An Assessment of Forest-based Woody Biomass Supply and Use in Montana

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Executive Summary

This report was prepared at the request of the Montana DNRC and quantifies the volumes of woody biomass supply and use in Montana. Four woody biomass sources were examined: live trees, standing dead trees, logging residue, and primary mill residue. Not all of the woody biomass supply described in this paper is or would be available to users because of various economic, logistic, and social factors. Estimates of the quantity potentially available from live and standing dead trees were made using the latest (2003 to 2007) Forest Inventory and Analysis (FIA) data. Estimates of logging residue and primary mill residue were made using the latest (2004) information in the FIA Timber Products Output (TPO) database.

In-state consumption of woody biomass is 2.2 to 2.7 million dry tons (MDT) annually. Mill residue volume is declining as a result of ongoing losses of milling capacity, declining timber harvest volumes, and increased milling efficiency. In-state production of mill residue has fallen from about 1.5 to 1.0 MDT annually between 2004 and 2008, and between 99 and 100% of mill residue in Montana is utilized. Logging residue generated in-state has dropped from about 0.86 to 0.52 MDT per year during the same period. The amount of logging residue generated in Montana is declining as a result of falling timber harvest levels and increased efficiency. This woody biomass supply source is believed to be underutilized, but availability is constrained, and the characteristics of logging residue often make it unsuitable for facilities that require clean, dry feedstock.

Total live and standing dead tree above-ground woody biomass on Montana's 20 million acres of non-reserved timberlands exceeds 850 MDT and represents the largest and most feasible source for additional woody biomass feedstock. Live and standing dead tree above-ground woody biomass are underutilized due to political and economic constraints on availability rather than supply levels. The availability of woody biomass supply was estimated to be constrained to somewhere closer to 40 MDT, which represents a multi-decade supply from just 3.59 million acre (18%) of timberlands in Montana and an even smaller proportion (5%) of total biomass on timberlands. Nearly 70% of this potentially available supply of biomass is located on national forests, while just 46% of the potentially available acres are in national forests.

Declining in-state timber harvest, especially on the largest landownership (i.e., national forests), has profoundly impacted the state's wood products industry and may impact the potential development of a biomass industry in Montana. More woody biomass material from the sources examined could become available through increases in commercial timber harvests, salvage logging, fire hazard reduction treatments, forest restoration, and/or pre-commercial thinnings.

Introduction

This report was prepared at the request of the Montana Department of Natural Resources and Conservation (DNRC) for the purpose of examining Montana forest biomass supply and availability. This paper describes and quantifies the volumes of woody biomass supply from several sources in Montana. Volumes of woody material used by existing Montana facilities (including woody biomass users and traditional timber users like saw, veneer, and pulp mills, log home manufacturers, and post and pole producers) are also summarized in order to provide perspective on the amount of wood used by in-state facilities relative to the supply. (Woody biomass does not include tree leaves or needles.) Four woody biomass sources are examined: live trees, standing dead trees, logging residue (i.e., slash left in the forest from the harvesting of commercial timber products), and primary mill residue (e.g., sawdust, bark, and chips from facilities that process timber into products such as lumber or log homes). Other potential sources for woody biomass not examined in this paper include mill wastes from secondary wood products (e.g., door, cabinet, or furniture) manufacturers, construction and municipal waste wood, and urban tree trimmings.

Not all of the woody biomass supply described in this paper is or would be available to existing or new biomass users because of various economic, logistic, and social factors. Changing market conditions for solid and reconstituted wood products, competition from existing roundwood and mill residue users (e.g., pulp mills, fiberboard and particle board plants, fuel pellet manufacturers, etc.), relatively high handling and transportation costs for small-diameter trees and slash, as well as political, administrative, and legal uncertainties surrounding public forest land influence the availability of woody biomass from the various supply sources examined.

Woody biomass supply from Montana forests

The Interior West Forest Inventory and Analysis (IW-FIA) Program (www.fs.fed.us/rm/ogden/) of the USDA Forest Service collects, processes, and provides data that can be used to estimate the abundance of woody biomass in the forests of Montana and seven other Rocky Mountain states. The forest inventory information summarized below is from the on-line "Forest Inventory EVALIDator" (http://fiatools.fs.fed.us/TableMaker/tmattribute.jsp) and "Forest Inventory Mapmaker version 3.0" (http://www.ncrs2.fs.fed.us/4801/fiadb/fim30/wcfim30.asp) tools. Information on standing dead trees is not currently available on line but was provided by IW-

FIA (personal communication with Larry DeBlander, Rocky Mountain Research Station, Ogden, UT).

According to the most recently available FIA information (data years 2003–2007), there are approximately 20 million acres of non-reserved timberland in Montana, and above-ground woody biomass in live and standing dead trees on Montana timberlands exceeds 850 million dry tons (MDT). Non-reserved timberland is a subset (78%) of all forest land in the state and is defined as "forest land that is producing or capable of producing in excess of 20 cubic feet per acre per year of wood at culmination of mean annual increment and which is not permanently reserved from wood products utilization through statute or administrative designation." Examples of reserved areas not included in timberland include forest land in the National Park System or in the National Wilderness Preservation System.

The supply of live tree and standing dead tree woody biomass is evaluated only on timberland in this paper. There are, however, portions of timberland in Montana from which the supply of woody biomass may not be available. These areas include approximately 6.4 million acres of Inventoried Roadless Area (IRA) on national forests in Montana (http://roadless.fs.fed.us/). Currently there are ongoing political and legal debates over the definition, status, and boundaries of roadless areas, and the FIA data in Montana are not readily searchable by IRA status. Roadless areas on federal timberland are thus included in this paper's analysis of live tree biomass supply, because currently there is no definitive/conclusive way to identify precisely how much woody biomass is inside versus outside the IRA in Montana.

Live tree woody biomass

Above-ground live tree woody biomass in trees with diameter at breast height (dbh) ≥ 1.0 inch (in.) on timberland in Montana totals 724.9 MDT (Table 1). Small live trees are very abundant in Montana, and many have suggested using small trees removed from the forest during restoration or hazardous fuels reduction treatments as a source of woody biomass. There are more than 9 billion live trees on Montana timberland, and more than 75% of those trees have dbh < 7.0 in. The amount of biomass per tree, however, increases with tree size, and less than 20% (133 MDT) of live tree woody biomass on Montana timberland is contained in trees smaller than 7.0 in. dbh. On average in Montana, roughly 200 live trees smaller than 3.0 in. dbh comprise one dry ton of biomass, and a dry ton contains about 50 live trees between 3.0 and 4.9 in. dbh. Whereas a single live tree between 19.0 and 21.0 in. contains just over 1 dry ton of biomass. Roughly one-half (375

MDT) of above-ground live tree woody biomass on timberland in Montana is contained in trees with a dbh of less than 12.0 in., and about one-quarter (167 MDT) of the biomass is in trees with a dbh of 17.0 in. or larger.

