Logging Utilization in Idaho: Current and Past Trends

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Abstract

A study of commercial timber-harvesting activities in Idaho was conducted during 2008 and 2011 to characterize current tree utilization, logging operations, and changes from previous Idaho logging utilization studies. A two-stage simple random sampling design was used to select sites and felled trees for measurement within active logging sites. Thirty-three logging sites and 815 felled trees were measured. Results of the 2008/2011 study indicated that harvesting efforts removed 1,011 cubic feet (cf) of timber volume from growing stock for every 1,000 cubic feet (mcf) delivered to the mill, created 24 cf of growing-stock logging residue, and that 13 cf of non-growing-stock (stump wood and tops above 4 inches diameter outside bark (dob)) were delivered to the mill. This compared to 1,086 cf of growing-stock removals that created 95 cf of growing-stock logging residue and utilized 9 cf of non-growing-stock per mill-delivered mcf in a 1990 study. This study confirmed two long-term timber harvesting trends in Idaho: declining diameter at breast height (dbh) of harvested timber, and declining amounts of logging residue generated per unit of mill-delivered volume.

Keywords: growing-stock removals, logging residue, removals factors, timber harvest

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Introduction

Forest managers require current information on the characteristics and effects of timber harvesting on forest inventory. For example, they may need to know how much woody material remains in the forest after commercial logging operations to understand fuel loads or amounts of down woody material remaining for wildlife, predict potential feedstock for woody biomass energy, or gauge the efficiency of logging operations. Likewise, the characteristics of harvested trees (e.g., dbh[1], total tree height, or species mix) and harvesting methods (e.g., mechanical vs. hand felling, merchandising at the stump vs. at the landing, or cable yarding vs. skidding) may be of interest for planning or policy purposes.

Logging utilization studies provide much of this information by identifying volumes of growing-stock[2] (Woudenberg and others 2010) trees (fig. 1) removed from forest inventory during commercial timber harvest activities. The studies also provide information by developing logging utilization factors, which quantify the amount of growing-stock volume cut and either delivered to the mill or left as logging residue in the forest or at the landing (Morgan and Spoelma 2008). These logging utilization factors are used in the calculation of logging residue volumes that are published in the Timber Products Output (TPO) database (http://srsfia2.fs.fed.us/php/tpo_2009/tpo_rpa_int2.php), which is maintained by the Forest Inventory and Analysis (FIA) Program of the USDA Forest Service. These factors can be applied to historic or projected levels of timber harvest at various spatial scales to provide estimates of logging residue volume. Logging utilization studies also characterize timber harvest activities and equipment used and can also provide estimates of the distributions of trees and volume harvested by species, size, and logging method. When conducted in a consistent manner, these studies can provide a great deal of information about changes in timber harvesting through time and differences between states or regions of the country.

[1] Diameter outside bark measured at 4.5 feet above ground on the uphill side.

[2] Growing stock is defined as all live trees of commercial species that meet minimum merchantability standards or have the potential to meet these merchantability standards. In general, these trees have at least one solid 8-foot section, are reasonably free of form defect on the merchantable bole, and at least 34 percent or more of the volume is merchantable. For the California, Oregon, and Washington inventories, a 26 percent or more merchantable volume standard is applied, rather than 34 percent or more.

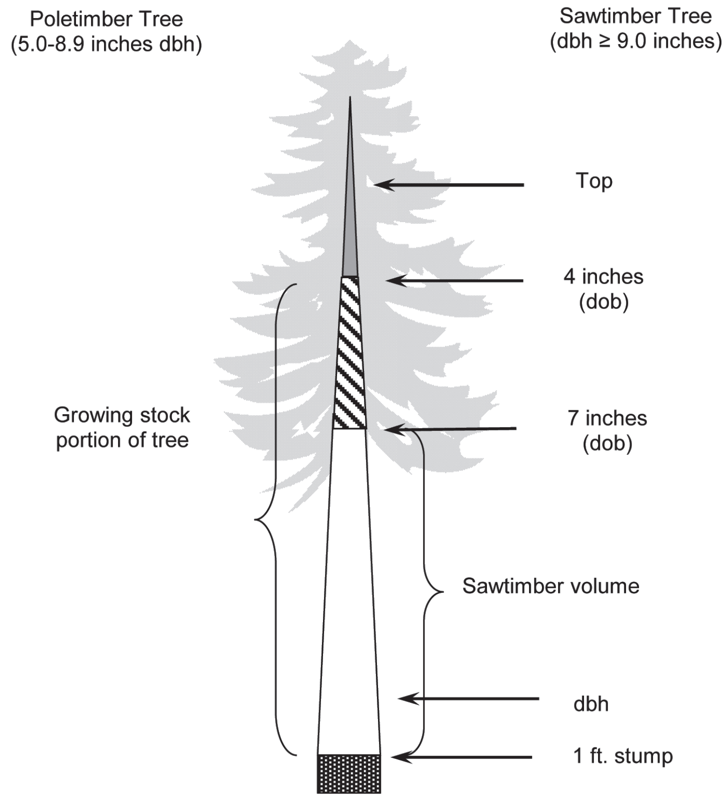

Figure 1—Sections of softwood trees.

Idaho Timber Harvest Trends

There are more than 16.6 million acres of unreserved timberland[3] potentially available for timber harvest activities in Idaho (Witt and others 2012). However, neither the timber resource nor harvesting activities are evenly distributed throughout the state; and the mere presence of forested unreserved timberland has not been a strong indicator of harvest activity in recent years. Markets and policy issues have influenced the geographic and ownership sources of harvested timber as well as annual harvest volumes.

