FOREST RESOURCES AND MARKETS:
TRENDS AND ECONOMIC IMPACTS

Oregon Forest Resources Institute

THE 2019 FOREST REPORT

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List of Abbreviations

BBF = billion board feet Scribner scale
BEA = Bureau of Economic Analysis
BLM = Bureau of Land Management
BLS = Bureau of Labor Statistics
Btu = British thermal unit
Dbh = diameter at breast height
FIA = Forest Inventory Analysis
GWh = Gigawatt hour
MMBF = million board feet Scribner scale
MBF = thousand board feet Scribner scale
ODF = Oregon Department of Forestry
OED = Oregon Employment Department
USD = U.S. Dollars
USFS = United States Forest Service

1. Introduction

The Oregon Forest Resources Institute (OFRI) was created by the Oregon Legislature in 1991 to improve public understanding of forest practices and products and to encourage sound forest management. In pursuing this mission, OFRI has sought to maintain an awareness of the state of the economic, environmental and social contributions of the forest sector to Oregon residents and businesses. As such, over the years OFRI has commissioned a series of reports on the forest sector. In 2004 the *Oregon Forest Sector Contributions & Potential* characterized Oregon's forest sector as one in transition and used a focus group approach to identify issues, opportunities and challenges. It was followed in 2005 with *Forest Tourism Baseline Economic Assessment* focusing in on forest related tourism. *The 2012 Forest Report: An Economic Assessment of Oregon's Forest and Wood Products Manufacturing Sector* again used stakeholder interviews to identify areas of opportunity as the recovery to the 2007-2009 recession lagged behind expectations. This qualitative exercise was accompanied by an in-depth assessment of the contributions of the sector to the state's economy.

This report builds off the scope of the 2012 study while reducing the qualitative aspects of past reports. The assessment begins in Chapter 2 with a thorough exploration of the state of the resource base on which the sector depends, including the growth and removals that define changes in the resource base over time. We follow with an examination of Oregon's forest products industry in Chapter 3. In Chapter 4, we analyze the economic contributions of the sector in year 2016 and compare these contributions to changes in employment and wages over time. Chapter 5 contains an assessment of risks and threats to the resource base. In the last chapter, we look briefly at non-traditional forest products and emerging market opportunities. It is our hope that this report serves to inform and educate others about the role of forestry in the Oregon economy.

2. Oregon's Forest Resource and Supply

Forest Land in Oregon

With 29.7 million acres, Oregon's forest land represents 3.9% of the total U.S. forest land (765.5 million acres).[1] This makes Oregon the fourth most forested state in the U.S. after Alaska, Texas, and California (Oswalt et al. 2018). Of the total land area in Oregon, 48.4 percent is defined as forest land (Palmer et al. 2018), which is higher than the national average (33.5%). The majority of Oregon's forest land is in wildland forest land use (91%), with developed and urbanized land uses impacting a relatively small proportion of forest land (Tables 1a and 1b).

The state can be broadly separated into dryer, less productive Ponderosa pine forests east of the Cascade Mountains (henceforth labeled eastern Oregon) and wetter more productive forests dominated by Douglas-fir west of the Cascade Mountain crest (henceforth labeled western Oregon). In addition to species composition and productivity, forest extent also varies from east to west as forest land comprises 33.9% of the eastern Oregon land base, while in western Oregon, 79.8% of total land area is classified as forest land. Forest lands are classified as "planted" if there is evidence of human generation of forest stocks or regeneration of stocks following a disturbance (e.g. harvest, fire, disease, insect, etc.). As a reflection of differences in ownership patterns and silvicultural practices in eastern and western Oregon, 37.4% of forest lands are planted in western Oregon, whereas in eastern Oregon, only 6.0% of forest lands are planted.

Timberland in Oregon

Of the total forest land in Oregon, 79.8% (or 23.7 million acres) is classified as timberland.[2] This is more than the national average (67.2%). Nationally, only Georgia has more timberland (24.1 million acres). Most of the state's timberland is in western Oregon with 75.6% of its land area classified as timberland. In eastern Oregon, this percentage is 24.2%. Despite having fewer timberland acres than Georgia, Oregon has the largest timberland volume in growing stock

[1] Forest land is defined as a minimum of one acre that is at least 10% stocked (or equivalent crown closure) with trees of any size (or has been previously) and is currently not developed for a non-forest use (Bansal et al., 2017).
[2] Timberland is defined as non-reserved land capable of producing at least 20 ft^3 of wood per acre (1.4 m^3 per hectare) per year.

nationally.[3] At 90,882 million ft^3, it represents about 10% of the national growing stock volume on timberland. Most of that volume, or 66,071 million ft^3 (73%), is on public lands. As a point of comparison, Georgia's timberland growing stock volume is 36,461 million ft^3, and only 12% of that volume is on public lands (Oswalt et al. 2018). In per acre terms, Oregon's growing stock volume density is 3,840 ft^3 (per acre of timberland). On public lands, the growing stock volume density is 4,623 ft^3/acre, and on private lands, it is 2,646 ft^3/acre. Only the states of California and Washington have higher growing stock volumes per acre of timberland.

[3] Net growing stock volume is defined as the net volume of growing stock trees at least 5 inches in diameter at breast height.

Table 1a. Oregon forest land area by land use

Land Use	*Percent of Total*
Wildland forest	91%
Wildland range	5%
Mixed forest/agriculture	1%
Mixed range/agriculture	<1%
Intensive agriculture	1%
Low-density residential	1%
Urban	<1%
Other	<1%
Total forest land, all land uses (29.7 million acres)	**100%**

Table 1b. Land use classes

Land Use Category	Description
Wildland Forest	- Area of land in forest use that is at least 640 acres in size and - Fewer than 5 structures per square mile on average.
Wildland Range	- Area of land in range use that is at least 640 acres in size and - Fewer than 5 structures per square mile on average.
Mixed Forest/Agriculture	- Area of land with intermixed forest and agricultural uses that is at least 640 acres in size and - Fewer than 9 non-farm-related structures per square mile on average.
Mixed Range/Agriculture	- Area of land with intermixed range and agricultural uses that is at least 640 acres in size and - Fewer than 9 non-farm-related structures per square mile on average.
Intensive Agriculture	- Area of land in agricultural use that is at least 640 acres in size and - Fewer than 9 non-farm-related structures per square mile on average.
Low-Density Residential	- An area of any size in rural residential or low-density commercial use that contains 9 or more structures.
Urban	- Area of land that is at least 40 acres in size and - Comprised of commercial, service, or subdivided residential uses with city street patterns and closely-spaced buildings.
Other (sand, rock, water, etc.)	- Area of naturally non-vegetated land that is at least 640 acres in size.

Source: USFS PNW FIA Database (2017); Development Zone Project 2014 land use classes, ODF Partnership and Planning Program.

Table 2a. Forest land area by ownership

	Thousand Acres	Percent of Total
U.S. Forest Service (Reserved and unreserved)	14,073	47%
Bureau of Land Management	3,566	12%
National Parks Service	161	1%
Miscellaneous other Federal	33	<1%
Total Federal	**17,833**	**60%**
State	945	3%
County/Municipal	203	1%
Total public forest land	**18,981**	**64%**
Industrial – prime timberland	6,085	21%
Other private – prime timberland	1,968	7%
Industrial – low productivity or highly developed	499	2%
Other private – low productivity or highly developed	1,639	6%
Total private forest land	*10,191*	*34%*
Native American	484	2%
Total forest land, all owners	**29,656**	**100%**

Source: USFS PNW FIA database (2017), Development Zone Project 2014 land use classes, ODF Partnership and Planning Program.

Table 2b. National percentages of forest land area by ownership

USFS	18.9%
BLM	4.9%
Other Federal	7.2%
State	9.2%
Other Local	1.8%
Private	57.9%

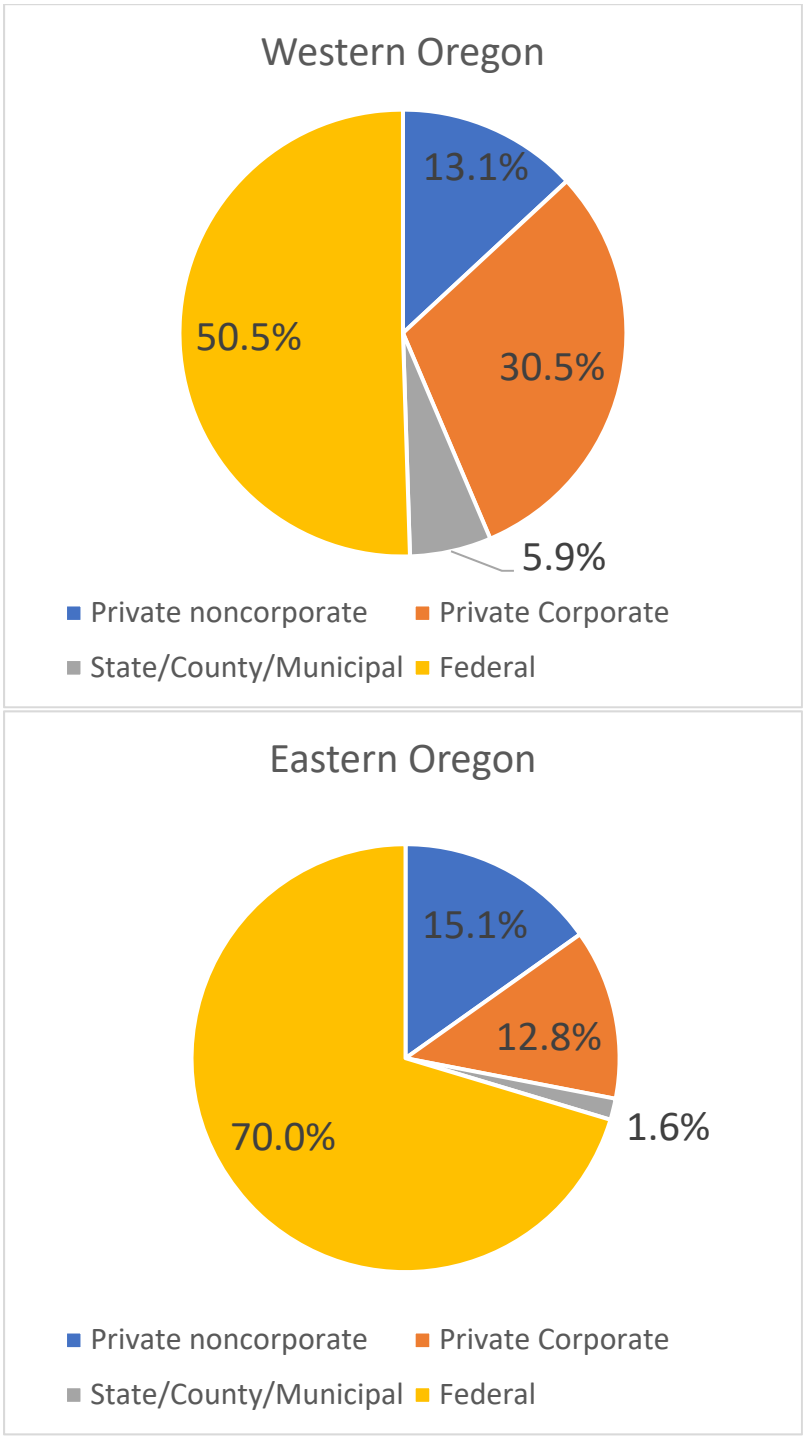
Source: Oswalt et al. (2018).

Who Owns Oregon's Forest Land?

Table 2a shows the forest land area (in 1000 acres) in Oregon by ownership. National totals are presented in Table 2b for comparison. Oregon has a lower percentage of its forest land held by private landowners relative to the nationwide percentage (36% vs. 58%). State and county/municipal governments own 4 percent of Oregon's forest land. This is lower than the national average (11%). Federal forests comprise 60 percent of the total forest land area in Oregon. This is higher than the national average of 31 percent. Private corporate forest lands comprise 61% (6.49 million acres) of the total private forest land in Oregon (10.67 million acres). This share is higher than the national average (34%). As a point of comparison, of Georgia's private forest land, 38% is owned by corporate landowners.

The ownership patterns differ considerably between western and eastern Oregon (Figure 1). In western Oregon, 43.6% of the forest land is privately held, and the corporate share of the total private forest land is 70%. In eastern Oregon, these shares are 27.9% and 46%, respectively. Federal government owns 51.2% of the forest land in western Oregon. Of those forests, U.S. Forest Service manages 72% and BLM 28%. In eastern Oregon, federal forests comprise nearly 70% of the total forest area. Of those forests, USFS manages 85%, BLM manages 14%, and NPS manages 1%.

Figure 1. Percent forest land area by ownership in western and eastern Oregon.



Source: *Palmer et al. (2018). Tribal lands are included within private noncorporate lands. Note: percentages do not add to 100 due to rounding.*

Growth Greater than Removals

Forest land

Table 3 shows the annualized growth, mortality, removals, and net change in volume on private and public forest lands in Oregon (ft^3/acre). During the latest FIA observation period, the annualized net change in volume per acre was positive across all ownerships, in both western and eastern Oregon. A greater increase in forest land volume has occurred on public lands in both western and eastern Oregon compared to private lands. Additionally, annualized removals per acre are considerably higher on private lands than on public lands (117.6 vs. 18.9 in western Oregon and 22.9 vs. 5.6 in eastern Oregon). However, annualized mortality per acre is higher on public lands than on private lands (39.1 vs. 14.4 in western Oregon and 23.1 vs. 7.1 in eastern Oregon).

Timberland

At 2.127 billion ft^3 per year (89.9 cubic feet per acre per year), Oregon had the highest net growth on timberland in the U.S according to the most recent FIA data (Oswalt et al. 2018). Annual removals were 1.087 billion ft^3, the second highest after Georgia (1.167 billion ft^3). Tree mortality in Oregon was 0.544 billion ft^3/year, the fifth highest in the U.S. after Montana, Idaho, Washington, and California. Table 4 shows comparisons between selected states using cubic feet per acre of timberland per year as a measure. Oregon and Washington have comparable net growth and removals. However, mortality per acre is lower in Oregon than in other western states.

*Table 3. Annualized gross growth, mortality, removals, and net change in western and eastern Oregon (**ft^3**/acre).*

	GROWTH	MORTALITY	REMOVALS	NET CHANGE
	2001-05 to 2011-15			
WEST				
PUBLIC	141.5	39.1	18.9	83.6
PRIVATE	147.1	14.4	117.6	15.1
EAST				
PUBLIC	44.2	23.1	5.6	15.5
PRIVATE	38.5	7.1	22.9	8.4

Source: Palmer et al. (2018). Point estimates given in annualized cubic feet per acre. Note: Net change = Growth – Mortality – Removals. "Net growth" would be defined as Growth – Mortality.

*Table 4. Selected states for comparisons (**ft^3**/acre of timberland per year).*

State	Net growth	Removals	Mortality
Oregon	89.9	45.9	23.0
California	63.5	21.4	34.5
Georgia	75.5	48.5	12.9
Idaho	27.3	13.9	37.6
Montana	3.2	5.2	33.8
Washington	88.8	45.3	36.9

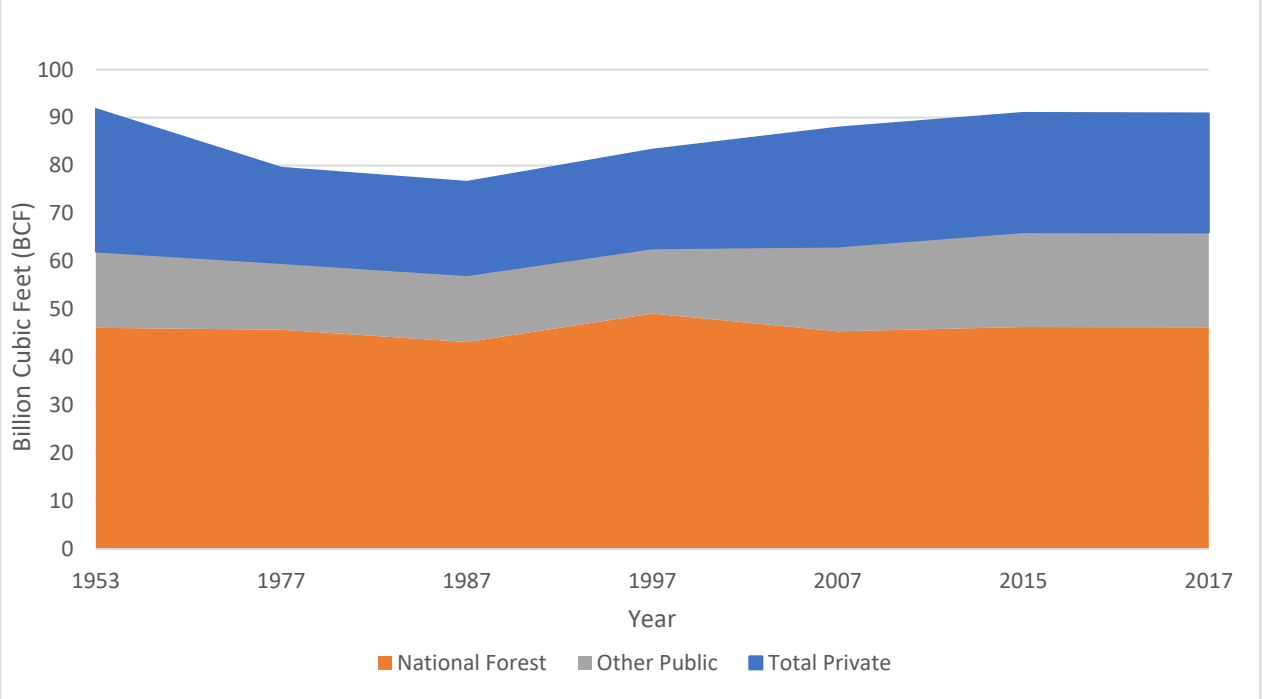
Source: Oswalt et al. (2018).

How Much Wood Is There?

Figure 2a shows the growing stock inventory (in billion ft^3) for all timberland in Oregon by ownership. The total volume of trees (greater than 5 inches in dbh) was an estimated 90.9 billion ft^3 in 2017 (Oswalt et al. 2018). Due to differences in field survey methodologies, comparisons between time periods in Figure 2a should be interpreted with caution (Palmer et al. 2018).

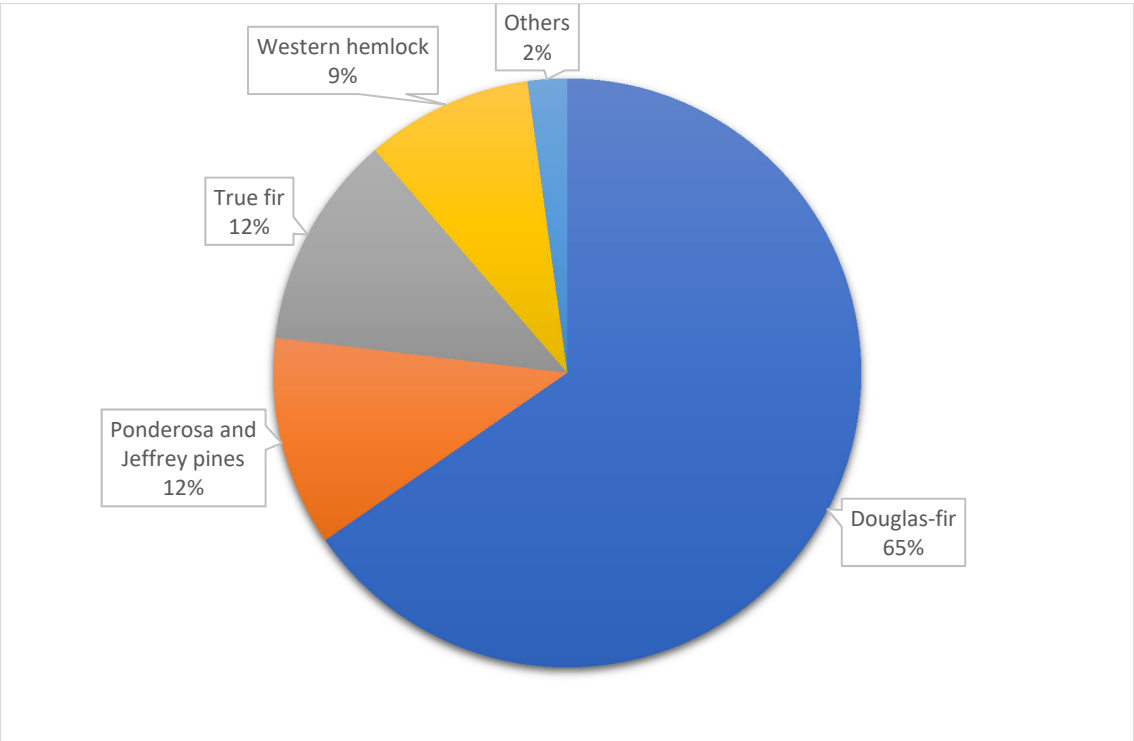
Oregon's growing stock volume of timber represents 9.2% of the nation's total growing stock volume (Oswalt et al. 2018). Figure 2b shows trees species shares. Most of the growing stock is Douglas-fir (65%), with species of pine trees, true firs, and western hemlock comprising most of the other tree species. While the growing stock volume can represent useful information for assessing sustainability, it does not easily translate into a useful measure of readily available timber and future supply. These are ultimately driven by markets and forest owners' management decisions (Simmons et al. 2016).

Figure 2a. Growing stock inventory for all Oregon timberland owners (1953-2017)



Source: 1953-2007 from Smith et al. (2009); 2015 from Palmer et al. (2018); 2017 from Oswalt et al., (2018).

Figure 2b. Timberland growing stock shares by species



Source: Oswalt et al. (2018).

Oregon's Timber Harvests

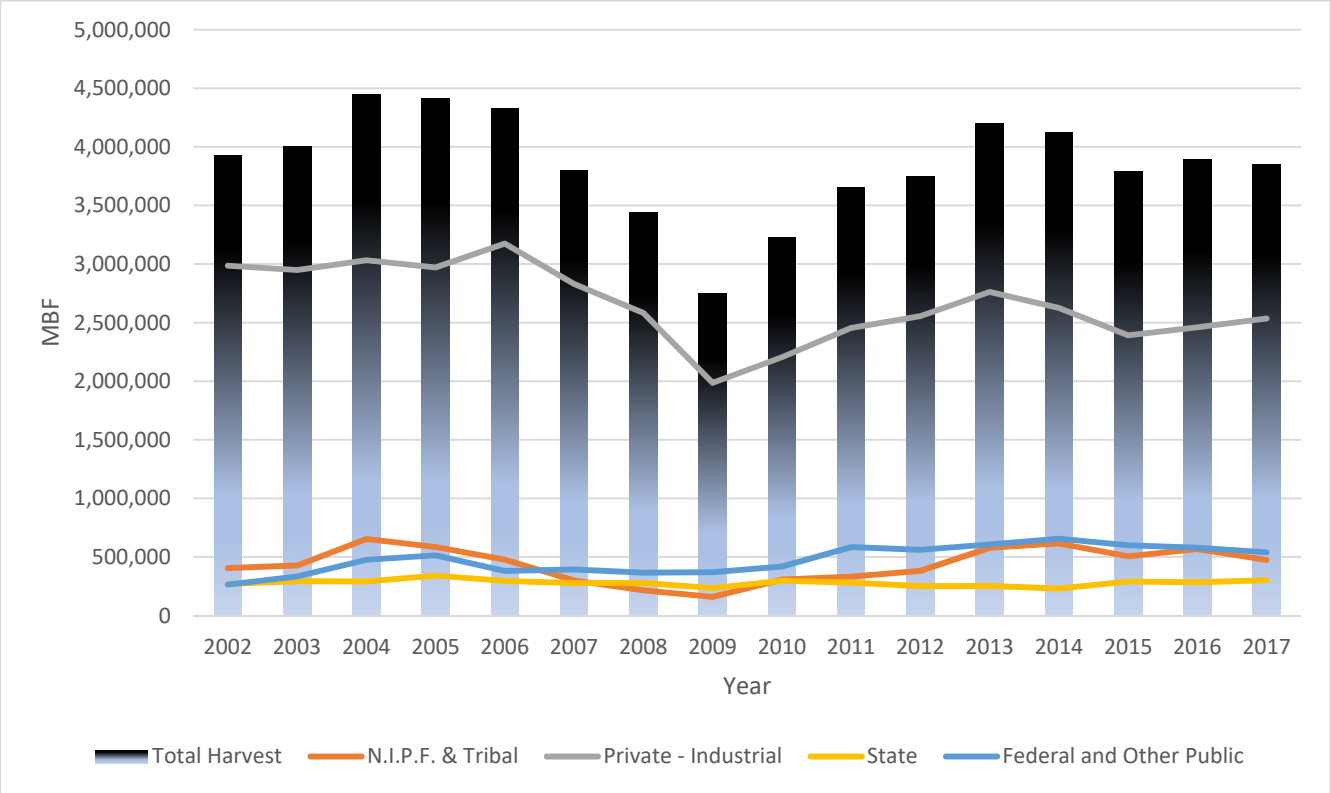
Figure 3 shows annual timbers harvests in Oregon during the period 2002-2017. In total, over 3.851 billion board feet were harvested in 2017. About 8.7% of that volume is attributable to U.S. Forest Service land and 13.2% to other public land ownerships (BLM, state, local). The rest is attributable to private lands. Figure 3 also shows that harvest volumes have gradually returned to the pre-recession levels. However, real log prices were still slightly below the pre-recession levels in 2016 (Figure 4). The average log price in western Oregon was $568.14/MBF in 2016. This represents a 27% increase over the average log price from 2009-2015.

