Northeastern Idaho
Biomass Feedstock Supply Assessment

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I. Introduction

This report was prepared by Sustainable Northwest as part of its participation in the Idaho Statewide Wood Energy Team[1]. This report assesses the availability and price of woody biomass to be used for bioenergy projects in a feedstock supply area (FSA) consisting of Lemhi and Custer Counties in Idaho and Ravalli County in Montana.

The report identifies land ownerships, volume, and cost of biomass feedstock available to supply potential bioenergy projects in this three-county region. It also identifies biomass providers who expressed interest in providing the biomass to potential facilities. Finally, it includes a risk assessment of competing uses for this biomass feedstock, and market and policy changes that could impact supply availability. One important note is that this assessment does not address feedstock volume or quality needs for specific individual projects in the FSA. Rather, it provides a general overview of total feedstock volume and sources that could supply potential bioenergy projects to be developed in the FSA.

II. Background

The responsible use of woody biomass to meet energy needs in rural Idaho presents an opportunity to save money, support local jobs, retain wealth in communities, and create an incentive to steward and restore the health of forests. Rural communities spend billions of dollars annually on foreign energy sources, with as much as 78% of every dollar paid to the utility leaving the community[2]. Conversely, the jobs and services associated with procuring wood fuel and manufacturing wood energy products create wealth that is recirculated and reinvested in local communities.

Woody biomass energy also supports forest restoration and landscape health. Across the western U.S., millions of acres of forested land are experiencing overcrowded and unhealthy conditions exacerbated by drought, invasive species, and climate change. These circumstances are resulting in abnormal wildfires that are devastating communities, damaging wildlife habitat and watersheds, and costing taxpayers billions of dollars in suppression. Sustainable harvest and utilization of woody biomass can support restoration and fuels reduction efforts for healthy and resilient forests on public and private lands. Markets for woody biomass can reduce the cost of restoration activities to treat more acres, remove hazardous fuels, and enhance community wildfire protection.

The use of woody biomass to help meet energy demands in homes, institutional facilities, and businesses has a long history in Idaho. For decades, sawmills and industrial businesses in the state have used mill residuals and hog fuel from logging and forest thinning projects to generate heat for manufacturing processes and electricity consumed on site and sold to local utilities. In recent years, this trend has focused on smaller community-scale applications that are choosing woody biomass to meet their heating needs. Schools, hospitals, and small businesses are saving thousands of dollars annually by switching from expensive fossil fuels like fuel oil and propane to locally produced wood chips and pellets. Idaho is currently home to four schools that use woody biomass to heat their facilities.

These institutional users of woody biomass are relatively small compared to their industrial counterparts, consuming between 200-1000 tons of wood pellets or chips annually, depending on system size and heating season. These facilities also utilize modern technologies that maximize heat efficiency and reduce pollutants in the community. Creating thermal energy is the most efficient use of

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[1] Special thanks to Marcus Kauffman for his guidance in the drafting and completion of this report.

[2] "Heating the Northeast with Renewable Biomass: A Vision for 2025"; p. 35. http://www.biomassthermal.org/resource/pdfs/heatne_vision_full.pdf

wood for energy production. Using woody biomass to generate heat alone can be up to 90% efficient, whereas using woody biomass to generate electricity alone ranges between 15-40% efficiency. In combined heat and power (CHP) systems, the overall system efficiencies can approach 80%[3]. Furthermore, when harvested from sustainably managed forests and used for heat, wood greatly reduces net carbon dioxide emissions over time if substituted for heating oil.

III. Methodology[4]

The report serves as an expansion on a detailed biomass supply assessment already completed by researchers at the University of Idaho (Cook & O'Laughlin) in January 2011. Cook & O'Laughlin sought to refine existing state-level forest biomass supply estimates for western states (WGA 2008) to county-level estimates, and make this county-level data available to interested parties. The data used by Cook & O'Laughlin was supplied by U.S. Forest Service researchers (Skog et. al) at the Forest Products Lab in Madison, WI. The complete data sets from Cook & O'Laughlin are available in Appendix A.

Biomass supply estimates were made for each county in selected western states. A base case supply estimate was made for each source and for some sources a high case estimate was made to cover a range of uncertainty about supply from the source. Supply estimates include amounts available at roadside in each county for each of several successively higher costs.

Skog et. al created the supply and cost estimates referenced in this assessment using data available in the U.S. Forest Service's Forest Inventory and Analysis (FIA) and Timber Products Output (TPO) databases. Biomass availability estimates in these data sets was derived from the following four sources on both public and private lands:

1. Thinning of timberland with high fire hazard
2. Logging residue left behind after anticipated logging operations for conventional products
3. General thinning on private woodlands
4. Unused mill residue

The following control assumptions were applied to the data sets to further refine supply estimates:

- Biomass removal is a byproduct, or secondary output, of other forest management objectives including forest health treatment, fire hazard reduction, or the treatment of fuels after logging.
- 70% of removals will be used for higher-value products and 30% will be available for use as fuel.
- "Sustainability screens" have imposed constraints on forest management activities in order to protect soil productivity, wildlife habitat, biodiversity maintenance, and water quality. To further refine and ensure conservative supply estimates, we carried forward the decision from previous analyses to exclude lodgepole pine and spruce-fir forest types from consideration as fire hazard thinning sources. These higher elevation forest types are typically remote from human development and in stand-replacing fire regimes. While thinning would not be the typical treatment in these areas on federal lands, mechanical treatment is expected to be used where appropriate to protect infrastructure such as ski areas and to create landscape variation that would mimic the results of wildfire. Increased management in these areas is also possible on private lands, which may pursue management prescriptions to meet landowner objectives. Increased management of lodgepole pine and spruce-fir types would increase available biomass

[3] http://ewp.uoregon.edu/sites/ewp.uoregon.edu/files/downloads/2009_ipthermal.pdf
[4] For a complete review of methodology, please see Cook & O'Laughlin's report in Appendix B.

supply. However, because volumes are likely to be variable based on ownership and relatively remote, we have opted to carry forward the conservative methodology in this assessment.

The following base cost calculations are included in the supply price estimates:

- Stumpage prices for fire hazard thinnings and logging residues are $0 and $2 per dry ton on public and private lands, respectively.
- The cost of chipping biomass is $8 per dry ton for both public and private lands.
- There is no cost ($0) for unused mill residues.

IV. Feedstock Supply Area (FSA)

The feedstock supply area (FSA) for this study consists of public and private lands in Lemhi and Custer Counties in Idaho and Ravalli County in Montana. This FSA was selected for detailed analysis, as the Idaho State Wood Energy Team has identified potential bioenergy facilities within these three counties that could be supplied with a locally sourced and economically available supply of woody biomass. Ideally, these facilities would purchase woody biomass fuel from within 100 miles of their location, and be supplied by sources within the radius of the three counties analyzed in this report.

V. Summary Findings

The supply assessment found that the three-county FSA contains timber harvest, pre-commercial thinning, and fuels reduction operations on public and private lands that generate a moderate, but adequate supply of forest biomass for potential small to medium size bioenergy facilities in the region. As of January 2015, three current facilities identified in the FSA for conversion to bioenergy would use approximately 800 Bone Dry Tons (BDT) of wood chips annually, and 400 tons of wood pellets annually. The FSA also contains wood chip and pellet fuel providers that could supply the potential bioenergy projects. The existing wood fuel/wood chip businesses interviewed noted that they could provide the quantity of wood fuel required for potential bioenergy projects in the three-county region.

Potentially Available Wood Chip Supply

The feedstock supply area contains over 75,000 BDT of forest-sourced biomass that could be made available annually to the potential bioenergy projects at a roadside price of $40/BDT or less. When generic transportation costs for the delivery of this fuel to bioenergy projects are factored in, the price of the fuel rises by approximately $15/BDT[5]. These assumptions therefore conclude that 75,000 BDT of forest-sourced biomass within the three-county FSA could be made available annually to potential bioenergy projects at a final delivered price of $55/BDT. Actual delivered costs may vary depending on supplier and contracting issues not addressed in this analysis.

A substantial amount of feedstock could also be obtained and delivered at lower cost rates, although less total volume is available at these reduced rates, and fuel quality may vary. Price tables in this report provide tiered cost estimates and associated volume availability. While these numbers are derived from models projecting available feedstock from public and private lands, historical volume records and future official vegetation management plans show that there is more than adequate feedstock to meet the needs of prospective bioenergy projects in the FSA. Supporting information is provided below.

[5] Transportation costs are generated based on an estimated cost of $80/hour for operation of a standard 25 ton chip van. For this analysis, five hours of loading and transportation time was factored into the final delivered price.

Potentially Available Wood Pellet Supply
The three-county FSA is also serviced by a pellet production company (QB Corporation) that could deliver high quality wood pellets to potential bioenergy projects with pellet boilers. The delivered cost of wood pellets to these bioenergy facilities would range from $170 - $200. However, QB Corporation does not provide delivery services, which fall to the responsibility of the consumer. Actual delivered costs may vary depending on supplier and contracting issues not addressed in this analysis.

VI. Detailed Feedstock Availability

Types of Biomass Fuel Available
The FSA is located in northeastern Idaho and western Montana on public and private land, with the majority ownership comprised of National Forest System Lands managed by the U.S. Forest Service. Forestry operations in the area include selective logging on public and private lands, pre-commercial thinning, fuels reduction, and forest restoration activities. In addition to high-value merchantable material, these operations produce logging slash and small diameter material that is sold as firewood and various quality chips that are produced off-site at nearby wood products businesses. Forest-sourced biofuels in the FSA include pulp wood, tops, limbs, cull logs, and other non-merchantable material. The FSA also includes sawmill residue feedstock generated from milling residues in Ravalli County.

The vast majority of feedstock in Lemhi and Custer Counties is supplied by fire hazard thinning on public lands, with additional moderate residues from logging activities on public and private lands. Logging residues present the lowest cost feedstock options, with prices increasing when obtaining feedstock from fire hazard thinning. Feedstock from Ravalli County could be supplied from a variety of sources, including fire hazard thinning on public and private lands, residues from logging activities on public and private lands, and unused mill residues. Logging residues and unused mill residues present the lowest cost feedstock options, with prices increasing when obtaining feedstock from fire hazard thinning.

Total Fuel Economically Available and Price Estimates
The FSA contains over 75,000 BDT of forest-sourced biomass within the three-county area that could be made available annually to the potential bioenergy projects at a roadside price of $40/BDT or less. When transportation costs for the delivery of this fuel to bioenergy projects are factored in, the price of the fuel rises by approximately $15/BDT[6]. As a result, 75,000 BDT of forest-sourced biomass within the three-county area could be made available annually to potential bioenergy projects at a final delivered price of $55/BDT.

The following amounts of forest-sourced biomass could be available annually in each of the counties at a delivered price of $55/BDT, including costs for transportation to the bioenergy facility.