Recent annual timber harvest volumes in Idaho have ranged from mid-decade highs of more than 1.1 billion board feet (BBF) Scribner in 2004 and 2005, to lows, not seen since World War II, of 760 million board feet (MMBF) Scribner during 2009 (Brandt and others 2012; Morgan and others 2013). The ownership mix of Idaho's timber harvest has been in transition since the 1990s, with federally managed forests providing 30 to 40 percent of the harvest volume in the early 1990s and less than 15 percent since 2000 (fig. 2). There was a corresponding increase in the private lands proportion of the harvest throughout the 1990s and early 2000s. However, since the collapse of U.S. home building and markets for lumber, there was a marked decline in the harvest volume and proportion from private lands after 2007, and harvest volumes from state-owned lands have nearly doubled since mid-decade. As federal harvest volumes declined in the 1990s and 2000s, the geographic source of Idaho's timber harvest made a pronounced shift

[3] Timberland is defined as unreserved forest land capable of producing 20 cubic feet per acre per year of wood from trees classified as a timber species on forest land designated as a timber forest type (Witt and others 2012).

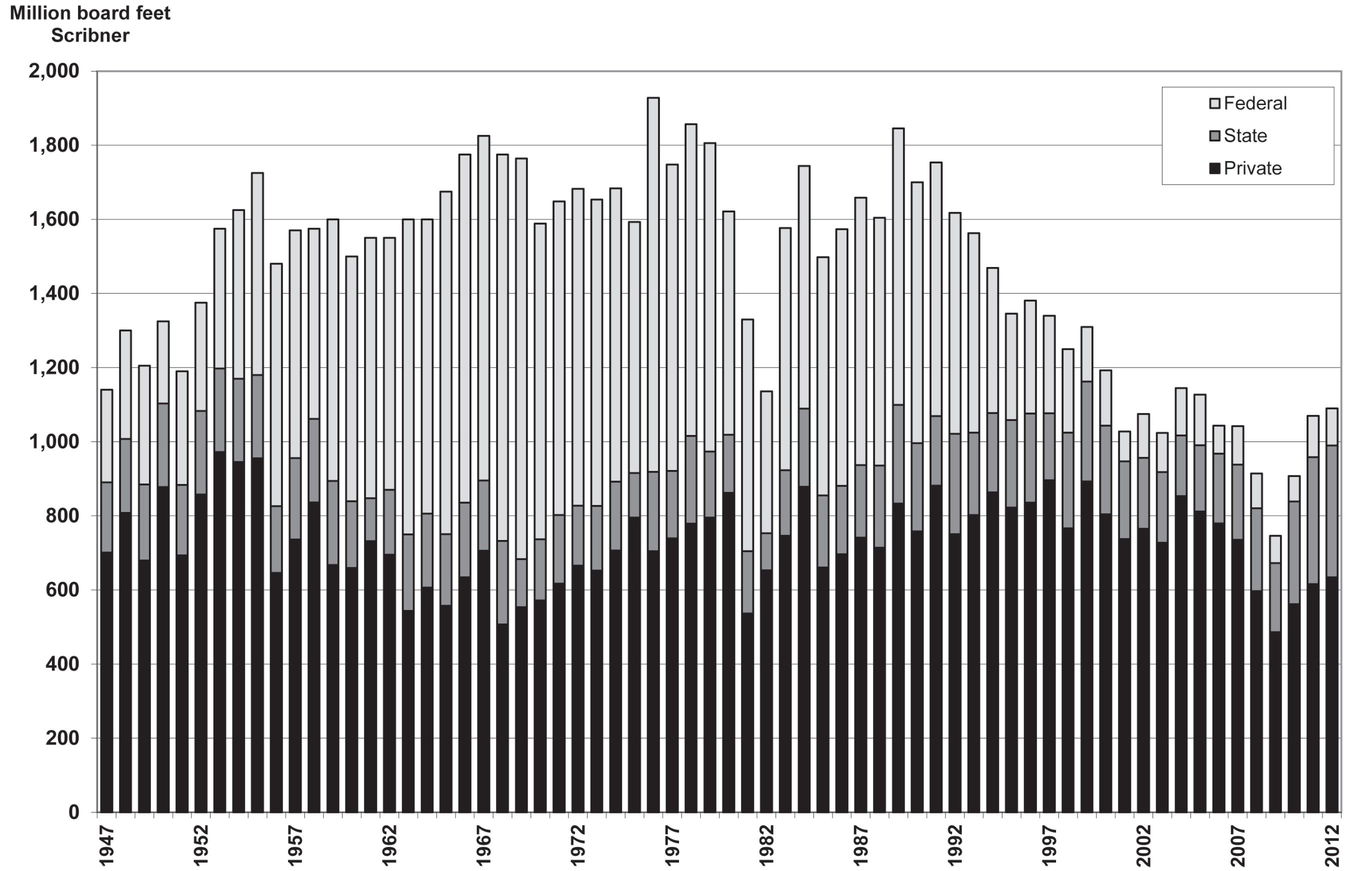

Figure 2—Idaho timber harvest by ownership 1947-2012 (source: Bureau of Business and Economic Research, The University of Montana-Missoula; USDA Forest Service Region One, Missoula, Montana).

to northern Idaho (i.e., north of the Salmon River), which currently accounts for 80 to 90 percent of the annual state harvest volume. Since 1995, six of Idaho's 44 counties consistently account for 65 to 75 percent of annual harvest (Brandt and others 2012).

