energy as sustainable renewable energy option.

Gunn, J. S., D. J. Ganz, et al. (2011). "Biogenic vs. geologic carbon emissions and forest biomass energy production." GCB Bioenergy: n/a-n/a.
In the current debate over the CO2 emissions implications of switching from fossil fuel energy sources to include a substantial amount of woody biomass energy, many scientists and policy makers hold the view that emissions from the two sources should not be equated. Their rationale is that the combustion or decay of woody biomass is simply part of the global cycle of biogenic carbon and does not increase the amount of carbon in circulation. This view is frequently presented as justification to implement policies that encourage the substitution of fossil fuel energy sources with biomass. We present the opinion that this is an inappropriate conceptual basis to assess the atmospheric greenhouse gas (GHG) accounting of woody biomass energy generation. While there are many other environmental, social, and economic reasons to move to woody biomass energy, we argue that the inferred benefits of biogenic emissions over fossil fuel emissions should be reconsidered.

Han, H. S. (2004). "Economic feasibility of an integrated harvesting system for small-diameter trees in southwest Idaho." Forest Products Journal **54**(2): 21-27.
Mechanical thinning in dense, small-diameter stands is being increasingly considered to reduce the risk of wildfire in the Interior Northwest of the United States. Economic feasibility of small wood thinning and utilization is in question

due to the low market value of thinning materials and high costs for thinning and transportation. Two cost models were used to estimate thinning costs for various harvesting systems. Tree volume and potential product recovery (roundwood, clean chip, and biomass fuel) were computed and used to analyze the economic feasibility of small wood thinning and transportation in southwest Idaho. Harvesting costs for small-diameter trees increased with decrease of tree size, especially with skyline and helicopter systems. At average 10-inch diameter at breast height (DBH), skyline and helicopter stump-to-truck logging and chipping costs were about three and six times more expensive, respectively, compared with a mechanized whole-tree harvesting system that showed the lowest cost at $34.23/100ft.(3). A sawlog harvest only option with a mechanical whole-tree harvesting system showed a positive return ($/acre) when hauling distances were less than 53 miles. Other harvest options that included clean chip and/or biomass fuel as well as sawlogs were not financially viable, indicating that transportation of low market value materials (clean chip and biomass fuel) resulted in more cost than revenue. The factors affecting economic feasibility of small wood harvesting include forest harvesting systems used, road accessibility and conditions, hauling distance to manufacturing facilities, and market price of thinning materials.

Han, J., A. P. J. Mol, et al. (2008). "Small-scale bioenergy projects in rural China: Lessons to be learnt." Energy Policy **36**(6): 2154-2162.

Large amounts of small-scale bioenergy projects were carried out in China's rural areas in light of its national renewable energy policies. These projects applied pyrolysis gasification as the main technology, which turns biomass waste at low costs into biogas. This paper selects seven bioenergy projects in Shandong Province as a case and assesses these projects in terms of economy, technological performance and effectiveness. Results show that these projects have not achieved a satisfying performance after 10 years experience. Many projects have been discontinued. This failure is attributed to a complex of shortcomings in institutional structure, technical level, financial support and social factors. For a more successful future development of bioenergy in rural areas, China should reform its institutional structure, establish a renewable energy market and enhance the technological level of bioenergy projects.

Hjerpe, E. E. and Y.-S. Kim (2008). "Economic impacts of southwestern national forest fuels reductions." Journal of Forestry **106**(6): 311-316.

Hudiburg, T. W., B. E. Law, et al. (2011). "Regional carbon dioxide implications of forest bioenergy production." Nature Clim. Change **1**(8): 419-423.

Johnson, E. (2009). "Goodbye to carbon neutral: Getting biomass footprints right." Environmental Impact Assessment Review **29**(3): 165-168.

Most guidance for carbon footprinting, and most published carbon footprints or LCAs, presume that biomass heating fuels are carbon neutral. However, it is recognised increasingly that this is incorrect: biomass fuels are not always carbon neutral. Indeed, they can in some cases be far more carbon positive than fossil fuels. This flaw in carbon footprinting guidance and practice can be remedied. In carbon footprints (not just of biomass or heating fuels, but all carbon footprints), rather than applying Sequestration credits and combustion debits, a 'carbon-stock change' line item could be applied instead. Not only would this make carbon footprints more accurate, it would make them consistent with UNFCCC reporting requirements and national reporting practice. There is a strong precedent for this change. This same flaw has already been recognised and partly remedied in standards for and studies of liquid biofuels (e.g. biodiesel and bioethanol), which now account for land-use change, i.e. deforestation. But it is partially or completely missing from other studies and from standards for footprinting and LCA of solid fuels. Carbon-stock changes can be estimated from currently available data. Accuracy of estimates will increase as Kyoto compliant countries report more land use, land use change and forestry (LULUCF) data. (C) 2008 Elsevier Inc. All rights reserved.