- Custer County: 18,438 BDT
- Lemhi County: 3,857 BDT
- Ravalli County: 55,636 BDT

Interviews with Forest Service and Idaho Department of Lands personnel, as well as annual forest harvest plans confirm these estimates. The Salmon-Challis National Forest alone produced an average of 19,000 green tons of biomass annually for the past three years, with projections for the next three years

[6] Transportation costs are generated based on an estimated cost of $80/hour for operation of a standard 25 ton chip van. For this analysis, five hours of loading and transportation time was factored into the final delivered price.

averaging 14,000 green tons per year. Likewise, the Bitterroot National Forest has produced an average of 5,500 green tons of biomass annually for the past 10 years, with future trends expected to remain similar. Interviews with Forest Service personnel also confirm that these National Forest System lands would be capable of sustainably producing significantly higher biomass volume if a market opportunity existed. Coupled with additional volume from private lands in the region and logging and mill residues, these historical records and projected estimates support the conclusions regarding volume availability in the Cook & O'Laughlin study. Even if actual volume in the FSA was substantially lower than the estimates in the models, historical volume records and future vegetation management plans in the FSA could supply multiple small to medium size bioenergy projects under consideration in the region.

Another important note is that a substantial amount of feedstock could also be obtained and delivered at lower cost tiers, although less total volume is available at these reduced rates, and fuel quality may vary. The price tables below provide cost estimates and associated volume availability for each county in the FSA under a series of pricing ranges.

TABLE 1. Forest biomass supply by county at roadside prices from $10 - $40 per bone dry ton[7].

County	$ 10	$ 15	$ 20	$ 25	$ 30	$ 35	$ 40
Custer County, ID	3,491	3,491	9,652	9,652	17,110	17,110	18,438
Lemhi County, ID	1,474	1,474	1,474	1,474	1,474	3,857	3,857
Ravalli County, MT	20,034	20,034	36,458	51,508	53,539	55,636	55,636

VII. Fuel Pricing Verification and Contractor Capacity

Delivered Wood Fuel Volume and Price

The feedstock supply area does not contain any large users of forest biomass, although forest biomass from the area is occasionally utilized by outside entities. Current facilities identified in the FSA for conversion to bioenergy would use approximately 800 BDT of wood chips annually, and 400 tons of wood pellets annually. Existing forest, chipping, and pellet producers have the capacity to process and transport a quality wood fuel chip and/or pellet that would meet the needs of prospective bioenergy facilities in the three-county region. Interviews with these biomass contractors also indicated that the quantities of biomass required by the potential bioenergy projects could be easily procured without causing disruption or price escalation. Biomass fuel providers servicing the FSA and interviewed for this study included:

- England Sawmill – Salmon, Idaho
- QB Corporation – Salmon, Idaho

Wood Chips

An interview with the largest wood chip provider in the three-county FSA region (England Sawmill) verified that the price for high quality wood fuel chips delivered to potential project sites in the FSA would range from $55 - $65 BDT[8]. This price range is consistent with the estimates projected in the Cook

[7] Figures do not include additional loading and transportation costs.

[8] It would be prudent to include a cost escalator of 3% annually in fuel supply cost estimates to account for inflation and cost of living adjustments.

& O'Laughlin assessment when additional loading and transportation costs are included. Higher prices may reflect superior quality fuels, more expensive primary feedstocks, additional handling, processing, or drying activities, or profits incurred by the wood chip producer.

England Sawmill has the capacity to produce approximately 2,000 tons of green chips annually. The facility also has a dry kiln to dry the chips if necessary. Their primary chip feedstock consists of Lodgepole Pine, but Douglas Fir is available upon request. England Sawmill would also arrange for delivery of chips to a potential bioenergy facility.

Wood Pellets

The price for quality wood pellets from the single provider in the FSA (QB Corporation) was estimated at $115 a ton. However, the producer does not provide delivery services, so consumers are responsible for transport logistics and costs associated with pellet delivery. With these transportation and delivery costs factored in, bioenergy facilities in the FSA could expect to pay between $170 - $200 a ton for wood pellets, depending on hauling distance[9].

The pellet production capacity of QB Corporation is a relatively minor 1,000 tons annually. Pellets are produced from sawdust residues resulting from the business' primary output of laminated beams. QB Corporation has no intention to increase production capacity, unless consistent market demand is present. Historically, production capacity has exceeded demand. However, in 2014, QB sold its entire output of pellets, due to increased demand from a commercial consumer in Montana.

<u>Existing and Competing Uses</u>

The fuel supply area contains a minor market in timber, pulp, and some forest biomass. Demand for forest biomass in the fuel supply area appears to be low. Just a few facilities and operations in northeast Idaho utilize the same or similar feedstock as is required by proposed bioenergy facilities in the FSA. These potential competing sources of demand include:

- Centennial Post and Pole: A small post and pole operation located in Salmon, ID.
- QB Corporation: The glulam plant and pellet producer referenced previously in this report. However, QB Corporation is currently importing all of its material, so feedstock competition is not an issue at this time.
- Small firewood producers: These small businesses and individuals harvest relatively modest amounts of material annually. These amounts are detailed in the Forest Service's annual cut and sold volume summaries.

While it is beyond the scope of this assessment to identify wood fuel demand at each business/entity, it is apparent that the FSA is a relatively quiet market area for timber, residuals, and forest biomass. Conversely, interviews with Forest Service personnel suggested that new markets for forest biomass would result in material being removed from the forest that is currently being left or disposed of on site. This further decreases the likelihood of competition for existing feedstock. This review also found no planned or future projects that would consume large quantities of forest biomass.

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[9] Ibid.

Risk Assessment

Forest biomass is a low value product and can be negatively affected by market and policy changes beyond the control of forestland owners and managers. For example, the cycles of the domestic housing market have a dramatic impact on the availability of biomass material, as demand for structural lumber and panel products from regional manufacturers dictates commercial timber harvest levels, which impact forest biomass availability. Similarly, the global demand for forestry residuals also presents risks as these markets rise and fall over time. The risks for federal forests include the market risks noted above, as well as legal and policy risks. Federal forest management in eastern Idaho has a litigious past, but recent history is more hopeful. For instance, the Lemhi County Forest Restoration Group operating on the Salmon-Challis National Forest has improved the likelihood of project implementation on the forest. In 2009, the Hughes Creek Fuels Reduction Project approved the treatment of over 13,000 acres in the Hughes Creek Drainage on the North Fork Ranger District. This work involved the use of prescribed burning, commercial timber harvest and non-commercial thinning.

The risk of rising fossil fuel prices also has the ability to impact the price of forest-sourced woody biomass. Transportation accounts for approximately one-third of the cost of forest biomass and the risk of rising fuel costs present an uncertainty. However, data from the Energy Information Administration (EIA) indicates that diesel fuel prices are likely to rise by just .7% by 2040[10], less than the rate of inflation. Furthermore, the price for forest-based biomass is not expected to increase beyond the standard rate of inflation (3%). If these forecasts are accurate, fossil fuel prices are unlikely to significantly impact the price of forest-sourced woody biomass for the projects under consideration in this assessment.

New competition for forest-sourced biomass also presents a risk. Increased demand for forest-sourced biomass from newly developed facilities could drive prices upward and decrease availability of low-cost material. However, at this time, there are no plans for any new significant biomass utilization projects in the three-county FSA. Finally, the project could face risk from the escalation of pulp and paper chip prices. The pulp chip market is notoriously volatile. However, given the small volume of material required by proposed projects in the FSA at this time, it is reasonable to assume that this risk could be mitigated with sound contract management.

[10] http://www.eia.gov/forecasts/aeo/pdf/tbla12.pdf

Idaho* Forest Biomass Supply Estimate by County†

Philip S. Cook and Jay O'Laughlin‡

January 24, 2011

* Similar estimates are available for other western states, and a final project report cited often herein provides details on methods and assumptions that were used by U.S. Forest Service and University of Idaho researchers to develop these estimates (see Cook and O'Laughlin 2011, in **References Cited** section on page 6).

† Estimates for sustainable supplies of forest biomass (i.e., forest health or fire hazard reduction thinning and logging residues) for public and private lands at roadside prices of $10 to $40 per dry ton by $5 increments, plus unused mill residues. This information was originally prepared in December 2009 by the University of Idaho's College of Natural Resources for the Western Governors' Association in fulfillment of Contract #20108-0840.

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Introduction

County-level forest biomass* estimates can help states develop wood bioenergy policies and work with local government officials to plan new wood bioenergy facilities. The U.S. Forest Service continues its efforts to improve the forest biomass supply estimates first made available in the “Billion-ton Supply” report (Perlack et al. 2005), and an update is expected in the near future. Meanwhile the forest biomass estimates herein (**Table 1**) fill an information gap and are likely accurate enough for planning purposes. These estimates could be used to supplement U.S. Forest Service CROP (Coordinated Resource Offering Protocol, see USFS 2011) project assessments of near-term supply plans from public lands where such information exists.

Table 1. Forest biomass supply for western states at roadside prices from $10 to $40 per dry ton.

State	*$10*	*$15*	*$20*	*$25*	*$30*	*$35*	*$40*
AZ	75,829	145,672	170,010	222,846	230,036	231,423	231,601
CA	1,904,370	2,733,657	3,155,708	3,425,863	3,538,764	3,569,309	3,602,018
CO	100,120	123,366	197,806	228,948	274,847	300,161	312,104
ID	796,410	853,887	992,527	1,208,995	1,338,801	1,395,282	1,429,463
KS	8,720	8,720	8,720	8,720	8,720	8,720	8,720
MT	646,769	729,152	1,030,913	1,272,212	1,417,237	1,477,018	1,533,464
NE	4,971	4,971	4,971	4,971	4,971	4,971	4,971
NV	4,799	7,791	7,791	7,871	7,871	7,943	7,943
NM	78,314	90,450	143,710	213,109	279,713	292,336	301,716
ND	265	265	265	265	265	265	265
OR	1,339,728	1,466,478	1,541,285	1,585,410	1,611,490	1,618,589	1,648,377
SD	95,407	95,407	97,729	103,466	108,020	108,020	108,020
TX	3,022	3,022	3,022	3,022	3,022	3,022	3,022
UT	37,927	42,887	50,736	77,294	98,360	104,654	116,094
WA	1,152,105	1,274,302	1,360,558	1,467,007	1,517,302	1,550,350	1,606,562
WY	83,644	105,728	126,208	156,919	183,664	196,388	197,171
Total	6,332,399	7,685,757	8,891,960	9,986,918	10,623,082	10,868,450	11,111,511

As illustrated in **Table 1**, west-wide forest biomass supply increases from about 6.3 million dry tons per year at a roadside price of $10 per dry ton to 11.1 million dry tons at a price of $40 per ton. Five states contribute most of the available forest biomass: California, Oregon, Washington, Montana, and Idaho. The tables in this report, starting on page 7, provide county-level estimates of forest biomass supply for one of the states in **Table 1**.

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* Forest biomass is a category of woody biomass that includes three components: [1] forest thinning (removal of small-diameter trees or brush to reduce hazardous fuels and/or improve forest health conditions), [2] forest residues (logging slash), and [3] mill residues.

Limitations

Before using the county-level tables that begin on page 7, one should know what they do not include. These results are based on U.S. Forest Service assumptions and models that in addition to "sustainability screens" excluded lodgepole pine and spruce-fir forest types from fire hazard thinning because stand-replacing fire is considered the norm in these forest types. Furthermore, moist forests west of the Cascade Range in Oregon and Washington received pre-commercial thinning rather than fire hazard reduction thinning. Further explanation is provided in the **Methods** section below, and in our final project report document (Cook and O'Laughlin 2011).