Two prior investigations of logging utilization were conducted in Idaho during 1965 (Wilson and others 1970) and 1990 (McLain 1996). However, because Idaho's timber harvest volume, source of ownership, species mix, and milling infrastructure have changed substantially since the 1960s and particularly the 1990s (Brandt and others 2012; Morgan and others 2004), managers need updated information that reflects the characteristics and effects of contemporary timber harvesting practices. Thus, to obtain updated information, a study of logging utilization across Idaho was conducted during the 2008 and 2011 field seasons. This study was designed to quantify the creation of logging residue at the state level, and characterize harvested trees and harvesting activities within Idaho. The specific objectives were to:

1. characterize Idaho's timber harvest by tree species and dbh;
2. characterize Idaho timber harvest operations by felling, yarding, and merchandising methods;
3. compute current Idaho logging utilization factors to express:
    a. volumes of growing-stock logging residue generated per mcf of mill-delivered volume,
    b. proportions of mill-delivered volume coming from growing-stock vs. non-growing stock portions of harvested trees, and
    c. total removals (i.e., timber product and logging residue) from growing stock.

Methods

Conducting a statewide logging utilization study in Idaho presents challenges. As Morgan and Spoelma (2008) pointed out, it is not possible to know in advance the full population of logging sites in a state for a given year and simply draw a sample of those sites to measure. Harvest volumes and characteristics change from year-to-year and even scheduled harvests may not be executed as planned; so the characteristics of recent harvests are the best predictors of geographic location and ownership of current and future harvests. Publicly available information about recent timber harvests in Idaho was used to identify the target population and sampling design that would do the following:

1. provide the data necessary to meet the study objectives,
2. be logistically and financially feasible,
3. assure the safety of the crews conducting the field work, and
4. be consistent with methods currently used in other states and regions.

The target population for this study was active logging sites in Idaho where green (live) trees were being commercially harvested for conversion into wood products including lumber and veneer/plywood. Because of the need to measure harvesting impacts on growing stock, only green-tree sites were targeted. Salvage sales, where many or most trees were dead prior to harvest, were not included. Historically, 90 to 95 percent of Idaho's annual timber harvest volume had been used for lumber and veneer/plywood production (Brandt and others 2012; Morgan and others 2004). Other timber products (e.g., pulpwood, posts, and fuel wood) are commonly merchandised with sawlogs. Thus, sites where sawlogs and veneer logs were the primary products to be harvested were identified, because these would account for the vast majority of annual harvest volume while also capturing some volume for other products.

A two-stage random sampling scheme was used to select logging sites and trees within logging sites for measurement (Levy and Lemeshow 1999). Logging sites with active harvesting of green trees for commercial products served as the stage 1 sampling units and were selected at random across the entire state. Annual timber harvest summaries provided by the Idaho Department of Lands (http://www.idl.idaho.gov/news/annual_reports/index_ar.htm) and Idaho forest industry reports (Brandt and others 2012; Morgan and others 2004) provided the geographic locations (i.e., county) and ownerships of these potential logging sites (fig. 3). Timberland owners and sawmills throughout the state were contacted to identify when and where logging activities would be occurring, and to request access to logging sites to conduct measurements. When land managers denied access to a site, a replacement site was selected at random from the pool of remaining identified sites.

The stage 2 sampling units consisted of felled trees at each selected logging site. To qualify as a potential measurement tree, it had to be growing stock (live prior to harvest, dbh $\geq$ 5 inches, and meet minimum merchantability standards) and the entire stem, including the stump and top, had to be measureable (Morgan and Spoelma 2008; Woudenberg and others 2010).

Sample sizes for stage 1 and 2 sample units were guided by standard errors achieved on previous utilization studies. Zarnoch and others (2004) found that standard errors for utilization ratios dropped substantially by increasing the number of measured logging sites from 10 to 20. Previous logging utilization studies in California and Montana garnered low standard errors by measuring 25 to 35 trees on each of 30 to 35 logging sites (Morgan and Spoelma 2008; Morgan and others 2005). Further, logging utilization studies conducted by the USDA Forest Service Southern Research Station (Bentley and Johnson 2004; Zarnoch and others 2004) suggested that a sample of 30 to 50 logging sites with 20 to 35 felled trees measured at each logging site would be sufficient to determine state-level utilization factors.