In 2013, about 70% of the total harvest was Douglas-fir, about 11% western hemlock, and about 9% true firs (Simmons et al. 2016). Western Oregon supplied about 90% of the total harvest. In the same year, Oregon had the highest value of timber sales in the nation, worth $1.07 billion from all timberlands combined. The total value of timber sales in the U.S. was

about $8.2 billion (Forest2Market 2016). About 75% of the Oregon's timber harvest was sawlogs, about 15% veneer logs, and 9% pulp/chipped logs (Simmons et al. 2016).

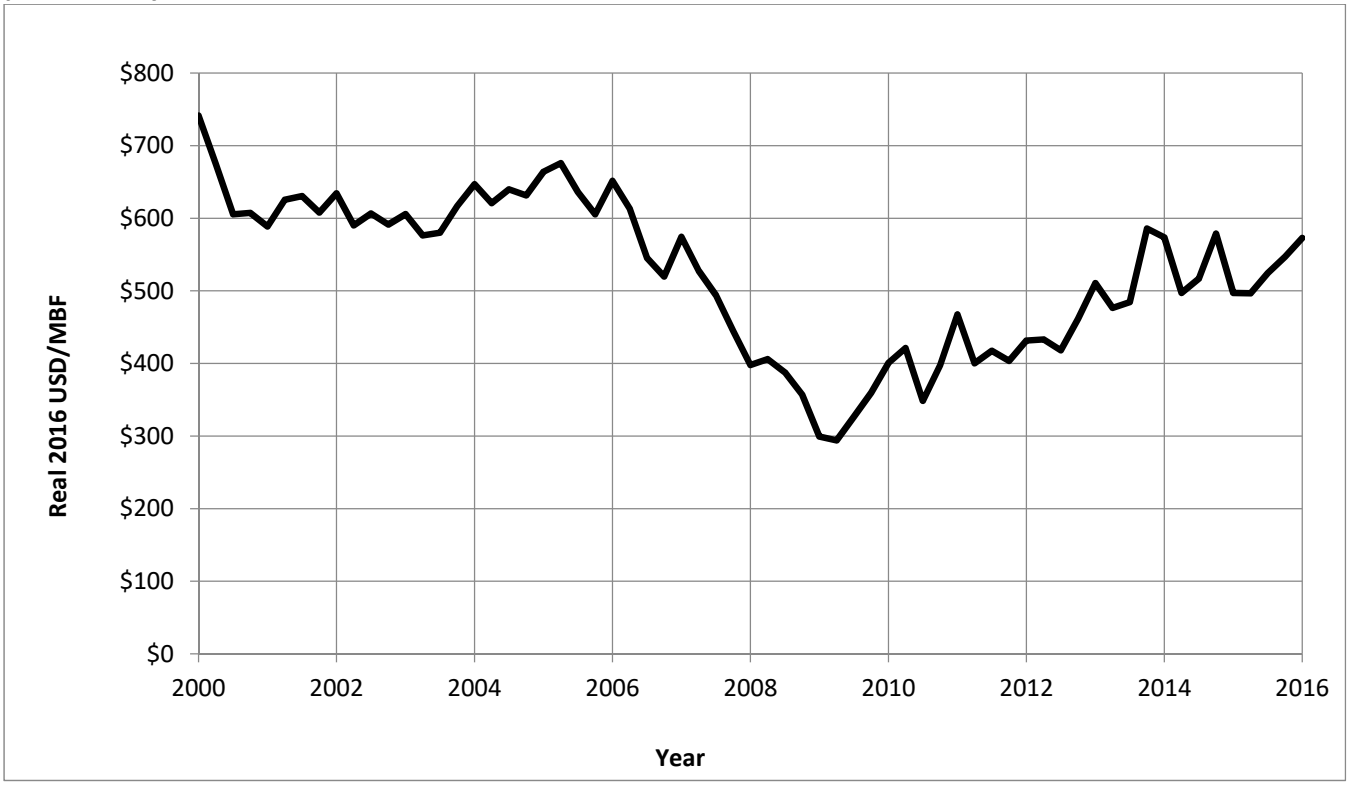
Table 5 shows the relative changes in harvest volumes among ownerships between years 1987-2017. Logging on federal lands has remained low relative to historical levels since the beginning of 1990's. About 77% of the volume harvested came from private lands during period 2012-2017, whereas between 1970-1990, federal harvests constituted about half of the total volume harvested annually (Simmons et al. 2016). In 2017, the value of cut timber from National Forests in Oregon was $34.2 million representing 386.7 MMBF, and the value of sold timber was $41 million representing 416.1 MMBF. These were the highest levels from National Forests in any state (USDA Forest Service Cut and Sold Report 2017).

Figure 3. Oregon timber harvest by ownership and combined harvest, 2002-2017



Source: ODF Partnership and Planning.

Figure 4. Average Western Oregon Log Price Index, adjusted for species, grade, and inflation (2000-2016)



Source: ODF Partnership and Planning.

Table 5. Percentage of total harvest volume by ownership group

	Federal	State/Local	Private	Tribal
2017	13%	9%	78%	<1%
2012-2016	14.0%	7.8%	76.7%	1.5%
2007-2011	11.6%	9.2%	77.4%	1.9%
2002-2006	8.2%	8.1%	82.1%	1.6%
1997-2001	10.7%	6.8%	80.7%	1.8%
1992-1996	23.0%	3.2%	72.1%	1.8%
1987-1991	50.9%	2.9%	44.7%	1.5%

Source: ODF Partnership and Planning.

3. Oregon's Forest Products Manufacturing and Markets

How Is Oregon Timber Used?

Oregon wood is used to produce a wide range of consumer and industrial products. Some important examples of forest products include

- Softwood/hardwood lumber and plywood
- Engineered wood products
- Composite wood products
- Posts, poles and timbers
- Pulp and paper products
- Millwork
- Biomass energy
- Heating

Table 6 shows that 188 primary forest products facilities operated in Oregon during 2013 (Gale et al. 2012, Simmons et al. 2016).[4] Most of these facilities are located in western Oregon, close to the state's main timber stocks. Significant changes have occurred in Oregon's forest products sector during the past three decades with respect to production technology, product types, and log supplies. Figure 5 illustrates the downward trend in the total number of facilities during this period (numbers are not perfectly comparable between years due to changes in data collection). Some explanations behind these trends are discussed in more detail below.

In 2013, Oregon's timber processing facilities received more than 3.7 BBF Scribner of timber (Simmons et al. 2016). Of that volume, approximately 94.5% was harvested from Oregon.[5] The list below shows the delivered allocation of the total volume harvested in 2013 by use (Simmons et al. 2016):

- 59 percent was delivered as sawlogs to sawmills;

[4] "Other" facilities include cedar products through year 2008, posts, poles, chipping, biomass/energy, bark products, and fuel pellets/fire logs and log homes/furniture. Sawmill data for 2013 and 2017 includes cedar products facilities.

[5] The total harvest in Oregon was 4.25 BBF in 2013.

- 12.4 percent was veneer logs delivered to veneer and plywood plants;
- 14.4 percent was delivered to export facilities;
- 13 percent was chipped for pulp mills and board plants;
- 0.9 percent was delivered as other timber products to various facilities.

However, the delivered allocation does not reveal the actual use of harvested wood by facilities since wood residues are frequently sold from one facility type to another.

Figure 6 shows the actual use of Oregon wood in 2013. Of the volume delivered to sawmills, 49.4% became finished lumber or other sawn products and 48% became mill residues (Simmons et al. 2016). About 87.4% of the residues were sold as raw material for other facilities (pulp and paper, particleboard, medium-density fiberboard, and hardboard) in Oregon and elsewhere, and 10.6% was used for energy. The rest of the residues were used for miscellaneous purposes (2%).

Of the volume delivered to veneer plants, approximately 63 percent was processed into veneer, and 37 percent became residue. Of the residue, 88.8% was sold to other manufacturers and the rest was used for energy (Simmons et al. 2016). While pulp mills and board plants in Oregon received 13% of the roundwood harvest, they ended up using 40% of the total volume harvested when residues from other manufacturers are included (Simmons et al. 2016).

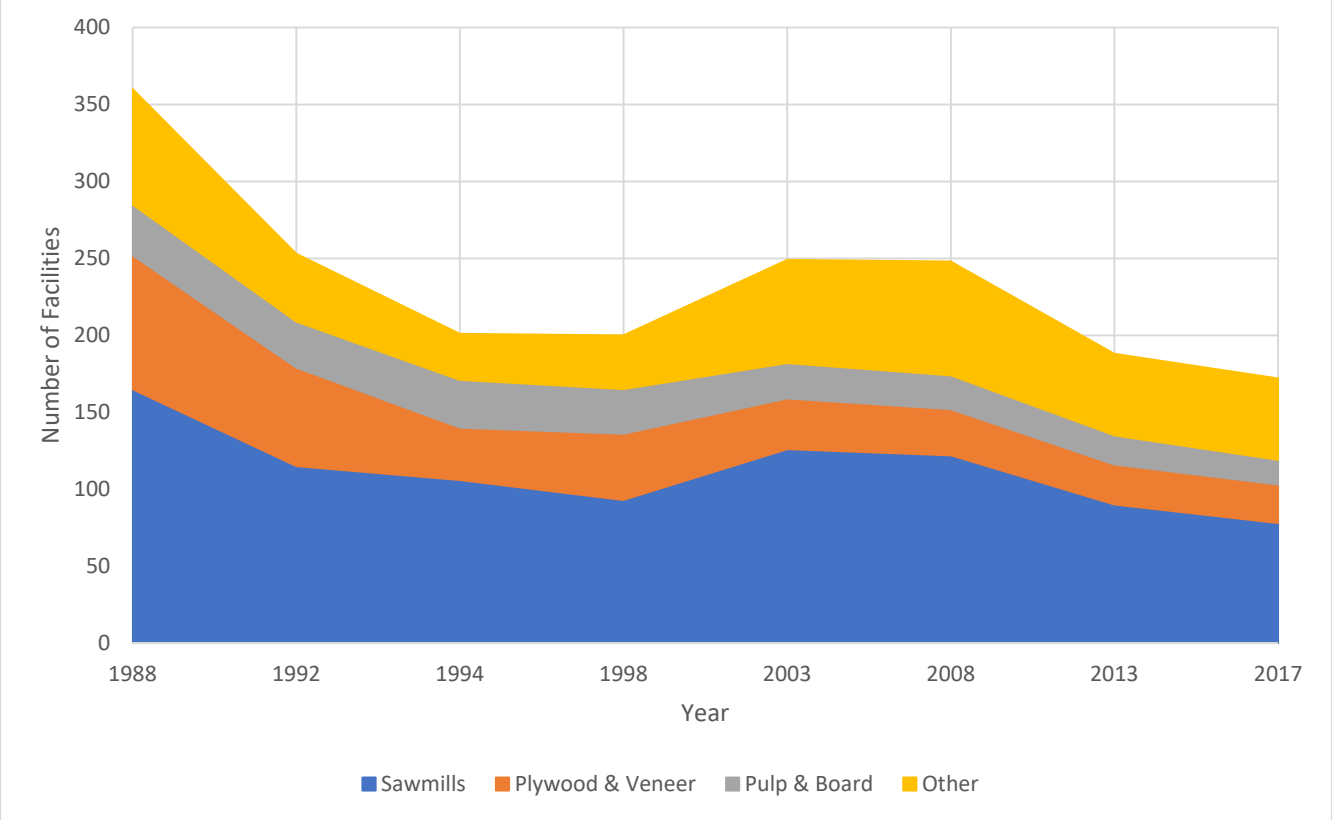
Of the volume delivered to other facilities, about 85.4% became finished products, 8.9% was used for energy, and 4.2% was sold as raw material to other manufacturers, 0.3% in other residue uses, and 0.8% was not utilized (Simmons et al. 2016).

Table 6. Number of wood processing facilities in Oregon, 1988-2017.

Survey Year	Sawmills	Plywood & Veneer	Pulp & Board	Other/Export	Total
1988	165	87	33	75	360
1992	115	64	30	44	253
1994	106	34	31	30	201
1998	93	43	29	35	200
2003	126	33	23	67	249
2008	122	30	22	57	248
2013	90	26	19	53	188
2017	78	25	16	53	172

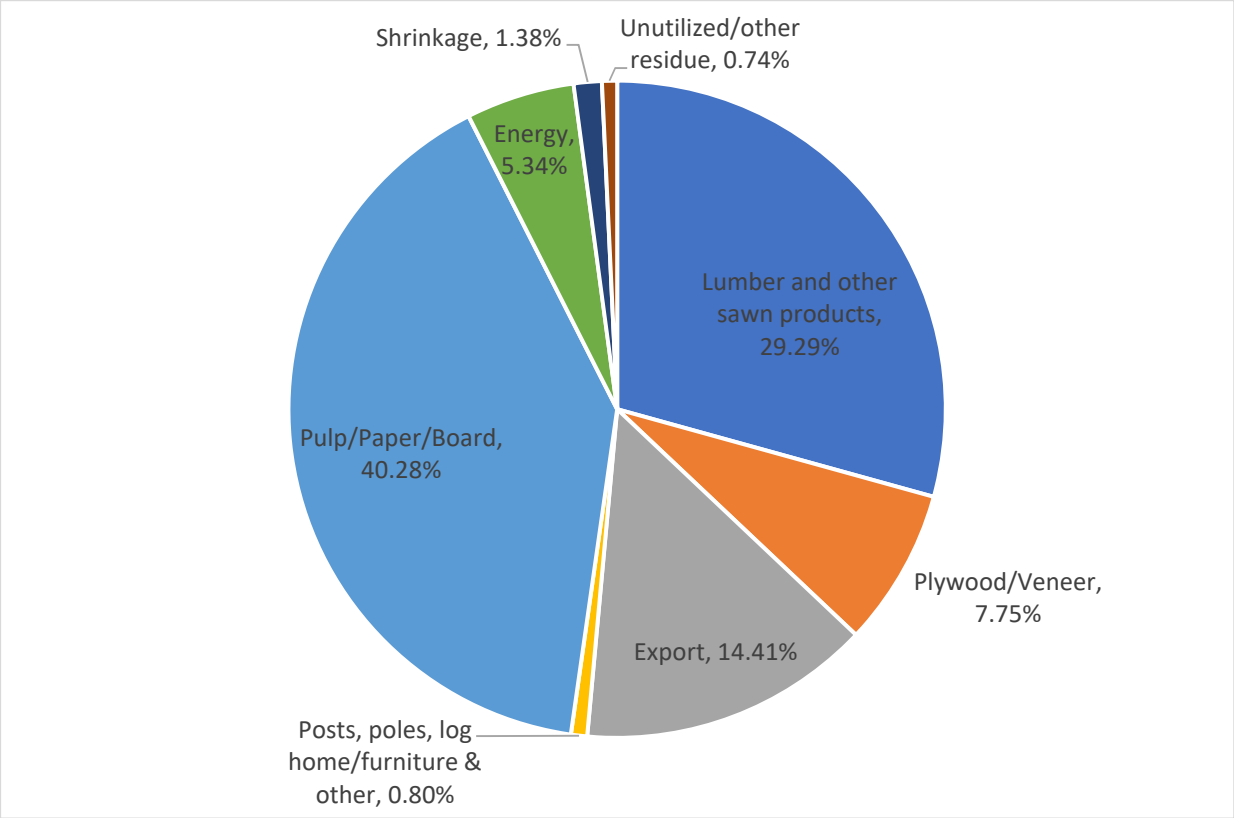
Sources: Simmons et al. (2019); Forest Econ Inc. Field Surveys (2012); Gale et al. (2012); Brandt et al. (2006); Latta (2018).

Figure 5. Active primary wood products facilities in Oregon (1988-2017)



Sources: Simmons et al. (2019); Forest Econ Inc. Field Surveys (2012); Gale et al. (2012); Brandt et al. (2006); Latta (2018).

Figure 6. Percent of Oregon forest products output volume attributable to various processing facilities or markets for raw material in 2013.



Source: Simmons et al. (2016).

Oregon Sawmills

Oregon is consistently the leading producer of softwood lumber in the United States (WWPA 2015, 2017). In 2017, the lumber production in Oregon sawmills was over 5.4 BBF (Figure 7). Majority of that volume (78.0%) was produced using Douglas-fir and Larch species, 17.3% was produced using Hemlock-Fir, 3.3% using Ponderosa pine, and 1.5% using other mixed softwood species. As shown in Figure 7, annual lumber production in Oregon increased by 33.7% from 2010 to 2017. This occurred alongside with a 4.7% average annual increase in softwood lumber prices over the same period (Random Lengths International).

Total timber processing capacity of Oregon sawmills was 4.2 BBF in 2013, while the utilized capacity was 60% of the total (Simmons et al. 2016).[6] Measured in lumber tally, Oregon mills had 8.1 BBF of total production capacity in 2013. In the same year, 28 sawmills (out of 90) had a total capacity exceeding 100 MMBF. These mills represented 81.1% of the total lumber production capacity in Oregon. They produced 77.3% of the total volume and had utilization rate of 62.5% (Simmons et al. 2016). Figure 8 shows the locations of active mills in Oregon, distinguishing by capacity the mills exceeding 200 MMBF.

In 2017, 50% of Oregon sawmill production was distributed by railway. The other 50% of production was primarily transported by truck (WWPA 2017). Most lumber in Oregon is distributed to either stocking distributors or directly to retailers (WWPA 2017). In 2017, 34.2% of lumber was transported from Oregon sawmills to stocking distributors and 31.9% was distributed directly to retailer. Other distribution channels include independent office wholesalers (13.2%), remanufacturing facilities (9.5%), other lumber companies (4.8%), treating facilities (4.3%), company owned distribution yards (1.1%), and direct channels to users (1.0%).

The number of lumber mills has decreased by 53% during the period 1988-2017 and by 38% during the period 2003-2017. While the number of sawmills has considerably declined over this period, it may not necessarily be due to a declining industry. The decrease in the number of mills can also be partly explained by changes in mill efficiency, timber supply, and industry consolidation (Keegan et al. 2006, McIver et al. 2013, Morgan et al. 2012, Simmons et al. 2016).

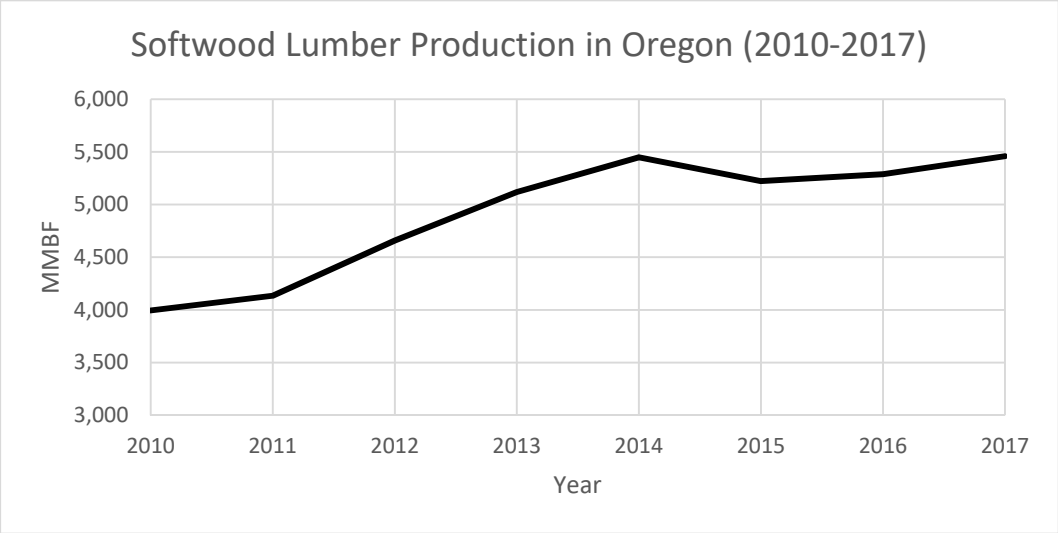
Technical efficiency expresses the volume of output achieved per unit of inputs utilized. One measure of technical efficiency in terms of timber-processing capacity is the lumber recovery ratio (i.e. the volume of lumber output in thousand board feet per thousand cubic feet of timber processed). The number of sawmills decreased from 1998 to 2008 alongside an 8.4% increase in the lumber recovery ratio (Simmons et al., 2016). However, the most recent available estimates of lumber recovery ratios show a decline from 9.0 in 2008 to 8.63 in 2013 (Simmons et al., 2016). One likely explanation for this drop is the increased use of smaller

[6] At the time of writing this report, 2013 is the most recent year for which data are available on capacities and utilization rates.

diameter logs during 2013. The bias in both the lumber recovery ratio and lumber overrun is sensitive to the diameter of the sawlogs (Simmons et al. 2016).

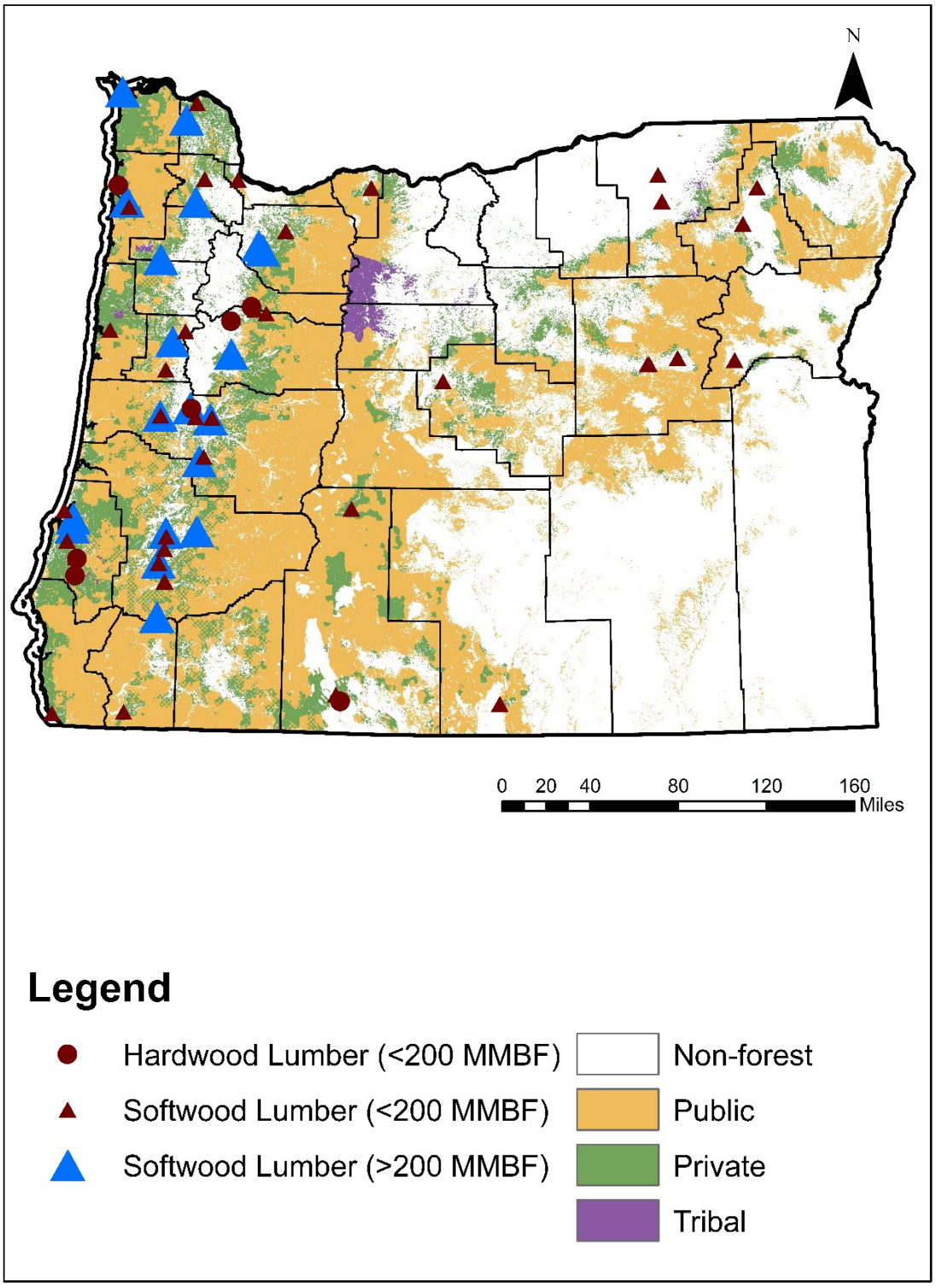
Broader measures of technical efficiency, which express the volume of lumber output produced per labor-hours, machinery-hours, or energy use may also indicate increasing or decreasing efficiency of Oregon sawmills. Such broader measures of technical efficiency indicate that technical efficiency has increased at a decreasing rate from 1968 to 2002. Over this time period, Oregon sawmills became more capital intensive and less labor intensive (Helvoigt and Adams, 2009).

Figure 7. Softwood lumber production in Oregon (2010-2017)



Source: WWPA (2017).