Table 1: Live tree above-ground woody biomass on Montana timberland

Tree dbh class (inches)	# live trees	% of trees	dry tons	% of biomass	trees per ton	tons per tree
1.0-2.9	4,163,772,866	44.345%	21,233,883	2.9%	196.09	0.005
3.0-4.9	1,959,992,132	20.874%	41,193,857	5.7%	47.58	0.021
5.0-6.9	1,211,685,094	12.905%	70,644,181	9.7%	17.15	0.058
7.0-8.9	835,806,505	8.901%	95,251,534	13.1%	8.77	0.114
9.0-10.9	510,045,514	5.432%	100,127,043	13.8%	5.09	0.196
11.0-12.9	299,544,722	3.190%	92,170,455	12.7%	3.25	0.308
13.0-14.9	174,619,123	1.860%	78,164,970	10.8%	2.23	0.448
15.0-16.9	96,678,165	1.030%	59,044,135	8.1%	1.64	0.611
17.0-18.9	57,158,627	0.609%	45,994,661	6.3%	1.24	0.805
19.0-20.9	32,173,506	0.343%	33,171,698	4.6%	0.97	1.031
21.0-22.9	19,338,883	0.206%	24,917,284	3.4%	0.78	1.288
23.0-24.9	11,510,971	0.123%	18,518,373	2.6%	0.62	1.609
25.0-26.9	6,963,950	0.074%	13,787,455	1.9%	0.51	1.980
27.0-28.9	3,945,978	0.042%	9,045,317	1.2%	0.44	2.292
29.0-30.9	2,849,369	0.030%	8,022,447	1.1%	0.36	2.816
31.0-32.9	1,718,543	0.018%	5,639,120	0.8%	0.30	3.281
33.0-34.9	685,296	0.007%	2,346,264	0.3%	0.29	3.424
35.0-36.9	288,767	0.003%	1,263,736	0.2%	0.23	4.376
37.0-38.9	298,119	0.003%	1,308,806	0.2%	0.23	4.390
39.0-40.9	223,346	0.002%	1,401,039	0.2%	0.16	6.273
41.0+	297,382	0.003%	1,686,509	0.2%	0.18	5.671
Total	9,389,596,868	100%	724,932,771	100%	12.95	0.077

Another key variable related to the supply and availability of woody biomass is landowner. Almost three-quarters—74% (538 MDT)—of live tree woody biomass on Montana timberland is within national forests (Table 2). The next largest ownership class is private lands, with 18% (130 MDT). Statewide, the Bureau of Land Management and State of Montana each have about 4% of the live tree woody biomass.

Table 2: Live tree woody biomass and timberland acreage by ownership in Montana

Ownership class	dry tons	% of biomass	acres	% of acres	tons per acre
National Forest	538,449,891	74.28%	12,214,715	61.0%	44.08
Bureau of Land Mgmt	27,054,323	3.73%	901,251	4.5%	30.02
State	29,287,009	4.04%	785,388	3.9%	37.29
County and Municipal	66,388	0.01%	13,647	0.1%	4.86
Private	130,075,160	17.94%	6,109,211	30.5%	21.29
Total	724,932,771	100%	20,024,214	100%	36.20

National forests comprise 61% (12.2 million acres) of the timberland in Montana, and private lands about one-half that much. Thus on average, national forests have about 44 dry tons per acre of live

tree woody biomass versus 21 tons per acre on private timberland. BLM and State of Montana timberlands have 30 to 37 tons per acre. The statewide average is 36 tons per acre of live tree woody biomass on timberland.

If the utilization of live tree woody biomass is going to increase appreciably in Montana, it will likely require using material from all ownership classes. National forests will play a pivotal role in biomass availability, if for no other reason than their majority shares of timberland and biomass supply in the state. Other studies have also indicated that national forests in Montana have substantial acreages of timberland that would benefit from restoration and hazardous fuels reduction treatments that involve the removal of woody material that is suitable for both biomass and traditional wood products utilization (Fiedler and others 1999, 2001, 2004; Keegan and others 2004).

Table 3: Live tree woody biomass distance to road on Montana timberlands

Distance to road	dry tons	% of biomass
100 ft or less	19,714,370	2.7%
101-300 ft	26,729,264	3.7%
301-500 ft	39,886,892	5.5%
501-1,000 ft	61,588,647	8.5%
1,001 ft to 1/2 mile	136,805,752	18.9%
1/2 to 1 mile	144,767,295	20.0%
1 to 3 miles	203,644,216	28.1%
3 to 5 miles	64,021,514	8.8%
Greater than 5 miles	27,774,820	3.8%
Total	724,932,771	100%

Distance to a road and slope are additional factors that can play substantial roles in the financial and logistic feasibility of utilizing the live tree woody biomass supply. About 20% (148 MDT) of live tree woody biomass on timberlands in Montana is located within 1,000 feet (ft.) of a road, while about 40% (295 MDT) is located more than 1 mile from a road (Table 3). Nearly 65% (468 MDT) of the live tree biomass on Montana timberlands is located on land with slopes of less than 40%, and 29% (210 MDT) is located on land with less than 20% slope (Table 4). These figures suggest that substantial volumes of live tree biomass are accessible to ground-based harvesting systems, which are substantially less costly than cable or helicopter logging, and likely would not require new forest roads to be built.

Table 4: Live tree woody biomass by slope class on Montana timberlands

Slope	dry tons	% of biomass
0-20 percent	210,421,122	29.03%
21-40 percent	258,039,848	35.60%
41-60 percent	193,005,872	26.62%
61-80 percent	57,608,883	7.95%
81-100 percent	5,544,206	0.76%
100+ percent	312,845	0.04%
Total	724,932,771	100%

Standing dead tree woody biomass

Standing dead trees are also quite abundant in Montana, and many have suggested using standing dead trees removed from the forest during timber salvage or hazardous fuels reduction treatments as a source of woody biomass. Above-ground standing dead tree woody biomass does not include trees, logs, limbs, or leaves and needles lying on the forest floor. This material is referred to as coarse woody debris or forest litter. Above-ground standing dead tree woody biomass in trees with dbh ≥ 5.0 in. totals 135.8 MDT. (FIA does not measure standing dead trees with dbh < 5.0 in.) More than 60% of the standing dead tree woody biomass is in standing dead trees with dbh < 15.0 in., and more than 40% is in trees with dbh < 11.0 in. (Table 5).