Joshi, O. and S. R. Mehmood (2010). "Factors affecting nonindustrial private forest landowners' willingness to supply woody biomass for bioenergy." Biomass and Bioenergy **35**(1): 186-192.

Bioenergy is a renewable form of potential alternative to traditional fossil fuels that has come to the forefront as a result of recent concerns over high price of fuels, national security, and climate change. Nonindustrial private forest (NIPF) landowners form the dominant forest ownership group in the southern United States. These forests often tend to have large quantities of small diameter trees. Use of logging residues and non-marketable small diameter trees for bioenergy production can create economic opportunities for NIPF landowners. The results demonstrated that landowners' willingness to harvest woody biomass was influenced by their ownership objectives, size of the forest, structure and composition of tree species, and demographic characteristics. The model found that relatively younger landowners who owned large acres of forestland with pine plantations or mix forests had the potential to become a preferable choice for contractors, extension foresters and bioenergy industries as they were more likely to supply woody biomass for bioenergy. Findings of this study will be useful to bioenergy industries, extension foresters, nonindustrial private forest landowners and policy makers.

Kumar, A., J. B. Cameron, et al. (2003). "Biomass power cost and optimum plant size in western Canada." Biomass & Bioenergy **24**(6): 445-464.

The power cost and optimum plant size for power plants using three biomass fuels in western Canada were determined. The three fuels are biomass from agricultural residues (grain straw), whole boreal forest, and forest harvest residues from existing lumber and pulp operations (limbs and tops). Forest harvest residues have the smallest economic size, 137 MW, and the highest power cost, $63.00 MWh(-1) (Year 2000 US$). The optimum size for agricultural residues is 450 MW (the largest single biomass unit judged feasible in this study), and the power cost is $50.30 MWh(-1). If a larger biomass boiler could be built, the optimum project size for straw would be 628 MW. Whole forest harvesting has an optimum size of 900 MW (two maximum sized units), and I a power cost of $47.16 MWh(-1) without nutrient replacement. However, power cost versus size from whole forest is essentially flat from 450 MW ($47.16 MWh(-1)) to 3150 MW ($48.86 MWh(-1)), so the optimum size is better thought of as a wide range. None of these projects are economic today, but could become so with a greenhouse gas credit. All biomass cases show some flatness in the profile of power cost vs. plant capacity. This occurs because the reduction in capital cost per unit capacity with-increasing capacity is offset by increasing biomass transportation cost as the area from which biomass is drawn increases. This in turn means that smaller than optimum plants can be built with only a minor cost penalty. Both the yield of biomass per unit area and the location of the biomass have an impact on power cost and optimum size. Agricultural and forest harvest residues are transported over existing road networks, whereas the whole forest harvest requires new roads and has a location remote from existing transmission lines. Nutrient replacement in the whole forest case would make power from the forest comparable in cost to power from straw. (C) 2002 Elsevier Science Ltd. All rights reserved.

Larson, E. D. (1993). "TECHNOLOGY FOR ELECTRICITY AND FUELS FROM BIOMASS." Annual Review of Energy and the Environment **18**: 567-630.

Long, J. N. (2009). "Emulating natural disturbance regimes as a basis for forest management: A North American view." Forest Ecology and Management **257**(9): 1868-1873.

Lowell, E. C., D. R. Becker, et al. (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.

This research provides an important step in the conceptualization and development of an integrated wildfire fuels reduction system from silvicultural prescription, through stem selection, harvesting, in-woods processing, transport, and market selection. Decisions made at each functional step are informed by knowledge about subsequent functions. Data on the resource characteristics of small-diameter ponderosa pine (Pinus ponderosa Dougl. ex Laws.), harvest equipment productivity, lumber recovery, and net profit (loss) by level of fuels reduction achieved were collected from four 8.1-ha (20 ac) sites in northern Arizona. These data were used to develop a Windows-based, financial and engineering software program, the harvest cost-revenue (HCR) estimator, to identify the economic costs of wildfire fuel reduction treatments that may be used to evaluate cost per acre thresholds for logging contractors, appraise contract bid rates, or assess stumpage values for ponderosa pine stands in the southwestern United States. Application of the model illustrates variability in fuels reduction costs owing to the level of fuels reduction achieved, the volume of merchantable wood removed from different forest stands, and the availability of markets for removed material. Machine productivity helps predict differences

in harvest costs but is secondary to market constraints and the volume of wood harvested.

Lundmark, R. (2006). "Cost structure of and competition for forest-based biomass." Scandinavian Journal of Forest Research **21**: 272-280.