Figure 8. Active Oregon sawmills (2014) and forest ownership (2016)



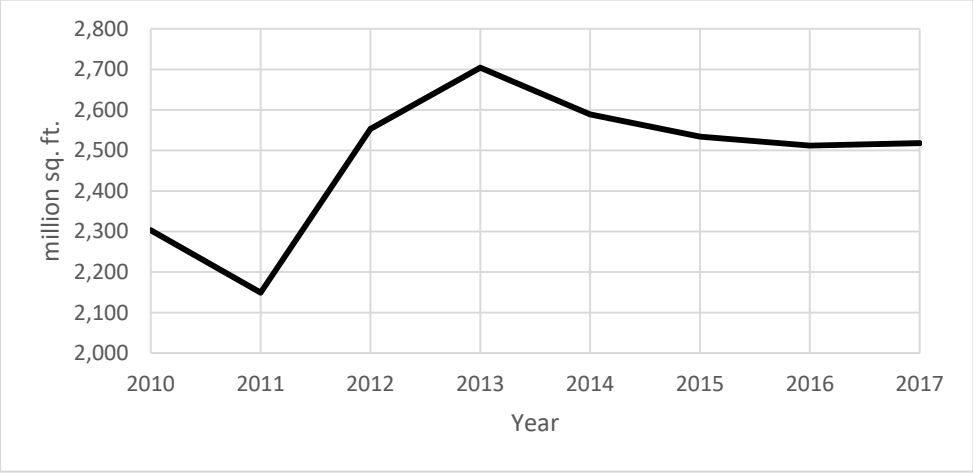
Source: Latta (2018), Hewes et al. (2017).

Oregon Plywood, Panel, and MDF Facilities

Oregon is the leading producer of plywood in the United States (Simmons et al., 2016; Elling, 2015). Manufacturers in Oregon produced 2,518 million square feet of 3/8 –inch basis plywood in 2017 (Elling, 2018). This represents 28% of total U.S. production. Annual production of 3/8-inch basis plywood is around 200 million sq. ft. higher than it was in 2010 (see Figure 9).

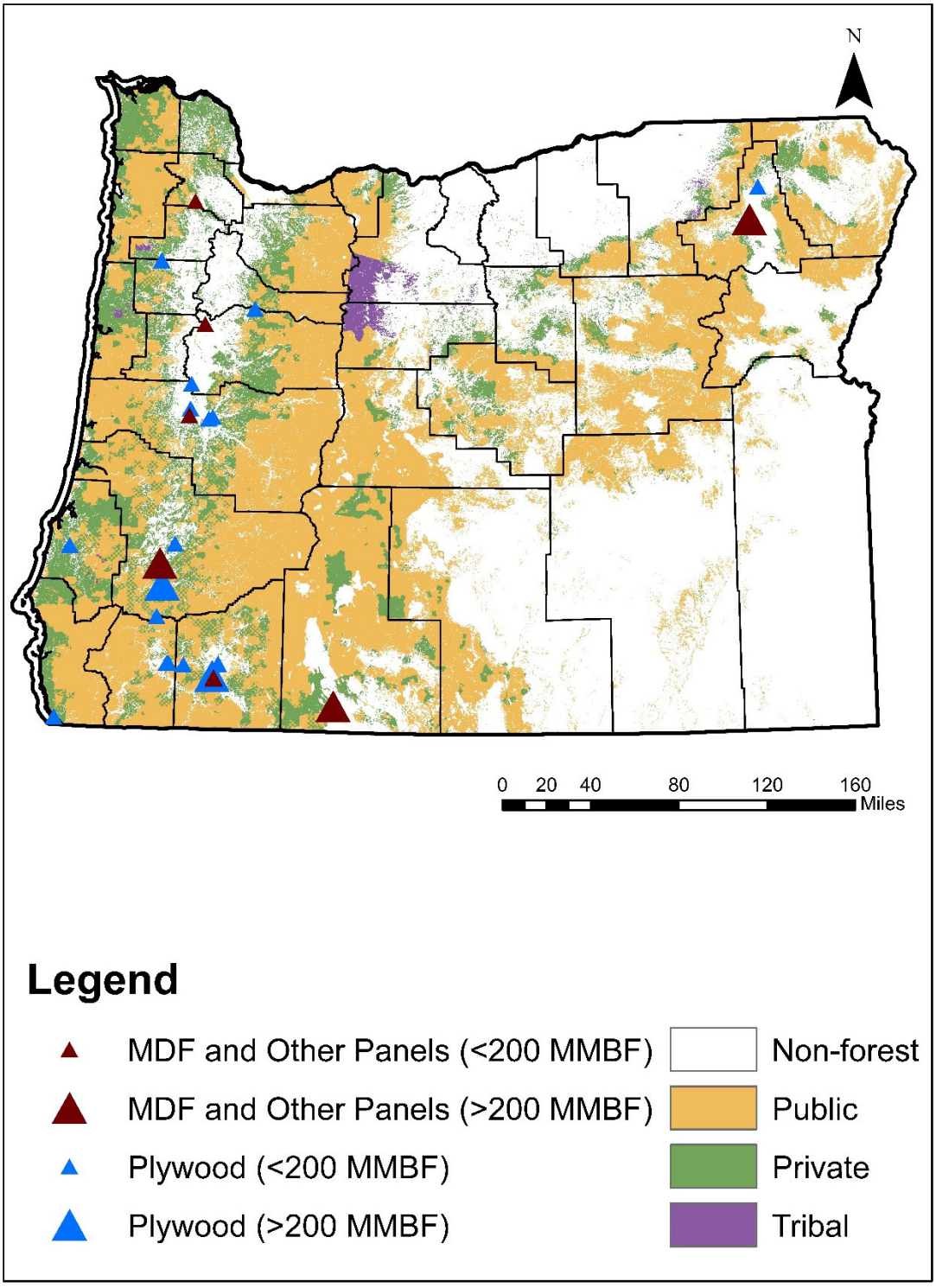
Figure 10 shows the most recent data available on active plywood and medium density fiberboard (MDF) facilities, distinguishing by production capacity those facilities exceeding 200 MMBF. The number of Oregon plywood production facilities decreased from 30 in 2008 to 25 in 2017 (Table 6). This is consistent with the long-run trend showing a significant reduction in plywood facilities in Oregon. The number of plywood and veneer facilities decreased by 71% during the period 1988-2017 and by 24% during the period 2003-2017. The historical decline in plywood facilities has been attributed to increased competition from strand-board producers, lower volumes of veneer-quality timber on private lands, lower harvest volumes on public lands, periodic increases in veneer-quality timber in export markets, and unfavorable economic conditions (Gale et al., 2012). More recent analysis of the potential causes for a decline in plywood mills since 2012 has not been conducted. As with sawmills, this decline may be due, in part, to changes in plywood mill technology, competition from substitute products, and increases in technical efficiency.

Figure 9. Production of plywood with (3/8)" basis in Oregon (2010-2017)



Source: Forest Economic Advisors (2018).

Figure 10. Active plywood, panel and medium density fiberboard (MDF) facilities (2014) and forest ownership (2016)



Source: Latta (2018), Hewes et al. (2017).

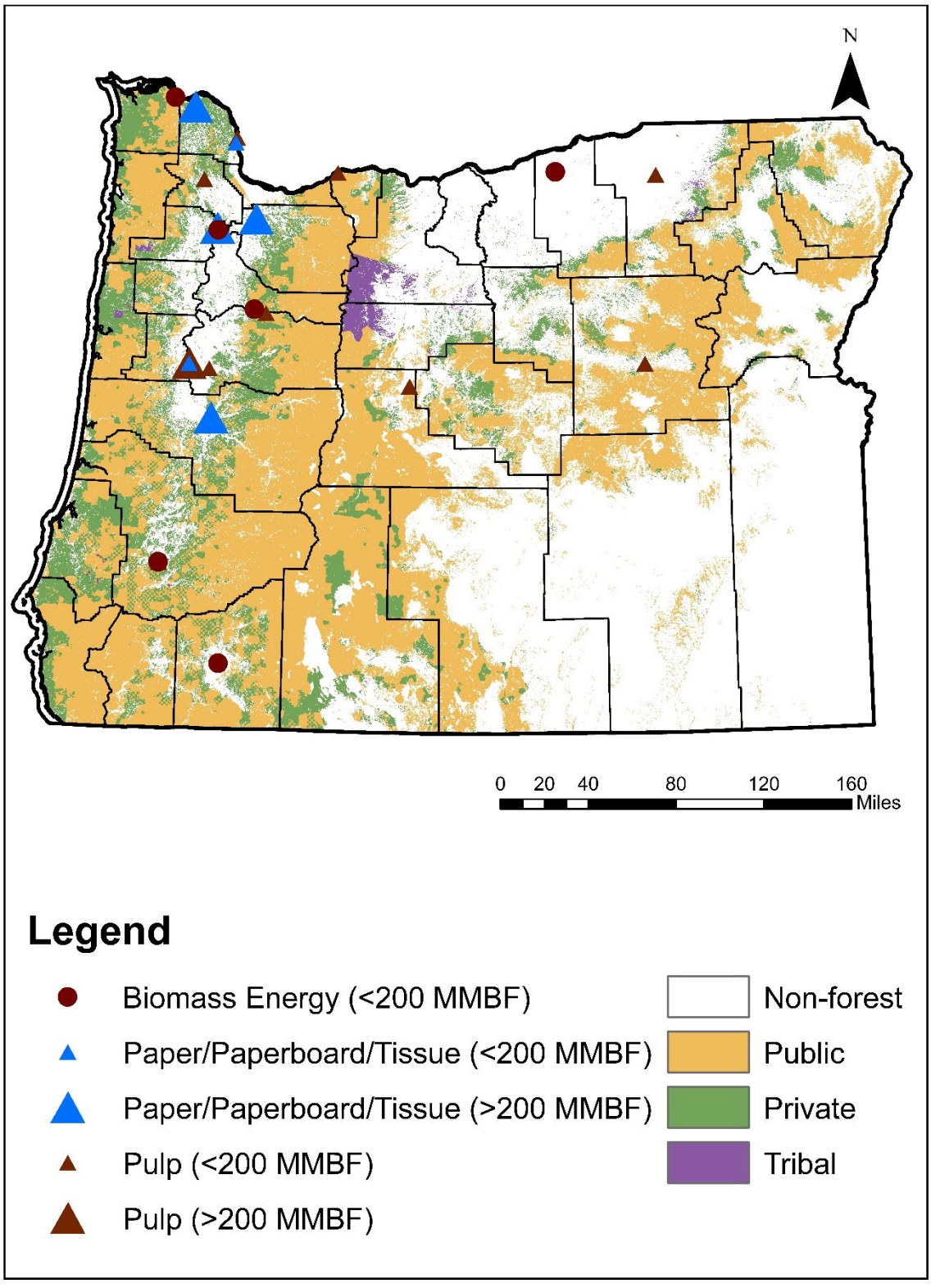
Oregon Pulp/Paper Mills and Biomass Energy Facilities

Figure 11 shows the location of Oregon's pulp/paper mills and distinguishes facilities with capacities greater than 200 MMBF. As of 2017, there are currently 16 active pulp/paper and board facilities in Oregon. Significant reductions in the number of facilities and production volumes have occurred during the recent years, consistent with the long run trends in the industry. The number of pulp and board facilities decreased by 52% during the period 1988-2017 and by 30% during the period 2003-2017 (Table 6). Between 2008 and 2013, total volume of pulp and paper/board production decreased by 32% (Simmons et al. 2016).

Biomass energy facilities are small but a growing proportion of Oregon wood products markets. There are currently seven biomass processing facilities in Oregon (Figure 11). Biomass energy facilities in the western United States retained a monthly average of total receipts over $5.4 million through October of 2018. These monthly average revenues fall below the U.S. average. Oregon's utility scale facility net generation from biomass increased from 994 GWh in 2013 to 1040 GWh in 2017 (EIA 2015, 2018). However, in 2015 it was 1,116 GWh. By comparison, California had the highest net biomass generation in 2017 at 5,911 GWh. Considerable portion of the nation's net generation from biomass is concentrated in the southern U.S. with Florida (4,941 GWh), Georgia (4,917 GWh), Virginia (4,035 GWh), and Alabama (3,377) GWh) all having over 3,000 GWh of net generation.

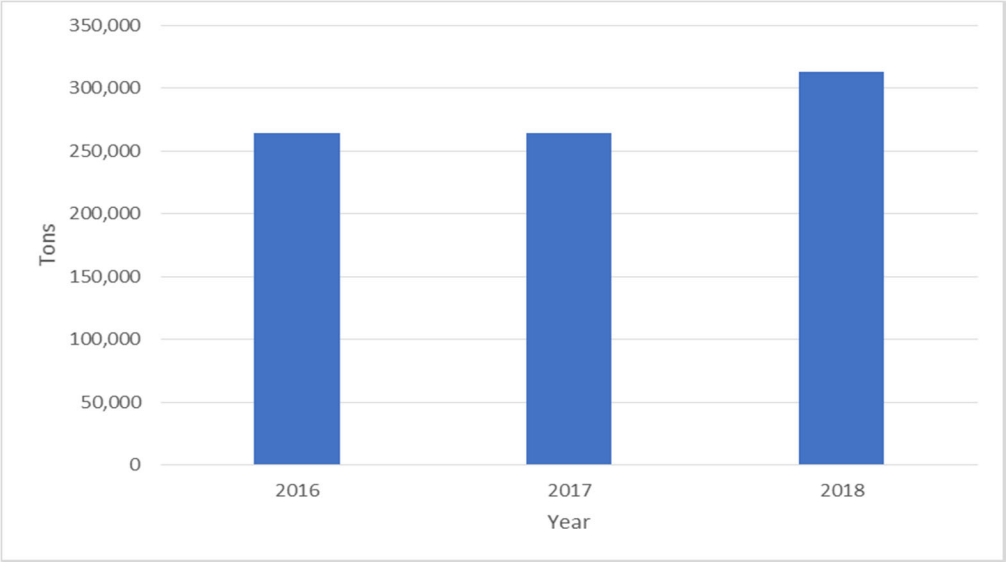
Consumption of wood and wood waste biomass for electricity generation was 7,458 billion Btu in Oregon in 2017. By comparison, California's consumption was 44,257 billion Btu, and Washington's 14,385 billion Btu. Several states in the southeast and in the northeast had consumptions in excess of 20,000 billion Btu (EIA 2018). Densified biomass fuel manufacturing capacity was 313,200 tons in Oregon in 2018 (Figure 12). This represents 2.48% of the total capacity in the U.S. As of October 2018, there are seven densified biomass fuel manufacturing facilities in Oregon.

Figure 11. Active Oregon pulp/paper and biomass energy facilities (2014) and forest ownership (2016)



Source: Latta (2018), Hewes et al. (2017).

Figure 12. Densified biomass fuel manufacturing capacity in Oregon (2016-2018)



Source: https://www.eia.gov/biofuels/biomass/.

Sales, Value Added and Capital Expenditures

The metrics commonly evaluated when determining economic contributions of manufacturing sectors are: output (dollar value of sales of goods and services), employment (jobs), and value added (dollars). Value added first accounts for gross output and then deducts for the costs of the various inputs required to produce the final good. The sum of value added for all parts of the county or state's economy is called gross domestic product (GDP). This value added, or GDP, is the most commonly used indicator of the level to which an organization, industry, or sector contributes the economy of the county or state as a whole. Chapter 4 provides a detailed evaluation of the economic contributions of Oregon's forest product industries, going beyond the direct measures of economic contributions. This section presents industry-level data on sales, value added, and capital expenditures.

Total wood products sales in Oregon have gradually increased from the lows set in 2011, as the economy started to recover from the financial crisis years (Figure 13). In 2011, total sales were $8.2 billion, whereas in 2016, total receipts from the sale of wood products exceeded $10.34 billion (all sales values are reported in real prices, using 2017 as the base year). While sales from pulp/paper and board facilities have decreased from 2010-2016, sales from sawmills,

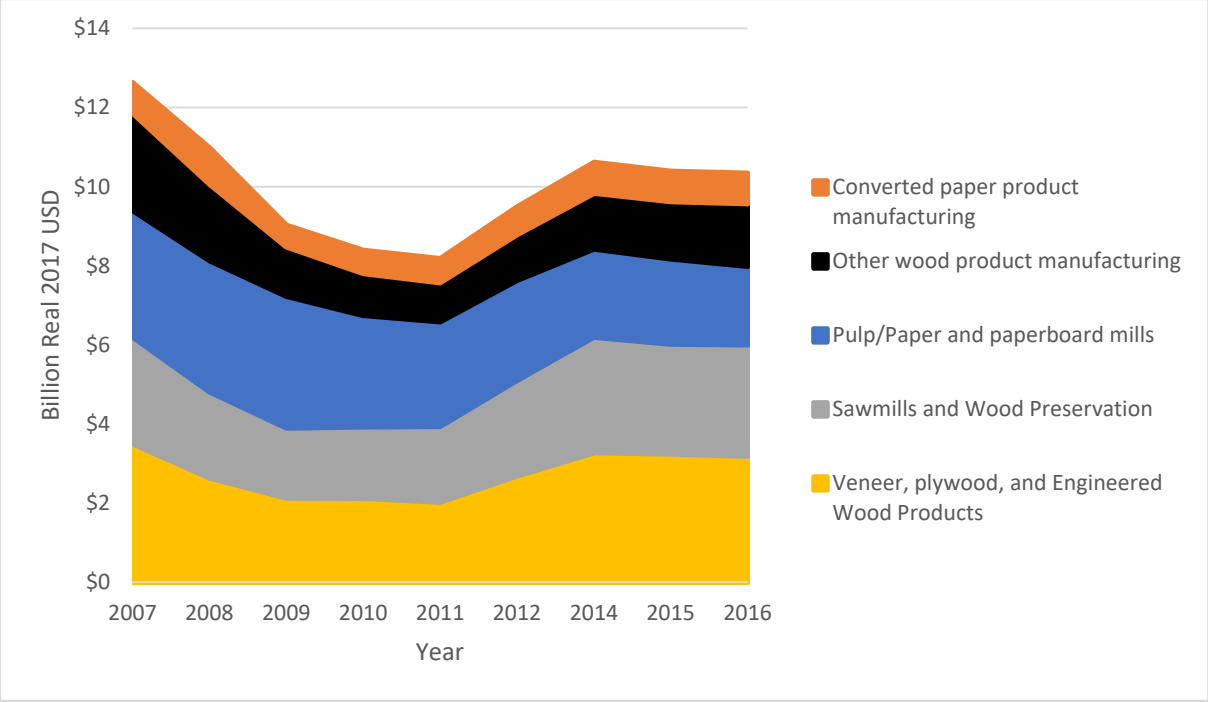
plywood and veneer facilities, chipping facilities, and other sectors substantially increased (Figures 14a and 14b).

Oregon sawmills and wood preservation sectors generated $1.0 billion of value added in 2017 (see Figure 15a). That is slightly higher than the value added in 2007 (values are expressed in real dollars). Also, total receipts were higher than in 2007, while total cost of materials was slightly lower than in 2007 (in real terms). Total capital expenditures have consistently increased since 2012, reaching almost $120 million in 2016 (Figure 15b). That is considerably higher than the level in 2010 when capital expenditures bottomed at $20 million (in real terms).

Production of veneer, plywood, and engineered wood products (including truss manufacturing and reconstituted wood products) generated approximately $1.05 billion of value added in 2016 (Figure 16a). Total receipts and total cost of materials were slightly lower in 2016 than in 2007 (in real terms). Total capital expenditures were nearly $120 million in 2016, which is slightly higher than in 2007 and considerably higher than the 2011 lows of $30 million (Figure 16b).

Annual value added in Oregon's pulp, paper, and paperboard sectors has remained relatively stable around $1.53 billion, on average in real terms, since 2005 (see Figure 17a). However, total receipts and total cost of materials have both remained at a lower level during the post-recession period. During the past years, capital expenditures have gradually increased after bottoming in 2009 at around $60 million (in real terms). A recent peak was reached in 2015 when capital expenditures were nearly $150 million (see Figure 17b).

Figure 13. Total receipts in wood products sectors (2007-2016).



Source: U.S. Census Bureau. Note: 2013 is omitted due to missing data values.

Figure 14a. Total receipts in wood manufacturing sector (2007-2016)

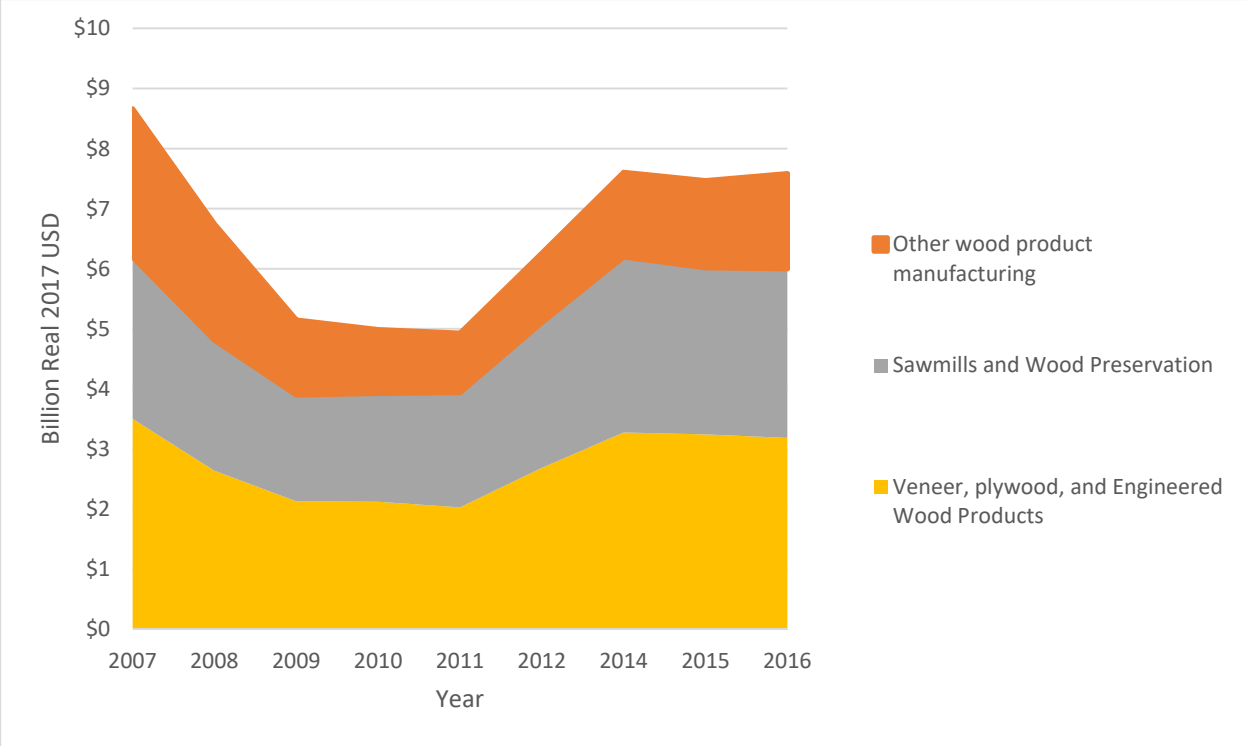
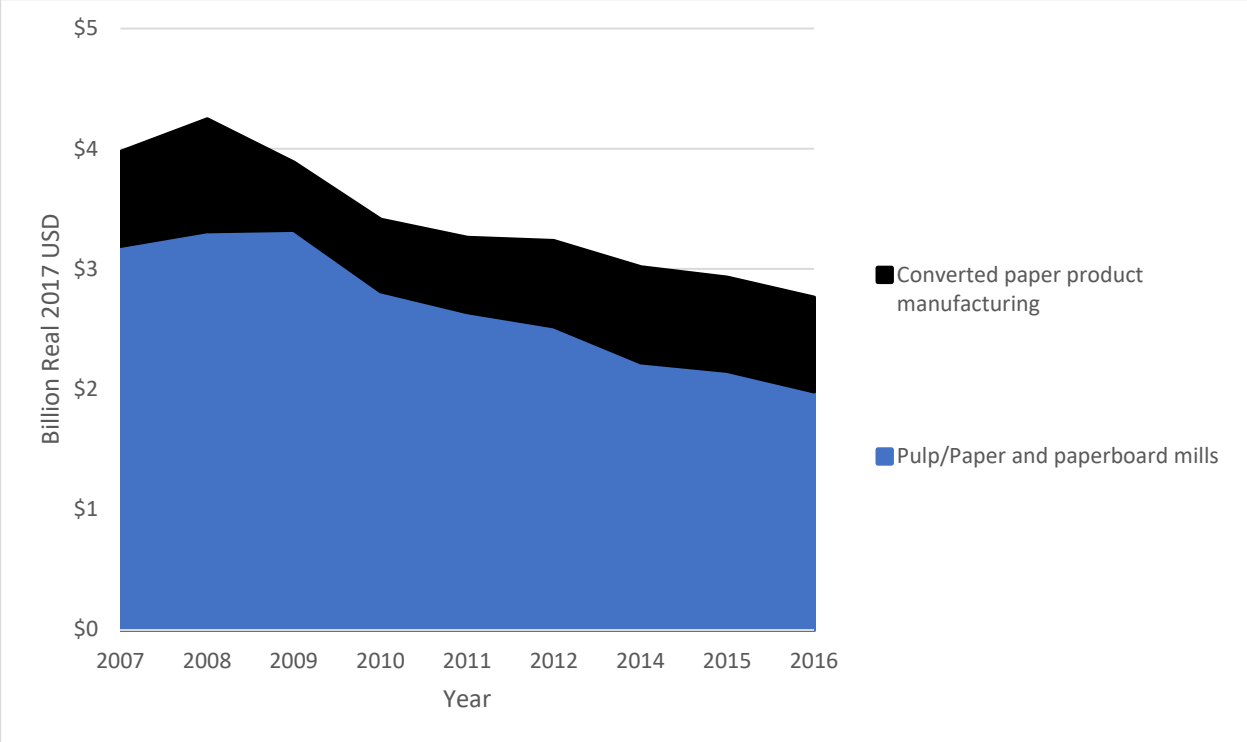


Figure 14b. Total receipts in pulp and paper sector (2007-2016)



Source: U.S. Census Bureau.