Table 5: Standing dead tree above-ground woody biomass on Montana timberland

Tree dbh class (inches)	dry tons	% of biomass
1.0-2.9	N/A*	N/A*
3.0-4.9	N/A*	N/A*
5.0-6.9	16,456,029	12.1%
7.0-8.9	20,042,779	14.8%
9.0-10.9	19,544,718	14.4%
11.0-12.9	17,226,415	12.7%
13.0-14.9	14,233,275	10.5%
15.0-16.9	11,639,383	8.6%
17.0-18.9	8,416,649	6.2%
19.0-20.9	7,174,052	5.3%
21.0-22.9	6,197,588	4.6%
23.0-24.9	3,368,341	2.5%
25.0-26.9	4,689,629	3.5%
27.0-28.9	2,377,551	1.8%
29.0-30.9	1,337,610	1.0%
31.0-32.9	1,079,165	0.8%
33.0-34.9	402,309	0.3%
35.0-36.9	804,211	0.6%
37.0-38.9	560,224	0.4%
39.0-40.9	245,180	0.2%
41.0+	-	0.0%
Total	135,795,109	100%

*N/A = FIA does not measure standing dead trees with dbh < 5.0 inches.

More than 85% (115.7 MDT) of standing dead tree woody biomass on Montana timberlands is located in national forests, followed by 9.4% (12.8 MDT) located on private timberlands (Table 6). There is an average of 9.47 tons per acre of standing dead tree woody biomass on national forest lands, followed by 5.61 tons per acre on State lands, and 2.09 tons per acre on private lands. The total and per acre amounts of dead tree biomass on national forests seem disproportionately high given that national forests account for 61% of timberland and private lands account for 30%.

Table 6: Standing dead tree woody biomass and timberland acreage by ownership in Montana

Ownership class	dry tons	% of biomass	acres	% of acres	tons per acre
National Forest	115,715,924	85.2%	12,214,715	61.0%	9.47
Bureau of Land Mgmt	2,892,950	2.1%	901,251	4.5%	3.21
State	4,409,443	3.2%	785,388	3.9%	5.61
County and Municipal	-	0.0%	13,647	0.1%	-
Private	12,776,792	9.4%	6,109,211	30.5%	2.09
Total	135,795,109	100%	20,024,214	100%	6.78

Live and standing dead tree woody biomass estimates refined

The live and standing dead tree woody biomass figures provided above strongly suggest that there is a substantial supply of woody biomass on Montana timberlands that could help support new and existing biomass and traditional wood products facilities. But because availability of the woody biomass supply is constrained by social and/or economic factors, it would be beneficial to examine the potentially available supply using data filters to refine woody biomass estimates based on socio-economic constraints. The FIA data can be filtered by different criteria (e.g., distance to road, stand age, slope, tree dbh, species, county, etc.) simultaneously. Examples of this type of data filtering are provided below. The data filters used in this paper are for illustrative purposes only (i.e., they are somewhat arbitrary, not ecologically based, not policy recommendations) and include the following:

- timberlands, to filter out reserved areas and non-productive forests.
- distance from road of 0.5 mile or less, to filter out most or all roadless areas;
- stand ages of 0 to 100 years, to filter out most older forest;
- slopes from 0 to 40 percent, to filter out most steep areas where ground-based harvesting equipment may not be feasible; and
- tree dbh of 5.0 to 10.9 inches, to filter out live and dead saplings as well as the larger-diameter material which is more often used for other wood products like lumber, plywood, and house logs.

Simultaneously applying these filters is thought to provide very conservative (i.e., low) estimates of the potentially available portion of the land base and woody biomass supply found in live and standing dead trees on Montana timberland.

Filtered estimates indicate that there are 93.1 MDT of live and standing dead tree above-ground woody biomass on the 3.59 million acres of Montana timberland that is 0.5 mile or less from a road, on slopes of 0 to 40%, and in stands with ages from 0 to 100 years (Table 7). This 3.59 million acres would account for less than one-third of the 13.6 million timberland acres not in IRA.

Table 7: Live and standing dead tree above-ground woody biomass on Montana non-reserved timberland, 0.5 mile or less from a road, slope 0-40%, stand ages 0-100 years.