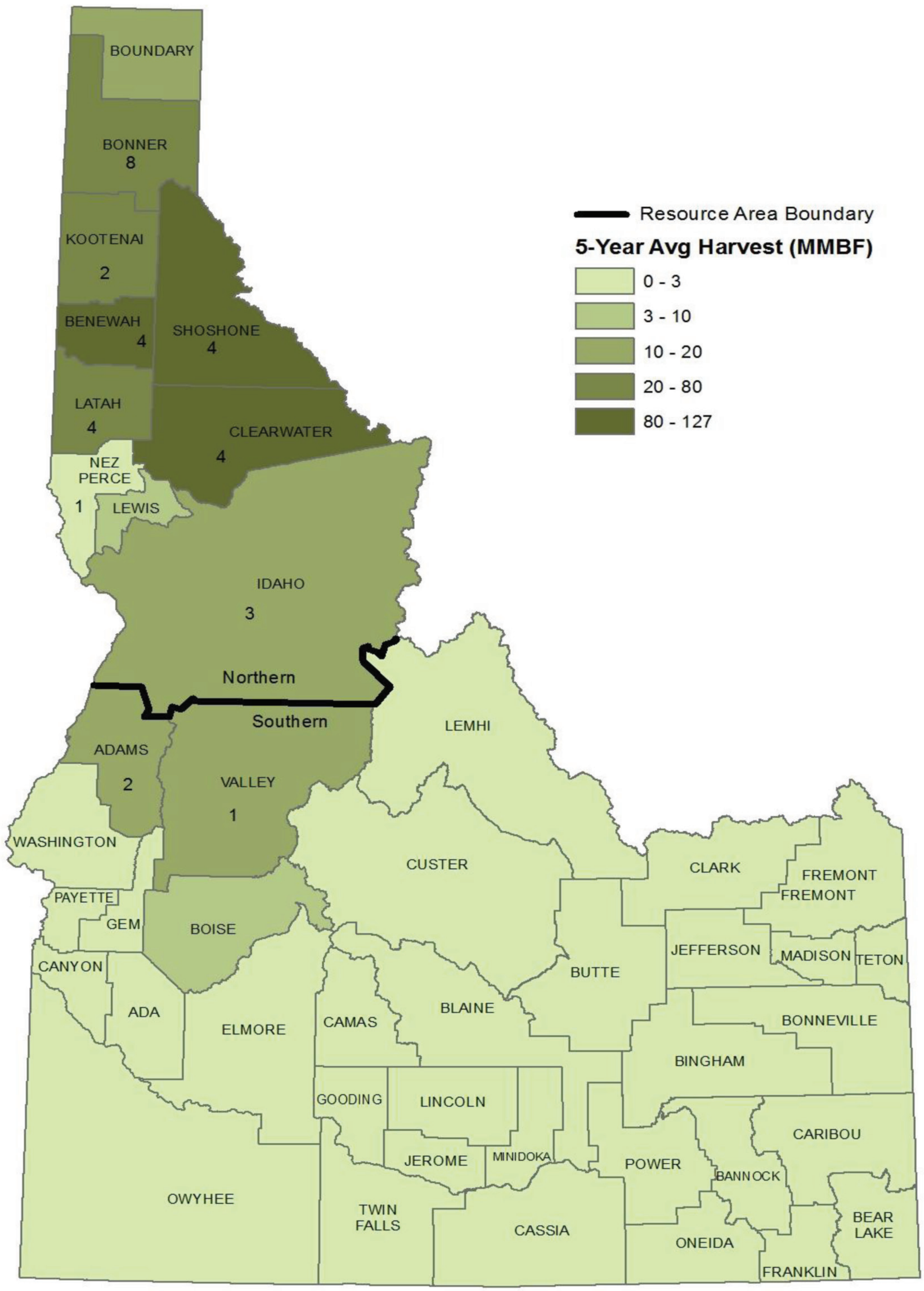

Figure 3—Sample site distribution and harvest volumes by geographic region.

Data Collection

Logging contractors or foresters were contacted at each selected site 3 to 5 days prior to site visits to confirm access and outline protocols to ensure field crew safety. At each logging site, they provided information on tree species, products merchandised, and preferred and acceptable log lengths delivered to receiving mill(s). Field crews recorded this information along with the date, county, land ownership class, felling method, yarding/skidding method, log merchandising location and method, logging contractor name, equipment in use, and receiving mill(s).

Field crews randomly selected felled trees that met the specified requirements. Individual trees or piles accumulated for skidding were scattered throughout the logging site, depending on the operation and equipment used. A unique identification number was assigned to each measurement tree, and species, dbh, and primary product (e.g., sawlog, veneer log, etc.) information was recorded. Diameter and section length measurements were taken at the cut stump, at 1 foot above ground level (uphill side of the tree), at dbh, at the 7.0-inch dob (end of sawlog portion of sawtimber tree), at the 4.0-inch dob point (end of growing stock), and at the end-of-utilization. Each tree had diameter (in 0.1 inch increments) and section length (in 0.1 foot increments) measurements recorded with a maximum section length of 16 feet. Thus, for each bole section, lower and upper dob and length were recorded. The percent cubic cull for each section was also recorded and each bole section was identified as utilized (delivered to the mill) or unutilized (logging residue).

A minimum of 25 felled live trees were measured at each of 19 logging sites during the 2008 field season and at 14 logging sites in 2011. These 33 active logging sites were spread across 10 Idaho counties and more than 825 felled trees were measured. Approximately 10 measurement trees were excluded from data analysis because of errors or omissions in data collection. The final sample contained 815 trees for analysis.

Data Analysis

Following the methods of Morgan and Spoelma (2008), cubic volumes of individual tree sections were calculated using Smalian's formula (Avery and Burkhart 1994), section volumes were summed for each tree by category (e.g., utilized vs. unutilized stump, bole, and upper stem sections of the trees), and utilization factors were calculated for each tree and site. For the Idaho logging utilization data set, means, standard errors, and 95 percent confidence intervals (CIs) were computed for state-level utilization factors based on the two-stage random sampling design using the ratios of means estimator (Zarnoch and others 2004) obtained from SAS PROC SURVEYMEANS (SAS 2010). Characteristics of the felled trees, harvest operations, and utilization factors were then summarized and compared with historic Idaho logging utilization studies and with recent studies from other western states.

Results

Characteristics of Felled Trees

The 815 trees that were analyzed ranged from 5.0 inches to 29.3 inches dbh. About 50 percent of the harvested trees had a dbh $\leq$ 12 inches and accounted for 18 percent of the mill-delivered (utilized) volume, 19 percent of growing-stock removals, and 20 percent of the growing-stock logging residue (table 1). Roughly one-half of the mill-delivered volume, growing-stock removals, and growing-stock logging residue came from trees with dbh < 16 inches.

Table 1—Distribution of trees, mill-delivered volume, and growing-stock logging residue volume by dbh class.

dbh class (inches)	Number of trees	Percent of sample trees	Cumulative percent	Percent of mill de-livered volume	Cumulative percent	Percent of growing-stock removals	Cumulative percent	Percent of growing-stock logging residue	Cumulative percent
6	50	60.1	6.1	00.7	0.7	00.6	0.6	1.9	1.9
8	132	16.3	22.4	30.8	4.5	30.8	4.4	5.6	7.6
10	145	17.7	40.1	80.0	12.4	70.9	12.3	8.0	15.6
12	145	17.7	57.9	12.3	24.8	12.1	24.4	9.2	24.8
14	104	12.7	70.6	13.1	37.8	13.0	37.4	11.7	36.5
16	79	90.7	80.3	13.8	51.6	14.0	51.3	18.8	55.3
18	59	70.3	87.6	13.7	65.3	13.7	65.1	13.4	68.7
20	42	50.1	92.8	11.8	77.1	11.9	77.0	10.5	79.2
22	21	20.6	95.3	70.0	84.1	70.0	84.0	6.8	86.0
24	24	20.9	98.3	90.2	93.3	90.2	93.2	6.2	92.1
26	10	10.2	99.5	40.7	98.0	40.8	98.0	5.3	97.4
28	3	00.4	99.9	10.2	99.3	10.3	99.3	2.5	99.9
30	1	00.1	100.0	00.7	100.0	00.7	100.0	0.1	100.0