Figure 15a. Value added in Oregon's sawmills and wood preservation sectors (2007-2016)

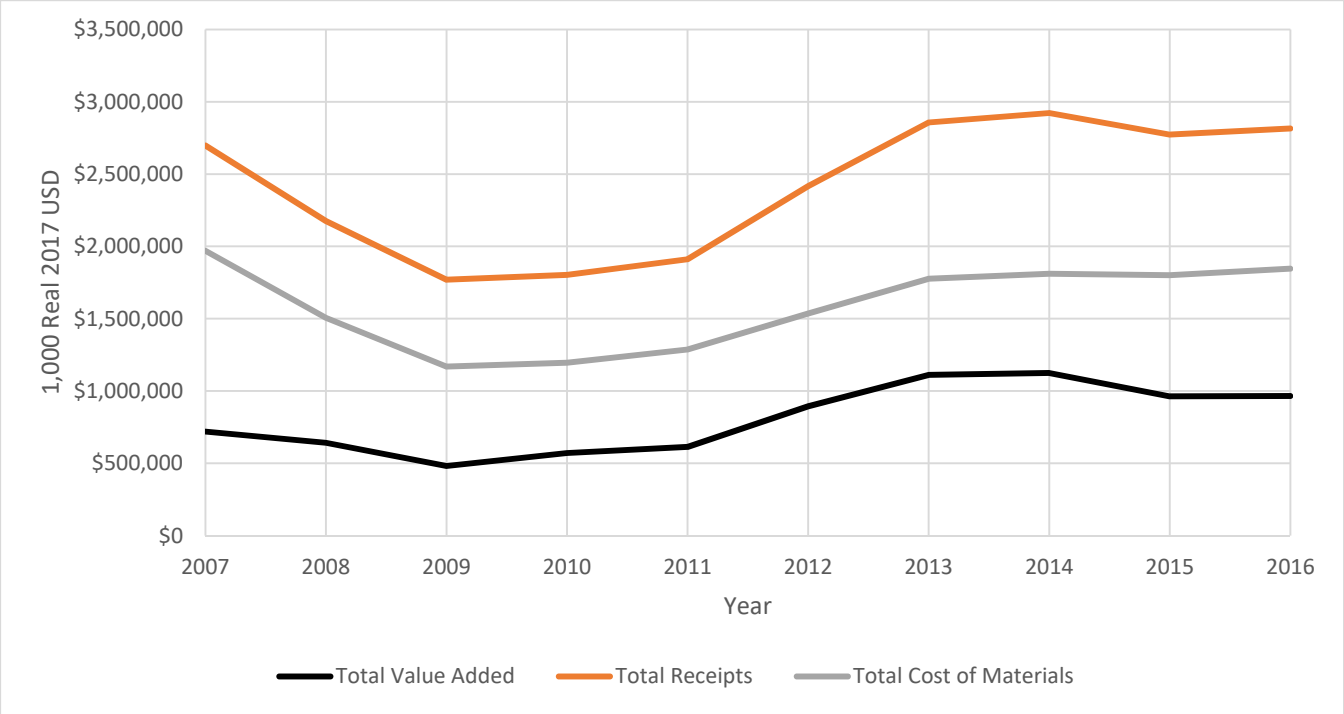
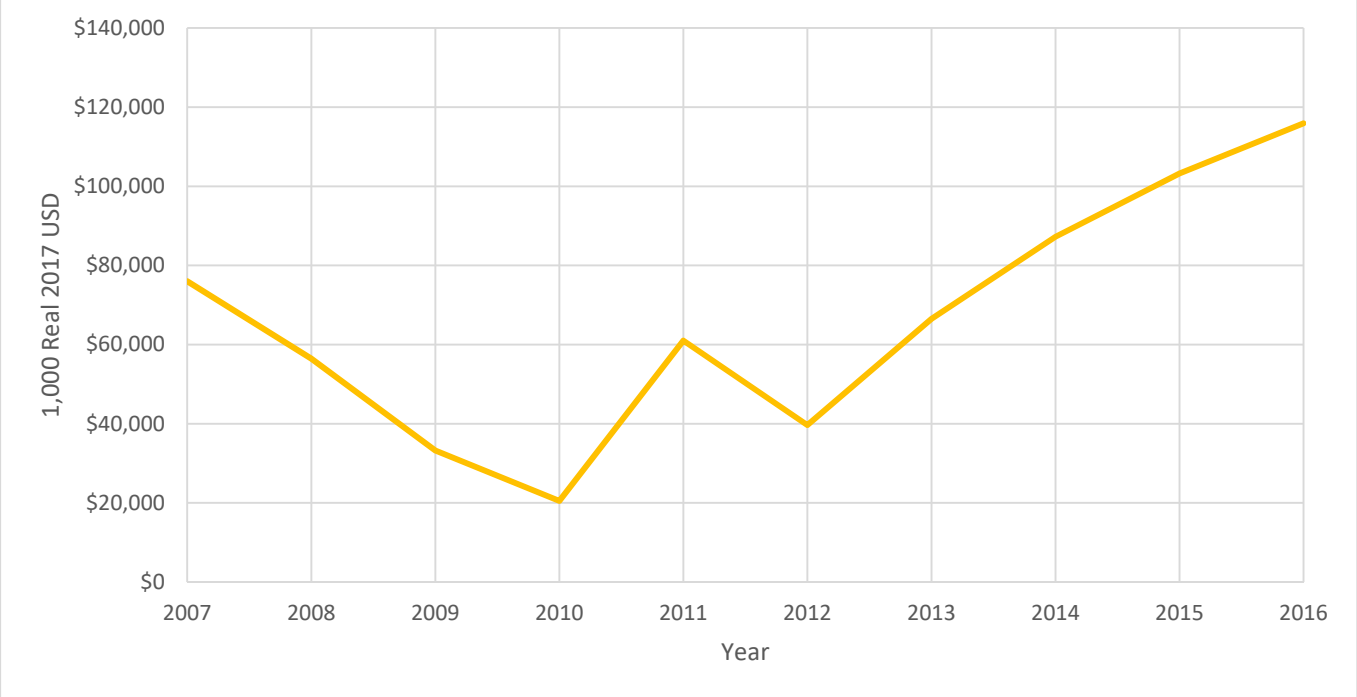


Figure 15b. Total capital expenditures in Oregon's sawmills and wood preservation sector (2007-2016)



Source: U.S. Census Bureau. Values deflated using U.S. Producer Price Index for Lumber and Wood Products (2017 base year, U.S. Bureau of Labor Statistics).

Figure 16a: Value added in Oregon's veneer, plywood, and engineered wood products manufacturing sectors (2007-2016)

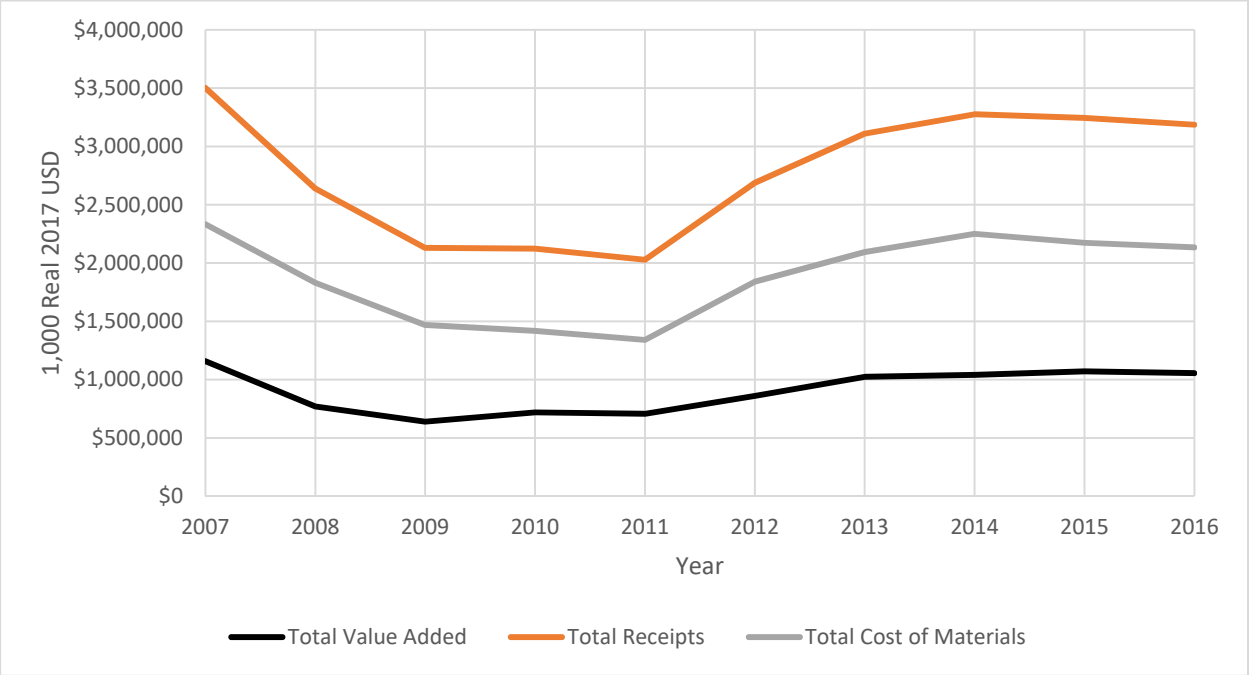
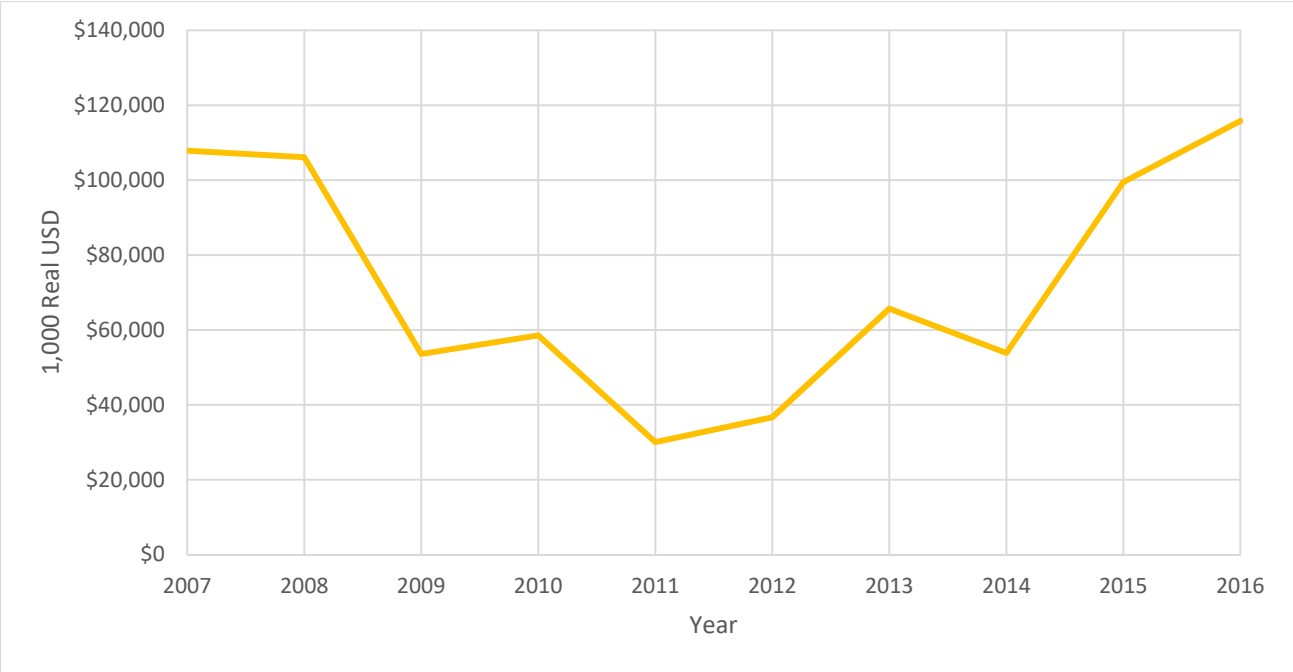


Figure 16b. Total capital expenditures in Oregon's veneer, plywood, and engineered wood products manufacturing sectors (2007-2016)



Source: U.S. Census Bureau. Values deflated using U.S. Producer Price Index for Lumber and Wood Products (2017 base year, U.S. Bureau of Labor Statistics).

Figure 17a. Value added in Oregon's pulp, paper, and paperboard sectors (2005-2016)

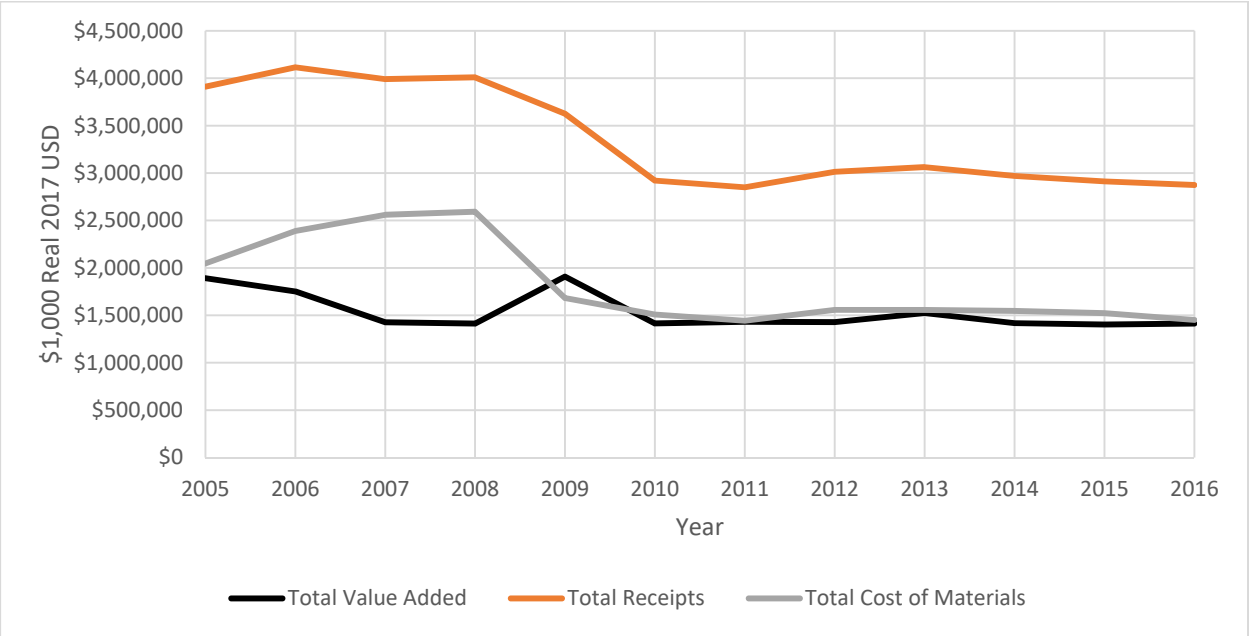
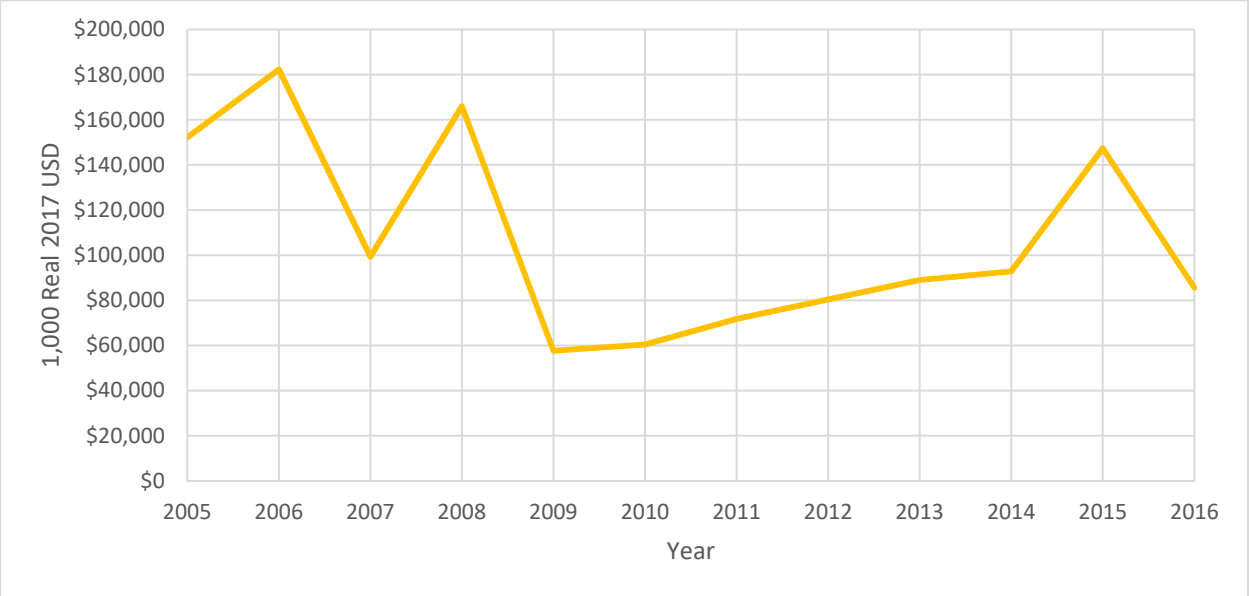


Figure 17b. Total capital expenditures in Oregon's pulp, paper, and paperboard sectors (2005-2016)



Source: U.S. Census Bureau. Values deflated using U.S. Producer Price Index for Pulp, Paper, and Allied Products: Wood Pulp (2017 base year, U.S. Bureau of Labor Statistics).

Export Markets

Log export markets are a significant source of revenue for Oregon's timberland owners. During times of low domestic demand for wood products, favorable prices in log export markets offer an opportunity for landowners to realize higher revenues. All of Oregon's export volume originates from harvests on private land, as material harvested from public lands is banned from sale in log export markets (Daniels 2005).

Historically, international demand for Oregon logs has been driven by the Pacific Rim nations of China, Japan, and Korea. These nations are projected to remain the primary international buyers of Oregon softwood logs (Tokarczyk and Lettman 2017). In the peak year 2013, 662 MMBF of logs originating from Oregon were exported to Pacific Rim countries (Simmons et al. 2016). This volume represents about 15.6% of Oregon's timber harvest, 33% of total U.S. log exports to Pacific Rim countries, and about 3.9% of total Pacific Rim log imports. Due to reinvigorated domestic demand, attractiveness of export markets has decreased, and consequently, approximately 9% of Oregon's timber harvest was exported in 2017 (Figure 18a). This represents over 333 MMBF of volume exported from Oregon (Figure 18b). However, due to considerable uncertainties associated with log export data, these figures should be interpreted with caution. A PNW conversion factor was used to report export orders of given lengths as volume estimates in board feet (Figures 18a and 18b); however, this is known to systematically overestimate export volumes.[7]

Oregon logs are typically exported from Coos Bay, Astoria, or Longview, WA. Table 7 shows the percentage of Oregon exported logs that leave through each of these ports (a PNW conversion factor was used to convert export data to board foot volume estimates). The share of log exports leaving through Astoria and Coos Bay has been increasing since 2010. Overall, annual log exports from Oregon ports and Longview in 2017 are down 17.3% from a recent peak in 2014 (see Figure 19). Note that numbers in Figure 19 will over-represent Oregon's contribution to export volumes since Longview and Astoria also ship logs sourced from Washington.[8] Nearly

[7] PNW conversion factor: 4.55 $m^3 \approx 1$ MMBF.

[8] In 2017, about 53% of the volume exported from Longview and 85-88% of the volume exported from Astoria is attributable to Oregon harvests (estimates are based on personal communication with G. Lettman, ODF).

all the volume exported from Coos Bay is attributable to Oregon harvests. In 2016, the total export value of logs exported from Oregon and Longview averaged $42.5 million/month. In the same year, the monthly value of lumber and plywood exported from Oregon and Longview averaged $10.3 million/month and $5.5 million/month respectively (see Figure 20). The total value of Oregon exports of wood products (excluding roundwood) in 2016 was over $237.2 million.

Table 7. Distribution of Oregon's log export volume by primary export ports (in %)

	2010	2012	2014	2016	2017
Longview	96.8%	83.2%	83.9%	81.6%	82.4%
Astoria	0.5%	6.6%	8.2%	7.8%	9.1%
Coos Bay	2.7%	10.2%	7.9%	10.6%	8.5%

Data Courtesy of Gary Lettman (ODF) and Dorian Smith (Washington Dept. of Natural Resources).

Emerging Global Forest Products Markets

China has emerged as a large player in global wood products markets. We first saw its potential during the recession of 2008 where log demand from China provided a lifeline to Oregon's forest landowners. What was once seen as an anomaly has proved to be the new normal as this demand has continued through the US recovery (Haim 2019). A recent move by the Chinese government to create industrial zones in the inland saw the Chinese industry move from one of small inefficient mills capitalizing on cheap labor on the coast to large state-of-the-art wood products facilities in the inland industrial zones. Chinese demand for softwood logs and wood products is driven in part by residential and real estate construction. While Chinese housing investments are still considered attractive, the pace of growth in this sector is slowing alongside emerging information about the extent of unoccupied housing (Haim 2019). Volume wise, log shipments to China have been at a comparable level to Japanese shipments since 2015 (Figure 21a). Oregon's softwood lumber exports to countries other than Japan were at an elevated level during the years 2010-2014 (Figure 21b). More recently, lumber exports have been at a considerably lower level.

Figure 18a. Percent of Oregon's timber harvest exported (2004-2017)