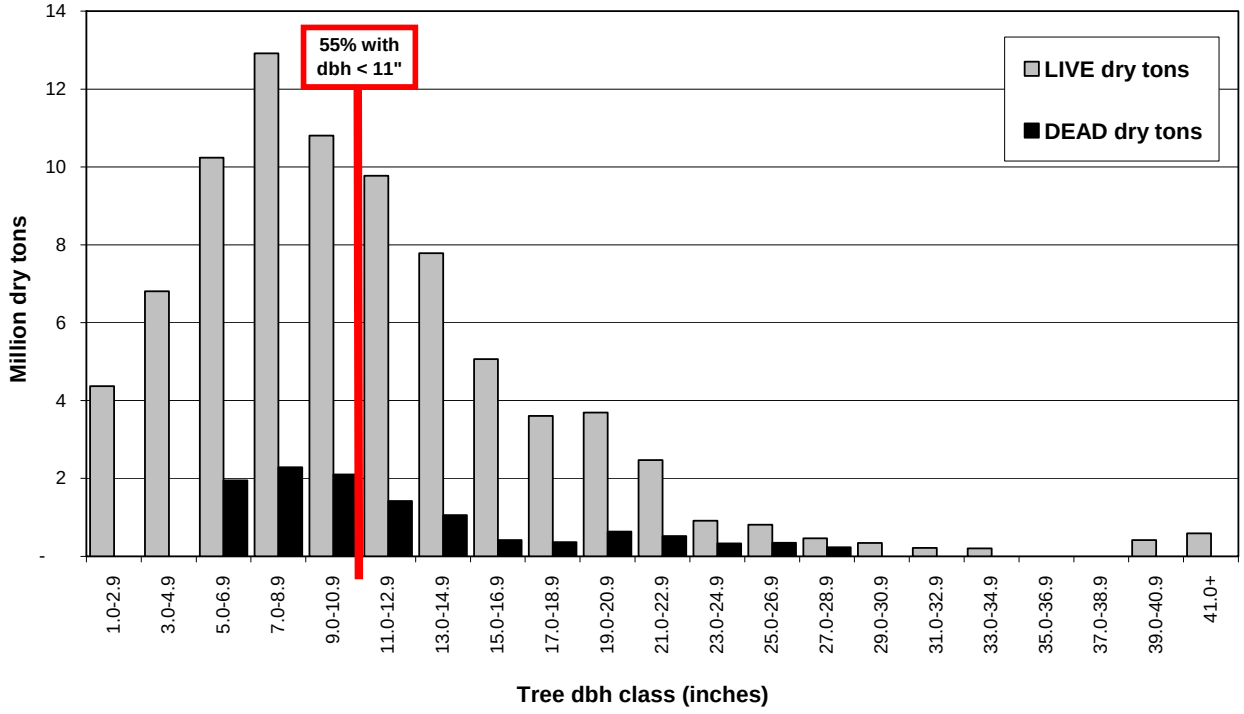
Tree dbh class (inches)	LIVE dry tons	DEAD dry tons	TOTAL dry tons	% of Total
1.0-2.9	4,372,354	N/A*	4,372,354	4.7%
3.0-4.9	6,804,653	N/A*	6,804,653	7.3%
5.0-6.9	10,235,339	1,947,824	12,183,163	13.1%
7.0-8.9	12,918,920	2,286,209	15,205,129	16.3%
9.0-10.9	10,805,529	2,100,034	12,905,563	13.9%
11.0-12.9	9,775,991	1,418,339	11,194,330	12.0%
13.0-14.9	7,783,465	1,059,530	8,842,995	9.5%
15.0-16.9	5,061,985	418,690	5,480,675	5.9%
17.0-18.9	3,607,809	364,383	3,972,192	4.3%
19.0-20.9	3,691,317	636,090	4,327,407	4.6%
21.0-22.9	2,471,635	519,294	2,990,929	3.2%
23.0-24.9	911,969	327,879	1,239,848	1.3%
25.0-26.9	812,114	348,347	1,160,461	1.2%
27.0-28.9	461,809	230,698	692,507	0.7%
29.0-30.9	341,589	-	341,589	0.4%
31.0-32.9	212,832	-	212,832	0.2%
33.0-34.9	204,226	-	204,226	0.2%
35.0-36.9	-	-	-	0.0%
37.0-38.9	-	-	-	0.0%
39.0-40.9	415,226	-	415,226	0.4%
41.0+	590,958	-	590,958	0.6%
Total	81,479,722	11,657,317	93,137,039	100%

*N/A = FIA does not measure standing dead trees with dbh < 5.0 inches.

From this example, one can see that a relatively small portion (18%) of timberland in Montana could provide a substantial amount of woody biomass for existing and new facilities. As explained in greater detail below, existing woody biomass users in Montana consume approximately 2.2 to 2.7 MDT of woody biomass (including mill residue, roundwood pulpwood, industrial fuelwood, recycled cardboard, and some slash) each year, and mill residue accounts for 1.0 to 1.5 MDT of current woody biomass consumption annually. So, even this small proportion of

timberland could readily provide a multi-decade supply to supplement the mill residue source. Likewise, because more than one-half (55%) of this above-ground woody biomass is in trees with a dbh < 11.0 in. (Figure1), one can see that statewide much of the biomass is in relatively smaller-diameter live and dead trees and relatively little is contained in the largest-diameter trees.

Figure 1: Live and standing dead tree above-ground woody biomass on Montana non-reserved timberland, 0.5 mile or less from a road, on slope less than 40%, in stand ages 0-100 years.



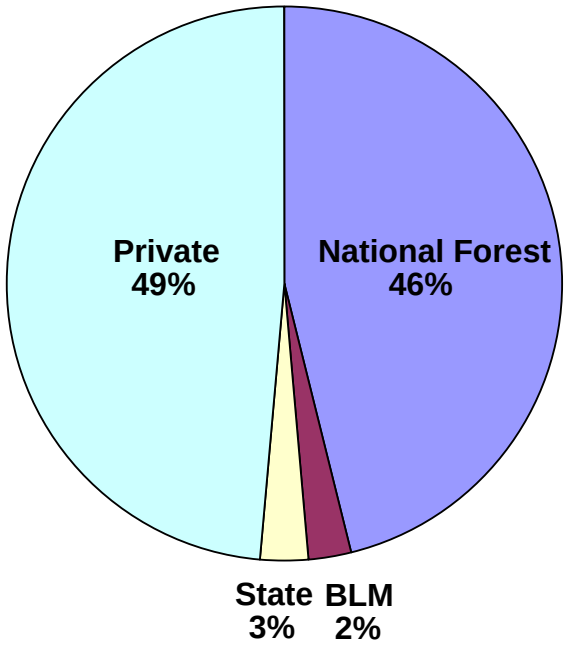
Using the same filters, among just those live and standing dead trees with dbh of 5.0 to 10.9 in. there are 40.3 MDT of above-ground woody biomass on Montana timberlands 0.5 mile or less from a road, on slopes of 0 to 40%, and in stands with ages from 0 to 100 years (Table 8). Again, only considering relatively small-diameter trees on just a fraction of the non-reserved timberland, there is evidence of an ample supply of woody biomass to meet the needs of existing and potentially new woody biomass users for several decades.

Table 8: Live and standing dead tree above-ground woody biomass and acreage by ownership of Montana non-reserved timberland, 0.5 mile or less from a road, slope 0-40%, stand ages 0-100 years, for tree dbh 5.0-10.9 inches.