Background

For several years researchers have been developing and refining estimates of forest biomass supply in the western United States. In 2006, the Biomass Task Force for the Western Governors' Association (WGA) Clean and Diversified Energy project refined a national estimate of biomass supply from the U.S. Departments of Energy and Agriculture "Billion-ton Supply" report (Perlack et al. 2005) to obtain a west-wide estimate (WGA 2006). In 2008, the 2006 west-wide estimate was refined further to provide state-level supply estimates for western states (WGA 2008). These estimates were compiled from county-level estimates that were not published.

Objective

The objective of this project was to further refine the state-level forest biomass supply estimates for western states (WGA 2008) to county-level estimates, similar to published estimates for Idaho (see O'Laughlin 2009), and make county-level data available to interested parties. The county-level estimates of forest biomass supply are in easily-read tabular format and are reported for public and private lands at roadside prices of $10 to $40 per dry ton in $5 increments. This report is one of several made available by the Western Governors' Association for individual western states.

Methods

Although WGA (2008) estimates of biomass supply were reported at the state level, the model used to derive the estimates was based on county-level data provided from a U.S. Forest Service (USFS) Forest Inventory and Analysis (FIA) project. We obtained the unpublished, county-level data and spreadsheet model from Dr. Ken Skog of the U.S. Forest Service (Skog et al. 2007). Our county-level forest biomass estimates are derived from the same data using the same methods, models, and results from which the state-level estimates reported by the WGA (2008) were developed. We describe those methods briefly in the following paragraphs. Due to numerous complexities and assumptions of the modeling process used to create both the 2008 and 2006 WGA forest biomass supply estimates, the appropriate sections of each of those reports were appended to the final project report so users of this information would know exactly what they had (see Cook and O'Laughlin 2011, Appendices A and B).

The most important of these assumptions is that biomass removal is a byproduct, or secondary output, of other forest management objectives including forest health treatment, fire hazard reduction work, or the treatment of fuels after logging (see Cook and O'Laughlin 2011, Appendix A, p. 9). In the earlier WGA (2006) study, it was assumed that 50% off the removals would be used for higher-valued products and 50% available for use as fuel (see Cook and O'Laughlin 2011, Appendix B, pp. 16-17).

The later WGA (2008) study allocated a higher proportion of removals to higher-valued products (30 million dry tons ÷ 43 million dry tons = 70%; see Cook and O'Laughlin 2011, Appendix A, p. 10). It should be noted that previous estimation efforts by the WGA (2006) established "sustainability screens" that imposed constraints on forest management activities in order to protect soil productivity, wildlife habitat, biodiversity maintenance, and water quality. These screens reduced the "Billion-ton Supply" estimates for western states by about one-third. In addition, lodgepole pine and spruce-fir forest types were excluded from fire hazard thinning because stand-replacing fire is considered to be the norm in such forest types, and moist forests west of the Cascade Range in Oregon and Washington pre-commercially thinned instead of fire hazard reduction treatment (see Cook and O'Laughlin 2011, Appendix A, pp. 10-13).

Skog et al. (2007) used the USFS's Forest Inventory and Analysis (FIA) and Timber Products Output (TPO) databases to model forest biomass supply for western states.* In general, forest biomass in the model comes from four sources: [1] thinning of timberland with high fire hazard, [2] logging residue left behind after anticipated logging operations for conventional products, [3] general thinning on private woodlands, and [4] unused mill residue.†

Skog et al. (2007) modeled fire hazard thinnings using two tools developed by U.S. Forest Service researchers. First they used the Fuel Treatment Evaluator 3.0 (Skog and Miles 2006), applying several screens and treatments (see Cook and O'Laughlin 2011, Appendix A). Then they used the Fuel Reduction Cost Simulator (Fight et al. 2006) to estimate forest hazard thinning biomass quantities that would be available at various prices. Fire hazard thinning treatments were not applied to national forest timberlands in counties in western Oregon and Washington; instead a pre-commercial thinning treatment was applied.

We used the same supply assumptions that Skog et al. (2007) used in their Base Case estimates (WGA 2008; see Cook and O'Laughlin 2011, Appendix A). Fire hazard thinning

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* Western states include: Arizona, California, Colorado, Idaho, Kansas, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oregon, South Dakota, Texas, Utah, Washington, and Wyoming.

† Skog et al. (2007) also included biomass from treatment of pinyon-juniper woodlands. However, it is excluded in our analysis because the price at which it enters the model ($60 per dry ton) is above our range of analysis ($10 to $40 per dry ton).

volumes are harvested over a period of 22 years, while private timberland thinning volumes for various purposes are harvested over a period of 30 years. Stumpage prices for fire hazard thinnings and logging residues are $0 and $2 per dry ton on public and private lands, respectively, while the cost of chipping biomass is $8 per dry ton for both public and private lands. There is no cost ($0) for unused mill residues.

Difference in modeling method for logging residue. One assumption used in estimating the amount of logging residue in the model is that as thinning to reduce fire hazard increases and general thinning on private land increases (including harvesting biomass for fuels) then the extent of traditional timber harvesting operations will decrease along with associated logging residue. Both the WGA 2008 estimates and our estimates account for this reduction in volume by decreasing logging residue used for fuels by one-quarter unit for each unit increase in biomass for fuels coming from new thinnings (WGA 2008, p. 16). However, the method by which we decrease logging residue is different than the way Skog et al. (2007) did, and our method results in slightly different estimates.

The model used by Skog et al. (2007) model divides biomass from thinnings and logging residue into two land ownership categories: public and private. They computed the reduction in logging residue by subtracting one-quarter unit for each new unit of thinning regardless of land ownership. We compute the reduction for public and private land ownerships separately. Despite the differences in computation, our results aggregated at the state level did not differ by more than 4% from the results attained by Skog et al. (2007).

Dividing "public" categories into federal and state categories. Both fire hazard thinning volumes and logging residue volumes are computed and reported by public and private land categories based on model results by Skog et al. (2007). It was our desire to further divide the public category into federal and state categories. We hypothesize that there are differences in the availability of forest biomass based on land ownership. Federal lands contain a greater proportion of public timberlands and timber volumes in western states than state lands do (Smith et al. 2004). However, federal timberlands tend to be managed under objectives and laws that are more restrictive of biomass removal (e.g., timber harvesting) compared to state trust timberlands that generally are managed for revenue production (Cook and O'Laughlin 2000).

Current forest conditions also may make a difference in biomass availability. Because state trust timberlands tend to be actively managed for revenue production, we hypothesize that there is less need to conduct fire hazard thinning operations on state lands compared to federal lands, which tend to be less actively managed (Koontz 1997). An informal survey of state forest land managers generally confirmed this hypothesis. Both of the above hypotheses led us to attempt to divide the "public" estimates into federal and state categories. Our attempts were unsuccessful for a variety of reasons (see Cook and O'Laughlin 2011, Appendix C); therefore, we report the results herein using only "public" and "private" categories.

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Forest biomass supply at roadside price of **$10** per dry ton

County	Fire hazard thinning		Private land thinning	Logging residue		Unused mill residues	TOTAL
	Public	Private		Public	Private		
Idaho							
Ada	0	0	0	0	6,714	0	6,714
Adams	6,739	0	1,479	1,835	11,609	0	21,663
Bannock	0	0	0	11	416	0	427
Bear Lake	0	0	841	30	483	0	1,355
Benewah	0	0	1,436	7,938	62,909	264	72,546
Bingham	0	0	0	0	1,110	0	1,110
Blaine	1,404	1,234	0	0	0	0	2,638
Boise	647	34	0	20,460	15,028	0	36,169
Bonner	0	0	1,907	22,026	72,324	170	96,426
Bonneville	130	0	0	451	322	0	904
Boundary	0	0	3,219	14,393	21,618	610	39,840
Butte	0	0	0	229	0	0	229
Camas	0	722	0	69	0	0	791
Canyon	0	0	0	0	223	0	223
Caribou	0	0	0	739	198	0	937
Cassia	0	0	0	459	56	0	515
Clark	0	0	0	0	82	0	82
Clearwater	0	0	0	36,911	81,667	42	118,619
Custer	460	0	0	3,031	0	0	3,491
Elmore	825	21	0	6,908	5,021	0	12,775
Franklin	0	0	0	30	113	0	143
Fremont	0	0	0	240	210	0	450
Gem	0	0	0	12	0	360	372
Gooding	0	0	0	0	603	13	616
Idaho	0	1,969	4,394	20,116	36,973	122	63,574
Jefferson	0	0	0	0	5	0	5
Jerome	0	0	0	0	0	0	0
Kootenai	0	0	0	9,393	70,924	3,936	84,254
Latah	116	240	0	7,675	52,819	0	60,849
Lemhi	0	0	0	1,343	131	0	1,474
Lewis	0	0	0	0	14,027	0	14,027
Lincoln	0	0	0	0	0	0	0
Madison	0	0	0	0	0	0	0
Minidoka	0	0	0	0	0	0	0
Nez Perce	0	0	3,928	0	3,148	0	7,076
Oneida	0	0	0	0	0	0	0
Owyhee	0	0	0	0	2,654	0	2,654
Payette	0	0	0	0	0	0	0
Power	0	0	0	0	317	0	317
Shoshone	0	0	1,496	21,953	85,496	0	108,946
Teton	0	0	0	131	82	0	213
Twin Falls	0	0	0	0	0	0	0

Valley	2,365	168	359	16,640	11,455	488	31,474
Washington	0	0	0	861	1,652	0	2,513
TOTAL	12,686	4,389	19,058	193,884	560,387	6,005	796,410

Forest biomass supply at roadside price of **$15** per dry ton

	Fire hazard thinning			Logging residue			
County	Public	Private	Private land thinning	Public	Private	Unused mill residues	TOTAL
Idaho							
Ada	0	0	0	0	6,714	0	6,714
Adams	6,739	0	1,479	1,835	11,609	0	21,663
Bannock	0	0	0	11	416	0	427
Bear Lake	0	0	841	30	483	0	1,355
Benewah	0	0	10,276	7,938	60,699	264	79,176
Bingham	0	0	0	0	1,110	0	1,110
Blaine	1,404	1,234	0	0	0	0	2,638
Boise	6,793	34	0	18,923	15,028	0	40,779
Bonner	0	0	6,784	22,026	71,105	170	100,084
Bonneville	5,446	0	0	0	322	0	5,768
Boundary	0	0	3,219	14,393	21,618	610	39,840
Butte	5,350	0	0	0	0	0	5,350
Camas	876	722	0	0	0	0	1,598
Canyon	0	0	0	0	223	0	223
Caribou	1,576	0	0	345	198	0	2,119
Cassia	0	0	0	459	56	0	515
Clark	0	0	0	0	82	0	82
Clearwater	0	0	0	36,911	81,667	42	118,619
Custer	460	0	0	3,031	0	0	3,491
Elmore	1,031	21	0	6,856	5,021	0	12,929
Franklin	666	0	0	0	113	0	779
Fremont	1,846	0	0	0	210	0	2,056
Gem	0	0	0	12	0	360	372
Gooding	0	0	0	0	603	13	616
Idaho	2,176	8,538	4,394	19,572	35,331	122	70,133
Jefferson	0	0	0	0	5	0	5
Jerome	0	0	0	0	0	0	0
Kootenai	0	1,151	0	9,393	70,636	3,936	85,117
Latah	116	240	0	7,675	52,819	0	60,849
Lemhi	0	0	0	1,343	131	0	1,474
Lewis	0	988	2,575	0	13,136	0	16,700
Lincoln	0	0	0	0	0	0	0
Madison	0	0	0	0	0	0	0
Minidoka	0	0	0	0	0	0	0
Nez Perce	0	0	3,928	0	3,148	0	7,076
Oneida	0	0	0	0	0	0	0
Owyhee	0	0	0	0	2,654	0	2,654
Payette	0	0	0	0	0	0	0
Power	0	0	0	0	317	0	317
Shoshone	0	0	1,496	21,953	85,496	0	108,946
Teton	0	0	0	131	82	0	213
Twin Falls	0	0	0	0	0	0	0