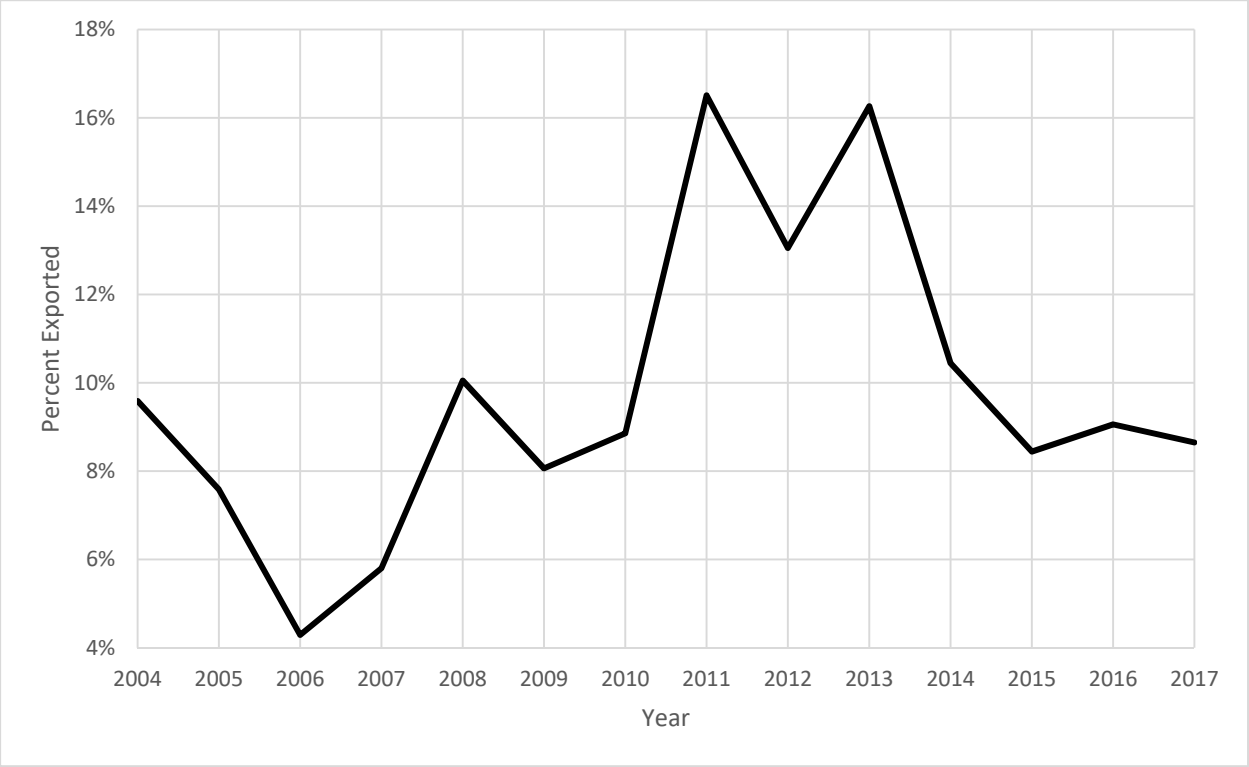
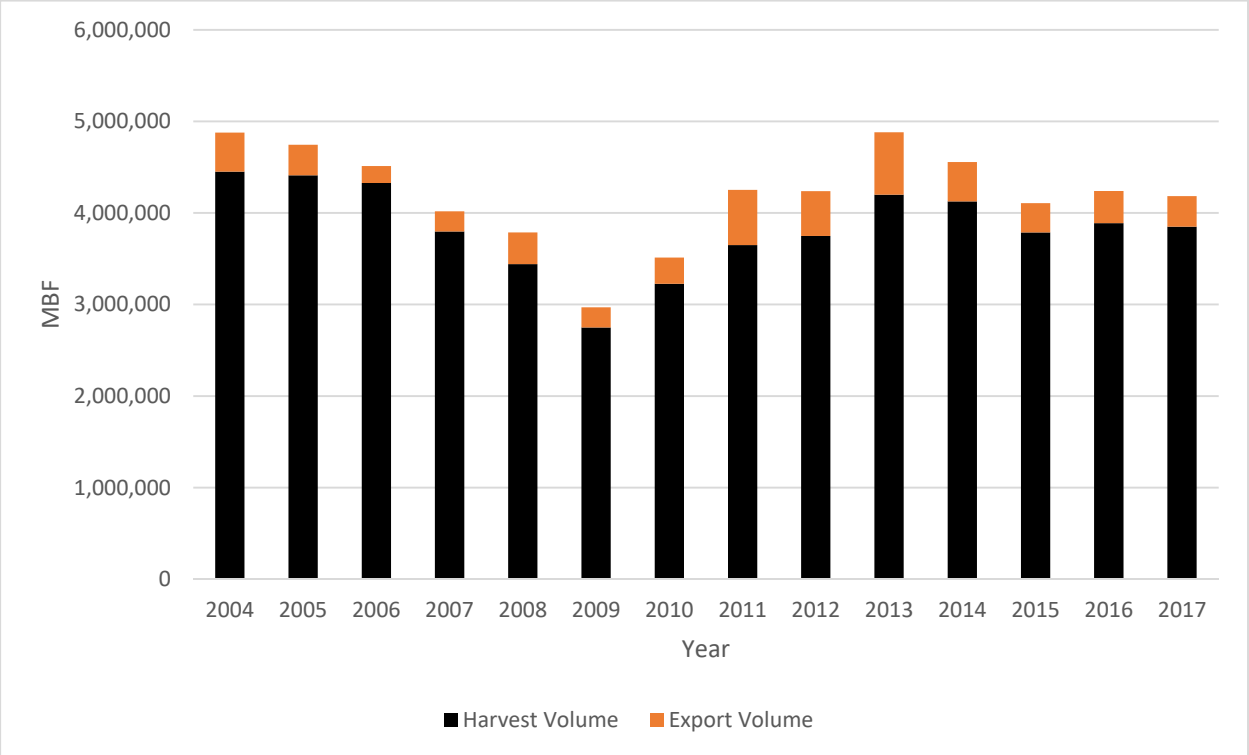
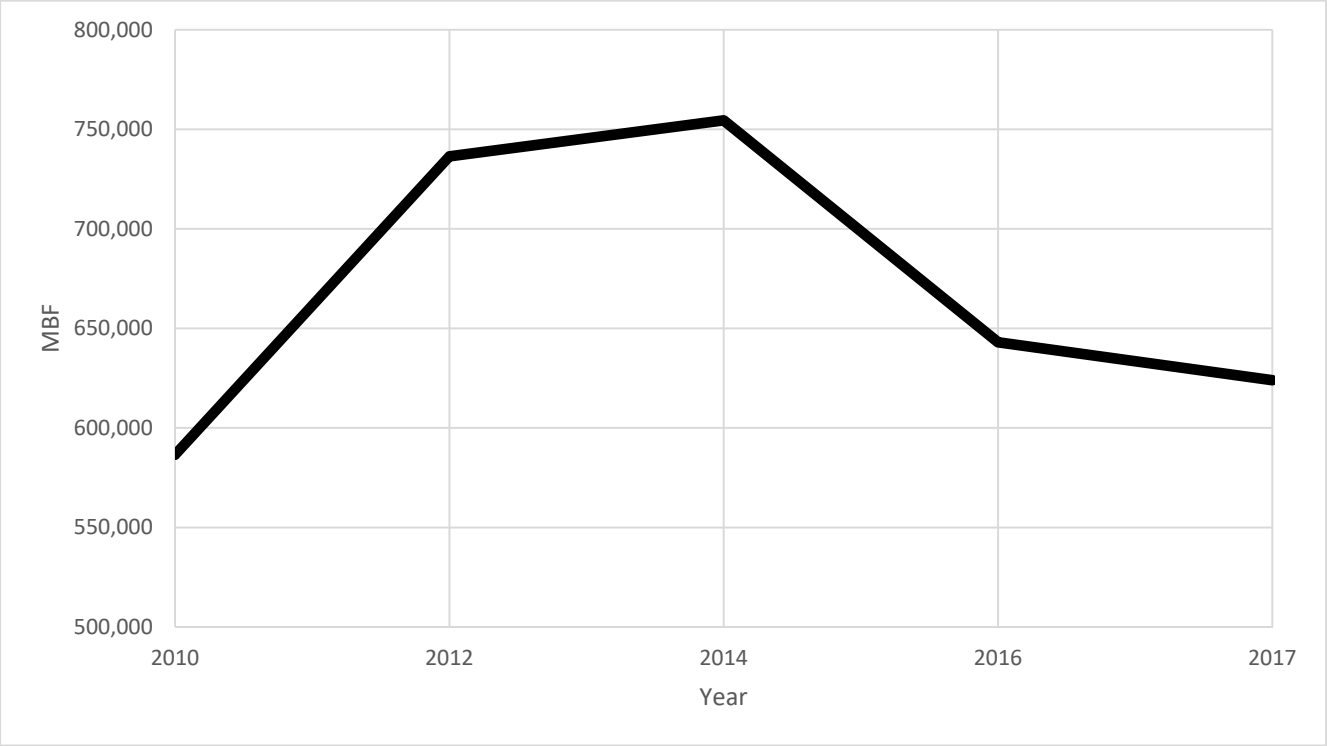


Figure 18b. Comparison of Oregon timber harvest exported to total harvest (2004-2017)



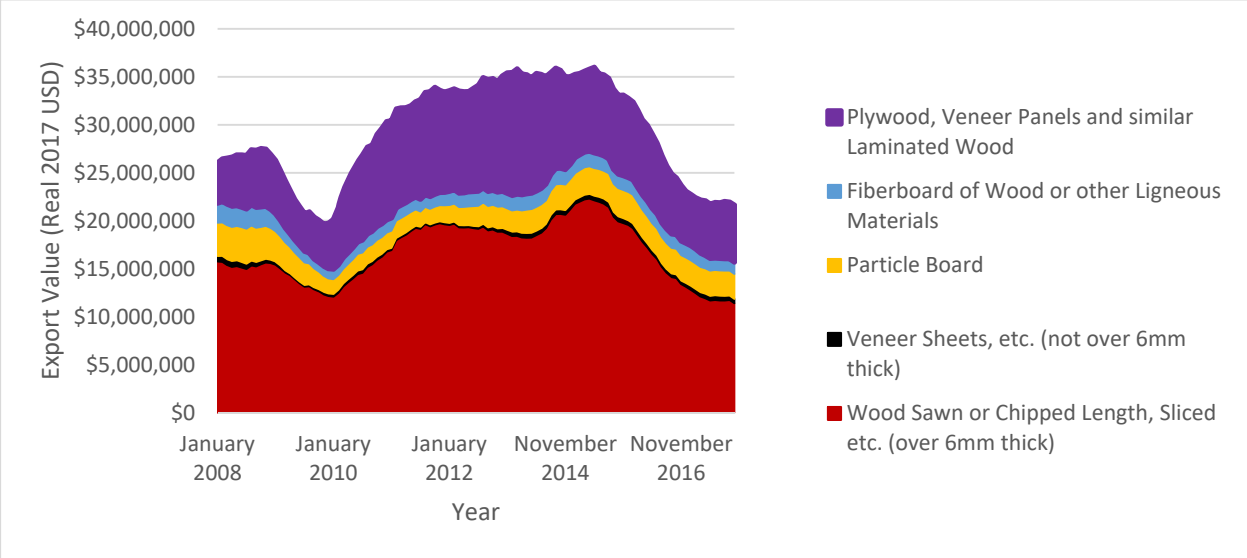
Data courtesy of G. Lettman (ODF) and Dorian Smith (Washington Dept. of Natural Resources).

Figure 19. Log exports from Oregon ports and Longview (2010-2017)



Source: International Trade Commission; data courtesy of Gary Lettman (ODF) and Dorian Smith (Washington Dept. of Natural Resources).

Figure 20. Oregon Lumber and Plywood Export Value (12-month moving average, January 2012-December 2016)



Source: U.S. Census Bureau.

Figure 21a. Annual Oregon Exports of Softwood Logs (2009-2017)

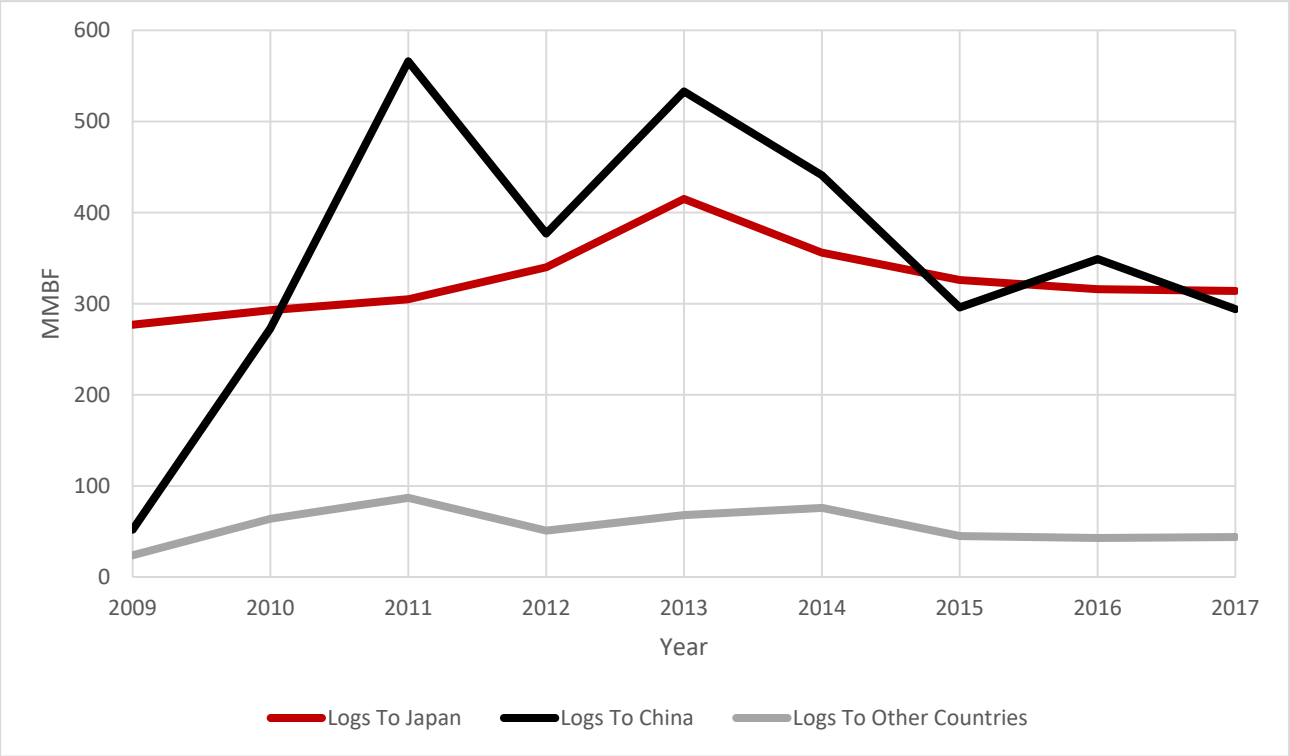
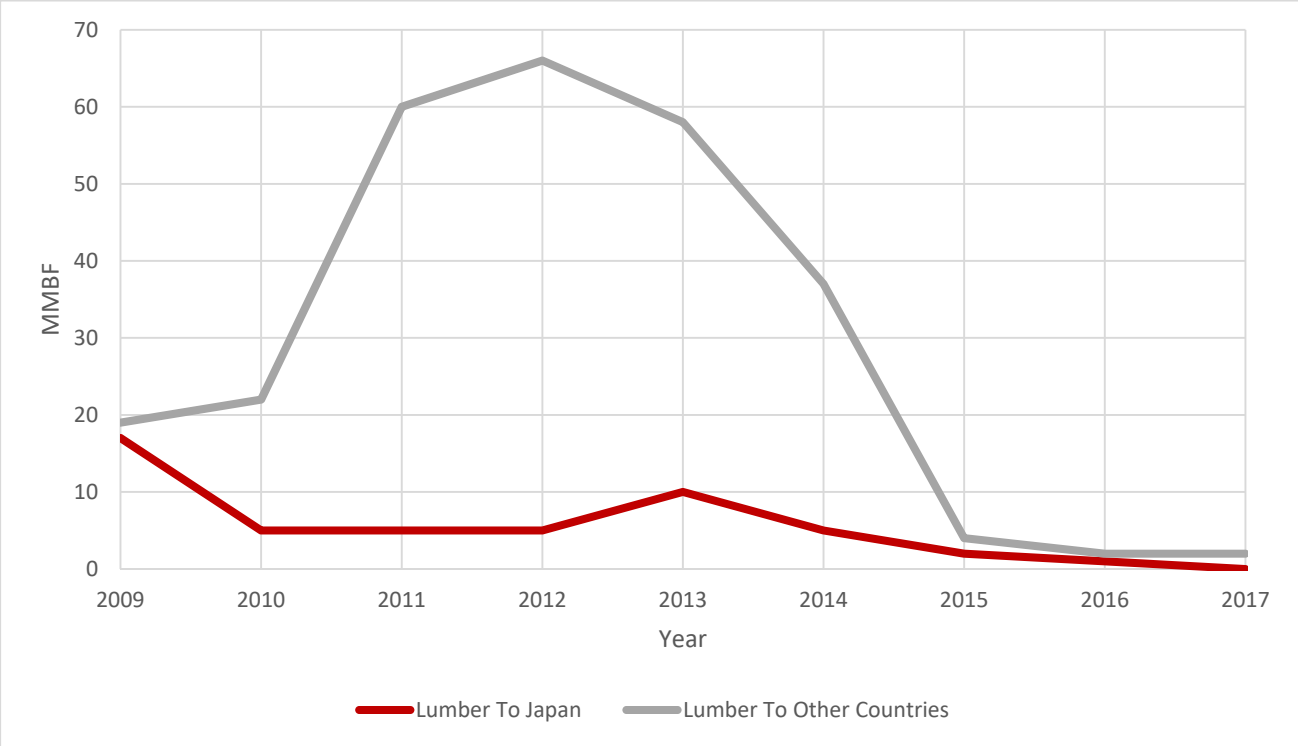


Figure 21b. Annual Oregon Exports of Softwood Lumber (2009-2017)



Source: WWPA (2017).

4. Economic Contributions of Oregon's Forest Sector

What are Economic Contributions?

An evaluation of the economic contribution of Oregon's forestry and wood products estimates the cumulative effects of spending within the sector and account for how it cycles through the state's economy. To account for this cycling, it is necessary to go beyond the "gross" measures of economic activity typically reported by government agencies (e.g. BEA, BLS, and OED) and account for the economic activity generated within other sectors. This chapter presents an in-depth economic contribution analysis of Oregon's forest sector for the year 2016. We follow that with a look at the "gross" statistics across a range of years to give an indication of how the sector's employment and wages have been changing over time.

Economic Contributions in 2016

The most common method used to determine economic contributions is an input-output (I-O) model. A common issue with traditional I-O modeling is a double-counting, or inflation of outputs. To avoid this issue, we use a Social Accounting Matrix (SAM) approach which takes IMPLAN I-O data and adjusts it using OED employment data. A SAM is a statistical framework that utilizes double-entry bookkeeping to trace all monetary flows within a regional economy over a given period. It provides a method to organize the flow-of-value statistical data for a national, state, or regional economy. The approach takes the "gross" observable employment and output and yields the "base" values which include the economic activity generated in other sectors as a result. A full description of the methodology and county-level results can be found in the Appendix.

The base economic contribution of forestry can also be broken down into direct and indirect/induced effects. The direct effects are the new dollars or jobs brought into the state of Oregon and the indirect/induced effects are the jobs created in other sectors from the linkages of forestry to the broader state economy. The indirect effects come from forestry operations creating additional economic activity through input purchases (i.e. supply chain) from other sectors of the Oregon economy. Induced effects are created when forestry sectors pay wages, salaries, and profits to Oregon households who then use that money to purchase goods and

services from other sectors. Table 8 provides a breakdown of the economic base contributions in terms of both direct and indirect/induced effects.

Table 8. The Total Economic Base Contributions of Forestry in Oregon Broken Out by Direct and Indirect/Induced Effects

Base Contribution	Direct	Indirect and Induced	Total
Output ($M)	$9,360	$8,733	$18,093
Employment	36,401	34,817	71,218
Value Added (GDP in $M)	$3,239	$4,835	$8,074

The economic base model results indicate that forestry was responsible for generating over $18 billion in output, over 71,000 jobs, and over $8 billion in state gross domestic product (as measured by value added). This translates to 4.7% of total state output, almost 3% of state employment, and 3.7% of state GDP. When applying an identical analysis to other sectors of the Oregon economy provides some context as to the relative size of the forestry sector in the state's economy (Table 9). For example, the forestry sector has a larger economic base contribution than chemical manufacturing (North American Industry Classification System (NAICS) 325), transportation equipment manufacturing (NAICS 336), and publishing industries (NAICS 511).

Table 9. Comparison of economic contributions of other notable sectors to the Oregon economy

Other NAICS Sectors	Base Output ($1M)	Base Employment	Base GDP ($1M)
111/112 Production Agriculture	$4,990	53,728	$2,630
311 Food Processing	$20,422	86,923	$6,687
315 Apparel Manufacturing	$314	2,456	$143
325 Chemical Manufacturing	$4,804	14,441	$1,727
333 Machinery Manufacturing	$7,347	30,569	$3,036
336 Transportation Equipment Manufacturing	$8,148	29,384	$2,811

511 Publishing Industries	$4,781	24,713	$3,073
541 Professional, Technical, and Scientific Services	$22,679	160,350	$13,946

Table 10 presents a breakdown of the gross OED employment data and the base economic contributions at the half-state level. The OED employment data is further broken down by forestry subsectors. As expected the largest component in terms of employment is western Oregon primary forest product production with forestry support as the next largest labor component. In eastern Oregon the importance of secondary forest products is evident as its employment exceeds that of primary forest products.

Table 10. Oregon gross and base economic accounts by subsector and subregion.

Subsector or Economic Account	West	East	Oregon
Gross Economic Data	*---------- jobs unless otherwise indicated ----------*		
Primary Forest Products	17,476	2,923	20,399
Forestry Support	11,709	1,479	13,188
Secondary Forest Products	7,986	4,317	12,303
Forestry Management	4,735	705	5,440
Other Forestry Sector Firms	571	29	600
Truck Transportation	3,811	1,060	4,871
All other	3,019	197	3,216
Total Gross Employment	49,310	10,710	60,020
Average Annual Wage ($/yr)	54,807	47,894	53,518
Base Economic Contributions[1]			
Base Output ($1M)	15,039	3,054	18,093
Base Jobs	58,192	13,026	71,218
State GDP ($1M)	6,757	1,006	8,074

1. Base economic contributions apportioned to east and west using county proportions from Table A21 applied to Table 1 state-level totals.

Employment and Wages over Time

While an in-depth evaluation of economic contributions is important, it is equally important to gain a perspective on how those values have been changing over time. To do this, we focus on the gross accounts of Oregon's wood products manufacturing sector. Total annual wages have steadily increased since 2010 (Figures 22a and 22b). As of 2016, these wages were about $1.1 billion. In pulp and paper sector, total real wages have witnessed a slight downward trend during the same time period (Figure 22c). As of 2016, these wages were about $320 million dollars. The number of employees and the number of hours worked have been increasing in Oregon's wood products manufacturing sector after bottoming in 2011. As of 2016, there were about 22,600 workers employed in the sector (Figure 23a). The number of employees and the number of hours worked in Oregon's pulp and paper sector have not experienced a similar increase. As of 2016, there were about 4,020 workers employed in the sector, which is approximately the same as in 2011 (Figure 23b).

Figure 22a. Total annual wages in Oregon's wood products sectors (2007-2016)

Source: U.S. Census Bureau. Prices deflated using U.S. Consumer Price Index (2017 base year).

Figure 22b. Total annual wages in Oregon's wood manufacturing sectors (2007-2016)

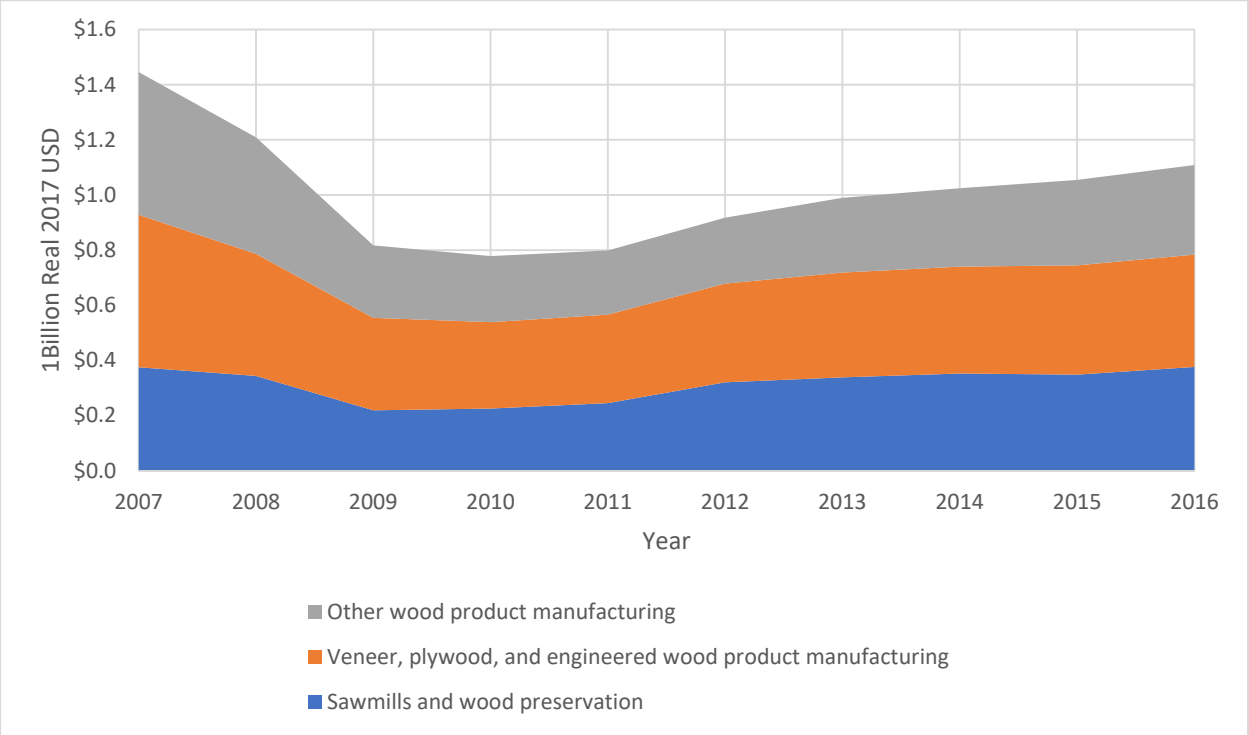
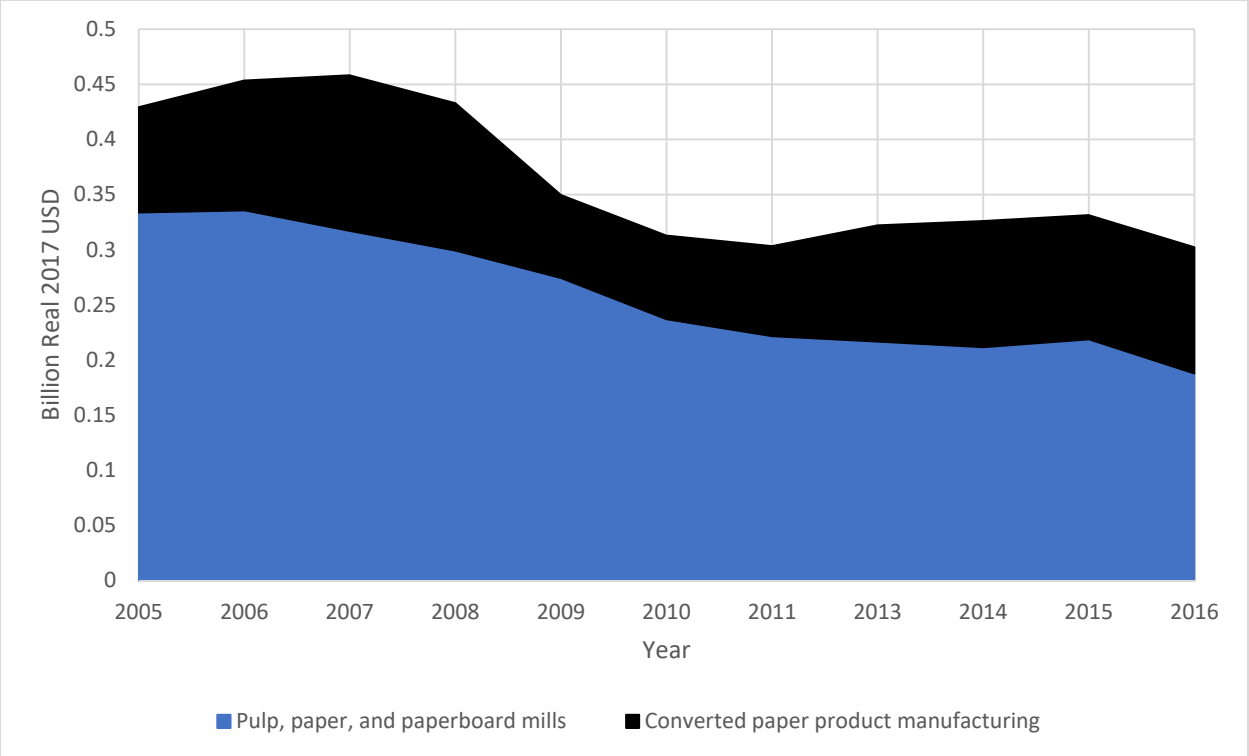


Figure 22c. Total annual wages in Oregon's pulp and paper sectors (2005-2016)



Source: U.S. Census Bureau. Prices deflated using U.S. Consumer Price Index (2017 base year).