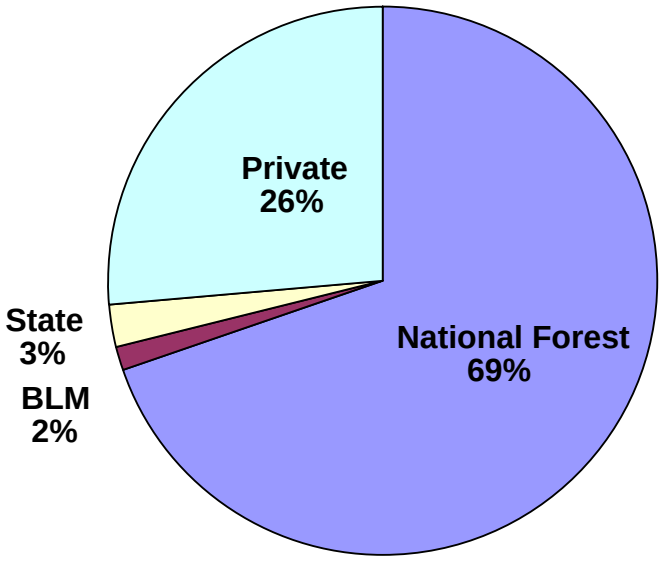
Ownership class	TOTAL dry tons	% of biomass	acres	% of acres	tons per acre
National Forest	28,066,368	69.7%	1,650,675	46.0%	17.00
Bureau of Land Mgmt	609,974	1.5%	88,239	2.5%	6.91
State	1,040,096	2.6%	99,642	2.8%	10.44
Private	10,577,416	26.3%	1,746,044	48.7%	6.06
Total	40,293,854	100%	3,584,600	100%	11.24

Nearly 70% (28.1 MDT) of the potentially available (i.e., filtered, smaller-diameter) live and standing dead tree woody biomass described above is located on 1.65 million acres of national forest land (Figure 2), with an average of 17 tons per acre. About 26% (10.6 MDT) of the woody biomass is located on 1.75 million acres of private timberland, at an average of 6 tons per acre.

Figure 2: Potentially available acres and woody biomass by ownership



Total acres = 3.6 million



Total dry tons = 40.3 million

Only about 4% (1.6 MDT) of the filtered, smaller-diameter tree woody biomass is found on BLM and State lands, combined. State lands meeting the filter criteria have slightly more than 10 tons per acre on average of live and standing dead tree woody biomass in trees with dbh of 5.0 to 10.9 in. These figures further illustrate the importance of national forests as a supply source for woody

biomass, while demonstrating the tremendous amount of potential fuel for wildfires that live and standing dead tree woody biomass on potentially available national forest timberland represent.

Assuming that the data filters used in this paper provide reasonable approximations of the social constraints impacting availability of woody biomass from live and standing dead trees on Montana timberlands, the 40.3 MDT of potentially available smaller-tree woody biomass represents just 5% of the current (860.7 MDT) total live and standing dead tree woody biomass across all Montana timberlands. This small fraction of total biomass that could be available for utilization suggests ample supplies of woody biomass remaining on timberlands across the state to support natural ecological processes, wildlife habitat requirements, and other uses of wood for products.

Logging residue supply

Logging residue is the woody material cut or killed and left in the forest or at the log landing during the harvesting of timber for commercial products (e.g., sawlogs, pulpwood, house logs, etc.). It is important to note that, by definition, the material counted as logging residue is not used for energy or wood products and is often burned in "slash piles." Slash or tree tops and limbs that are utilized from logging sites would be considered a timber product and are accounted for in product volumes—often as roundwood pulpwood or industrial fuelwood (i.e., wood harvested specifically for use as fuel by industrial users). An unknown volume of small trees (with dbh < 5.0 in.) is also removed from the forest as part of pre-commercial thinnings and fire hazard reduction treatments where no commercial product is being removed. The volume of this type of material is expected to increase as public and private landowners become aware of and attempt to reduce fire hazard. Reliable estimates of the amount of this type of material, however, are not currently available.

It is also important to note that it is not economically or logistically feasible to collect and use all of the logging residue that is generated. In some harvesting units most logging residue is dispersed across the site and would be very costly to collect. In other units, particularly where whole-tree harvesting and skidding are used, the majority of logging residue is concentrated at log landings but some residue inevitably remains near where each tree was felled and along skid trails. Where cut-to-length (CTL) harvesting systems are used, slash is often placed on the skid trail and is referred to as a "slash mat" for the CTL machinery to operate on to reduce impacts to the soil. The slash mat can then be left in the forest or gathered to a central location, but may often be unusable for biomass because of dirt, rocks, and other contaminates in the slash. Because of these factors as

well as ecological concerns, not all logging residue is or would be available for use as a woody biomass feedstock.

Table 9: Montana logging residue by county and ownership, 2004 (dry tons)

County name	national forest	other public	private	Total	% of total
Beaverhead County	745	1,385	4,235	6,365	0.7%
Big Horn County			4,350	4,350	0.5%
Broadwater County	1,631		850	2,481	0.3%
Carter County	2		10,398	10,399	1.2%
Cascade County	< 0.5		4,236	4,236	0.5%
Chouteau County		< 0.5	13	13	0.0%
Custer County			1,816	1,816	0.2%
Deer Lodge County	< 0.5		4,047	4,047	0.5%
Fergus County			21,402	21,402	2.5%
Flathead County	29,660	27,973	114,252	171,885	20.0%
Gallatin County	1,088		7,364	8,451	1.0%
Glacier County		65	10,657	10,722	1.2%
Golden Valley County			2,072	2,072	0.2%
Granite County	4,342	3,717	17,636	25,695	3.0%
Hill County			562	562	0.1%
Jefferson County	3,767	23	10,671	14,462	1.7%
Judith Basin County			611	611	0.1%
Lake County	258	5,580	30,975	36,813	4.3%
Lewis and Clark County	3,199	696	18,233	22,129	2.6%
Lincoln County	29,829	4,065	90,104	123,998	14.4%
Madison County	< 0.5	446	5,030	5,476	0.6%
Meagher County	743		5,205	5,948	0.7%
Mineral County	10,902	6,267	24,185	41,354	4.8%
Missoula County	7,639	7,354	108,681	123,674	14.4%
Musselshell County		320	1,646	1,966	0.2%
Park County	492		9,237	9,730	1.1%
Petroleum County			75	75	0.0%
Phillips County		346		346	0.0%
Powder River County	3,436	1,193	20,599	25,228	2.9%
Powell County	4,493	2,530	47,243	54,266	6.3%
Ravalli County	6,075	6	8,677	14,758	1.7%
Rosebud County		6,534	2,526	9,060	1.1%
Sanders County	16,604	3,844	62,578	83,027	9.6%
Silver Bow County	< 0.5		4,951	4,951	0.6%
Stillwater County	17		850	867	0.1%
Sweet Grass County			3,040	3,040	0.4%
Toole County			39	39	0.0%
Treasure County			1,542	1,542	0.2%
Yellowstone County			2,784	2,784	0.3%
Total	124,921	72,345	663,375	860,641	100.0%

Figures presented below are from the FIA timber products output (TPO) database (http://ncrs2.fs.fed.us/4801/fiadb/rpa_tpo/wc_rpa_tpo.ASP) and are based on mill census data from CY 2004 (Spoelma and others 2008) and logging utilization factors from CY 2002 (Morgan and others 2005). Logging residue is commonly reported in cubic feet, but are presented here in dry tons (DT) so that logging residue volumes can be compared to mill residue and live and standing

dead tree woody biomass. The conversion factor used was 30 dry pounds per cubic foot or 15 DT of logging residue per thousand cubic feet (MCF) of logging residue (Perlack and others 2005).