Biomass has become a popular alternative to satisfy expanding energy demand and as a substitute for fossil fuels and phased out nuclear energy in Europe. The European Union White Paper stipulates that the utilization of biomass shall increase to 1566 TWh by 2010. However it is often overlooked that the forest resources are already, to a large extent, used by the forest industries. When promoting biomass for energy generation the consequences for the forest industries also need to be considered. Sweden is an excellent case study, as there are vast quantities of forest resources, nuclear power is starting to be phased out, there are restrictions on expanding hydropower and the political desire exists to ‘‘set an example’’ with respect to carbon dioxide emissions. This paper attempts to estimate and analyse the supply of two types of forest resource, namely, roundwood and harvesting residues derived from final harvesting and commercial thinnings. Two separate supply curves are estimated: one for roundwood and one for harvesting residues. The cost structure is based on an economic-engineering approach where the separate cost components are constructed from the lowest cost element into aggregates for labour, capital, materials and overhead costs for each forest resource. The results indicate an unutilized economic supply of 12 TWh of harvesting residues in Sweden. However, after these 12 TWh have been recovered it becomes more profitable to use roundwood for energy purposes than to continue extracting further amounts of harvesting residues.

Lunnan, A. (1997). "Agriculture-based biomass energy supply - a survey of economic issues." Energy Policy **25**(6): 573-582.

There is a large potential for the production of energy crops on agricultural land, Most of the biomass produced has alternative use as food, feed or fiber, In most cases, energy utilization of the biomass is far from competitive given today's prices, If dedicated energy crops are to be more competitive in the future, fossil energy prices must increase relative to the price of food, feed and fiber, Considerable spread exists among published future fossil fuel price forecasts. From currently available evidence, there is small hope that fossil energy prices will increase relative to the price of food and feed, The impact on the greenhouse gas balance is the most important positive factor for biomass energy, compared,vith fossil energy, For the time being there is no consensus among economists about the magnitude of the environmental costs of greenhouse gas emissions, Reasonable values on the external effects are in most cases not enough to make agriculture-based biomass energy competitive, Considerable government subsidies are needed, There is, however, no economic justification for such subsidies, Biomass energy systems using low quality biomass, originating as a by-product from the production of food, feed

and/or fiber, is the most promising niche for energy from agricultural biomass. (C) 1997 Published by Elsevier Science Ltd.

MacFarlane, D. W. (2009). "Potential availability of urban wood biomass in Michigan: Implications for energy production, carbon sequestration and sustainable forest management in the U.S.A." Biomass and Bioenergy **33**(4): 628-634.

Tree and wood biomass from urban areas is a potentially large, underutilized resource viewed in the broader social context of biomass production and utilization. Here, data and analysis from a regional study in a 13-county area of Michigan, U.S.A. are combined with data and analysis from several other studies to examine this potential. The results suggest that urban trees and wood waste offer a modest amount of biomass that could contribute significantly more to regional and national bio-economies than it does at present. Better utilization of biomass from urban trees and wood waste could offer new sources of locally generated wood products and bio-based fuels for power and heat generation, reduce fossil fuel consumption, reduce waste disposal costs and reduce pressure on forests. Although wood biomass generally constitutes a "carbon-neutral" fuel, burning rather than burying urban wood waste may not have a net positive effect on reducing atmospheric CO2 levels, because it may reduce a significant long term carbon storage pool. Using urban wood residues for wood products may provide the best balance of economic and environmental values for utilization.

Makarieva, A. M., V. G. Gorshkov, et al. (2010). "Comprehending ecological and economic sustainability." Annals of the New York Academy of Sciences **1195**: E1-E18.

The global environmental imperative demands urgent actions on ecological stabilization, yet the global scale of such actions is persistently insufficient. This calls for investigating why the world economy appears to be so fearful of any potential environmental expenditure. Using the formalism of Lyapunov potential function it is shown that the stability principles for biomass in the ecosystem and for employment in economics are mathematically similar. The ecosystem has a stable and unstable stationary state with high (forest) and low (grasslands) biomass, respectively. In economics, there is a stable stationary state with high employment in mass production of conventional goods sold at low cost price, and an unstable stationary state with lower employment in production of novel products of technological progress sold at higher prices. An additional stable state is described for economics with very low employment in production of life essentials, such as energy and raw materials that are sold at greatly inflated prices. In this state the civilization pays 10% of global GDP for energy produced by a negligible minority of the working population (currently □0.2%) and sold at prices exceeding the cost price by 40 times, a state when any extra expenditures of whatever nature appear intolerable. The reason lies in the fundamental shortcoming of economic theory, which allows for economic ownership over energy sources. This is shown to be equivalent to equating measurable variables of different dimensions (stores and fluxes), which leads to effective violation of the laws of energy and matter conservation in modern economics.

Manley, A. and J. Richardson (1995). "Silviculture and economic benefits of producing wood energy from conventional forestry systems and measures to mitigate negative impacts." Biomass & Bioenergy **9**(1-5): 89-105.