Figure 23a. Employment trends in Oregon's wood products sectors (2007-2016)

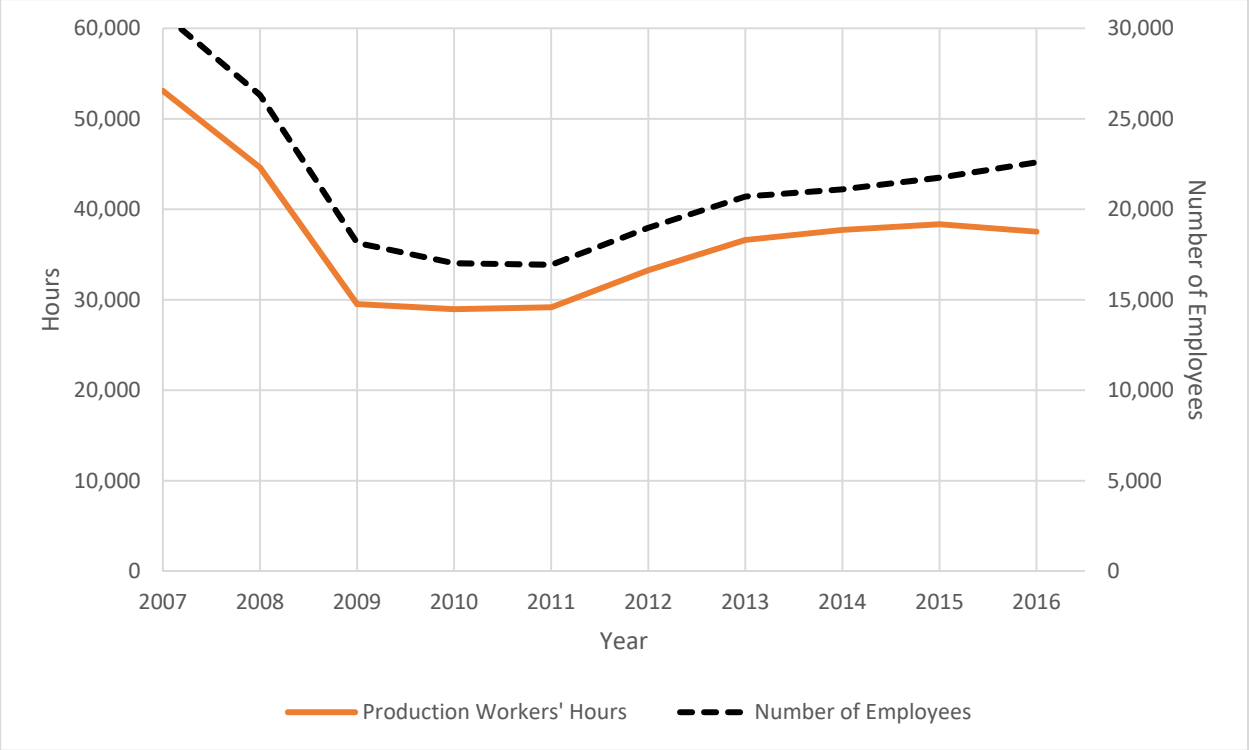
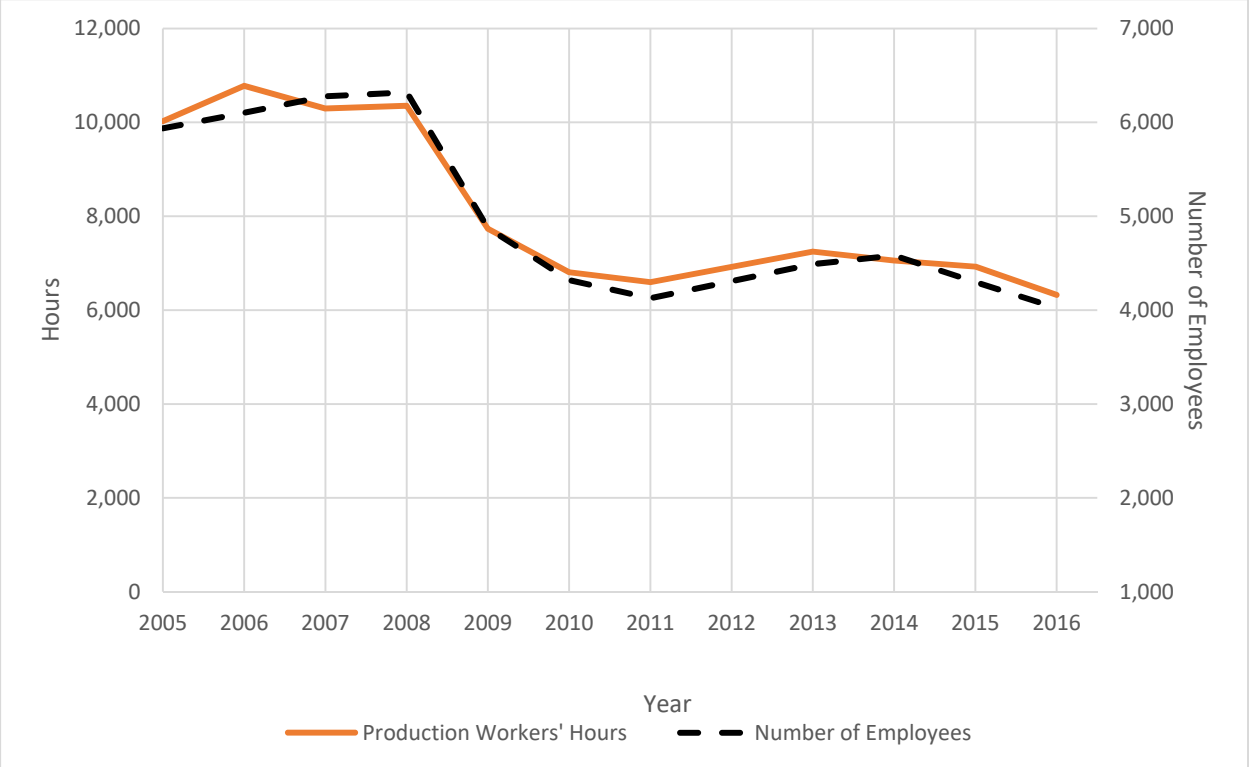


Figure 23b. Employment trend in Oregon's pulp, paper, and board sectors (2005-2016)



Source: U.S. Census Bureau.

5. Forest Health and Risks

Oregon's forests are subject to various biotic and abiotic disturbances — with many of them being a natural part of the ecological succession processes in forests. Nevertheless, they may also cause severe economic losses and the loss of human lives, as tragically demonstrated by the recent fire seasons. This section of the report discusses the main natural risks to forests in Oregon and their policy and economic implications.

Fire in Oregon's Forests

Severity and size of wildfires have been increasing in western U.S. during the past three decades, alongside an expectation of further increases in federal and state resources allocated to suppression activities (USFS, 2015). Big fire years have also occurred more frequently in Oregon. Figures 24a and 24b show the time series of acres burned in eastern and western Oregon on lands protected by the Oregon Department of Forestry (ODF). The figures also show estimated suppression expenditures. Notice that the scales are different in the two figures.

The acres in Figures 24a and 24b do not, however, represent all the burned acres in Oregon since ODF does not protect USFS lands. Figure 24c shows the total acreage burned from all fires originating from Oregon. Hence the burned acres in Figure 24c includes fires on USFS lands, but they may slightly overestimate burned acres in Oregon, since some of these fires may have spread to adjacent states. Those out-of-state burned acres are still included in the data in Figure 24c.

Federal and state fire protection agencies cooperate to protect forests and people from wildfire damage. In 2018, the total cost to fight fires in Oregon was $504 million, with most of it incurred by the federal government (NWCC, ODF Fire Season Reports). The ODF is primarily responsible for managing unplanned wildfires on state, BLM, and private lands. These lands encompass approximately 16 million acres in total. The U.S. Forest Service, National Parks Service, BIA, and Fish and Wildlife Service are primarily responsible for fire protection on all other federal lands. Figure 25 shows the geographical distribution of fire regime condition classes in Oregon in relation to ODF's fire protection districts. These conditions classes represent varying degrees of deviation from a historical pattern of succession cycles, typical

rates of fire occurrence, and burn severity (FRCC III represents the largest deviation from a historical fire regime).

State and federal fire protection agencies respond differently to wildfire, partly due to differences in values at risk. This is reflected by a difference in suppression strategies across federal and state agencies. Monitoring, point protection, or containment strategies is more common within federal agencies, whereas state agencies like the ODF do not adopt such policies. Between 2005 and 2013, 13.8% of incident reports filed by federal fire protection units indicate the choice of a “wildland fire-use” strategy (these strategies include active fire monitoring, point or zone protection, and wildfire confinement). Most such reports were filed by the U.S. Forest Service, National Parks Service, and the U.S. Fish and Wildlife Service. While the BLM typically delegates fire protection responsibilities to ODF, 5.7% of reports filed under a fire-use strategy were filed by the BLM. All other reports filed in Oregon in this time indicate that incident managers adopted a full suppression strategy, including all such reports filed by the ODF (NWCG, 2018).

Every fire season, ODF hires about 700 seasonal workers to fight wildland fires (FCS Group 2013). The objective of local crews is to keep 97% of the wildfires at 10 acres burned or less. Landowners and timber companies collaborate with ODF to guarantee swift initial attack and suppression. The funding of suppression expenditures in Oregon is organized in three tiers: 1) base funding, 2) statewide severity funding, and 3) large fire funding (Cook and Becker 2017). The base funding tier pays for pre-suppression, preparedness, and initial attack by the fire protection districts. It is funded from two sources: 1) public and private landowner assessments (based on protected acreage), and 2) the state's General Fund.

The second tier utilizes funding from the Oregon Forest Land Protection Fund (OFLPF) and from the General Fund. The annual revenue into the OFLPF is approximately $11.2 million and it is largely coming from taxes levied on harvest volume (Cook and Becker 2017). The third tier additionally relies on wildfire insurance coverage. Oregon is the only state with such coverage and has purchased an insurance plan almost every year since 1973. In the wildland urban interface (WUI), landowners must comply with the minimum fire hazard reduction

requirements set by the ODF. A landowner found negligent can become liable for suppression costs, with maximum liability set at $100,000 (Cook and Becker 2017).

Figure 26a and 26b show the total area in need of restoration by ownership. Total acres in need of restoration in eastern parts of Oregon and Washington is 28,637,000 ac as measured by a fire return interval and succession class cycle that has deviated from its historical range of variation (DeMao et al., 2018). Most such acres occur on USFS land. Total acres in need of restoration in western parts of Oregon and Washington is 22,805,400 ac (DeMao et al., 2018).

Figure 24a. Acres Burned on Quarterly reported Fires over land with ODF fire protection jurisdiction (State, BLM, and private land in Eastern Oregon, 1980-2018)

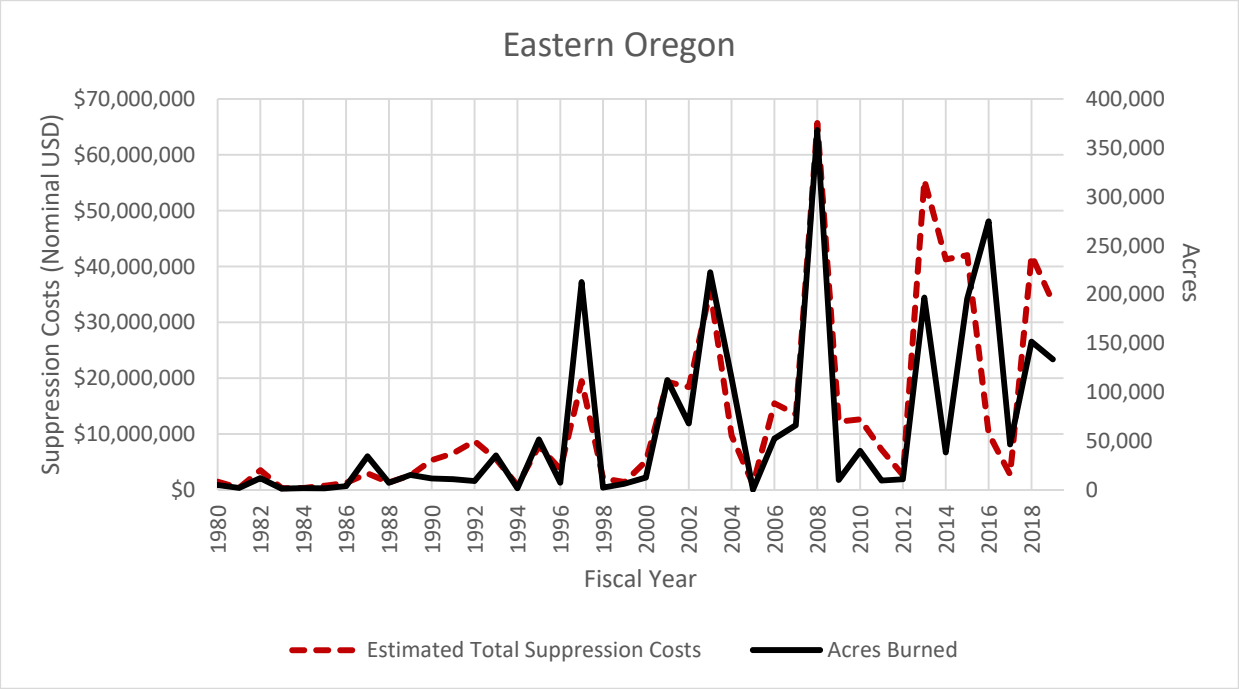
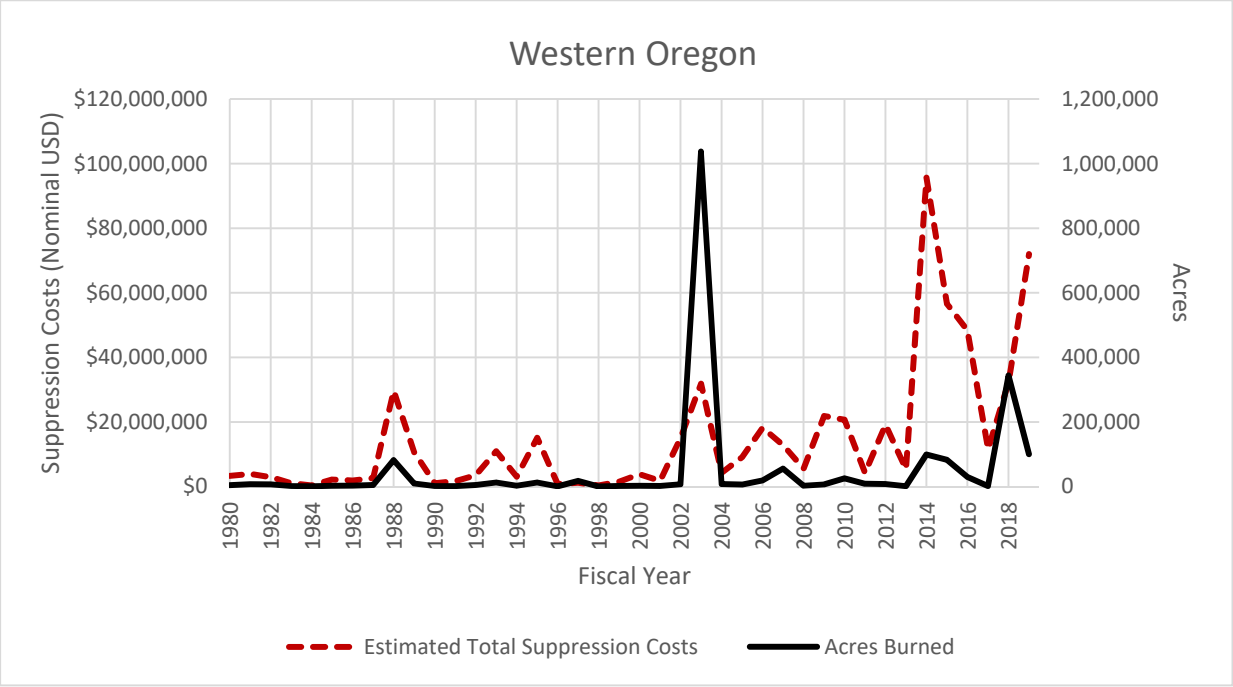
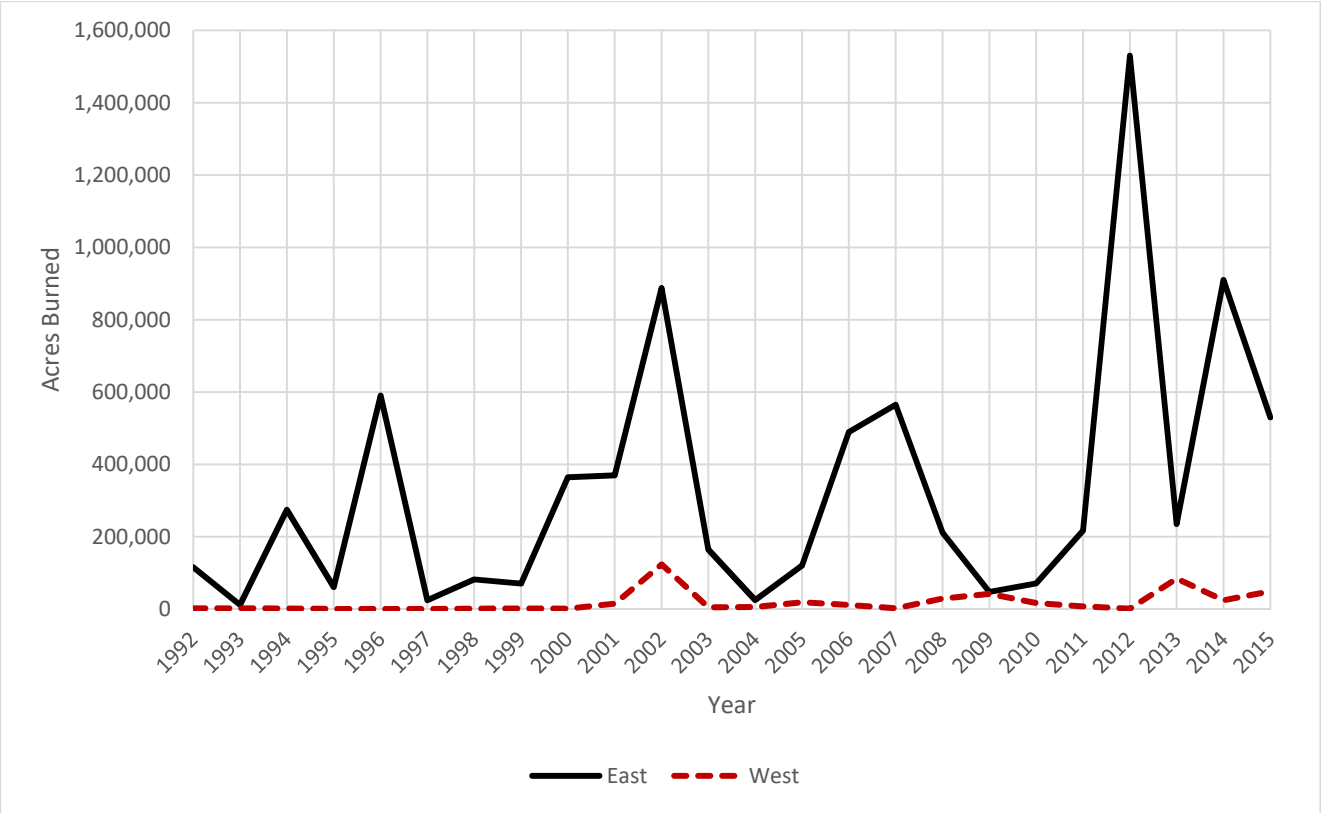


Figure 24b. Acres burned on quarterly reported fires and suppression costs over land with ODF fire protection jurisdiction (State, BLM, and private land in Western Oregon, 1980-2018)



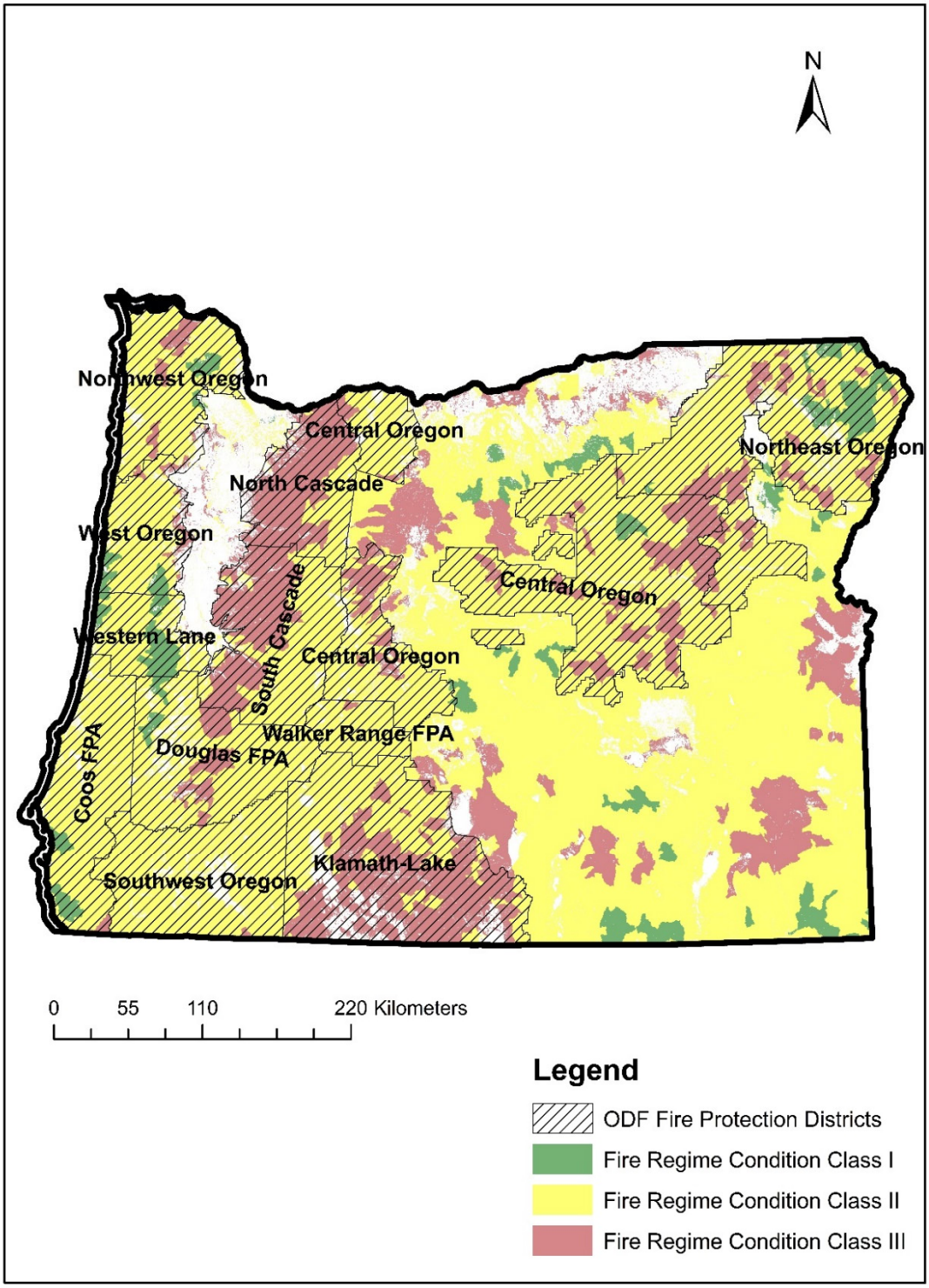
Source: ODF Fire Statistics Database.

Figure 24c. Acres burned on fires originating in eastern and western Oregon (1992-2015)



Source: Short et al. (2017).

Figure 25. Approximate forest land areas by Fire Regime Condition Class in Oregon and ODF Forest Protection Districts



Sources: Ecosphere, 2010; ODF.