Valley	2,862	168	359	16,515	11,455	488	31,847
Washington	18,602	0	0	0	1,652	0	20,253
TOTAL	55,943	13,097	35,351	189,353	554,137	6,005	853,887

Forest biomass supply at roadside price of **$20** per dry ton

	Fire hazard thinning			Logging residue			
County	Public	Private	Private land thinning	Public	Private	Unused mill residues	TOTAL
Idaho							
Ada	0	0	0	0	6,714	0	6,714
Adams	9,471	0	1,479	1,152	11,609	0	23,712
Bannock	4,020	0	0	0	416	0	4,436
Bear Lake	0	0	841	30	483	0	1,355
Benewah	0	10,970	10,276	7,938	57,956	264	87,404
Bingham	0	0	0	0	1,110	0	1,110
Blaine	2,219	1,234	0	0	0	0	3,454
Boise	8,096	52	0	18,598	15,023	0	41,769
Bonner	4,812	851	6,784	20,823	70,892	170	104,332
Bonneville	5,446	0	0	0	322	0	5,768
Boundary	8,703	980	3,219	12,217	21,373	610	47,103
Butte	5,350	0	0	0	0	0	5,350
Camas	876	848	0	0	0	0	1,723
Canyon	0	0	0	0	223	0	223
Caribou	1,576	0	0	345	198	0	2,119
Cassia	0	0	0	459	56	0	515
Clark	20,022	0	0	0	82	0	20,104
Clearwater	11,705	5,925	0	33,984	80,186	42	131,842
Custer	8,675	0	0	977	0	0	9,652
Elmore	1,448	1,535	0	6,752	4,642	0	14,378
Franklin	666	0	0	0	113	0	779
Fremont	7,662	510	0	0	83	0	8,254
Gem	0	0	0	12	0	360	372
Gooding	0	0	0	0	603	13	616
Idaho	2,176	8,538	4,394	19,572	35,331	122	70,133
Jefferson	0	0	0	0	5	0	5
Jerome	0	0	0	0	0	0	0
Kootenai	30,178	9,814	5,684	1,849	67,050	3,936	118,510
Latah	494	20,238	8,189	7,580	45,772	0	82,274
Lemhi	0	0	0	1,343	131	0	1,474
Lewis	0	988	2,575	0	13,136	0	16,700
Lincoln	0	0	0	0	0	0	0
Madison	1,218	0	0	0	0	0	1,218
Minidoka	0	0	0	0	0	0	0
Nez Perce	0	0	3,928	0	3,148	0	7,076
Oneida	1,413	0	0	0	0	0	1,413
Owyhee	0	0	0	0	2,654	0	2,654
Payette	0	0	0	0	0	0	0
Power	0	0	0	0	317	0	317
Shoshone	2,370	1,164	1,496	21,361	85,205	0	111,596
Teton	0	0	0	131	82	0	213
Twin Falls	0	0	0	0	0	0	0

Valley	7,003	168	359	15,480	11,455	488	34,953
Washington	19,256	0	0	0	1,652	0	20,908
TOTAL	164,858	63,815	49,224	170,604	538,021	6,005	992,527

Forest biomass supply at roadside price of **$25** per dry ton

	Fire hazard thinning			Logging residue			
County	Public	Private	Private land thinning	Public	Private	Unused mill residues	TOTAL
Idaho							
Ada	0	0	0	0	6,714	0	6,714
Adams	9,471	0	1,479	1,152	11,609	0	23,712
Bannock	4,020	0	0	0	416	0	4,436
Bear Lake	0	0	841	30	483	0	1,355
Benewah	4,332	10,970	10,276	6,855	57,956	264	90,653
Bingham	0	0	0	0	1,110	0	1,110
Blaine	6,809	1,234	0	0	0	0	8,044
Boise	8,096	52	0	18,598	15,023	0	41,769
Bonner	4,812	25,119	6,784	20,823	64,825	170	122,532
Bonneville	5,446	0	0	0	322	0	5,768
Boundary	8,703	980	3,219	12,217	21,373	610	47,103
Butte	6,188	0	0	0	0	0	6,188
Camas	876	848	0	0	0	0	1,723
Canyon	0	0	0	0	223	0	223
Caribou	9,661	0	0	0	198	0	9,859
Cassia	0	0	0	459	56	0	515
Clark	20,379	0	0	0	82	0	20,461
Clearwater	43,459	20,010	0	26,046	76,664	42	166,221
Custer	8,675	0	0	977	0	0	9,652
Elmore	1,448	1,711	0	6,752	4,598	0	14,510
Franklin	666	0	0	0	113	0	779
Fremont	7,662	510	0	0	83	0	8,254
Gem	0	0	0	12	0	360	372
Gooding	0	0	0	0	603	13	616
Idaho	64,578	8,538	4,394	3,971	35,331	122	116,935
Jefferson	0	0	0	0	5	0	5
Jerome	0	0	0	0	0	0	0
Kootenai	30,178	12,809	5,684	1,849	66,301	3,936	120,757
Latah	9,663	20,842	8,189	5,288	45,621	0	89,603
Lemhi	0	0	0	1,343	131	0	1,474
Lewis	0	988	2,575	0	13,136	0	16,700
Lincoln	0	0	0	0	0	0	0
Madison	2,906	0	0	0	0	0	2,906
Minidoka	0	0	0	0	0	0	0
Nez Perce	0	0	3,928	0	3,148	0	7,076
Oneida	1,413	0	0	0	0	0	1,413
Owyhee	0	0	0	0	2,654	0	2,654
Payette	0	0	0	0	0	0	0
Power	5,752	0	2,359	0	0	0	8,111
Shoshone	74,236	36,101	1,496	3,394	76,470	0	191,698
Teton	0	0	0	131	82	0	213
Twin Falls	0	0	0	0	0	0	0

Valley	7,003	1,029	359	15,480	11,240	488	35,598
Washington	19,633	0	0	0	1,652	0	21,284
TOTAL	366,067	141,740	51,583	125,378	518,222	6,005	1,208,995

Forest biomass supply at roadside price of **$30** per dry ton

	Fire hazard thinning			Logging residue			
County	Public	Private	Private land thinning	Public	Private	Unused mill residues	TOTAL
Idaho							
Ada	0	0	0	0	6,714	0	6,714
Adams	9,575	0	1,479	1,126	11,609	0	23,790
Bannock	4,020	0	0	0	416	0	4,436
Bear Lake	0	0	841	30	483	0	1,355
Benewah	4,332	10,970	10,276	6,855	57,956	264	90,653
Bingham	0	0	0	0	1,110	0	1,110
Blaine	6,809	1,234	0	0	0	0	8,044
Boise	8,096	1,092	2,034	18,598	14,255	0	44,075
Bonner	101,828	25,119	6,784	0	64,825	170	198,725
Bonneville	5,446	0	0	0	322	0	5,768
Boundary	29,120	2,790	3,219	7,113	20,921	610	63,772
Butte	6,188	0	0	0	0	0	6,188
Camas	2,154	1,410	0	0	0	0	3,564
Canyon	0	0	0	0	223	0	223
Caribou	9,661	0	0	0	198	0	9,859
Cassia	0	0	0	459	56	0	515
Clark	26,414	0	0	0	82	0	26,496
Clearwater	60,010	26,869	0	21,908	74,950	42	183,779
Custer	17,110	0	0	0	0	0	17,110
Elmore	1,448	1,711	0	6,752	4,598	0	14,510
Franklin	666	0	0	0	113	0	779
Fremont	8,140	510	0	0	83	0	8,732
Gem	0	0	0	12	0	360	372
Gooding	0	0	0	0	603	13	616
Idaho	64,578	8,538	4,394	3,971	35,331	122	116,935
Jefferson	0	0	0	0	5	0	5
Jerome	0	0	0	0	0	0	0
Kootenai	30,178	12,809	5,684	1,849	66,301	3,936	120,757
Latah	9,663	20,842	8,189	5,288	45,621	0	89,603
Lemhi	0	0	0	1,343	131	0	1,474
Lewis	0	988	2,575	0	13,136	0	16,700
Lincoln	0	0	0	0	0	0	0
Madison	2,906	0	0	0	0	0	2,906
Minidoka	0	0	0	0	0	0	0
Nez Perce	0	0	3,928	0	3,148	0	7,076
Oneida	1,413	0	0	0	0	0	1,413
Owyhee	0	0	0	0	2,654	0	2,654
Payette	0	0	0	0	0	0	0
Power	5,752	0	2,359	0	0	0	8,111
Shoshone	74,236	36,101	2,267	3,394	76,278	0	192,276
Teton	0	0	0	131	82	0	213
Twin Falls	0	0	0	0	0	0	0

Valley	7,003	1,029	359	15,480	11,240	488	35,598
Washington	20,245	0	0	0	1,652	0	21,897
TOTAL	516,992	152,012	54,388	94,310	515,094	6,005	1,338,801

Forest biomass supply at roadside price of **$35** per dry ton

County	Fire hazard thinning: Public	Fire hazard thinning: Private	Private land thinning	Logging residue: Public	Logging residue: Private	Unused mill residues	TOTAL
Idaho							
Ada	0	0	0	0	6,714	0	6,714
Adams	9,793	0	1,479	1,072	11,609	0	23,953
Bannock	4,020	0	0	0	416	0	4,436
Bear Lake	0	0	841	30	483	0	1,355
Benewah	4,332	13,884	10,276	6,855	57,228	264	92,839
Bingham	0	0	0	0	1,110	0	1,110
Blaine	6,809	1,234	0	0	0	0	8,044
Boise	8,096	1,092	2,034	18,598	14,255	0	44,075
Bonner	101,828	35,258	6,784	0	62,290	170	206,329
Bonneville	8,315	0	0	0	322	0	8,637
Boundary	29,120	2,790	3,219	7,113	20,921	610	63,772
Butte	6,188	0	0	0	0	0	6,188
Camas	2,154	1,410	0	0	0	0	3,564
Canyon	0	0	0	0	223	0	223
Caribou	12,023	1,700	0	0	0	0	13,723
Cassia	0	0	0	459	56	0	515
Clark	27,629	0	0	0	82	0	27,711
Clearwater	60,010	26,869	0	21,908	74,950	42	183,779
Custer	17,110	0	0	0	0	0	17,110
Elmore	1,448	1,711	0	6,752	4,598	0	14,510
Franklin	666	0	0	0	113	0	779
Fremont	8,140	1,625	0	0	0	0	9,765
Gem	0	0	0	12	0	360	372
Gooding	0	0	0	0	603	13	616
Idaho	64,578	9,262	4,394	3,971	35,150	122	117,477
Jefferson	0	0	0	0	5	0	5
Jerome	0	0	0	0	0	0	0
Kootenai	31,766	15,273	5,684	1,452	65,685	3,936	123,796
Latah	9,663	20,842	8,189	5,288	45,621	0	89,603
Lemhi	3,177	0	0	549	131	0	3,857
Lewis	0	4,092	2,575	0	12,361	0	19,028
Lincoln	0	0	0	0	0	0	0
Madison	2,906	0	0	0	0	0	2,906
Minidoka	0	0	0	0	0	0	0
Nez Perce	0	0	3,928	0	3,148	0	7,076
Oneida	1,413	0	0	0	0	0	1,413
Owyhee	0	0	0	0	2,654	0	2,654
Payette	0	0	0	0	0	0	0
Power	5,752	0	2,359	0	0	0	8,111
Shoshone	97,692	47,828	2,267	0	73,346	0	221,134
Teton	0	0	0	131	82	0	213
Twin Falls	0	0	0	0	0	0	0