Activity "Forest Energy Production" focused on the development and evaluation, in the context of conventional forestry systems, silvicultural and forest management practices which optimise productivity for traditional products and wood for energy, while safeguarding the forest ecosystem. A series of meetings, workshops, and review papers involving the three participating countries of Canada, Sweden, and the United Kingdom were planned and completed. An additional workshop in Switzerland was also held. Increasing production of biomass for energy is generally found to be positive, from silvicultural, economic, and environmental perspectives. Eight specific forest management systems were investigated and/or reported: five conventional systems involving multiple products in softwood and mixed wood, and three hardwood systems emphasising production of biomass for energy. Modifications in silvicultural practice to also produce biomass for energy included increased opportunities for thinnings, intermediate cuttings, and stand and site rehabilitation as well as more flexible and efficient harvesting systems, Economic benefits accrued from increased investment in harvesting and burning technology, improvements in stand quality and site utilisation, and substitution for more expensive fuels, especially if all costs are considered. Environmental effects were found to be generally positive, but negative effects of nutrient acid organic matter removal on the overall sustainability of specific systems are possible. These need to be addressed. Harvest and management guidelines are being designed and put into practice. Social, institutional, and technical barriers to the increased use of biomass for energy are being addressed by specific strategies and initiatives involving programs and incentives for production, market development, research and education. Net positive effects indicate increased use of forest biomass for energy, in the short and long term. The development of comprehensive sustainable strategies to capitalise on this trend have the potential to realise numerous benefits.

McGinnis, T. W., C. D. Shook, et al. (2010). "Estimating Aboveground Biomass for Broadleaf Woody Plants and Young Conifers in Sierra Nevada, California, Forests." Western Journal of Applied Forestry **25**(4): 203-209.

Quantification of biomass is fundamental to a wide range of research and natural resource management goals. An accurate estimation of plant biomass is essential to predict potential fire behavior, calculate carbon sequestration for global climate change research, assess critical wildlife habitat, and so forth. Reliable allometric equations from simple field measurements are necessary for efficient evaluation of plant biomass. However, allometric equations are not available for many common woody plant taxa in the Sierra Nevada. In this report, we present more than 200 regression equations for the Sierra Nevada

western slope that relate crown diameter, plant height, crown volume, stem diameter, and both crown diameter and height to the dry weight of foliage, branches, and entire aboveground biomass. Destructive sampling methods resulted in regression equations that accurately predict biomass from one or two simple, nondestructive field measurements. The tables presented here will allow researchers and natural resource managers to easily choose the best equations to fit their biomass assessment needs.

McKinley, D. C., M. G. Ryan, et al. (2011). "A synthesis of current knowledge on forests and carbon storage in the United States." Ecological Applications **21**(6): 1902-1924.

Using forests to mitigate climate change has gained much interest in science and policy discussions. We examine the evidence for carbon benefits, environmental and monetary costs, risks and trade-offs for a variety of activities in three general strategies: (1) land use change to increase forest area (afforestation) and avoid deforestation; (2) carbon management in existing forests; and (3) the use of wood as biomass energy, in place of other building materials, or in wood products for carbon storage. We found that many strategies can increase forest sector carbon mitigation above the current 162-256 Tg C/yr, and that many strategies have co-benefits such as biodiversity, water, and economic opportunities. Each strategy also has trade-offs, risks, and uncertainties including possible leakage, permanence, disturbances, and climate change effects. Because; similar to 60% of the carbon lost through deforestation and harvesting from 1700 to 1935 has not yet been recovered and because some strategies store carbon in forest products or use biomass energy, the biological potential for forest sector carbon mitigation is large. Several studies suggest that using these strategies could offset as much as 10-20% of current U. S. fossil fuel emissions. To obtain such large offsets in the United States would require a combination of afforesting up to one-third of cropland or pastureland, using the equivalent of about one-half of the gross annual forest growth for biomass energy, or implementing more intensive management to increase forest growth on one-third of forestland. Such large offsets would require substantial trade-offs, such as lower agricultural production and non-carbon ecosystem services from forests. The effectiveness of activities could be diluted by negative leakage effects and increasing disturbance regimes. Because forest carbon loss contributes to increasing climate risk and because climate change may impede regeneration following disturbance, avoiding deforestation and promoting regeneration after disturbance should receive high priority as policy considerations. Policies to encourage programs or projects that influence forest carbon sequestration and offset fossil fuel emissions should also consider major items such as leakage, the cyclical nature of forest growth and regrowth, and the extensive demand for and movement of forest products globally, and other greenhouse gas effects, such as methane and nitrous oxide emissions, and recognize other environmental benefits of forests, such as biodiversity, nutrient management, and watershed protection. Activities that contribute to helping forests adapt to the effects of climate change, and which also complement forest carbon storage strategies, would be prudent.

Mitchell, S. R., M. E. Harmon, et al. (2009). "Forest fuel reduction alters fire severity and long-term carbon storage in three Pacific Northwest ecosystems." Ecological Applications **19**(3): 643-655.