The total amount of logging residue produced during the harvesting of 785 MMBF Scribner of timber products (e.g., sawlogs, pulpwood, house logs, etc.) in Montana during 2004 was estimated to be 860,641 DT (or 57.376 million cubic feet). That is roughly 1,096 DT per 1 MMBF Scribner of commercial timber harvested. Logging residue volumes are largest among the counties and ownerships where timber harvest volumes are largest (Table 9). Because private timberlands account for the majority of timber harvested in Montana they also account for the majority of logging residue. At 663,375 DT, private lands accounted for 77% of logging residue generated during 2004, with non-industrial private timberlands accounting for 303,593 DT (35%) and industrial lands accounting for 359,782 DT (42%) of logging residue.

Three Montana counties typically account for nearly one-half of the timber harvest in the state: Flathead, Lincoln, and Missoula (Spoelma and others 2008). These three counties each had more than 120,000 BDT of logging residue, and together accounted for nearly 50% (419,556 DT) of the logging residue generated in the state during 2004. Another 12 counties, each with logging residue volumes between 10,000 and 85,000 DT, accounted for 42% (360,225 DT) of logging residue in 2004. With the exception of Carter, Fergus, and Powder River counties, each of the counties with more than 10,000 DT of logging residue are located in western Montana.

Since 2004, timber harvest levels in Montana have declined substantially. The 2007 harvest was about 70% of the 2004 harvest level, and the 2008 timber harvest was about 60% of the 2004 harvest. Consequently the volume of logging residue currently being produced is likely to be much lower than 2004 levels. Declining timber harvest levels have also impacted timber-processing facilities in Montana and the amount of mill residue being produced.

Mill residue supply and use in Montana (from Spoelma and others 2008)

Wood residue from the manufacturing of primary wood products is the major source of material for the state's sole pulp and paper mill, two reconstituted board plants, and other manufacturers of residue-based products. Mill residue is also used for fuel by sawmills, plywood plants, and the pulp mill, which require heat for dry kilns and manufacturing processes. Some schools that heat with wood under the "Fuels for Schools" program are also using mill residue as fuel, while others are using logging slash. The outlets provided by the residue-utilizing sector are very important to Montana's integrated forest products industry, because the residue would be

difficult and costly to dispose of without these outlets. Mill residue falls into three general categories: 1) coarse residue including chippable material such as slabs, edging, trim, log ends, and defective veneer; 2) fine residue including sawdust, sander dust, and planer shavings; and 3) bark.

The volume of mill residue produced in Montana during a given year is closely linked to in-state lumber production that year. During 2004, sawmills accounted for almost 84% of mill residue production in the state; plywood facilities accounted for 13%; log home manufacturers accounted for 2%; and the remaining 1% came from post and pole, cedar products, and log furniture manufacturers.

Milling equipment, species and size of logs, amount of defect in logs, and market conditions also influence the amount of residue generated by timber processors. Given the characteristics of the timber processed and milling technology used in Montana during 2004, the volume-weighted residue factor for Montana sawmills was 1.21 DT of mill residue generated per thousand board feet (MBF) of lumber produced in the state (Table 10).

Table 10: Montana sawmill residue factors (sources: Spoelma and others 2008; Keegan 1980; Keegan and others 1983, 1990, 1995, 2001).

Type of residue	1976	1981	1988	1993	1998	2004
	DT per MBF lumber tally[a]					
Coarse	0.54	0.56	0.61	0.58	0.59	0.56
Sawdust	0.29	0.30	0.26	0.28	0.26	0.23
Planer Shavings	0.26	0.26	0.22	0.19	0.20	0.18
Bark	0.30	0.28	0.25	0.25	0.23	0.24
Total	1.39	1.40	1.34	1.30	1.28	1.21

[a] Dry ton (DT = 2,000 lb of oven-dry wood) of residue generated for every 1,000 board feet of lumber manufactured.

Since 1981, the volume of residue generated per MBF of lumber produced has generally been decreasing. Coarse residue accounts for about one-half of the residue produced per unit of lumber, with sawdust, planer shavings, and bark accounting for 15 to 20 percent each. Decreases in the factors for sawdust and planer shaving are attributable to improved milling technology and a shift toward producing more dimension lumber rather than boards. The decrease in the bark factor is likewise due to improved milling technology. The coarse residue factor has varied slightly but has not decreased to the extent of other factors because of the increased use of smaller-diameter logs (Morgan and others 2005), which tend to create somewhat more residue despite the technological improvements that make lumber recovery possible from the smaller logs.

Primary timber-processing facilities (e.g., sawmills, plywood plants, log home manufacturers, etc.) in Montana produced 1.51 MDT of wood residue during 2004 (Table 11).

Only about 0.009 MDT (0.6%) of that residue was not utilized. About 1.075 MDT (71.2%) of residue were used as raw material by the pulp and reconstituted board industry, 0.286 MDT (18.9%) were burned as fuel, and 0.140 MDT (9.3%) went for other uses including mulch, landscape material, animal bedding, and other miscellaneous or unspecified uses. Utilization of mill residue in Montana has been between 99 and 100% for more than a decade and has been over 90% since the 1980s.

These figures indicate that, as of 2004, there was a limited amount (about 9,000 dry tons annually) of mill residue across the state not being utilized. The majority (54%) of unutilized mill residue was generated by Montana's log home industry and was comprised mainly of log shavings, log ends, and bark (Spoelma and others 2008). Sawmills generated 36% of the unutilized mill residue. Unutilized mill residue was not evenly dispersed throughout the state. About 36% (3,300 tons) was generated in Flathead County, 24% (2,200 tons) in Ravalli County, 7% (600 tons) in Gallatin County, 6% (550 tons) in Lincoln County, and 5% (440 tons) in Missoula County. The remaining 22% (2,000 tons) were distributed among 24 counties.