A majority (55 percent) of growing-stock logging residue came from trees with dbh between 13 and 21 inches, roughly 35 percent of the sampled trees. In general, smaller trees produced less volume delivered to the mill for every mcf of timber harvested. As well, they produced more logging residue per mcf delivered to the mill than larger diameter trees, although several trees in the 28-inch dbh class were damaged during felling and produced more residue per mill-delivered volume (fig. 4).

Grand fir (*Abies grandis* (Doug Ex D. Don) Lindl.), Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco), western larch (*Larix occidentallis* Nutt.), and western redcedar (*Thuja plicata* Donn ex D. Donn) were the top four species in the sample. Together, they accounted for 82 percent of the total mill delivered volume and 87 percent of the growing-stock logging residue (fig. 5).

Characteristics of Logging Operations and Sites

Harvesting methods included hand (i.e., with chainsaws) and mechanical felling and merchandising, as well as a mix of the two. Mechanical felling methods included the use of equipment with accumulating heads such as a “hot saw” or feller-buncher, as well as cut-to-length (CTL) harvesting heads. Hand felling and merchandising was done with chainsaws. Mechanical merchandising methods included the use of stroke (slide-boom) delimbers and dangle-head processors either at the landing or as part of a CTL system. Ground-based skidding included the use of rubber-tired skidders or dozers, which had either a grapple or a winch with chokers.

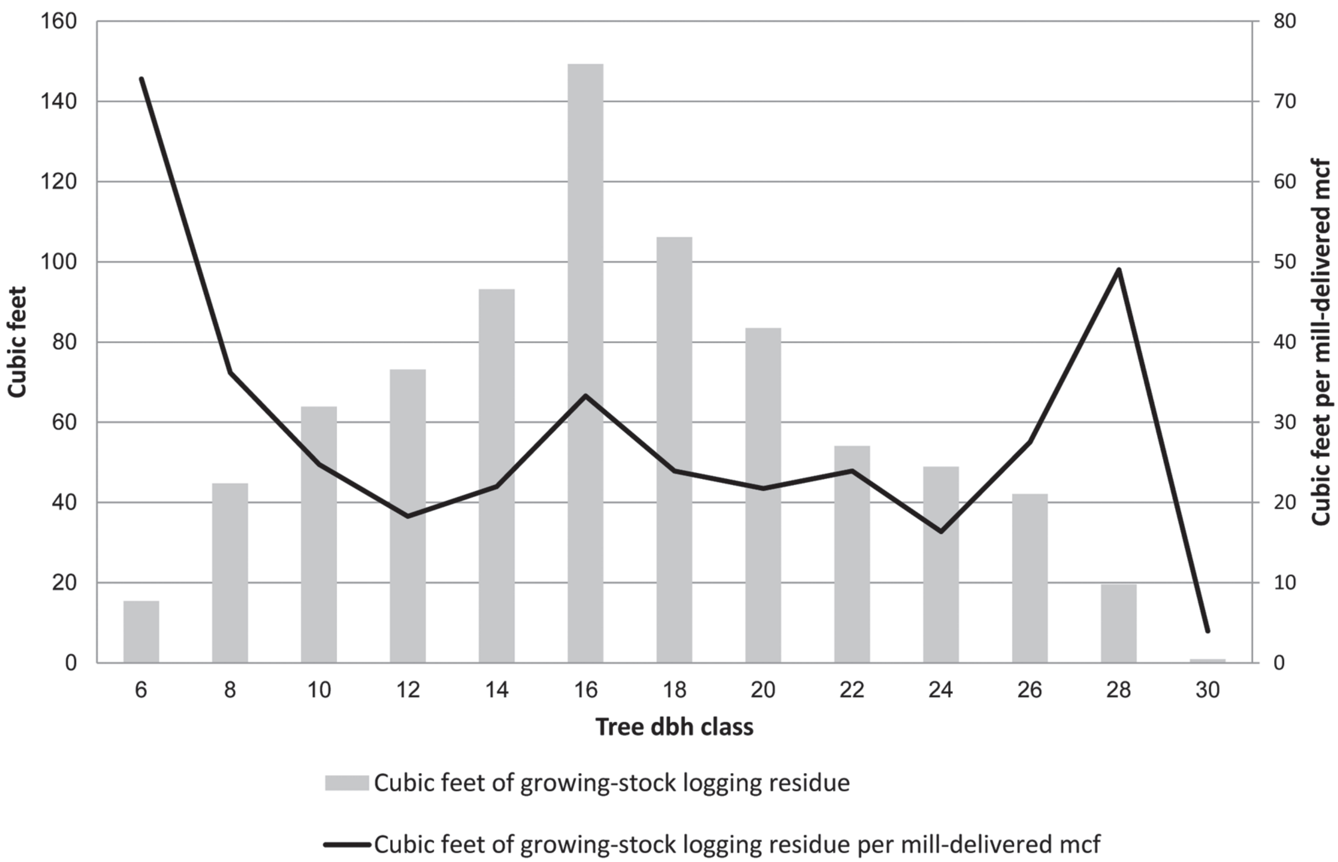

Figure 4—Volume of growing-stock logging residue and residue per mill-delivered mcf by tree dbh class.