Two forest management objectives being debated in the context of federally managed landscapes in the U. S. Pacific Northwest involve a perceived trade-off between. re restoration and carbon sequestration. The former strategy would reduce fuel (and therefore C) that has accumulated through a century of. re suppression and exclusion which has led to extreme. re risk in some areas. The latter strategy would manage forests for enhanced C sequestration as a method of reducing atmospheric CO(2) and associated threats from global climate change. We explored the trade-off between these two strategies by employing a forest ecosystem simulation model, STANDCARB, to examine the effects of fuel reduction on. re severity and the resulting long-term C dynamics among three Pacific Northwest ecosystems: the east Cascades ponderosa pine forests, the west Cascades western hemlock-Douglas-fir forests, and the Coast Range western hemlock-Sitka spruce forests. Our simulations indicate that fuel reduction treatments in these ecosystems consistently reduced. re severity. However, reducing the fraction by which C is lost in a wild. re requires the removal of a much greater amount of C, since most of the C stored in forest biomass (stem wood, branches, coarse woody debris) remains unconsumed even by high-severity wild. res. For this reason, all of the fuel reduction treatments simulated for the west Cascades and Coast Range ecosystems as well as most of the treatments simulated for the east Cascades resulted in a reduced mean stand C storage. One suggested method of compensating for such losses in C storage is to utilize C harvested in fuel reduction treatments as biofuels. Our analysis indicates that this will not be an effective strategy in the west Cascades and Coast Range over the next 100 years. We suggest that forest management plans aimed solely at ameliorating increases in atmospheric CO2 should forgo fuel reduction treatments in these ecosystems, with the possible exception of some east Cascades ponderosa pine stands with uncharacteristic levels of understory fuel accumulation. Balancing a demand for maximal landscape C storage with the demand for reduced wild. re severity will likely require treatments to be applied strategically throughout the landscape rather than indiscriminately treating all stands.

Mobini, M., T. Sowlati, et al. (2010). "Forest biomass supply logistics for a power plant using the discrete-event simulation approach." Applied Energy **88**(4): 1241-1250.

This study investigates the logistics of supplying forest biomass to a potential power plant. Due to the complexities in such a supply logistics system, a simulation model based on the framework of Integrated Biomass Supply Analysis and Logistics (IBSAL) is developed in this study to evaluate the cost of delivered forest biomass, the equilibrium moisture content, and carbon emissions from the logistics operations. The model is applied to a proposed case of 300 MW power plant in Quesnel, BC, Canada. The results show that the biomass demand of the power plant would not be met every year. The weighted

average cost of delivered biomass to the gate of the power plant is about C$ 90 per dry tonne. Estimates of equilibrium moisture content of delivered biomass and CO2 emissions resulted from the processes are also provided.

Morgan, T. A., J. P. Brandt, et al. (2010). "Use of Financial and Economic Analyses by Federal Forest Managers for Woody Biomass Removal." Western Journal of Applied Forestry **26**(1): 5-12.

This study was sponsored by the Joint Fire Science Program to understand and enhance the ability of federal land managers to address financial and economic (F&E) aspects of woody biomass removal as a component of fire hazard reduction. Focus groups were conducted with nearly 100 federal land managers throughout the western United States. Several issues and information disconnects were identified in two major areas: the RE analysis process and the tools and information used for F&E analyses. The most prevalent disconnects appeared to be between managers' knowledge versus acceptance and use of F&E tools developed by research entities. Most managers also tended to focus on financial rather than economic analysis. Findings suggest needs for continually updated local timber and biomass market information; training with F&E tools and methods currently used; ongoing technical support for tools currently used; and closer communication among forest management, research, and administrative personnel as new F&E tools or administrative processes are developed and implemented.

Morris, G. (2000). Biomass energy production in California : the case for a biomass policy initiative : final report. Golden, CO, National Renewable Energy Laboratory.

During the 1980s California developed the largest and most divers biomass energy industry in the world. Biomass energy production has become an important component of the state's environmental infrastructure, diverting solid wastes from open burning and disposal in landfills to a beneficial use application.

Nazzaro, R. M. C. A. U. S., Congress, et al. (2005). Natural resources federal agencies are engaged in numerous woody biomass utilization activities, but significant obstacles may impede their efforts : testimony before the Subcommittee on Forests and Forest Health, Committee on Resources, House of Representatives. Washington, D.C., U.S. Government Accountability Office.

Nechodom, M., D. Schuetzle, et al. (2008). "Sustainable forests, renewable energy, and the environment." Environmental Science & Technology **42**(1): 13-18.

Nechodom, M. C. A. C. E. C., R. Public Interest Energy, et al. (2010). Biomass to energy forest management for wildfire reduction, energy production, and other benefits : PIER final project report. Sacramento, Calif., California Energy Commission.

Office, G. A. (2006). Natural resources woody biomass users' experiences offer insights for government efforts aimed at promoting its use : report to the Chairman, Committee on Resources, House of Representatives. Corp Author(s): United States.