Valley	7,003	1,560	359	15,480	11,107	488	35,996
Washington	20,245	0	0	0	1,652	0	21,897
TOTAL	551,877	186,429	54,388	89,670	506,913	6,005	1,395,282

Forest biomass supply at roadside price of **$40** per dry ton

	Fire hazard thinning			Logging residue			
County	Public	Private	Private land thinning	Public	Private	Unused mill residues	TOTAL
Idaho							
Ada	0	0	0	0	6,714	0	6,714
Adams	9,793	0	1,479	1,072	11,609	0	23,953
Bannock	4,020	0	0	0	416	0	4,436
Bear Lake	0	0	841	30	483	0	1,355
Benewah	6,537	15,007	10,276	6,304	56,947	264	95,334
Bingham	0	0	0	0	1,110	0	1,110
Blaine	6,809	1,234	0	0	0	0	8,044
Boise	8,096	1,092	2,034	18,598	14,255	0	44,075
Bonner	113,514	37,935	6,784	0	61,621	170	220,024
Bonneville	8,315	0	0	0	322	0	8,637
Boundary	38,350	3,118	3,219	4,806	20,839	610	70,941
Butte	6,188	0	0	0	0	0	6,188
Camas	2,154	1,410	0	0	0	0	3,564
Canyon	0	0	0	0	223	0	223
Caribou	12,023	1,700	0	0	0	0	13,723
Cassia	0	0	0	459	56	0	515
Clark	27,629	0	0	0	82	0	27,711
Clearwater	60,010	26,869	0	21,908	74,950	42	183,779
Custer	18,438	0	0	0	0	0	18,438
Elmore	1,448	1,711	0	6,752	4,598	0	14,510
Franklin	666	0	0	0	113	0	779
Fremont	8,140	1,625	0	0	0	0	9,765
Gem	0	0	0	12	0	360	372
Gooding	0	0	0	0	603	13	616
Idaho	64,578	9,262	4,394	3,971	35,150	122	117,477
Jefferson	0	0	0	0	5	0	5
Jerome	0	0	0	0	0	0	0
Kootenai	37,654	15,273	5,684	0	65,685	3,936	128,232
Latah	9,663	22,968	8,189	5,288	45,089	0	91,198
Lemhi	3,177	0	0	549	131	0	3,857
Lewis	0	4,092	2,575	0	12,361	0	19,028
Lincoln	0	0	0	0	0	0	0
Madison	2,906	0	0	0	0	0	2,906
Minidoka	0	0	0	0	0	0	0
Nez Perce	0	0	3,928	0	3,148	0	7,076
Oneida	1,413	0	0	0	0	0	1,413
Owyhee	0	0	0	0	2,654	0	2,654
Payette	0	0	0	0	0	0	0
Power	5,752	0	2,359	0	0	0	8,111
Shoshone	97,692	52,061	2,267	0	72,288	0	224,308
Teton	0	0	0	131	82	0	213
Twin Falls	0	0	0	0	0	0	0

Valley	7,388	1,560	359	15,384	11,107	488	36,285
Washington	20,245	0	0	0	1,652	0	21,897
TOTAL	582,598	196,917	54,388	85,263	504,291	6,005	1,429,463

Forest Biomass Supply Analysis for Western States by County:*

Final Report to the Western Governors' Association†

Philip S. Cook and Jay O'Laughlin‡

January 24, 2011 (revised)**

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* Estimates for sustainable supplies of forest biomass (i.e., forest health or fire hazard reduction thinning and logging residues) for individual states are available separately.

† This report provides details on methods and assumptions that were used by U.S. Forest Service and University of Idaho researchers to develop county-level estimates woody biomass supply estimates for the western states.

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Introduction

County-level forest biomass* estimates can help states develop wood bioenergy policies and work with local government officials to plan new wood bioenergy facilities. The U.S. Forest Service continues its efforts to improve the forest biomass supply estimates first made available in the “Billion-ton Supply” report (Perlack et al. 2005), and an update is expected in the near future. Meanwhile the forest biomass estimates herein (**Table 1**) fill an information gap and are likely accurate enough for planning purposes. These estimates could be used to supplement U.S. Forest Service CROP (Coordinated Resource Offering Protocol, see USFS 2011) project assessments of near-term supply plans from public lands where such information exists.

Table 1. Forest biomass supply for western states at roadside prices from $10 to $40 per dry ton.

State	*$10*	*$15*	*$20*	*$25*	*$30*	*$35*	*$40*
AZ	75,829	145,672	170,010	222,846	230,036	231,423	231,601
CA	1,904,370	2,733,657	3,155,708	3,425,863	3,538,764	3,569,309	3,602,018
CO	100,120	123,366	197,806	228,948	274,847	300,161	312,104
ID	796,410	853,887	992,527	1,208,995	1,338,801	1,395,282	1,429,463
KS	8,720	8,720	8,720	8,720	8,720	8,720	8,720
MT	646,769	729,152	1,030,913	1,272,212	1,417,237	1,477,018	1,533,464
NE	4,971	4,971	4,971	4,971	4,971	4,971	4,971
NV	4,799	7,791	7,791	7,871	7,871	7,943	7,943
NM	78,314	90,450	143,710	213,109	279,713	292,336	301,716
ND	265	265	265	265	265	265	265
OR	1,339,728	1,466,478	1,541,285	1,585,410	1,611,490	1,618,589	1,648,377
SD	95,407	95,407	97,729	103,466	108,020	108,020	108,020
TX	3,022	3,022	3,022	3,022	3,022	3,022	3,022
UT	37,927	42,887	50,736	77,294	98,360	104,654	116,094
WA	1,152,105	1,274,302	1,360,558	1,467,007	1,517,302	1,550,350	1,606,562
WY	83,644	105,728	126,208	156,919	183,664	196,388	197,171
Total	6,332,399	7,685,757	8,891,960	9,986,918	10,623,082	10,868,450	11,111,511

As illustrated in **Table 1**, west-wide forest biomass supply increases from about 6.3 million dry tons per year at a roadside price of $10 per dry ton to 11.1 million dry tons at a price of $40 per ton. Five states contribute most of the available forest biomass: California, Oregon, Washington, Montana, and Idaho. County-level tables for individual states are available separately.

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* Forest biomass is a category of woody biomass that includes three components: [1] forest thinning (removal of small-diameter trees or brush to reduce hazardous fuels and/or improve forest health conditions), [2] forest residues (logging slash), and [3] mill residues.

Limitations

Before using this information one should know what it does not include. The results in **Table 1** are based on U.S. Forest Service assumptions and models that in addition to "sustainability screens" excluded lodgepole pine and spruce-fir forest types from fire hazard thinning because stand-replacing fire is considered the norm in these forest types. Furthermore, moist forests west of the Cascade Range in Oregon and Washington received pre-commercial thinning rather than fire hazard reduction thinning. Further explanation is provided in the **Methods** section below.

Background

For several years researchers have been developing and refining estimates of forest biomass supply in the western United States. In 2006, the Biomass Task Force for the Western Governors' Association (WGA) Clean and Diversified Energy project refined a national estimate of biomass supply from the U.S. Departments of Energy and Agriculture "Billion-ton Supply" report (Perlack et al. 2005) to obtain a west-wide estimate (WGA 2006). In 2008, the 2006 west-wide estimate was refined further to provide state-level supply estimates for western states (WGA 2008). These estimates were compiled from county-level estimates that were not published.

Objective

The objective of this project was to further refine the state-level forest biomass supply estimates for western states (WGA 2008) to county-level estimates, similar to published estimates for Idaho (see O'Laughlin 2009), and make county-level data available to interested parties. Separately available county-level estimates of forest biomass supply are in easily-read tabular format and are reported for public and private lands at roadside prices of $10 to $40 per dry ton in $5 increments. This report provides details on methods and assumptions, which excerpts from source documents included as appendices.

Methods

Although WGA (2008) estimates of biomass supply were reported at the state level, the model used to derive the estimates was based on county-level data provided from a U.S. Forest Service (USFS) Forest Inventory and Analysis (FIA) project. We obtained the unpublished, county-level data and spreadsheet model from Dr. Ken Skog of the U.S. Forest Service (Skog et al. 2007). Our county-level forest biomass estimates are derived from the same data using the same methods, models, and results from which the state-level estimates reported by the WGA (2008) were developed. We describe those methods briefly in the following paragraphs. Due to numerous complexities and assumptions of the modeling process used to create both the 2008 and 2006 WGA forest biomass supply estimates, the appropriate sections of each of those reports were appended to the final project report so users of this information would know exactly what they had (see **Appendix A** and **Appendix B**).

The most important of these assumptions is that biomass removal is a byproduct, or secondary output, of other forest management objectives including forest health treatment, fire hazard reduction work, or the treatment of fuels after logging (**Appendix A**, p. 9). In the earlier WGA (2006) study, it was assumed that 50% off the removals would be used for higher-valued products and 50% available for use as fuel (**Appendix B**, pp. 16-17).

The later WGA (2008) study allocated a higher proportion of removals to higher-valued products (30 million dry tons ÷ 43 million dry tons = 70%; see **Appendix A**, p. 10). It should be noted that previous estimation efforts by the WGA (2006) established “sustainability screens” that imposed constraints on forest management activities in order to protect soil productivity, wildlife habitat, biodiversity maintenance, and water quality. These screens reduced the “Billion-ton Supply” estimates for western states by about one-third. In addition, lodgepole pine and spruce-fir forest types were excluded from fire hazard thinning because stand-replacing fire is considered to be the norm in such forest types, and moist forests west of the Cascade Range in Oregon and Washington pre-commercially thinned instead of fire hazard reduction treatment (**Appendix A**, pp. 10-13).

Skog et al. (2007) used the USFS’s Forest Inventory and Analysis (FIA) and Timber Products Output (TPO) databases to model forest biomass supply for western states.* In general, forest biomass in the model comes from four sources: [1] thinning of timberland with high fire hazard, [2] logging residue left behind after anticipated logging operations for conventional products, [3] general thinning on private woodlands, and [4] unused mill residue.†

Skog et al. (2007) modeled fire hazard thinnings using two tools developed by U.S. Forest Service researchers. First they used the Fuel Treatment Evaluator 3.0 (Skog and Miles 2006), applying several screens and treatments (see **Appendix A**). Then they used the Fuel Reduction Cost Simulator (Fight et al. 2006) to estimate forest hazard thinning biomass quantities that would be available at various prices. Fire hazard thinning treatments were not applied to national forest timberlands in counties in western Oregon and Washington; instead a pre-commercial thinning treatment was applied.