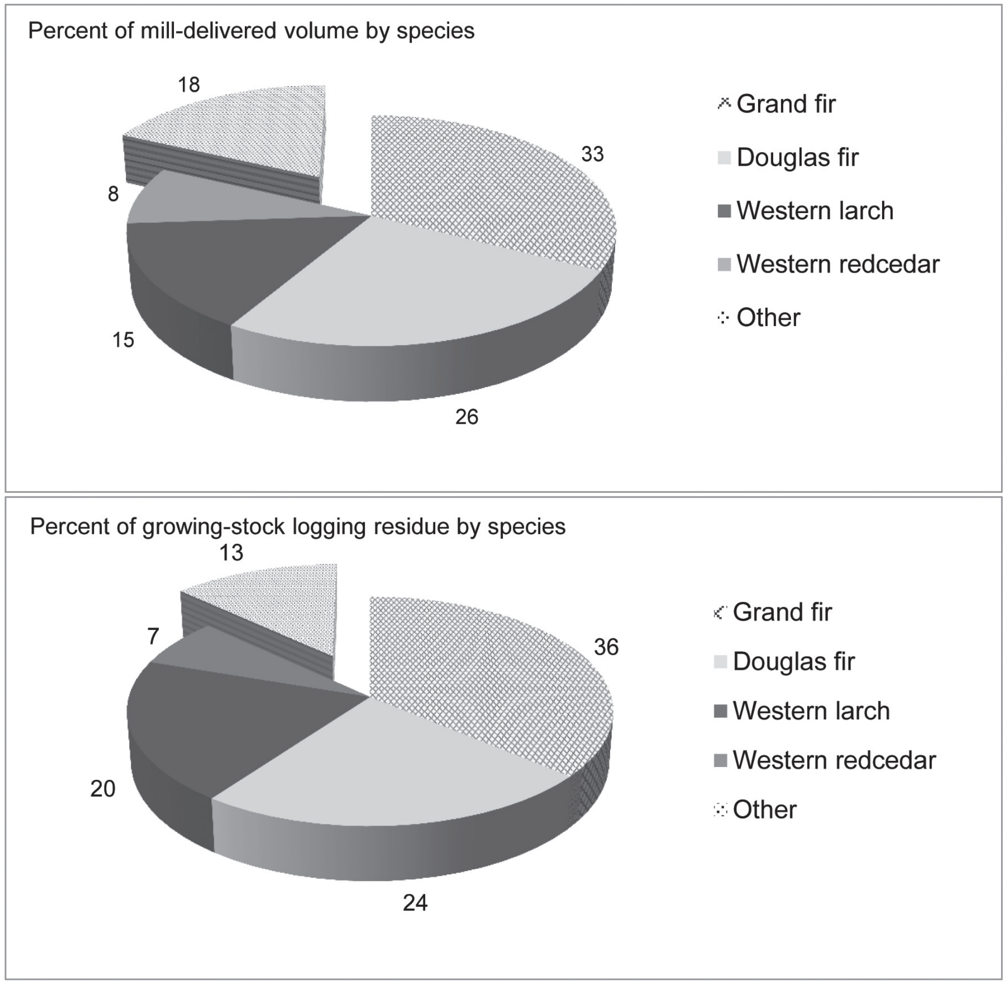

Figure 5—Proportions of mill-delivered volume and growing-stock logging residue by species.

Mechanized systems dominated Idaho logging operations in 2008 and 2011. Mechanical felling was employed nearly twice as often as hand felling, which was reserved for steep slopes and sensitive areas like riparian zones. Each of the following methods was employed at least four times as frequently as their alternative: ground based yarding, tree length skidding, merchandising at the landing, and merchandising with mechanical processors (table 2). Cable yarding was used on just 12 percent of sites, versus 88 percent of sites with ground skidding. Tree-length skidding was employed at 82 percent of sites. Merchandising at the landing was also far more common (88 percent of sites) than merchandising in the unit. CTL systems, where material was stacked on a forwarder in the unit and unloaded at a landing or transferred directly onto a logging truck, were used at only two locations (6 percent of sites).

Table 2—Number of sampled sites by logging methods and ownership class.

	Felling			Yarding		Skidding		Merch location		Merch method	
Ownership	**Hand [b]**	**Mechanical**	**Mixed**	**Ground**	**Cable**	**Tree length**	**Log length**	**In unit**	**At landing**	**Mechanical**	**Hand [b]**
Federal	1	1	0	1	1	1	1	1	1	2	0
State	3	2	1	5	1	3	3	1	5	4	2
NIPF [a]	1	2	0	3	0	3	0	1	2	3	0
Industrial private	6	14	2	20	2	20	2	1	21	19	3
Total	11	19	3	29	4	27	6	4	29	28	5

[a] Non-industrial private forest.
[b] With chainsaws.

State-Wide Logging Utilization Factors

Logging utilization removals factors are state-wide ratios of removals volumes versus mill delivered volumes (Morgan and Spoelma 2008). Removals factors, quantifying impacts on growing stock, revealed that harvesting removed 1,011 cf of timber volume from growing stock for every mcf delivered to the mill; 987 cf of growing stock was utilized, plus 24 cf of growing stock was left in the forest or at the landing as logging residue (table 3). In addition, 13 cf of non-growing stock from stumps and tops went to the mill.

Among the major harvested species, western redcedar showed the lowest residue per delivered volume, with only 21 cf of growing-stock residue created per mcf delivered to the mill. Douglas-fir followed closely at 22 cf, and grand fir at 27 cf per mcf. Western larch had the highest residue factor, with 32 cf of growing-stock logging residue generated per mcf delivered to the mill.