Government Accountability Office. ; United States.; Congress.; House.; Committee on Resources. Washington, D.C., U.S. Government Accountability Office.

Page-Dumroese, D. S., M. Jurgensen, et al. (2009). "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.

> Forest biomass thinnings, to promote forest health or for energy production, can potentially impact the soil resource by altering soil physical, chemical, and/or biological properties. The extent and degree of impacts within a harvest unit or across a watershed will subsequently determine if site or soil productivity is affected. Although the impacts of stand removal on soil properties in the western United States have been documented, much less is known on periodic removals of biomass by thinnings or other partial cutting practices. However, basic recommendations and findings derived from stand-removal studies are also applicable to guide biomass thinnings for forest health, fuel reduction, or energy production. These are summarized as follows: (1) thinning operations are less likely to cause significant soil compaction than a stand-removal harvest, (2) risk-rating systems that evaluate soil susceptibility to compaction or nutrient losses from organic or mineral topsoil removal can help guide management practices, (3) using designated or existing harvesting traffic lanes and leaving some thinning residue in high traffic areas can reduce soil compaction on a stand basis, and (4) coarse-textured low fertility soils have greater risk of nutrient limitations resulting from whole-tree thinning removals than finer textured soils with higher fertility levels.

Peterson, D. H. S. C. A. N. R. E. L. (2009). Market assessment of biomass gasification and combustion technology for small- and medium-scale applications. Golden, Colo., National Renewable Energy Laboratory.

> This report provides a market assessment of gasification and direct combustion technologies that use wood and agricultural resources to generate heat, power, or combined heat and power (CHP) for small- to medium-scale applications. It contains a brief overview of wood and agricultural resources in the U.S.; a description and discussion of gasification and combustion conversion technologies that utilize solid biomass to generate heat, power, and CHP; an assessment of the commercial status of gasification and combustion technologies; a summary of gasification and combustion system economics; a discussion of the market potential for small- to medium-scale gasification and combustion systems; and an inventory of direct combustion system suppliers and gasification technology companies.

Radetzki, M. (1997). "The economics of biomass in industrialized countries: an overview." Energy Policy **25**(6): 545-554.

> Biomass accounts for 3.5% of primary energy use in the OECD region, and 3.1% of final energy consumption. Biomass is the source of 14% of total heat produced in the region. Its role in electricity production (1.4% of total) is much less significant. Most biomass energy is consumed by households (wood

burning) and paper pulp and wood industries. The political and public interest in expanded biomass use is based on the supposition that the external costs of this fuel are much smaller than those of coal, oil and gas. Comparison of full social costs are very hard to make, since uniform value measures of the respective external costs do not yet exist. The scattered and limited assessments that are available suggest that the difference between biomass and fossil fuels in this regard may have been exaggerated in policy debates, and may not be sufficient to warrant a large-scale expansion of biomass use.

Reinhardt, E. D., L. Holsinger, et al. (2010). "Effects of Biomass Removal Treatments on Stand-Level Fire Characteristics in Major Forest Types of the Northern Rocky Mountains." Western Journal of Applied Forestry **25**(1): 34-41.

Removal of dead and live biomass from forested stands affects subsequent fuel dynamics and fire potential. The amount of material left onsite after biomass removal operations can influence the intensity and severity of subsequent unplanned wildfires or prescribed burns. We developed a set of biomass removal treatment scenarios and simulated their effects on a number of stands that represent two major forests types of the northern Rocky Mountains: lodgepole and ponderosa pine. The Fire and Fuels Extension to the Forest Vegetation Simulator was used to simulate effects including stand development, fire behavior, and fire effects prior to the biomass removal treatment and 1, 10, 30, and 60 years after the treatment. Analysis of variance was used to determine whether these changes in fuel dynamics and fire potential differed significantly from each other. Results indicated that fire and fuel characteristics varied within and between forest types and depended on the nature of the treatment, as well as time since treatment. Biomass removal decreased fire potential in the short term, but results were mixed over the long term.

Research, A. E. (2009). Chapter 7: Regional and national biomass market and technology review. Biomass Report, ABS Energy Research. **3:** 101-178.

Chapter 7 of the book "Biomass Report: Direct and Indirect Use" is presented. It presents statistics on biomass market and technology in the U.S. and abroad. It reveals the annual percentage of biomass and waste supply in the U.S. from 2001 to 2007, the level of biomass electricity production in the U.S. from 1980 to 2008, and the state of biomass utilization in China in 2009.

Richard, T. L. (2010). "Challenges in Scaling Up Biofuels Infrastructure." Science **329**(5993): 793-796.