We used the same supply assumptions that Skog et al. (2007) used in their Base Case estimates (WGA 2008; see **Appendix A**). Fire hazard thinning volumes are harvested over

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* Western states include: Arizona, California, Colorado, Idaho, Kansas, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oregon, South Dakota, Texas, Utah, Washington, and Wyoming.

† Skog et al. (2007) also included biomass from treatment of pinyon-juniper woodlands. However, it is excluded in our analysis because the price at which it enters the model ($60 per dry ton) is above our range of analysis ($10 to $40 per dry ton).

a period of 22 years, while private timberland thinning volumes for various purposes are harvested over a period of 30 years. Stumpage prices for fire hazard thinnings and logging residues are $0 and $2 per dry ton on public and private lands, respectively, while the cost of chipping biomass is $8 per dry ton for both public and private lands. There is no cost ($0) for unused mill residues.

Difference in modeling method for logging residue. One assumption used in estimating the amount of logging residue in the model is that as thinning to reduce fire hazard increases and general thinning on private land increases (including harvesting biomass for fuels) then the extent of traditional timber harvesting operations will decrease along with associated logging residue. Both the WGA 2008 estimates and our estimates account for this reduction in volume by decreasing logging residue used for fuels by one-quarter unit for each unit increase in biomass for fuels coming from new thinnings (WGA 2008, p. 16). However, the method by which we decrease logging residue is different than the way Skog et al. (2007) did, and our method results in slightly different estimates.

The model used by Skog et al. (2007) model divides biomass from thinnings and logging residue into two land ownership categories: public and private. They computed the reduction in logging residue by subtracting one-quarter unit for each new unit of thinning regardless of land ownership. We compute the reduction for public and private land ownerships separately. Despite the differences in computation, our results aggregated at the state level did not differ by more than 4% from the results attained by Skog et al. (2007).

Dividing "public" categories into federal and state categories. Both fire hazard thinning volumes and logging residue volumes are computed and reported by public and private land categories based on model results by Skog et al. (2007). It was our desire to further divide the public category into federal and state categories. We hypothesize that there are differences in the availability of forest biomass based on land ownership. Federal lands contain a greater proportion of public timberlands and timber volumes in western states than state lands do (Smith et al. 2004). However, federal timberlands tend to be managed under objectives and laws that are more restrictive of biomass removal (e.g., timber harvesting) compared to state trust timberlands that generally are managed for revenue production (Cook and O'Laughlin 2000).

Current forest conditions also may make a difference in biomass availability. Because state trust timberlands tend to be actively managed for revenue production, we hypothesize that there is less need to conduct fire hazard thinning operations on state lands compared to federal lands, which tend to be less actively managed (Koontz 1997). An informal survey of state forest land managers generally confirmed this hypothesis. Both of the above hypotheses led us to attempt to divide the "public" estimates into federal and state categories. Our attempts were unsuccessful for a variety of reasons (see **Appendix C**); therefore, we report the results herein using only "public" and "private" categories.

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Western Governors' Association (WGA). 2006. *Biomass Task Force Report: Supply Addendum*. Clean and Diversified Energy Initiative, Western Governors' Association, Denver, CO. 50 p. http://www.westgov.org/index.php?option=com_joomdoc&task=doc_download&gid=93&Itemid=

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Appendix A

Material copied from pages 13-18 of

Strategic Assessment of Bioenergy Development in the West:

Biomass Resource Assessment and Supply Analysis for the WGA Region

(WGA 2008)

4 Forest Biomass Resources

4.1 Sustainability

Estimates of forest biomass supply were developed for several sources by first identifying sustainability principles to guide their use. Specific guidelines are noted for each source discussed. In general terms sustainability means today's management actions will not degrade the ecological functioning of a natural system[11]. In the context of biomass removal from forests, the question of sustainability requires consideration of a wide range of issues, including: nutrient cycling and soil productivity, maintenance of biodiversity, water quality, and wildlife habitat. These factors, and resulting constraints on forest operations to address concerns, are generally very site-specific. Soil productivity in certain soil types, for example, may be more sensitive to micro-nutrient levels and thus require retention of some level of woody residue. Wildlife habitat requirements may stipulate retention of snags or maintenance of coarse woody debris. Again, ecological factors including wildlife and endangered species need careful site-specific evaluations in determining biomass availability.

Sustainability is explicitly addressed in this analysis through several assumptions. On Federal lands, vegetation management projects are implemented within the framework of environmental analyses and regulations that ensure consideration of ecological effects and sustainability. While less restricted, treatments on private lands are also constrained through various environmental laws and regulations[12]. The potential forest biomass supply that is modeled here is a secondary output of other management objectives. We consider biomass that would be available from forest health treatments, fire hazard reduction work, or treatment of activity fuels after logging where questions of sustainability are addressed in the larger management plan.

The present assessment also assumes ecological considerations and practical limitations would have the effect of reducing the amount of biomass available for removal and utilization. The process used models silvicultural treatments and estimates total available biomass. The total available biomass is then further reduced to reflect material left on site to meet ecological constraints or is otherwise impractical to remove. The reduced amount is the net biomass available for removal. For example, a previous study[13] with limited environmental screens estimated 345 million oven dry tons (odt) of biomass may be available from fire hazard reduction thinnings whereas with our additional screens – for our Base Case – we estimate 114 million odt tons are currently available. For each estimate it is assumed these amounts would be harvested over a period of years.

As a final gross check on sustainability, the net annual growth in western forest types was calculated from Forest Inventory and Analysis (FIA) plot data and compared to the estimated biomass removal volumes. While growth, mortality and removal are not

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[11] Helms, J.A., ed. The Dictionary of Forestry. Society of American Foresters, Bethesda, MD. 210 p. (1998).
[12] Ellefson, P.V., Chen, A.S., Moulton, R.T. "State forest practice regulatory programs: an approach to implementing ecosystem management on private forest lands in the United States." Environmental Forestry 21(3):421-432. (1997).
[13] USFS. 2003. A strategic assessment of forest biomass and fuel reduction treatments in western states. http://www.fs.fed.us/research/infocenter.html

holistic measures of ecological integrity, they provide a benchmark of management intensity and impact. For 2002 the total net annual growth of growing stock on timberland in western states was about 97 million odt per year and of this 43 million odt was removed[14]. Growing stock growth does not include growth in tops and branches or in non growing stock trees. Our Base Case would use about 13 million odt of biomass per year, which is an amount less than 25% of currently unremoved net growth of growing stock (13/ (97-43) = 0.24). The estimated fraction would be less if we included, in the denominator, the growth of tops of growing stock trees and growth of non-growing stock trees.

The key effort is to recognize that forest practice laws and guidelines[15] will place ecological constraints on the impacts biomass removal can have. Our adjustments to attempt to reflect these guidelines are very gross and further evaluations will be needed to determine availability in local areas. However, we estimate that public lands would allow less removal than private lands. For a County Commissioner looking at this report, and if they knew that there were no endangered species in their county and no water quality issues or sensitive soils, the estimates of available biomass from this report would be overly conservative. Similarly, if they were in a county with the only remnant population of an endangered species, the estimates may not be conservative enough.

4.2 Biomass sources

The forest biomass sources used for this report are very similar for those used for the Western Governors Association CDEAC report[16]. In general terms the forest biomass sources for the current report are:

- Thinning of timberland with high fire hazard,
- Logging residue left behind after anticipated logging operations for conventional products,
- Treatment of Pinyon Juniper woodland,
- General thinning of private timberland,
- Precommercial thinning on National Forest land in western OR and WA, and
- Unused mill residue.

Our analysis includes supply of biomass from federal lands. But this supply from federal land may not be a viable since the Energy Independence and Security Act of 2007 would not allow biofuels made using biomass from most federal lands[17] to count toward the

[14] Smith, W. Brad; Miles, Patrick D.; Vissage, John S.; Pugh, Scott A. 2003. Forest Resources of the United States, 2002. Gen. Tech. Rep. NC-241. St. Paul, MN: USDA Forest Service, North Central Research Station. 137 p. See Table 36 – Net growth for ND, SD, all intermountain states, OR, WA, CA is (6.5 billion cu. ft. x 30 lbs/ cf / 2000 lbs/ton =) 97.5 million od tons. Removal of growing stock in 2002 was 2.9 billion cf (= 43 million od tons).

[15] Ellefson, P.V., Chen, A.S., Moulton, R.T. "State forest practice regulatory programs: an approach to implementing ecosystem management on private forest lands in the United States." *Environmental Forestry* 21(3):421-432. (1997).

[16] Western Governors Association. 2006. Forest fuel treatment & thinning biomass – Timberland. In: 2006 Biomass Taskforce Report: Clean and diversified energy initiative – Biomass Task Force Report - Supply Addendum. Denver, CO. p 11-12ff. http://www.westgov.org/wga/initiatives/cdeac/Biomass-supply.pdf

17 Supply would be allowed from tribal lands held in trust by the federal government and from all lands in " the immediate vicinity of buildings and other areas regularly occupied by people, or of public infrastructure, at risk from wildfire."

biofuels RFS (renewable fuels standard). The RFS requires 21 billion gallons of "advanced biofuels" need to be supplied by 2022 and only certain biomass sources may be used in meeting meet this standard. The only one of our sources that would not be notably reduced by this restriction would be the estimated 2.7 to 4.3 million od tons of biomass per year from general thinning on private land.

Biomass supply estimates were made for each county in selected Western states. We make a Base Case supply estimate for each source and for some sources we make a High Case estimate to cover a range of uncertainty about supply from the source. Supply estimates include amounts available at roadside in each county for each of several successively higher costs.

Base Case and High Case estimates of total potential annual supply by source are shown in Table 6. Base Case and High Case estimates of potential annual supply by state and roadside cost are shown in Tables 8 and 9, and in Figures 5 and 6.

4.2.1 Thinning of timberland with high fire hazard

Thinning of timberland with high fire hazard contributes to forest sustainability by reducing the risk of uncharacteristically severe fire. By conducting a thinning, the intent is to move toward a natural fire regime pattern with natural recurrence of less severe fire. Supply was estimated by simulating thinnings on federal and non-federal land using the FTE 3.0 model[18] and Forest Service FIA plot data[19]. It is assumed that timberland with current high fire hazard will be thinned over a period of years with either 1) an uneven aged thinning (where some trees of all size classes may be taken) or 2) an even aged thinning where trees where small diameter trees are taken first followed by successively larger trees until the hazard reduction target is met. A series of screens were applied to identify about 23 million federal and non federal acres that would receive simulated treatment (see Clean and Diversified Energy (CDEAC) Biomass Task Force Exhibit 1-1). One screen excluded from treatment is those forest types where stand replacement fire is the norm (lodgepole pine and spruce-fir). An additional screen excluded treatment of wet climate counties in western Oregon and Washington (see separate source below). These areas were excluded because such treatments would not be consistent with our ecological objectives. These screening steps are the same as those used for the WGA CDEAC report.