Table 11: Montana primary mill wood residue by county of production and residue use, 2004

	Mill residue use (dry tons)				
County name	not used	fiber products	fuelwood	miscellaneous	Grand Total
Beaverhead County	23		642	461	1,126
Broadwater County*	628	86,652	26,129	2,434	115,842
Carbon County	136		53	31	221
Cascade County	124		147	32	303
Fergus County**	16		122	25	163
Flathead County	3,298	354,679	76,232	44,850	479,060
Gallatin County	625		450	829	1,904
Lake County	141	62,440	13,890	2,737	79,208
Lewis and Clark County	4		504	310	817
Lincoln County	551	125,956	30,076	32,298	188,881
Madison County	173		52	228	453
Mineral County	129	46,958	4,039	7,093	58,219
Missoula County	440	188,165	73,146	1,065	262,816
Musselshell County	72		517	269	858
Park County	36	88,740	20,410	1,414	110,599
Powell County***	143	87,640	7,369	25,197	120,349
Ravalli County	2,186		20,780	2,672	25,639
Sanders County	152	34,116	9,454	17,345	61,068
Stillwater County****	136		1,942	233	2,311
Yellowstone County	124		43	76	242
All counties	9,136	1,075,345	285,998	139,599	1,510,078

* includes Broadwater, Jefferson, Judith Basin, Meagher, and Silver Bow counties.
** includes Chouteau, Fergus, and Liberty counties.
*** includes Granite and Powell counties.
**** includes Stillwater, Sweet Grass, and Wheatland counties.

Since 2004, primary wood products manufacturing in Montana has declined substantially. According to WWPA (2008), lumber production in Montana during 2007 was about 20% lower than in 2004 (Table12), and lumber production in 2008 was 31% to 34% lower than in 2004 (Morgan and Keegan 2009). Plywood production in Montana has also declined since 2004, but precise figures are not available because only one plywood manufacturer is currently operating facilities in Montana. Likewise, log home production is expected to be substantially lower than in 2004. Consequently, the volume of mill residue generated in the state is expected to have declined significantly from 2004 levels and will probably remain low during the current economic recession.

Table 12: Montana lumber production

Year	WWPA MMBF*	BBER MMBF*
2004	985	1,040
2005	1,001	
2006	917	
2007	790	
2008 (estimate)		684

* MMBF = million board feet lumber tally
Sources: Western Wood Products Association, Bureau of Business and Economic Research

Use of woody biomass by existing Montana facilities

In addition to woody biomass supply from various sources, this paper also briefly considers current use of woody material. Montana has a substantial wood-using industry infrastructure, with more than 200 timber-processing facilities (Spoelma and others 2008). During 2004, timber processors in Montana used 747 million board feet (MMBF) Scribner of wood, and total timber harvest in the state was 785 MMBF Scribner. These timber volumes include saw and veneer logs, roundwood pulpwood, house logs, logs for posts, poles , and pilings, as well as industrial fuelwood. Approximately 57 MMBF (7.3%) of the timber harvested was for pulpwood, industrial fuelwood, posts and poles, cedar products, and log furniture combined (Spoelma and others2008).

Woody biomass users in the state consist of 10 bark or wood pellet plants, 10 active Fuels for Schools facilities with one more in design, two board facilities (MDF and particleboard), and one pulp mill. The 11 Fuels for Schools facilities, combined, can consume approximately 8,000 DT

(10,725 green tons at 35% moisture content) of woody biomass per year, plus another 310 DT of wood pellets annually, or on average roughly 755 DT per facility each year (DNRC 2008). The 10 bark and pellet plants each use 20,000 to 40,000 DT annually, the particleboard and MDF plants each use 200,000 to 400,000 DT annually, and the pulp mill uses more than 1.5 million dry tons (MDT) annually. Together, the woody biomass users in Montana consume approximately 2.2 to 2.7 MDT of woody biomass (including mill residue, roundwood pulpwood, industrial fuelwood, and recycled cardboard) each year, with a single facility accounting for more than one-half of total annual biomass consumption.

Mill residue production in Montana was only 1.5 MDT in 2004 (Table 11), indicating a sizeable deficit (0.7 to 1.2 MDT) between the amount of woody biomass demanded/consumed (2.2 to 2.7 MDT) in Montana versus the amount supplied from in-state mill residue. That deficit was filled in part by mill residue from out-of-state mills as well by the use of some slash, industrial fuelwood, and roundwood pulpwood harvested in Montana. These figures suggest that competition exists for the woody biomass supply currently available in Montana, particularly for "clean" (i.e., free of rocks, sand, dirt, char, needles, and bark) and dry wood chips and other mill residue.

Mill residue is the preferred form of woody biomass for most biomass users. Slash or logging residue is often not useable for facilities/processes that require clean chips because of contaminates in the slash. The Smurfit-Stone Container facility in Frenchtown has increased the amount of roundwood pulpwood purchased in recent years to help overcome the deficit of locally available clean chips, and the facility is using more slash and small material with bark on for fuelwood. Several woody biomass using facilities have experimented with using slash or roundwood as a substitute for the preferred mill residue with varying degrees of success. The difficulty and expense in handling slash and de-barking small roundwood means that these woody biomass sources are frequently not suitable substitutes for clean, dry mill residue, thus a potentially greater degree of competition exists for the shrinking supply of clean, dry in-state mill residue.

In addition to the woody biomass users, Montana's other primary timber processors (e.g., sawmills, veneer plants, post and pole manufacturers, and log home facilities) are using more smaller-diameter trees and fewer large trees than in the past. In 1988, trees smaller than 9 in. dbh accounted for about 8% of the timber volume harvested in Montana for lumber or plywood production. By 2002, that proportion increased to about 12% (Morgan and others 2005). During 2002, nearly 85% of the trees harvested in Montana for lumber and plywood production were 7 to

17 in. dbh, 9% of the trees were smaller than 7 in. dbh; and less than 7% were trees larger than 17.0 in. dbh.