Rapid growth in demand for lignocellulosic bioenergy will require major changes in supply chain infrastructure. Even with densification and preprocessing, transport volumes by mid-century are likely to exceed the combined capacity of current agricultural and energy supply chains, including grain, petroleum, and coal. Efficient supply chains can be achieved through decentralized conversion processes that facilitate local sourcing, satellite preprocessing and densification for long-distance transport, and business models that reward biomass growers both nearby and afar. Integrated systems that are cost-effective and energy-efficient will require new ways of thinking about agriculture, energy infrastructure, and rural economic development. Implementing these integrated systems will require innovation and investment in novel technologies, efficient value chains, and socioeconomic and policy frameworks; all are needed to support an expanded biofuels infrastructure that can meet the challenges of scale.

Rodden, G. (2011). "SUBSIDIES STILL NEEDED." PPI: Pulp & Paper International **53**(6): 26-29.

The article focuses on the "North American Bioenergy Review", a new report published by RISI Inc. due to the consideration of more producers for biofuels as an increasing energy source. It states that the report expanded the analysis from the report in 2008 entitled "Emerging Biomass Industry: Impact of Existing Woodfiber Markets." It mentions that the new report contain outlooks and trends in the three key segments including wood-to-electricity, wood pellets, and cellulosic ethanol.

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

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 current technologies, and with plausible potential technologies ten 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.

Sims, R. (2007). Bioenergy Project Development and Biomass Supply - Good Practice Guidelines. I. E. Agency. Paris IEA Publications**:** 66.

Snider, G., P. J. Daugherty, et al. (2006). "The irrationality of continued fire suppression: An avoided cost analysis of fire hazard reduction treatments versus no treatment." Journal of Forestry **104**(8): 431-437.

Without large-scale implementation of fire hazard reduction treatments, the costs of uncharacteristic crown fires in southwest forests will continue to increase. Federal policy continues to allocate vastly more funds to suppression than to prefire hazard reduction. We examined the economic rationality of continuing this policy of emphasizing fire suppression activities over restoration-based fire hazard reduction treatments. We 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. Using conservative economic values, we found that avoided future costs justifies spending $238-601/ac for hazard reduction treatments in the southwest. We

conclude that the policy of underfunding hazard reduction treatments does not represent rational economic behavior, because funding hazard reduction would pay for itself by lowering future fire suppression costs.

Stasko, T. H., R. J. Conrado, et al. (2011). "Mapping woody-biomass supply costs using forest inventory and competing industry data." Biomass & Bioenergy **35**(1): 263-271.

The goals of energy independence and sustainability have motivated many countries to consider biomass-based energy sources. The United States has substantial and increasing forest resources that could be used to produce both electricity and liquid fuel. However, these forest resources are highly heterogeneous in terms of the wood's properties, the logging cost, the spatial distribution, and the value to other industries. These factors make predicting costs and selecting plant locations particularly challenging. When dealing with forest biomass, feedstock cost and location have frequently been highly simplified in previous studies. This paper presents a methodology for combining highly resolved forest inventory and price data with records of competing industries to develop detailed maps of feedstock availability. The feedstock sourcing strategy of the proposed bioenergy plants is modeled by a cost-minimizing linear program, as is the feedstock selection of the competing mills. A case study is performed on the southeast United States. (C) 2010 Elsevier Ltd. All rights reserved.

Stidham, M. and V. Simon-Brown (2011). "Stakeholder perspectives on converting forest biomass to energy in Oregon, USA." Biomass and Bioenergy **35**(1): 203-213.

Within the state of Oregon, USA, there is considerable interest in the possibility of converting forest biomass to energy. A number of studies have assessed the technical feasibility of forest biomass energy, but few have focused on social aspects, an important consideration in projects involving public forests. This study explores the social context of converting forest biomass to energy, using qualitative research methods. Semi-structured interviews were conducted with forty individuals representing nine different stakeholder groups. Information gained through interviews was used to understand stakeholder views on forest biomass energy, including their perspectives on potential barriers and opportunities in Oregon. Findings indicate the most challenging barrier will be access to long-term, consistent supply. A related challenge is the long history of contention between parties over forest products coming from public lands. However, findings also show that there are many areas of common ground between these groups that have historically been at odds, such as agreement on the necessity of restoration treatments in certain forest types, the by-product of which could be used for biomass generation. Potential conflicts still exist, for instance over projects in mixed conifer forests. Development of policies and projects through inclusive, collaborative approaches could alleviate controversies, potentially allowing more activities to move forward. Information provided by this research creates a foundation for discussions as forest biomass

energy becomes an increasingly prominent issue in Oregon, the western USA, and other regions of the world.

Strittholt, J. R. and J. Tutak (2009). Assessing the Impact of Ecological and Administrative Considerations on Forest and Shrubland Biomass Projections for California Califronia Biomass Assessment. N. R. D. Council, Conservation Biology Institute**:** 74.

Verschuyl, J., S. Riffell, et al. "Biodiversity response to intensive biomass production from forest thinning in North American forests - A meta-analysis." Forest Ecology and Management **261**(2): 221-232.