Of the merchantable stem (i.e., portions of the tree from the cut stump to the end of utilization), 1.3 percent was mill-delivered volume from non-growing stock (i.e., stumps and tops above 4 inches dob), 96.4 percent was mill-delivered volume from growing stock, and 2.3 percent was unutilized growing-stock logging residue (fig. 6). Most of the growing-stock logging residue came from stumps cut higher than 1.0 foot above ground level and portions of the bole that were broken during felling. Relatively little logging residue came from stem sections near the end of growing-stock (i.e., the 4-inch dob). There is relatively less volume in the smaller-diameter (upper) portions of the bole, compared to stump sections. Also, with the frequent use of whole-tree harvesting and 23 of the 33 logging sites having pulpwood as a component, use of the smaller bole sections was quite common.

Table 3—Idaho 2008/2011 logging utilization removals factors.

Removals factors	Lower bound (95% CI)	Estimate (ratio of means)	Upper bound (95% CI)	Standard error	Cubic feet per mill-delivered mcf
Non-growing stock product delivered to mills (utilized non-growing stock ÷ total utilized)	0.009	0.013	0.018	0.002	13
Growing-stock product delivered to mills (utilized growing stock ÷ total utilized)	0.982	0.987	0.991	0.002	987
Growing-stock logging residue (unutilized growing stock ÷ total utilized)	0.017	0.024	0.032	0.004	24
Removals from growing stock ((utilized + unutilized growing stock) ÷ total utilized)	1.000	1.011	1.022	0.005	1,011

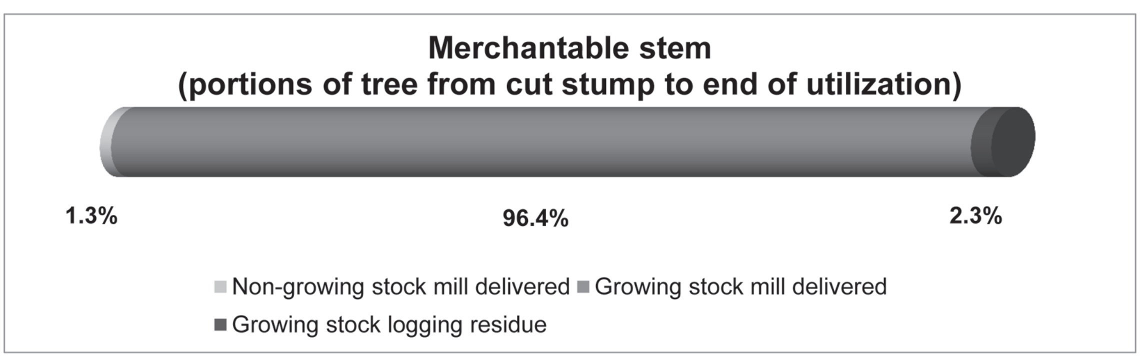

Figure 6—Merchantable stem utilization.

Discussion

Idaho Logging Utilization Through Time

Research methods, particularly site selection and volume calculation, differed between the current study and prior (i.e., 1965 and 1990) Idaho logging utilization investigations. Although methodological differences prevent comprehensive statistical tests between this study and earlier ones, useful and informative comparisons are still possible.

In his 1990 study, McLain (1996) allocated sample sites proportional to volume of harvest by ownership and volume of harvest by resource area. For this analysis, sampled logging sites were selected at random from the target population of all known sites across Idaho. Through a mill canvass, McLain estimated that National Forest System (NFS) lands provided approximately 45 percent of Idaho's harvested timber volume (McLain 1996; fig. 7). The current study's ownership distribution is a reflection of the dwindling volume harvested from NFS lands over the past 20 years. Only 6 percent of Idaho's 2006 timber harvest came from NFS compared to 40 percent or more prior to 1995 (Brandt and others 2012). Geographic distribution for this study paralleled the 1990 study's site distribution, in that the majority of harvest and therefore most of the sample sites were located in the northern Idaho resource area in both time periods.

Volume computation methods differed between this and previous investigations. Researchers in previous studies scaled felled tree sections using the Scribner Log Rule then converted board foot to cf volumes using a conversion factor of 4.5 board feet per cf (McLain 1996; Wilson and others 1970). Consistent with contemporary national logging utilization methods (Bentley and Johnson 2004; Morgan and Spoelma 2008), cubic volumes were calculated in the 2008/2011 study using large- and small-end diameters and section lengths with Smalian's formula (Avery and Burkhart 1994).

Removals factors have changed substantially through time. From 1965 to 2011, there has been a 10 percent (112 cf) reduction in total growing-stock removals per mcf of mill-delivered volume, and an 80 percent (99 cf) reduction in the volume of growing-stock logging residue generated per mcf harvested (table 4). Since 1990, growing-stock logging residue has decreased 72 percent (61 cf) per mill-delivered mcf, total removals from growing stock have declined 6 percent (65 cf) per mill-delivered mcf, and there has been a 44 percent increase in the utilization of non-growing stock components (i.e. stumps and tops). Contemporary logging activities generate far less growing-stock residue than historic practices, and have a lower overall impact on growing-stock, with more mill-delivered volume coming from non-growing stock portions of harvested trees.

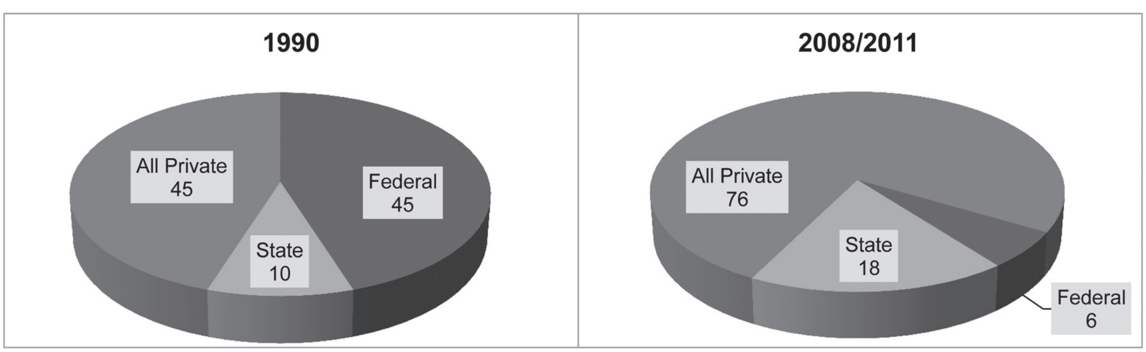

Figure 7—Percent of sample sites by ownership class, 1990 and 2008/2011.