Figure 26a. Acres in Need of Restoration by Ownership Class (Eastern Oregon and Washington)

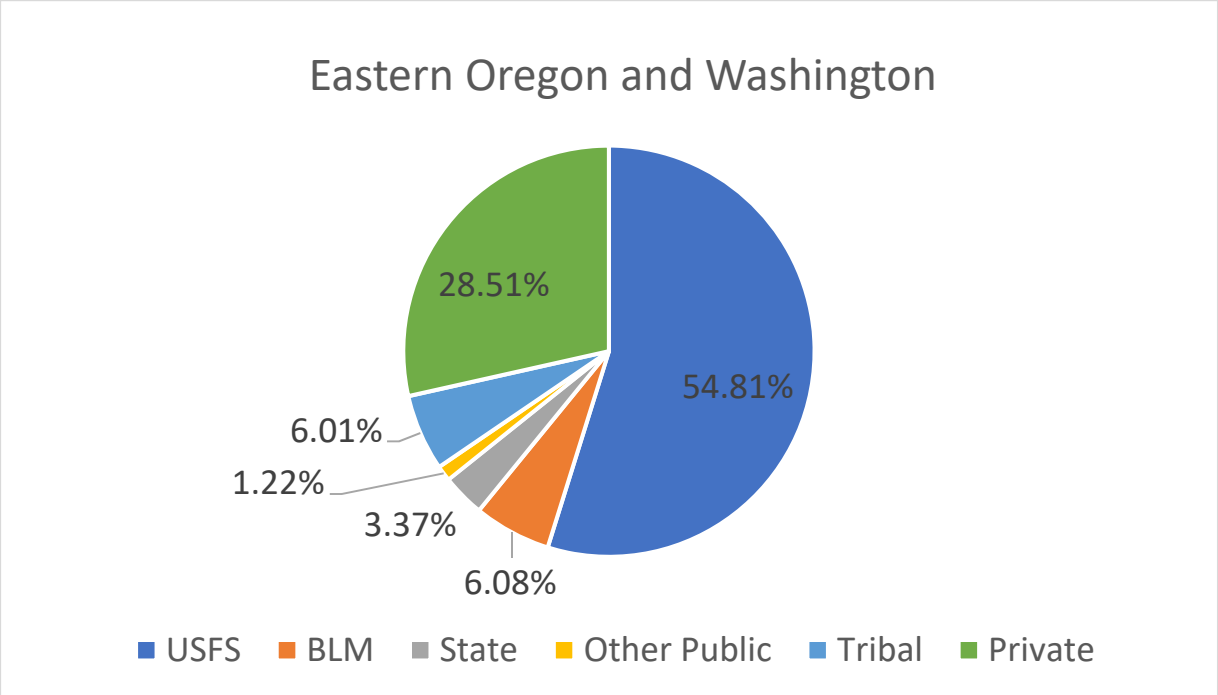
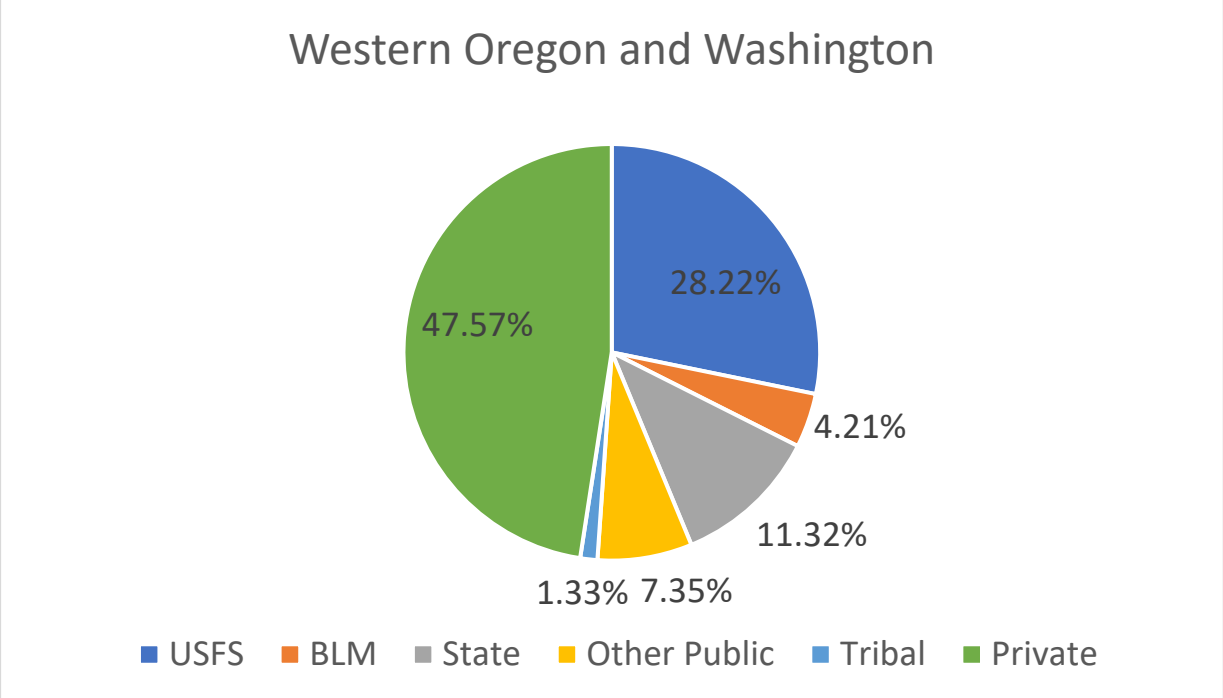


Figure 26b. Acres in Need of Restoration by Ownership Class (Western Oregon and Washington)



Source: DeMao et al., 2018.

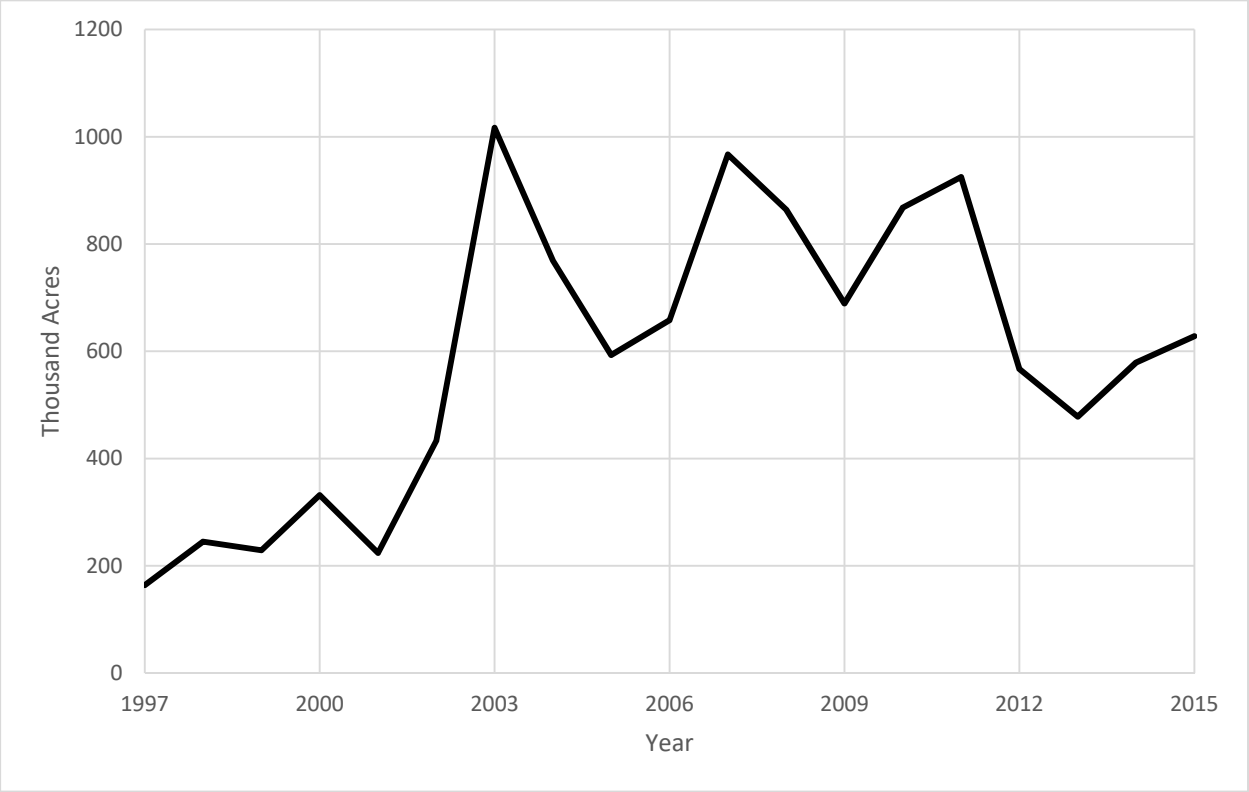
Oregon's Forest Health Issues

The risk of pests and tree diseases has also become more prevalent in the western U.S. In Oregon, one estimate puts the number of treed acres currently "at risk" of mortality at 6,723,000 acres (Krist et al., 2014). This represents 18% of treed acres. Figure 27 shows the acreage of pest damaged trees in Oregon for the past two decades. There has been a clear uptick since the end of 1990's in damaged acreage. Tables 11a and 11b show the spread of tree diseases and insects by county. For example, Swiss Needle Cast has been rapidly spreading in Oregon's Douglas-fir trees during the past two decades. Swiss Needle cast is a disease that effects tree foliage; caused by fungal pathogen Phaecryptopus gaeumannii. Figure 28 shows the upward trend in acres of Douglas-fir affected by Swiss Needle cast, although the last few years have witnessed a slight decrease in the number of infected acres (however, 2018 number is not final). In terms of dead standing trees, beetle kills are by far the most prevalent cause in Oregon (Table 12).

Sudden oak death is a pathogen infesting tanoaks. It continues to spread in southwest Oregon with potentially significant repercussions for forest industry reliant on the Coos Bay export market. While the disease does not directly affect commercial timber species like Douglas-fir, the potential for it to impact the timber industry may occur from restrictions on the Coos Bay timber export market through international sanctions that attempt to avoid its spread (MBG, 2019). Federal and state management expenditures exceed $1.5 million annually, but estimated economic impacts are currently limited and have no estimated effects on commercial timber harvests, export markets or log prices (MBG, 2019). Current economic impacts of the disease have primarily affected cultural values for tanoak species and some isolated cases of property value loss (MBG, 2019). Estimated impacts on property value indicate a loss of 3-6% of property value for residences near infested oak woodlands, but this discount increases to 8-15% in residential areas where dying oaks are also located within neighborhoods (Kovacs et al. 2011). Other economic impacts may eventually occur through more severe loss of amenity values, affecting both residential property markets and recreation industries. However, state and federal efforts to control the spread of the pathogen can potentially mitigate these impacts.

Other threats to forest health are invasive species and pathogens. Invasive weeds, such as Himalayan blackberry, Scotch broom and English ivy, can reduce the vigor of native plants and inhibit the growth of seedlings of native tree species.

Figure 27. Forest Acres Damaged by Pests (1997-2015)



Source: Krist et al. (2014) USFS.

Table 11a. Different Types of Alien Pests in Oregon

Species/Disease	Number of Counties Affected in Oregon
(Pre-2015) Eurasian Poplar Leaf. Rust	3
(Pre-2015) Sudden Oak Death	1
Balsam Woolly Adelgid	21
Banded Elm Bark Beetle	4
Birch Casebearer	2
Birch Leafminer	12
Black Vine Weevil	5
Cherry Bark Tortix	4
Elm Leaf Beetle	4
European Bark Beetle	8
European Elm Flea Weevil	2
Larch Casebearer	13
Larch Sawfly	7
Oystershell Scale	3
Peach Twig Borer	13
Pear Sawfly	13
Pear Thrips	24
Poplar-and-Willow Borer	6
Port-Orford-Cedar Root Disease	11
San Jose Scale	2
Satin Moth	3
Smaller European Elm Bark Beetle	22
Spruce Aphid	7
Spruce Bud Scale	5
Strawberry Root Weevil	20
White Pine Blister Rust	28
Willow Scab	1

Source: USFS Northern Research Station Alien Forest Pest Explorer

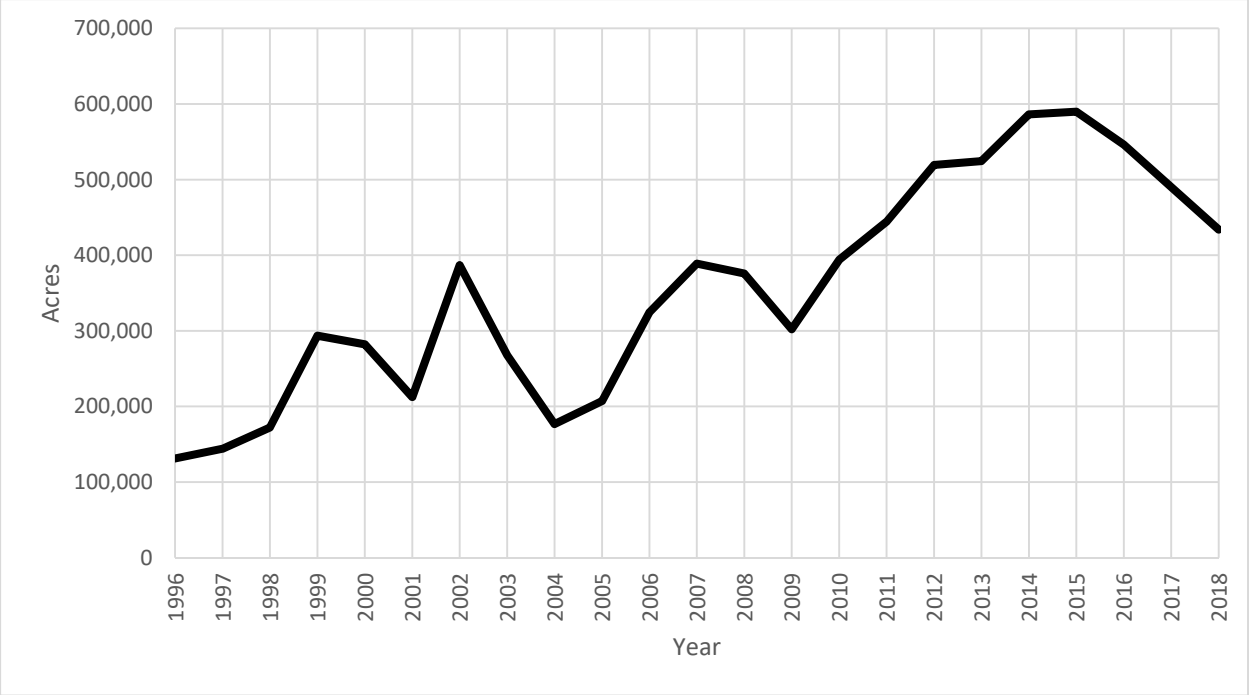
https://foresthealth.fs.usda.gov/portal/Flex/APE (Accessed: 2/7/2019).

Table 11b. Counties affected by various active, invasive pests

Bark Beetles	Crook, Deschutes, Gilliam, Grant, Harney, Hood River, Jackson, Jefferson, Josephine, Klamath, Lake, Linn, Malheur, Marion, Morrow, Multnomah, Sherman, Umatilla, Union, Wallowa, Wasco
Cankers	Benton
Defoliators	Baker. Benton, Clackamas, Crook, Deschutes, Douglas, Grant, Harney, Hood River, Jackson, Jefferson, Klamath, Lake, Lane, Linn, Malheur, Marion, Morrow, Multnomah, Polk, Umatilla, Union, Wallowa, Wasco, Washington, Wheeler, Yamhill
Foliage and Shoot Disease	Clatsop, Columbia, Multnomah
Other Chewing Insects and Allies	Benton, Clackamas, Columbia, Coos, Deschutes, Douglas, Gilliam, Grant, Hood River, Jackson, Josephine, Klamath, Lane, Linn, Marion, Multnomah, Polk, Sherman, Umatilla, Wasco, Washington, Yamhill
Root Diseases/Decay	Clatsop, Columbia, Coos, Curry, Douglas, Josephine, Lane, Lincoln, Multnomah, Tillamook, Yamhill
Rusts	Baker, Benton, Clackamas, Crook, Curry, Deschutes, Douglas, Grant, Hood River, Jackson, Jefferson, Josephine, Klamath, Lake, Lane, Lincoln, Linn, Marion, Multnomah, Polk, Tillamook, Umatilla, Union, Wallowa, Wasco, Washington, Yamhill
Sap Feeders	Baker, Benton, Clackamas, Clatsop, Columbia, Coos, Crook, Curry, Deschutes, Douglas, Grant, Hood River, Jackson, Jefferson, Klamath, Lane, Lincoln, Linn, Malheur, Marion, Morrow, Multnomah, Polk, Tillamook, Umatilla, Union, Wallowa, Wasco, Washington, Wheeler, Yamhill
Wood Borers	Benton, Clackamas, Clatsop, Columbia, Douglas, Jackson, Josephine, Lane, Linn, Marion, Morrow, Multnomah, Polk, Umatilla, Wasco, Washington, Yamhill

Source: USFS Northern Research Station Alien Forest Pest Explorer https://foresthealth.fs.usda.gov/portal/Flex/APE (Accessed: 2/7/2019).

Figure 28. Acres of Douglas-fir forests with Swiss Needle Cast symptoms (1996-2018)



Source: ODF/USFS http://sncc.forestry.oregonstate.edu/survey-maps.

Table 12. Percentage of dead trees attributable to various damaging agents (2017)

Damaging Agent	Percentage
Beetle:	96.31%
Fire:	0.03%
Other Insect:	0.48%
Other Damaging Agent:	3.18%

Source: USFS Region 6 Forest Insect and Disease Aerial Detection Survey, 2017.
"Other Damaging Agents" include wind throw, drought, bear, root disease, water damage, and other causes of tree mortality. Due to potential measurement error from aerial surveys, please interpret the above table with caution.

6. Present and Emerging Trends in Forest Products and Services

The long history of Oregon's forest products industry is a story of innovation and adaptation. Changes in demand for forest products and shifting public values have meant periods of painful adjustments, but also new opportunities, increasing efficiencies in production, and safer workplaces. This section looks at some recent opportunities to monetize the various benefits, or ecosystem services, our forests provide. From certification, which has been around for a while, to more recent opportunities in carbon sequestration. While the monetization of good forest management practices or carbon sequestration might be new concepts, the future also presents challenges and opportunities to more traditional forest products markets such as construction and trade. Exciting new uses of engineered mass timber products in tall buildings opens up an entirely new commercial construction market once unattainable.

Forest Certification on Private Lands

Private landowners in Oregon are subject to the standards set forth under the Oregon Forest Practices Act to ensure sustainability of harvests and protection of critical water resources and wildlife habitat.[9] In addition to these standards, many landowners choose to enroll in a forest certification program. The main certification programs in Oregon are Sustainable Forestry Initiative, American Tree Farm System, and Forest Stewardship Council (Figure 29). These programs certify wood harvested from lands that meet various environmental quality standards. As of October 2018, there were 4,960,099 acres of certified forest land in Oregon. This represents approximately 46% of private forest lands in the state and it represents 19.8% of all Oregon forest land. Of the certified forest land in the United States, 18% is located in the Pacific Coast region. From 2011-2016, 1.92 million additional acres of forest land were enrolled in a certification program, mainly under Sustainable Forestry Initiative. The standards set in Oregon's Forest Practices Act already meet many of the requirements of certification by the Sustainable Forestry Initiative (Alvarez).

[9] https://www.oregon.gov/ODF/Working/Pages/FPA.aspx.

Forest Carbon Offset Markets

Payments for carbon offsets can provide a new income source for some qualified forest owners. Potential buyers of carbon offsets include entities regulated under California's Cap and Trade System, and companies that are required or volunteer to offset part of their emissions. For example, recent auction prices in California were about $16/ton (CARB, 2019). Sellers of carbon offsets typically need to commit to a multi-decade management plan that verifiably increases the amount of carbon stored in forest land relative to a pre-determined "business-as-usual" baseline level. One example of current forest carbon projects in Oregon is Green Diamond's carbon offset project covering 600,000 acres in Klamath, Lake and Jackson counties. Another recent project is the City of Astoria's offset program comprising about 3,500 acres of old growth forests.

Emerging Markets for Mass Timber

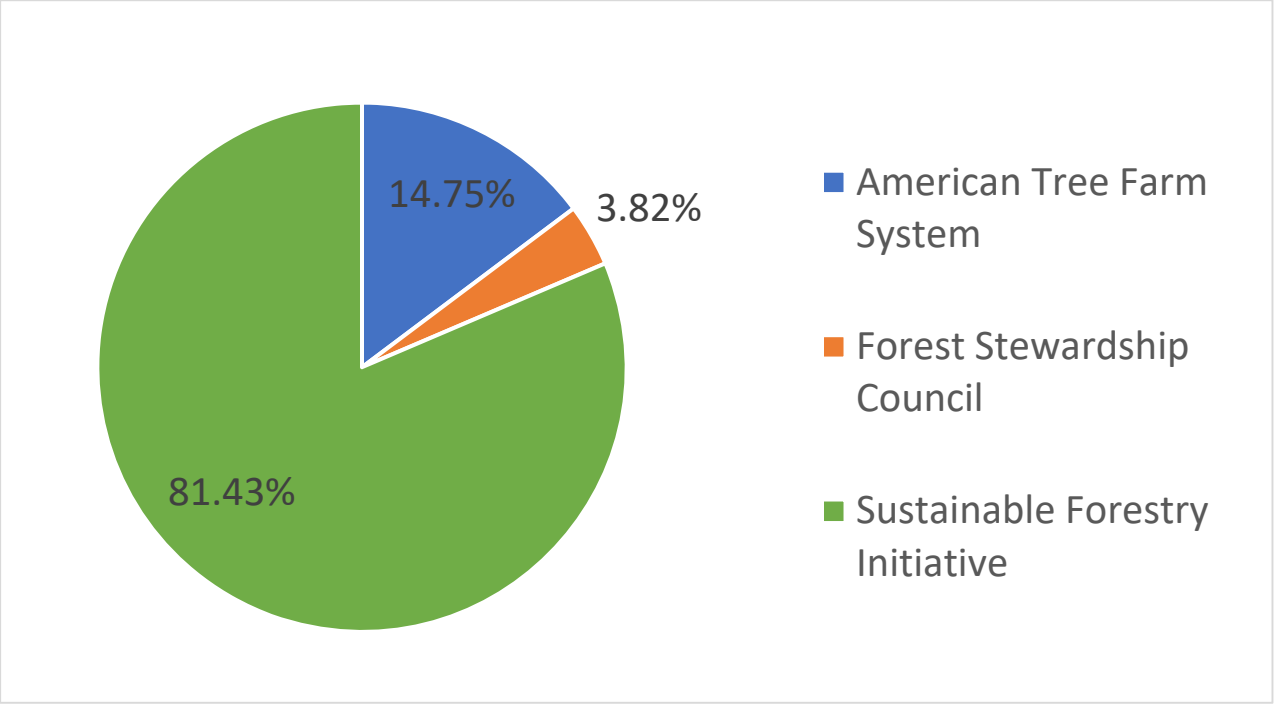
One of the most significant recent developments in the forest products sector is the use of Cross Laminated Timber (CLT) in multi-family and commercial construction. Wood as a construction material stores carbon and requires less energy than steel and concrete to manufacture comparable structures. CLT has been estimated to generate cost-savings of up to 10-20% relative to more conventional tall building materials (depending on ground conditions at the construction site and the types of cranes used for moving material; Waugh Thistleton Architects, 2018). CLT based construction should also be faster than construction with more traditional building materials.

In 2018, Oregon became the first state to revise its building codes to allow tall wood building construction using mass timber and CLT (DCBS, 2018; Hilburg, 2018). This represents an important regulatory change to facilitate greater use of CLT technologies in the design and construction of tall commercial and residential buildings. Consequently, increased demand for wood as construction material will translate to more economic activity and jobs in rural communities near to forest resources. D.R. Johnson Mill in Riddle, Oregon became the first certified Oregon mill to produce CLT for high-rise construction (Shoutis 2016). Both federal and state agencies continue to provide grants to further encourage the development of innovative uses of mass timber building.

Domestic Lumber Demand Factors

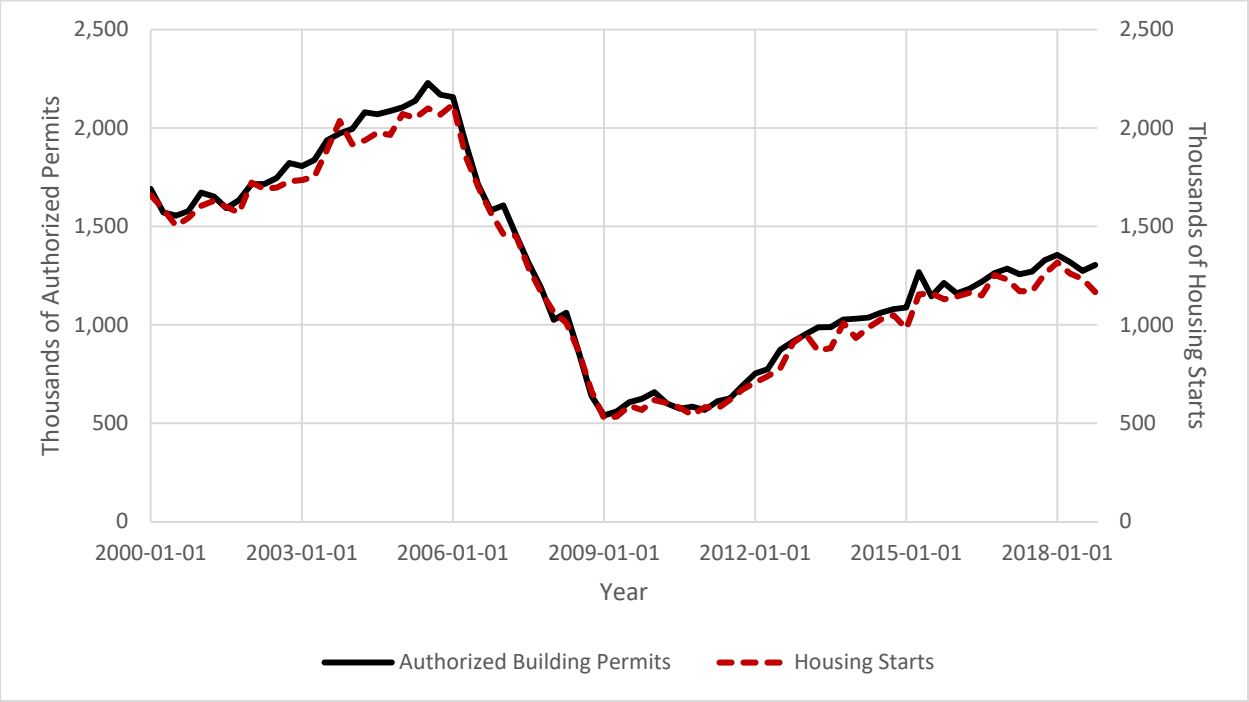
Approximately one third of all U.S. lumber produced is used to build new residential housing units (Prestemon et al. 2018). Figure 30a shows new authorized housing permits and actual housing starts from 2000-2018. The data show that housing construction activity is around its highest point since the U.S. housing crisis and economic recession in 2008, but still below its pre-recession peak. Spending on commercial construction has also experienced a significant growth during the same time period (Figure 30b). Based on a study by Prestemon et al. (2018), the demand for softwood lumber is expected to increase if GDP growth remains above 2% per year, but it is expected to fall if GDP growth falls below 2% per year. These estimates are sensitive to changes in the mortgage delinquency rate. Figure 31 show the recent decline in the mortgage delinquency rate since the 2008 housing crisis. The downward trend in delinquencies means lower risks in mortgage markets for lenders. While new construction remains an important source of demand for lumber, housing repair and remodeling is expected to be a greater source of lumber demand going forward (Haim, 2019).