For federal lands it is assumed even aged and uneven aged treatments are used equally but for non-federal land it is assumed only uneven aged treatments are used. The WGA CDEAC report assumed all eligible timberland was treated equally by each type of treatment. The change was made to reflect the likelihood that non-federal land would seek higher value and profit by using uneven aged treatments on all treated land.
For this source and sources C, D, and E in Table 6 it was assumed biomass volumes identified would be harvested over a period of years. Over this period of harvest, tree growth and mortality will continue and – depending on these growth and mortality rates – additional material would be available for harvest beyond the estimated harvest period. For the Base Case, for sources A and E, we chose a harvest period of 22 years. This time period was previously chosen for the CDEAC study, and used here, so fire

[18] Miles, Patrick D. Aug-04-2005. Fuel Treatment Evaluator web-application version 3.0. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Research Station. [Available only on internet: http://www.ncrs2.fs.fed.us/4801/fiadb/fte_test/fte_testwc.asp]
[19] See http://fia.fs.fed.us/tools-data/

hazard reduction treatments (source A) would be done on about 500,000 acres per year. For sources C and D we chose a harvest period of 30 years to match the harvest period used in the DOE/USDA "Billion ton supply" report[20] for thinning treatments.

For the source A Base Case it is assumed that tops and branches of all trees and main stem of trees up to seven inches diameter at breast height (dbh) are supplied for biofuels and for the High Case trees removed up to nine inches are also supplied for biofuels. Main stem of larger trees not used for biofuels are assumed to be used to make lumber or other higher value products. The cost to remove tops and branches to roadside was assumed to be covered by the cost of removing the whole tree. At roadside there is an assumed $8/dry ton chipping cost. The cost for removing the main stem of trees supplied for biofuels was estimated using the FRCS model[21] for wood removals from each FIA forest plot. It was assumed stumpage cost would be $2/odt on private land and $0 on public land. Using this data wood biomass supply curves were estimated for each county in 12 Western states[22].

4.2.2 Logging residue left behind after anticipated logging operations for conventional products

Wood harvested and left on the ground at harvesting sites (or land clearing sites) may be taken to a certain degree subject to limits including (but not limited to) the need to maintain nutrients on site and to retain habitat. For the Base Case supply estimate we use the allowable removal fractions from the DOE/USDA "Billion-ton-supply" report – 65% for logging residue is available for biofuels from harvest sites and 50% from land clearing sites. The High Case is the same as the Base Case for this source as only a Base Case exists for this source. Data on logging residue and land clearing is from the Forest Service 2002 RPA Timber Product Output data base[23]. To estimate the roadside cost we assume that whole tree removal will be used (where not already used) to bring out tops and branches to roadside. The cost for removing tops and branches to roadside will be covered by the cost of removing the main stem material. That is, the only cost to provide the wood at roadside will be to chip for $8/odt. It is assumed stumpage cost would be $2/odt on private land and $0 on public land. It is recognized logging residues come from current logging operations that provide sawlogs, pulpwood, posts and poles. It is assumed if thinning to reduce fire hazard expands and general thinning on private land expands (including biomass for fuels) then the extent of traditional operations will decrease along with associated logging residue. Given the uncertainty about the degree of displacement - we decrease logging residue use for fuels by one-quarter unit for each unit increase in biomass for fuels coming from new thinnings.

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[20] Perlack, R.D. et al. 2005 Biomass as feedstock for a bioenergy and bioproducts industry: the technical feasibility of a billion ton supply. Oak Ridge National Laboratory, Oak Ridge, TN 60 p. http://feedstockreview.ornl.gov/pdf/billion_ton_vision.pdf

[21] Biesecker, R.L.; Fight, R.D. 2006. My fuel treatment planner: a user guide. Gen. Tech. Rep. PNW-GTR-663. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 31 p. http://www.fs.fed.us/pnw/data/myftp/myftp_home.htm

[22] Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, South Dakota, Utah, Washington, and Wyoming

[23] See http://ncrs2.fs.fed.us/4801/fiadb/rpa_tpo/wc_rpa_tpo.ASP

4.2.3 Treatment of Pinyon-Juniper woodland

Pinyon-Juniper is a category of woodland forest which produces less than 20 cu. ft. per acre per year. Pinyon-Juniper forest type has expanded extensively beyond its historic range and our ecological objective in treating this area over time is to bring the extent of this forest type closer to its historic range. For the Base Case supply estimate we use allowable removal fractions from the DOE/USDA "Billion-ton-supply" report (table A-6) – 45.9% of wood on these public Pinyon-Juniper lands is available for biofuels and 61.2% of wood on private Pinyon-Juniper lands is available. This study excludes wood supply from other woodland categories in the west because we could not cite an ecological reason for such treatment.

For the Base Case we estimate 1/30 of the total volume would be supplied each year (as assumed in the Billion ton supply report.) We made a general estimate that the average cost of harvest would be $60/odt and roadside chipping would cost $12.60/odt for a total of $72.60/odt. The chipping cost for Pinyon-Juniper trees is estimated to be higher than for tops and branches of other trees based on case studies that indicate chipper throughput is lower for Pinyon-Juniper. This is though to be due in part because of the irregular form of Pinyon-Juniper trees. It was assumed stumpage cost would be $2/odt on private land and $0 on public land. For the High Case we assume that the treatments would occur over 20 years and costs would be subsidized at $20/odt based on proposed legislation.

Note that Figure 5 shows that large quantities of biomass from Pinyon-Juniper land become available in several states when price reaches $72.60. This is because we have a single price estimate for removing this biomass. In reality the supply would increase more gradually over a range of prices we estimate would be centered on a price of $72.60.

4.2.4 General thinning of private timberland

It is presumed that as demand and prices for biomass for fuels increases, there will be an increase in operations to harvest both woody biomass and sawlogs/pulpwood in combined operations on private land. Some private land is excluded from this source because it is already treated under the fire hazard reduction thinnings noted above. This source estimates supply from private land acres that have sufficient stocking to warrant thinning but have lower fire hazard. For the Base Case supply estimate we simulated an unevenaged thinning on private land FIA timberland plots that were not treated by a fire hazard thinning procedure (source A.) The estimation procedure is the same used to estimate biomass from thinning U.S. timberland for the Billion ton supply report (stands with density greater than 30% of maximum stand density index are thinned back to 30%.) Since the thinnings may be heavier than appropriate for lodgepole pine and spruce-fir forest types - they are subject to wind throw if thinned too heavily - we did not treat those forest types. A lighter thinning could have been developed and applied as was done in wildland urban interface areas for the CDEAC report and source A above.

The Base Case supply is assumed to be provided in equal annual amounts over 30 years. The supply costs were estimated in the same way as for the fire hazard reduction thinnings (source A.) For the High Case, trees removed up to nine inches are also supplied for biofuels and the annual supply is assumed to be provided in equal amounts over 20 years. It is assumed stumpage cost would be $2/odt.

4.2.5 Precommercial thinning on National Forest land in western counties in OR and WA

We did not simulate fire hazard reduction thinnings on National Forest[24] timberland in counties west of the Cascade Mountains in Oregon and Washington where the thinning objective would not be focused on reducing fire hazard but on maintaining appropriate stocking and habitat conditions. Instead, for source E, we simulated a precommercial thinning of FIA plots to remove trees five to nine inches dbh in stands up to 40 years old. For the Base Case it is assumed that 1/22 of this volume could be harvested each year (the same as for source A.) The cost to harvest and move wood to roadside was estimated for each treated FIA plot using the FRCS model. Harvest costs for individual plots ranged from a low of $22/odt to about $70/odt for many plots with some plots costing over $500/odt. It is assumed stumpage cost on National Forest land is $0/odt. The High Case supply is the same as the Base Case.

4.2.6 Unused mill residue

Forest Service surveys of wood products mills (e.g. lumber, plywood, pulp) periodically estimate amounts of coarse and fine wood and bark residue generated by county and how much goes for various uses (e.g. fuel, fiber input for pulp or panels.) Source F is the estimate of mill residue that goes unused. We assume this entire unused amount is available to make biofuels. The amount supplied is the same for the Base Case and High Case. It is assumed the cost at the mill is $0/odt.

Appendix B

Material copied from pages 9-13 of

Biomass Task Force Report: Supply Addendum

(WGA 2006)

1.2.2 Forest Biomass

Unused logging slash

Estimated quantities of unused logging slash were obtained from the Timber Products Output (TPO) interactive web assessment tool maintained by the US Forest Service[6]. Output from the TPO database in cubic feet of logging residue was converted to dry tons using a density of 25 lbs/ft^3.

Forest fuel treatment & thinning biomass – Timberland and Other Forest Land

The two sections below indicate estimates of wood biomass that may be supplied annually for fuel from: 1) timberland; and 2) other forest land given selected assumptions about treatments. Timberland and other forest land area in the sixteen Western states are 141 million acres, and 80 million acres, respectively.

Two sources are cited for biomass supply estimates from timberland: 1) FTE 3.0 and 2) the DOE/USDA "Billion-ton-supply" report (references below). The Billion-ton-supply report indicates wood biomass supply that may be removed from timberland area that has a higher density of trees that would benefit from thinning, including areas that are and are not currently at high risk for stand replacement fire - 10.8 million od tons per year. The FTE 3.0 estimate indicates supply from treatments focused on areas currently at high risk for stand replacement fire – 6.2 million od tons per year. The FTE 3.0 estimate would treat a subset of the area identified for treatment by the Billion-ton-supply report. The FTE 3.0 estimates are included in Exhibit 1-1 based on the assumption that there would be greater focus on treating land with high fire hazard. Annual biomass supply from timberland could be larger if some areas with lower fire risk are treated for other forest health reasons or because they could be treated to reduce fire hazard at low cost along with nearby high fire hazard areas.

Estimates for biomass supply from other forest land area are from the "billion-ton-supply" report and indicate thinning for all forest health purposes including high fire hazard – 10 million od tons per year.

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[5] Jenkins, B.M. (ed.). 2005. Biomass resources in California: preliminary 2005 Assessment, PIER Collaborative Report, California Energy Commission Contract 500-01-016, Sacramento, CA, (http://faculty.engineering.ucdavis.edu/jenkins/CBC/UpdateFiles/ResourceUpdate.html

6 http://ncrs2.fs.fed.us/4801/fiadb/rpa_tpo/wc_rpa_tpo.ASP

Forest fuel treatment & thinning biomass - Timberland

Estimates of forest thinning biomass to be removed in order to mitigate fire hazard *on timberland*[7] were obtained using the Fuel Treatment Evaluator Version 3.0.[8] The Fuel Treatment Evaluator identified 23 million acres of timberland in 12 Western states[9] at high risk for stand replacement fire (crowning index (CI) or torching index (TI) less than 25 mi/h).[10] Several thinning treatments were simulated for these acres to improve CI and TI values.[11] Treatments include (a) taking trees across all diameter classes (uneven-aged treatment) or (b) taking small trees first and then progressively larger trees until CI and TI targets are met (even-aged treatment).[12] For this Western Governors' Association study, a composite treatment scenario was developed for which half the eligible area (11.5 million acres) was considered for treatment *a* and half for treatment *b*. Treatment would be carried out on an eligible area only if it produced at least 300 ft^3 (or about 4 ovendry (od) tons) of merchantable wood per acre. Sales of merchantable wood (wood that can be used for higher value products, including pulpwood, lumber, posts, and poles) could offset thinning costs. Thinnings would also provide additional biomass from small trees, tops, and branches.