Table 4—Removals and residues over time.

	1965	1990 [a]	2011	Change	Percent change
	Cubic ft (cf) per 1,000 cf mill delivered				
Non-growing stock product delivered to mills	N/A	9	13	4	44
Growing-stock product delivered to mills	N/A	991	987	-4	0
Growing-stock logging residue	123	85	24	-61	-72
Removals from growing stock	1,123	1,076	1,011	-65	-6

[a] Base year for change comparison.

The decrease in the percentage of growing stock left in the woods as logging residue and the increase in the utilization of non-growing stock portions of the tree can be attributed to technological advancements in logging and milling operations. Most of the sites that field crews sampled were harvested with highly efficient, mechanized logging systems. Further, receiving mills were often equipped with computerized log profilers and state-of-the-art sawing capabilities, which allowed them to process logs more efficiently, especially small-diameter trees.

Over the last 20 years, timber harvests have shifted from larger to smaller diameter trees. In 1990, only 33 percent of felled tree volume came from trees with dbh ≤ 17 inches, and 28 percent came from trees with dbh > 27 inches. Results from the current study show that 51 percent of felled tree volume came from trees with dbh ≤ 17 inches, and just 2 percent came from trees with dbh > 27 inches (table 5). This progressive shift to the use of smaller-diameter timber over time is well documented. McLain noted the same trend when comparing his 1990 results to those of Wilson in 1965 (McLain, 1996; Wilson and others 1970), and analyses of sawmill data have revealed similar trends toward the use of smaller-diameter timber (Keegan and others 2010 a,b) throughout the western United States.

Table 5—Comparison of growing-stock removals by dbh class, 1990 vs. 2008/2011.

dbh class	1990 GS[a] volume removed	Percent of GS[a] volume	Cumulative percent	dbh class	2008/2011 GS[a] volume removed	Percent of GS[a] volume	Cumulative percent
6	5	1	33 percent of total volume	6	6	1	51 percent of total volume
8	25	2		8	38	4	
10	55	5		10	80	8	
12	71	7		12	123	12	
14	110	10		14	131	13	
16	97	9		16	141	14	
18	135	12	72 percent of total volume	18	139	14	98 percent of total volume
20	53	5		20	120	12	
22	119	11		22	71	7	
24	62	6		24	93	9	
26	46	4		26	48	5	
28	62	6	28 percent of total volume 30+	28	13	1	2 percent of total volume
30+	247	23		7	1		
Total GS[a] volume	1,087	100 [b]		Total GS[a] volume	1,011	100 [b]	

[a] Growing stock.

[b] Percentages may not sum to 100 due to rounding.

Idaho's Redcedar Phenomenon

Results indicated that western redcedar yielded somewhat smaller volumes of logging residue per mcf of mill-delivered volume than other Idaho tree species. Land managers may find this result counterintuitive because older, large-diameter cedars are typically found with heavy heart rot. The calculation of the growing-stock logging residue factor can partially explain this anomaly. This factor is a ratio of residue volume to mill-delivered volume, which can produce a low ratio, particularly when mill-delivered volumes are quite high. Although the butts of older cedar may contain much defect-related residue, older cedars are usually large-diameter trees with higher mill-delivered volumes that often dwarf the residue volumes and therefore lower the ratio. Efficient utilization of cedar trees in Idaho has contributed to sizeable volumes of cedar being delivered to mills. Brandt and others (2012) identified seven cedar product facilities operating in northern Idaho in 2006. A robust cedar products industry coupled with competition for high-value cedar products, utility poles, and cedar sawlogs have ensured that mill deliveries of cedar wood remain exceptionally high.

Conclusions

Logging utilization studies can help land managers understand the impacts of commercial timber harvesting on growing-stock inventories, woody residue volumes, and carbon dynamics. Variables including logging method, site quality, species, diameter, defect, and the presence/absence of a pulp market can have profound impacts on the production of logging residue.

The sampling design used in this study appears to have captured the range in variability of recent Idaho logging sites and harvested trees. Site locations as a reflection of geographic distribution and species mix in the sample closely approximated Idaho's 2006 timber harvest, as reported by Brandt and others (2012). Results also suggest that the sampling scheme did well at capturing information on the more frequently harvested species, but perhaps not as well with the very infrequently harvested species. This study produced removals factors that enabled meaningful comparisons to historical data as well as stand-alone analysis of current timber harvesting activities in Idaho. Findings of this study support the results of previous studies that indicate technology has reduced the amount of growing-stock logging residues with improved utilization of non-growing stock material over time.

Results show that in Idaho the diameter of harvested trees has been decreasing over time. With less volume per tree, more small trees are required to produce the same mill-delivered volume. Smaller trees have also been shown to produce more logging residue per unit of mill-delivered volume than larger diameter trees. This dynamic suggests that if the trend of harvesting smaller diameter timber continues and the total amount of volume delivered to the mill remains constant, then the total amount of logging residue generated from that harvest will increase. This growing volume of unutilized material could represent a potential source of material for the burgeoning woody biomass or biofuels industry.

Future logging utilization investigations could provide land managers with estimates of biomass specified by individual tree components, including unutilized tops and limbs. In addition, easy-to-use residue prediction models that integrate the effects of land ownership, logging systems, and other variables could greatly enhance the utility of these studies for land managers.

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