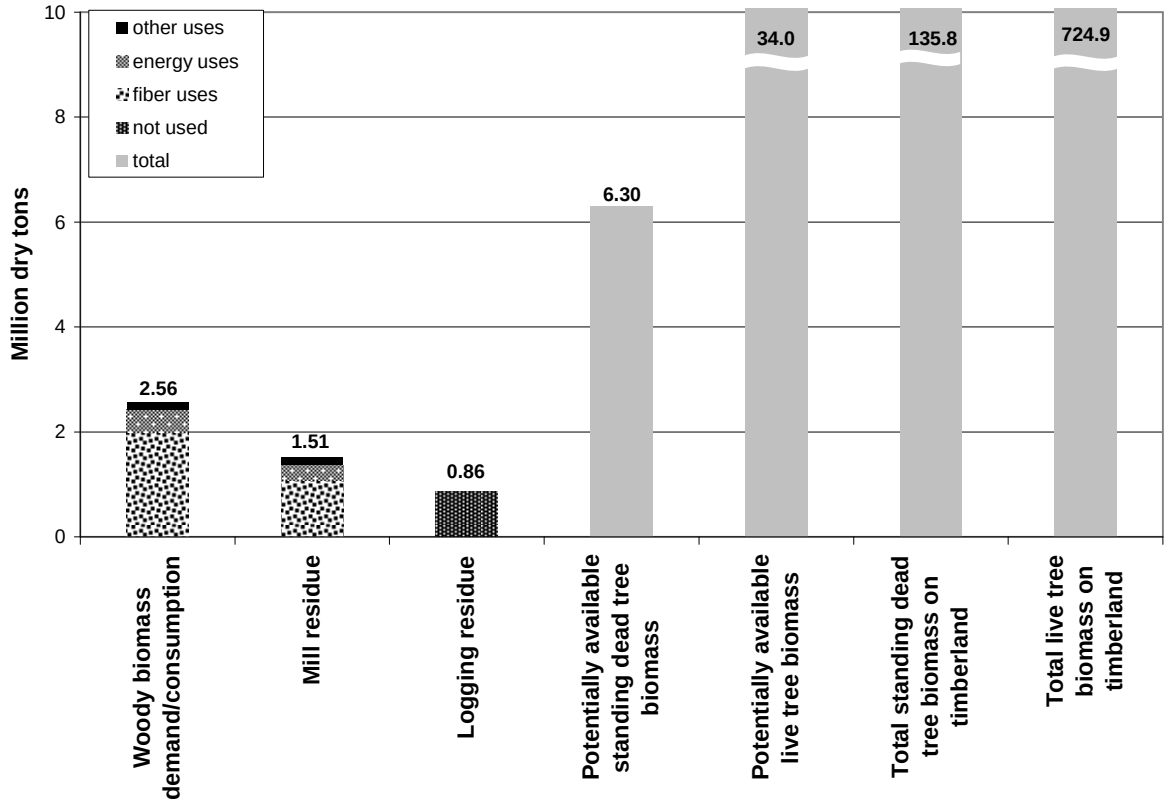
Timber-processing capacity and use among Montana's timber processors, excluding pulpwood and industrial fuelwood (i.e., woody biomass) users, was about 227 million cubic feet (MMCF) in 2003 (Keegan and others 2005, 2006). Of that total capacity, only about 4% (9.1 MMCF) of the timber-processing capacity in the state could efficiently utilize trees less than 7 in. dbh. About 2% (2.7 MMCF) of the timber volume used by these facilities during 2003 came from trees less than 7 in. dbh. Thus, utilization of capacity in the dbh < 7.0 in. size-class was about 30%, indicating that somewhat more small trees could be utilized by Montana's saw and veneer mills, post and pole manufacturers, and log home and log furniture industries. However, total timber-processing capacity in these Montana wood products sectors declined about 22% (216 MMCF) from 2003 to 2008.

Summary

Figure 3 illustrates consumption and supply of woody biomass in Montana from the various sources examined in this report. This initial examination of woody biomass supply and use in Montana has shown recent in-state consumption of woody biomass to be 2.2 to 2.7 million dry tons (MDT) annually. Mill residue volume is declining as a result of ongoing losses of milling capacity, declining timber harvest volumes, and increased milling efficiency. In-state production of woody biomass from primary timber-processing facilities' mill residue has fallen from about 1.5 to 1.0 MDT annually between 2004 and 2008, and between 99 and 100% of mill residue in Montana is utilized. Thus there is more demand for woody biomass than is being supplied from in-state mill residue sources. Some of the demand is being met by out-of-state mill residue, in- and out-of-state live tree sources, slash, and recycled fiber.

Logging residue could fill more of the demand, but the amount generated in-state has dropped from about 0.86 to 0.52 MDT per year during that 2004 to 2008 period. The amount of logging residue generated in Montana is declining as a result of falling timber harvest levels and increased logging utilization efficiency. This woody biomass supply source is believed by many to be underutilized, but availability is economically and logistically constrained, and the physical characteristics of logging residue often make it unsuitable for facilities that require clean, dry feedstock. Therefore, nearly complete utilization of logging residue, as found with mill residue, is not likely.

Figure 3: Montana woody biomass supply and use



A substantial supply of live and standing dead trees that could be used for biomass energy or biofuels, as well as traditional wood products, exists on timberland in the state. Total live and standing dead tree above-ground woody biomass on Montana's 20 million acres of non-reserved timberlands exceeds 850 MDT and represents the largest and most feasible source for additional woody biomass feedstock. Live and standing dead tree above-ground woody biomass are under-utilized due to political and economic constraints on availability rather than supply levels. More than 70% of live tree woody biomass and 85% of standing dead tree biomass are located on national forest timberland. The availability of woody biomass supply was estimated to be economically and politically constrained to somewhere closer to 40 MDT, which still represents a substantial, multi-decade supply from just 3.59 million acre (18%) of timberlands in Montana, and an even smaller proportion (5%) of total biomass on timberlands. Nearly 70% of this potentially available supply of biomass is located on national forests, while just 46% of the potentially available acres are in national forests.

Between 2004 and 2008 in-state timber harvest has declined about 41%, from about 751 million board feet Scribner (MMBF) to approximately 440 MMBF. Consequently, the in-state supplies of mill residue and logging residue have been declining, whereas the supplies of live and standing dead tree woody biomass have been increasing. Timber harvest in Montana has declined about 68% from 1987 to 2008, with private lands harvest falling 60% and national forest harvest dropping 88% during that period. This longer-term trend of declining in-state timber harvest, especially on the largest landownership (i.e., national forests), has profoundly impacted the state's wood products industry and may impact the potential development of a biomass industry in Montana. Much more woody biomass material from the sources examined in this report could become available through increases in commercial timber harvests, salvage logging, fire hazard reduction treatments, forest restoration, and/or pre-commercial thinnings. While there is no guarantee of these activities increasing in Montana's near or distant future, increasing these activities would help to slow or reverse current trends and would require significant changes in the social and economic factors influencing forest management in the state.

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