The 300-ft^3 amount was chosen to ensure minimal revenue from merchantable wood to help offset thinning costs. We assume that areas not providing 300 ft^3/acre of merchantable timber may be more inexpensively treated using other mechanical and/or burning treatments, without biomass removal. That is, the loss incurred in utilizing a small volume of small trees may exceed the cost of treating without utilization.

This composite scenario would treat 10.6 of the 23 million acres identified; more than half the eligible area did not meet the 300-ft^3/acre criterion. The 10.6 million acres would provide 270 million od tons of biomass. If 0.5 million acres were treated per year, then 12.3 million od tons of total biomass would be provided per year over 22 years. One-half million acres is chosen as a tentative annual treatment area to represent a plausible moderate increase in thinning area on public and private timberland. If 50% of the biomass would be used for higher value products,

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[7] This and the following section prepared by Ken Skog and Jamie Barbour, USDA Forest Service. Timberland is forest land that has not been withdrawn from timber utilization by statute or regulation and is capable of producing 20 ft^3/acre/year of merchantable wood in natural stands.

[8] Miles, Patrick D. Aug-04-2005. Fuel Treatment Evaluator web-application version 3.0. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Research Station. [Available only on internet: http://www.ncrs2.fs.fed.us/4801/fiadb/fte_test2/fte_test2.asp]

[9] Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, South Dakota, Utah, Washington, and Wyoming.

[10] Eligible timberland acres excluded forest types where high severity fire regimes are the norm—lodgepole pine type and spruce–fir type—with the qualification that these types received limited treatment in wildland urban interface areas. Eligible timberland acres also excluded inventoried roadless areas.

[11] The hazard reduction targets are to (1) increase CI and TI both to >25 mi/h *or* (2) increase CI to >40 mi/h. The attainment of TI and CI targets is limited for scenarios used here by a limitation to take no more that 50% of the initial basal area in order to limit change in ecosystem structure and habitat. Removing this constraint increases biomass yield and number of acres treated to a limited degree but ensures that TI and/or CI target are attained.

[12] The treatments exclude from treatment (1) timberland in counties west of the Cascade Mountains in Oregon and Washington, (2) timberland in inventoried roadless areas, and (3) timberland in severe fire regime forest types (lodgepole pine and spruce–fir). An exception to exclusion (3) was that severe fire regime forest types received limited treatments in wildland–urban interface areas—they were treated with a thinning from below until TI and/or CI targets were met or 25% of basal area was removed.

then the remaining 50%, or 6.2 million od tons per year, may be available for fuel (included in biomass estimates for the Forest portion of Exhibit 1-1 of the WGA full report). After 22 years, more area will have moved into the higher fire hazard class, and continued thinnings would likely be required on at least 0.5 million acres per year.

Total numbers of eligible and treated acres and amount of biomass to be removed were determined using treatment features developed by specialists in fire science, silviculture, wood utilization, and economics.[13] Features of these treatments may differ when implemented. The total number of acres treated and the total amount of biomass removed could be increased by lowering the 300-ft^3/acre merchantable wood requirement, removing the limitation to harvest no more than 50% of basal area, treating more area with the uneven-aged treatment rather than the even-aged treatment, treating areas with less stand replacement fire risk (higher CI and TI), or requiring hazard to be reduced by more than indicated by the current CI and TI targets. For example, if the requirement to provide at least 300 ft^3/acre were eliminated, then 23 million acres of timberland would be thinned (verus 10.6 million acres) and 318 million od tons would be removed in the 12 Western States (versus 270 million od tons).

In comparison to the 6.2 million od ton annual biomass supply for fuel estimated above, the DOE/USDA report Biomass as feedstock for a bioenergy and bioproducts industry: The technical feasibility of a billion-ton annual supply estimated 10.8 million od tons annual supply for fuel and bioproducts for 14 Western States. The DOE/USDA report estimated a total of 323 million od tons to be removed for fuel over 30 years while the estimate above would provide 135 million od tons for fuel over 22 years. The DOE/USDA estimate is higher primarily because it considered thinnings on all timberland without screens for fire hazard, fire regime severity, or change in structural diversity (BA removal limit).

Forest fuel treatment & thinning biomass – Other forest land

Estimates of forest thinning biomass to be removed in order to mitigate fire hazard *on "other forest land"* were obtained from the report *Biomass as feedstock for a bioenergy and bioproducts industry: The technical feasibility of a billion-ton annual supply.*[14] Other forest land is forest land other than timberland or reserved forest land. It includes forest land that is incapable of producing 20 ft^3/year of merchantable wood. 16 western states[15] contain 141 million acres of timberland and 80 million acres of other forest land. The "billion-ton" report estimates 10 million od tons of wood biomass could be supplied annually for fuel or bioproducts from other forest land (included in biomass estimates for the Forest portion of Exhibit 1-1 of the WGA full report). State-level estimates of biomass removals were apportioned to the county level in proportion to the amount of "other forest land" in each county in each state.

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[13] USDA Forest Service researchers designing the treatments include Elizabeth Reinhardt and Wayne Shepperd, Rocky Mountain Research Station; Jamie Barbour, Pacific Northwest Research Station; and Ken Skog, Forest Products Laboratory.

[14] Perlack, R.D. et al. 2005 Biomass as feedstock for a bioenergy and bioproducts industry: the technical feasibility of a billion ton supply. Oak Ridge National Laboratory, Oak Ridge, TN 60 p. http://feedstockreview.ornl.gov/pdf/billion_ton_vision.pdf

[15] Arizona, California, Colorado, Idaho, Kansas, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oregon, South Dakota, Texas, Utah, Washington, and Wyoming.

Primary Sawmill Residues

Estimates of unused mill residues were obtained from the Timber Products Output database[16]. The mill residue estimate does not so far include potential additional residues from sawlogs removed as part of forest thinning operations.

[16] http://ncrs2.fs.fed.us/4801/fiadb/rpa_tpo/wc_rpa_tpo.ASP

Appendix C

Description of Methods for Attempting to Separate

Fire Hazard Thinnings and Logging Residue Estimates

From Public Lands into Federal and State Categories

Separating Fire Hazard Thinning

Attempting to separate into federal and state categories the public fire hazard thinning category results produced by Skog et al. (2007) proved to be challenging. First, we attempted to recreate the results obtained by Skog et al. (2007), keeping separate the more specific land ownership categories (e.g., national forest, BLM, state) contained in RPA data on which the USFS's Full Treatment Evaluator 3.0 (FTE) is based rather than combining them into one "public" category. Unfortunately, we encountered numerous problems, including that the 2002 RPA database and FTE 3.0 are no longer publicly accessible via the internet.

We then attempted to develop a surrogate measure that would allow us to divide the "public" estimates generated by Skog et al. (2007) into separate federal and state categories. We analyzed proportions of total and overstocked timberland acreage and growing stock volume by ownership for logical patterns that might be useful for dividing the public fire hazard thinning estimates. No logical division was evident.

After discussions with state land management officials in Idaho, who indicated they did very few forest management activities on state timberlands with the primary purpose of fire hazard reduction, we decided to ask state land agencies throughout the West about their fire hazarding thinning activities. We developed a simple survey that we e-mailed to state lands agencies in 11 western states:

> Does your agency conduct thinnings on state timberlands with the primary purpose of reducing fire hazard? If yes, in what counties has your agency conducted thinnings on state trust timberlands to reduce fire hazard in the last 2 years (2008-2009)?

We did not send the survey to state foresters in several states because no public land fire hazard thinnings were estimated by the model in the price range we were examining (KS, NE, ND, and TX) or no state timberland existed in the county where public land fire hazard thinnings were estimated (NV-Washoe Co.).

Seven of the 11 state foresters we surveyed responded (**Table C1**). The only state that has a significant amount of forest biomass from public lands that did not respond is California (see Results). The other states that did not respond (AZ, UT, and WY) have lesser amounts of available biomass from fire hazard thinnings on public lands.

Table C1. State lands agencies responses about counties with fire hazard reduction thinnings.

State	*Response*
Colorado	No fire hazard reduction thinnings.
Idaho	One 6-acre project in Bonner County.
Montana	No fire hazard reduction thinnings.
New Mexico	Bernalillo, Colfax, Cibola, Lincoln, Otero, Grant, Rio Arriba, and Torrance counties.
Oregon	Klamath, Josephine, and Jackson counties in FY2008-2009. Douglas, Josephine, Jackson, Klamath, Marian, and Linn counties in FY2010-2011.
South Dakota	Custer and Pennington counties.
Washington	Lincoln, Spokane, Kittatas, Stevens, Klickitat, Yakima, Mason, Okanogan, and Pacific counties. 4,713 acres in FY2008; 5,593 acres in FY2009

State trust land managers in Colorado and Montana reported no fire hazard thinning treatments on state timberlands in 2008-2009 (Table C1). Idaho reported on one small project in one county. South Dakota reported projects in two counties. New Mexico, Oregon, and Washington reported projects in several counties.

Because of the variability in state lands agencies' participation in and reporting of fire hazard reduction projects, we decided not to split the public fire hazard thinning category into federal and state categories for all states and counties. In those states that report some fire hazard thinnings on state lands, further investigation of our estimates is recommended for the specific counties where fire hazard reduction activities are reported (**Table C1**).

Separating Logging Residue

We were able to obtain logging residue estimates with the “public” category divided into “U.S. Forest Service” (i.e., national forests) and “other public” from the 2007 TPO database. Although the “other public” category includes other federal agencies (e.g., BLM) and county and municipal lands, we assumed the majority of logging residue would come from state lands. However, after looking at results from both the TPO data and Skog et al. (2007), there were inconsistencies, with counties producing public logging residue in both cases (**Table C2**). Only 154 of the 272 (57%) counties west-wide had public logging residues appear in both the TPO estimate and the results from the model used by Skog et al. (2007). We felt this inconsistency made separating the public logging residue results into federal and state categories unreliable.

Table C2. Number of counties with public logging residue estimated in TPO database, Skog et al. (2007) model, or both.

State	*TPO database only*	*Skog et al. (2007) model only*	*Both TPO database and Skog et al. (2007) model*
AZ	1	3	2
CA	0	9	22
CO	6	9	17
ID	2	14	13
MT	4	12	19
NE	4	0	0
NV	1	1	0
NM	0	3	8
ND	1	0	0
OR	5	1	27
SD	2	0	4
TX	16	0	0
UT	3	4	12
WA	8	2	22
WY	3	4	8
Total	56	62	154

In addition, the model used by Skog et al. (2007) and our adaptation of it reduced available logging residue estimates by one quarter unit for each unit increase in fire hazard thinnings. Without the ability to separate fire hazard thinnings into federal and state categories, separating logging residue into those categories would have required further guesswork subject to question. Therefore, we did not separate public logging residues into federal and state categories.

In summary, we were unable to separate the public fire hazard thinning and public logging residue estimates into federal and state categories because of the difficulties described above. Therefore, our results are presented with public and private land categories only.