Demand for alternative energy sources has led to increased interest in intensive biomass production. When applied across a broad spatial extent, intensive biomass production in forests, which support a large proportion of biodiversity, may alter species composition, nutrient cycling and subsequently biodiversity. Because forest thinning and fuels treatment thinning are viewed as possible wide-spread biomass harvest options, it is important to understand what is known about forest biodiversity response to these practices and what additional information is needed by forest managers and policymakers. Therefore, we summarized documented relationships between forest thinning treatments and forest biodiversity from 505 biodiversity effect sizes (incl. taxa and guild abundance and species richness measures) from 33 studies conducted across North America. We used meta-analysis to summarize biodiversity response by region, taxa and harvest treatments. Biodiversity responses included species richness, diversity, abundance of taxa or groups of species (guilds) and abundance of individual species for birds, mammals, reptiles, amphibians, and invertebrates. Forest thinning treatments had generally positive or neutral effects on diversity and abundance across all taxa, although thinning intensity and the type of thinning conducted may at least partially drive the magnitude of response. Our review highlights the need for more research to determine effects of thinning on amphibians and reptiles and manipulative experiments designed to test the effects of biomass removal on biodiversity. (C) 2010 Elsevier B.V. All rights reserved.

Williams, R. B. (2008). Biomass Resources in California 2007 Assessment. Pier Collaborative Report Davis California Biomass Collaborative 155.

The California biomass assessment has been updated for 2007. Gross and technically available resources are quantified and compiled into statewide and county level inventories. Resource estimates were derived for agricultural (2007 NASS data) and forestry biomass (2004 CDFFP data), municipal wastes (primarily 2006 disposal data), and future dedicated biomass crops. Biomass in the state totals 83 million gross bone dry tons per year (BDT/y) at present and is projected to increase to 98 million BDT/y by 2020. Biomass considered to be available on a technically sustainable basis totals 32 million BDT/y in 2007, increasing to 40 million BDT/y in 2020. Of the gross resource in 2007, 21 million tons are from agriculture, 27 million from forestry, and 36 million tons from municipal wastes exclusive of waste in place in landfills and biomass in sewage. The current technical potential includes more than 8 million BDT/y in agriculture, 14 million BDT/y in forestry, and 9 million BDT/y in municipal wastes. Dedicated crops are being grown mostly on an experimental basis at the present and are not included in the total for 2007. Gross electrical generation potential from biomass is currently near 9,500 MWe with more than 1,900 MWe from agriculture, 3,500 MWe from forestry, and 3,900 MWe from municipal wastes including landfill and sewage digester gas. The technical resource generating potential is nearly 3,820 MWe. By 2020, as a result of resource growth and improvements in conversion efficiencies, technical generating potential could reach 6,800 MWe, representing nearly 9% of projected statewide peak power capacity. Existing and planned biomass power generation capacity in the state is currently 968 MWe including solid-fueled combustion power plants and engines, boilers, and turbines operating on landfill gas, sewage digester gas, and biogas from animal manures. Total biomass capacity is 1.5% of statewide peak power capacity (63,800 MWe). Electrical energy contributions in 2020 could reach 51 TWh, or nearly 14% of projected statewide consumption (363 TWh). Through 2020 the largest resources for development will be municipal solid waste, in forest biomass, animal manures, landfill gas, orchard and vineyard residues, and field crop residues. State biomass resources are sufficient to supply a substantially larger amount of renewable electricity than is presently generated as well as serving as feedstock for biofuels and bioproducts.

Williams, R. B. C. A. C. E. C., R. Public Interest Energy, et al. (2005). Environmental issues for biomass development in California : preliminary draft PIER collaborative report. Sacramento, Calif., California Energy Commission.

Yang, P. and B. M. Jenkins (2008). "Wood residues from sawmills in California." Biomass and Bioenergy **32**(2): 101-108.

Sawmill residue is an important component of biomass resources for California; however, factors allowing for projections of future resources are not well established. Differences exist relative to timber diameter class, species type, and milling technology used in other western states for which residue factors have been developed. In this study, sawmill residue production was estimated by two methods. The first utilized lumber production and a sawmill residue volume factor, while the second used total log consumption by sawmills and a sawmill residue weight factor. These two factors were developed based on literature, historic data, and experiences from timber specialists, which can be used to predict sawmill residue production in recent years in California. Estimated sawmill residue generation in California ranged from 2.2 to 2.6 Mt, dry weight basis, in 2002 and 2.2â€“2.5 Mt in 2003. Residues were also estimated for 1988, 1994, and 2000 for comparison to other

reported estimates for sawmill residues in these years. Coarse and fine residues and bark accounted for approximately 45%, 32%, and 23% of total sawmill residues generated. Potentially, more than two million metric tons of sawmill residues are available for bioenergy production and could contribute to California's Renewable Portfolio Standard (RPS) for increasing amounts of electricity from renewable resources and to other policy objectives for increasing amounts of renewable biofuels and bio-based products.