Figure 29. Percentage of certified lands enrolled in major forest certification programs (2018)



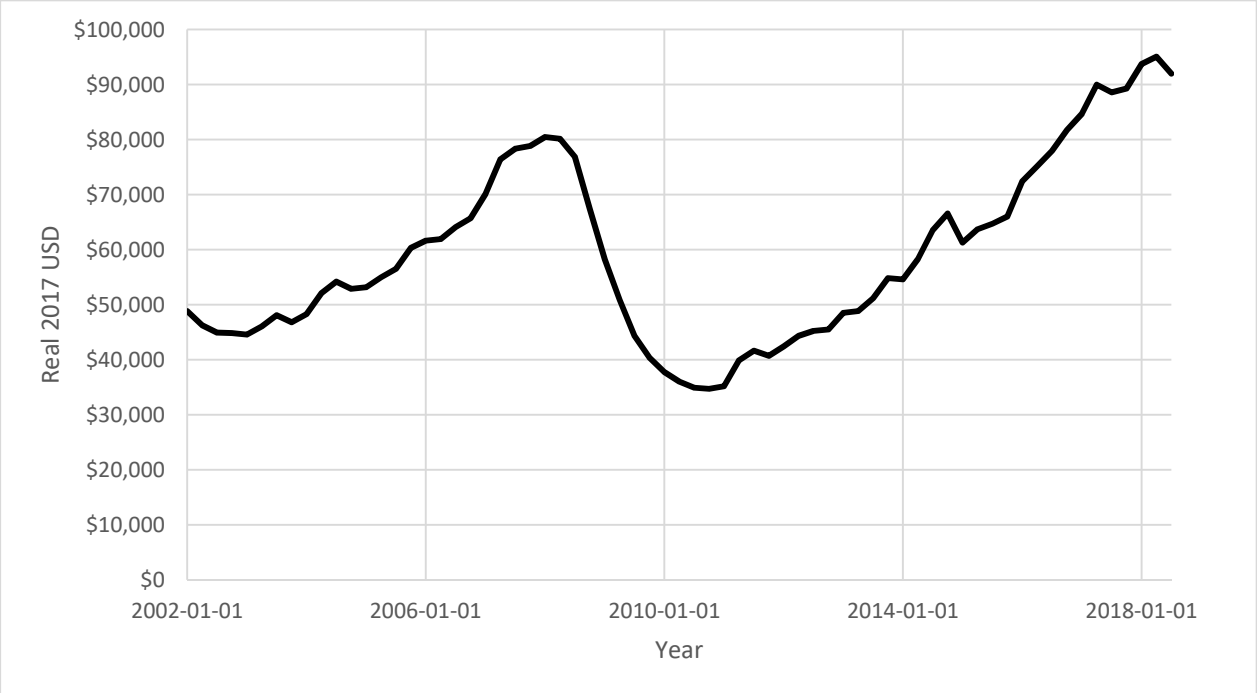
Source: American Tree Farm System, www.treefarmsystem.org; Forest Stewardship Council, www.us.fsc.org; Sustainable Forestry Initiative (as of October 14), www.sfiprogram.org. (2018 data is as of June 2018).

Figure 30a. U.S. New Private Housing Units Authorized by Building Permits and Total New Privately Owned Housing Units (2000:Q1 – 2018:Q4, seasonally adjusted)



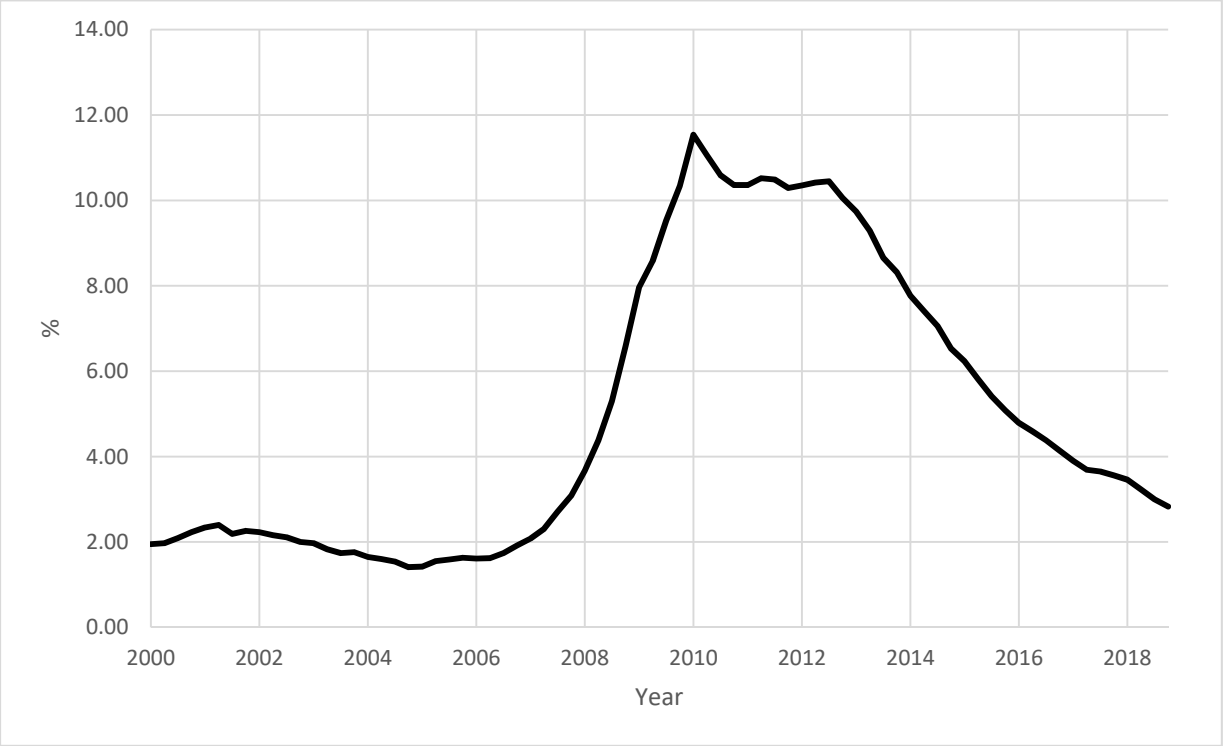
Source: U.S. Bureau of the Census.

Figure 30b. Total U.S. Spending on Commercial Construction (2002:Q1 – 2018:Q2)



Source: U.S. Bureau of the Census. Values deflated using U.S. Consumer Price Index (Jan. 2017 = 100).

Figure 31. U.S. Delinquency Rate on Single-Family Residential Mortgages, Booked in Domestic Offices (all commercial banks, 2000:Q1 – 2018:Q4, seasonally adjusted)



Source: U.S. Board of Governors of the Federal Reserve System.

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8. Appendix: Economic Contribution of the Forest Sector to the Oregon Economy

Philip Watson

Tim Nadreau

Economic Base Contribution Analysis

The economic contribution that the forestry and wood products sector makes to the Oregon economy is not limited simply to the jobs and income of the workers that are directly employed in those sectors, it extends to the economic activity (i.e. jobs, income, sales) that is supported in the Oregon economy when the forestry and wood products sector brings new dollars into the state's economy by selling products across the nation and the world. The employment and employee compensation data presented in the previous section are simply government statistics on who directly works in the forestry and wood product sector. These government statistics are based on "gross" measures of economic activity. For the purposes of this report, the term "gross" refers to the observed measures of economic activity that are reported in secondary data sources (e.g. BEA, BLS, Census).

Definitions of gross and base:

Both gross and base economic activity (i.e. employment and wages) are important aspects to consider when analyzing a regional economy.

- *Gross values are the directly observable employment and wages paid in a given sector. These are the values that are reported in government statistics.*
- *Base values are economic contributions that include the regional economic effect of that sector's production and how it spawns activity within other sectors. The total base contribution is calculated as the sector's sales outside the state times the sector's multiplier.*

In total, gross economic activity and base economic activity are equivalent. However, the gross and base measures of economic activity for a given sector are likely to be quite different.

For example, if you were to ask a restaurant how many people are on their payroll and they answer ten, then the gross employment of that restaurant is ten. However, just looking at gross employment can create a misleading picture of what drives economic production in a region. An alternative accounting framework that provides a different picture of what sectors are responsible for employment and income in a given region is an economic "base" analysis. Base analysis measures a sector's ability through its exports to bring in new dollars to the region and how those dollars generate economic activity (i.e. jobs and income) in other sectors of the economy. Across all sectors of the Oregon economy, the total jobs and employee compensation in the gross analysis will be the same total number as in the base analysis, they will simply be distributed differently. Gross analysis measures where people actually work and base analysis measure who brings money into the regional economy that then generates the jobs and income.

An example of a store selling a saw blade to a sawmill clarifies the difference between these two measures. The gross metric would attribute the saw blade sale (and associated jobs and employee compensation) to the non-base retail store. However, the saw blade sale is possible only because the base industry (the sawmill) brings the new dollars (exports) into the Oregon economy; and the base analysis credits the saw blade sale from the retail sector to the wood products industry. In summary, the base metric is propelled by exports and could be more accurately labeled as the "contribution of exports". The base metric implies that the source of economic growth are exports, thus the base analysis is useful for developing policies that increase sales, jobs, and income, through exports.

Method for Generating Economic Base Model

When doing comprehensive economic base analysis, data and method intersect in the concept of social accounts. Because of its central role, let's begin with a brief overview of social accounts and their expression within a social accounting matrix (SAM). Social accounts connect total aggregate demand and supply for an entire economy. A social accounting matrix connects total demand and supply by sector.

Table A1 - Notational Social Accounting Matrix (SAM) for a Three-Sector Regional Economy.

		Local Industries			**Local Households (Consumption)**	**Exogenous Demand (exports)**	**Total**
		I1	**I2**	**I3**			
Local Industries	1	z_{11}	z_{12}	z_{13}	c_{14}	y_1	x_1
	2	z_{21}	z_{22}	z_{23}	c_{24}	y_2	x_2
	3	z_{31}	z_{32}	z_{33}	c_{34}	y_3	x_3
Local Households (value added)		v_1	v_2	v_3		$y_4=v_4$	v
Exogenous Inputs (Imports)		m_1	m_2	m_3	m_4		m
Total		x_1	x_2	x_3	c	y	

Notes: Here we define "exogenous demand" as any sales outside the region. As per convention, SAMs present sales between the accounts across the row and purchases between accounts down a column. By definition, in total, $c=v$ and $y=m$.

The data necessary to evaluate the extent and economic contribution of local good can be derived from regional social accounts and organized into a regional SAM. A SAM is a statistical framework that utilizes double-entry bookkeeping to trace all monetary flows within a regional economy over a given period. It provides a method to organize the flow-of-value statistical data for a national, state, or regional economy. Mathematically, a SAM is a square matrix in which each nonzero element records the value of a financial transaction between economic actors. Table A1 presents a notational, three-sector SAM for a hypothetical economy. Industry rows record sales to all possible endogenous (i.e., local) and exogenous outlets including endogenous

intermediate demand (z_{ij}); endogenous final demand associated with household spending (c_{i4}); and exogenous final demand associated with, for example, household investment income, government spending, and exports (y_i). The total of these transactions represents the total industry output of a given sector (x_i). Note that total consumption (c_{i4}) is equal to total income (v_{4j}) and that y_4 and v_4 are identical and can be interpreted as both an export and income (i.e., income into the region from exogenous sources). Industry columns record purchases and represent Leontief production functions that include local input purchases (z_{ij}), factor payments (income; v_{4j}), and imported input purchases (m_{5j}). Within the SAM accounting framework, economic actors are required to meet their budget constraints to maintain equilibrium between buyers and sellers. As such, all row sums are balanced with corresponding column sums.

The requirements table (Table A2) is derived from the regional SAM, where a_{ij} equals the share of total industry outlay for every *i*th row and *j*th column and the full dimension matrix of a_{ij} coefficients is denoted as matrix **A** (Miller and Blair 2009, p. 16). This matrix is collectively referred to as the "A matrix" and it represents the matrix of technical coefficients, or how much of each dollar of output goes into purchasing inputs from other local sectors in the economy. The default A matrix from each of the respective regions analyzed in this study were then taken from the most up to date version of IMPLAN data available.

Table A2 - Endogenous Requirements Matrix (A) of Regional Economy

		Local Industries			Local Households
		I1	I2	I3	
Local Industries	I1	a_{11}	a_{12}	a_{13}	a_{14}
	I2	a_{21}	a_{22}	a_{23}	a_{24}
	I3	a_{31}	a_{32}	a_{33}	a_{34}
Local Households		a_{41}	a_{42}	a_{43}	

Notes: The a_{ij} elements are defined as $\frac{z_{ij}}{x_j}$ and represent the share of total inputs spent on local inputs.

While data for the non- forest sectors will be obtained from IMPLAN, we want to disaggregate the forestry related sectors to provide greater sectoral detail. Using the A matrix described above, the output of an economy can be expressed in equation 1.

1) $X = AX + Y$,

where X represents a vector or industry outputs, A is the matrix of technical coefficients, and Y is a vector of exogenous final demands. These input output matrices can always be thought of as both where a sector sells its output (that is the interpretation across the row) or where a sector buys its inputs (that is the interpretation down the columns). Since local sector A's sales to local sector B can also be thought of as sector B's purchases from sector A, the inputs and outputs are the same in total. Interpreting equation one by moving across a given row in A, the term AX represents the total amount of output a given sector sells locally. Another way to think about equation 1 is that all output of a given sector must either be sold locally or exported out of the region. In this way, equation one represents an accounting identity that says: for any given sector's output (X), they sell some percentage of its output locally (A) and the remaining output is sold outside the region (Y). Rearranging equation 1 to gather like terms together yields equation 2.

2) $(I - A)X = Y$

where *I* is an identity matrix of ones along the diagonal and zeros in the off diagonal cells. Finally, when we solve for X, we are left with equation 3, the fundamental equation of input/output analysis.

3) $X = (I - A)^{-1}Y$

This equation tells us how output (X) is related to exogenous final demand (Y) through the multiplier ($(I-A)^{-1}$). The column sum of the $(I-A)^{-1}$ matrix through the producing sectors is the output multiplier for each respective sector.

Waters, Holland, and Weber (1999) were the first to formally suggest a simple modification to the standard Leontief input-output model that increases the amount of useful information produced. The procedure consists of diagonalizing the vector of final demand to create the matrix $\hat{\mathbf{Y}}$**.** Diagonalizing a vector simply means placing the elements of the vector along the

major diagonal of an *n*×*n* matrix. By doing, so the *n*×*n* multiplier matrix can then be multiplied by an *n*×*n* diagonal matrix of final demand and yield an *n*×*n* matrix of gross and base output (**X**). Equation (4) presents the formal economic-base model:

$$4) \quad X = (I - A)^{-1}\hat{Y},$$

where **X** represents a matrix of industry output, $\widehat{\mathbf{Y}}$ represents a diagonalized matrix of final demands, and $\mathbf{(I-A)^{-1}}$ represents an *n*×*n* matrix of interactions between the endogenous sectors of the economy and is also called the "Leontief inverse." This Leontief inverse can also be thought of as a matrix of partial output multipliers, where the column sum of the endogenous sector columns through the output producing sector rows is the output multiplier for each respective sector. Note that for all equations we adopt the convention of denoting matrices in bold, upper-case letters, vectors in bold, lower-case letters, and scalars in italicized, lower-case letters.

Applied to the Leontief model, this procedure results in an *n*×*n* output matrix (**X**) rather than the *n*×1 output vector produced by standard Leontief input-output model. It squares the amount of useful information produced by the model, simultaneously separates each industry's export-base contribution (as a row vector of column sums) from gross contribution (as a column vector of row sums), and produces a square matrix that ensures that export-base contributions sum to total industry output. The principal diagonal of this output matrix contains an estimate of direct effects and own use by industry, while the off-diagonal elements contain an estimate of indirect export-base contributions by industry (down the columns). Given these subtle but important differences, Watson et al. (2015) recommended that all economic contribution studies be conducted in this manner to prevent the possibility of double-counting or over-estimation.

The sum of export-base output and gross output across all sectors is equal in total. However, export-base output and gross output are almost never equal by sector. The difference between gross and base output by sector can be used to discern the main role that an industry plays in bringing money to or keeping money within a regional economy (Watson et al., 2015).

State Level Analysis

Gross employment Data

The primary data for this analysis came from the Oregon Employment Department (OED). OED painstakingly evaluated unsuppressed employment data and extracted counts of employment that can be considered "forest-related" across the entire state. They reported these employment counts in the following groups: primary forest products (Table A3), forestry support (Table A4), secondary forest products (Table A5), forestry management (Table A6), forestry-dependent industries (Table A7), and transportation and other forestry sector firms (Table A8). These employment data were also broken-out and reported by five employment categories of: 1) federal, 2) state, and 3) local government sectors, as well as 4) private sector wage and salary employment and 5) "nonemployers", which consisted of proprietors and private contractors (Tables A3-A8). These groups and categories were summed to generate a grand total forest-related employment which is reported in Table A9.

Table A3 - Statewide gross forest-related employment in primary forest products industries

NAICS	Industry Name	Federal	State	Local	Private	Nonemployers	Total
321211	Hardwood veneer and plywood				1,439	573	**2,012**
3211	Sawmills and wood preservation				6,450		**6,450**
322	Paper manufacturing				4,238	17	**4,255**
321212	Softwood veneer and plywood				4,390		**4,390**
321219	Reconstitued wood products				1,245		**1,245**
321213	Engineered wood member (except truss)				895		**895**
321214	Truss manufacturing				590		**590**
Group Total	**Primary Forest Products**				**19,247**	**590**	**19,837**

Table A4 - Statewide gross forest-related employment in forestry support industries

NAICS	Industry Name	Federal	State	Local	Private	Nonemployers	Total
1133	Logging				5,947	1,471	**7,418**
11531	Support activities for forestry				3,624	520	**4,144**
333243	Sawmill, woodworking, and paper machinery				1,061		**1,061**
1132	Forest nurseries and gathering forest products		11		111		**122**
62431	Vocational rehabilitation services	46			-		**46**
Group Total	**Forestry Support**	**46**	**11**		**10,743**	**1,991**	**12,791**

Table A5 - Statewide gross forest-related employment in secondary forest products industries

NAICS	Industry Name	Federal	State	Local	Private	Nonemployers	Total
32191	Millwork				5,331		**5,331**
33711	Wood kitchen cabinets and countertops				2,964	481	**3,445**
321991	Manufactured and mobile homes				994		**994**
32192	Wood containers and pallets				810		**810**
321999	All other miscellaneous wood products				387		**387**
337212	Custom architectural woodwork and millwork				408		**408**
337122	Nonupholstered wood household furniture				321		**321**
321992	Prefabricated wood buildings				203		**203**
337211	Wood office furniture				64		**64**
Group Total	**Secondary Forest Products**				**11,482**	**481**	**11,963**

Table A6 - Statewide gross forest-related employment in forestry management industries

NAICS	Industry Name	Federal	State	Local	Private	Nonemployers	Total
1131	Timber tract operations	3,147	181		299		**3,627**
924120	Administration of conservation programs	1,632	662		-		**2,294**
551114	Corporate, subsidiary, and regional managing offices				725		**725**
6113	Colleges, universities, and professional schools			225	-		**225**
813910	Business associations				26		**26**
9211	County government foresters and support staff			27	-		**27**
-	Additional private certified foresters/consultants				22		**22**
Group Total	**Forestry Management**	**4,779**	**843**	**252**	**1,072**	**-**	**6,946**

Table A7 - Statewide gross forest-related employment in forest-dependent industries

NAICS	Industry Name	Federal	State	Local	Private	Nonemployers	Total
42331	Lumber, plywood, millwork, and wood panel merchant wholesalers				2,229	137	**2,366**
42411	Printing and writing paper merchant wholesalers				306	58	**364**
42413	Industrial and personal service paper merchant wholesalers				398		**398**
Group Total	**Forestry-Dependent Industries**				**2,933**	**195**	**3,128**

Table A8 - Statewide gross forest-related employment in transportation and other forest sector industries

NAICS	Industry Name	Federal	State	Local	Private	Nonemployers	Total
Multiple	Transportation				4,738		**4,738**
-	All other identified forestry sector firms				582		**582**
Group Total	**Transportation and Other**						**5,320**

Table A9 - Total gross forest-related employment in Oregon

Total Oregon Forest Products	Federal	State	Local	Private	Nonemployers	Total
Grand Total	4,825	854	252	50,797	3,257	59,985

Economic Base Contributions

In generating the economic base contributions of forest related sectors to the Oregon economy, we first built a social accounting matrix (SAM) using IMPLAN data and then applied the forest related sectoral employment numbers generated by OED to generate our forest related sector estimates. The primary assumptions that were made included 1) that forest related and non-forest related sectors within the same NAICS code have identical production functions, and 2) that splits of sectors were directly proportional to their employment numbers. For example, if the "forestry wholesale" sector employment from OED represented 40% of the total employment that was present in that sector from IMPLAN, then the sector was split into a "forestry wholesale" sector which would comprise 40% of the total of each cell in the SAM for each column and row and the remaining 60% would be considered "all other wholesale". In this way, it is identical to say that "forest wholesale" would be 40% of the base contribution of the total aggregated "wholesale" sector.

Using the OED employment data and IMPLAN SAM, the economic base model described above, we find that forestry was responsible for generating over $18 billion in output, over 71,000 jobs, and over $8 billion in state gross domestic product (as measured by value added). This translates to 4.7% of total state output, almost 3% of state employment, and 3.7% of state GDP (Table A10).

Table A10 - Economic Base Contributions of Forestry in Oregon in 2016

NAICS Sector	Base Output ($1M)	Base Employment	Base GDP ($1M)
113 Forestry & Logging	$692	7,139	$412
115 Forestry Svcs	$216	4,274	$148
321 Wood Products	$10,304	36,968	$4,427
322 Paper Manufacturing	$3,707	5,746	$1,449
333 Forest Machinery Mfg	$614	1,650	$254
337 Furniture & Related Mfg	$1,209	6,766	$534
42 Forestry Wholesale Trade	$393	1,813	$241
484 Forestry Truck transportation	$408	2,404	$215
541 Forestry Professional/Scientific Svcs	$3	19	$2
551 Management of Forestry Companies	$179	699	$109
611 Forestry Educational Services	$3	58	$2
624 Forestry Related Social Assistance	$1	17	$1
813 Forestry Related Clubs and NGOs	$0.4	3	$0.2
92 Forestry Related Government	$366	3,663	$280
Total	$18,093	71,218	$8,074
Percent of State Total	4.65%	2.92%	3.65%

The economic contribution of forestry can also be broken down into the direct and the indirect/induced effects. The direct effects are the new dollars or jobs brought into the state of Oregon and the indirect/induced effects are the jobs created in other sectors from the linkages of forestry to the broader state economy. The indirect effects come from forestry operations creating additional economic activity through input purchases (i.e. supply chain) from other sectors of the Oregon economy. Induced effects are created when forestry sectors pay wages, salaries, and profits to Oregon households who then go and use that money to purchase goods and services from other sectors of the Oregon economy. Table A11 provides a breakdown of the economic base contributions in terms of both direct and indirect/induced effects.

Table A11 - The Total Economic Base Contributions of Forestry in Oregon Broken Out by Direct and Indirect/Induced Effects

Base Contribution	Direct	Indirect and Induced	Total
Output ($1M)	$9,360	$8,733	$18,093
Employment	36,401	34,817	71,218
Value Added (GDP, $1M)	$3,239	$4,835	$8,074

Applying an identical analysis (Watson et al. 2015) as was conducted on Oregon forestry sectors to other sectors of the Oregon economy provide some context for the relative size of the forestry sector in the state's economy (Table A12). For example, the forestry sector has a larger economic base contribution than chemical manufacturing (NAICS 325), transportation equipment manufacturing (NAICS 336), and publishing industries (NAICS 511).

Table A12 - Comparison of economic contributions of other notable sectors to the Oregon economy

Other NAICS Sectors	Base Output ($1M)	Base Employment	Base GDP ($1M)
111/112 Production Agriculture	$4,990	53,728	$2,630
311 Food Processing	$20,422	86,923	$6,687
315 Apparel Manufacturing	$314	2,456	$143
325 Chemical Manufacturing	$4,804	14,441	$1,727
333 Machinery Manufacturing	$7,347	30,569	$3,036
336 Transportation Equipment Manufacturing	$8,148	29,384	$2,811
511 Publishing Industries	$4,781	24,713	$3,073
541 Professional, Technical, and Scientific Services	$22,679	160,350	$13,946

County Level Analysis

Generating Forestry Sector Specific County Gross Employment Data

The goal in this step of the analysis is to determine the employment mix of the forest product industry (FPI) for each county in Oregon. How many loggers, millworkers, or timber tract operators work in Umatilla County? Total employment by industry and total employment by

county are provided by the Oregon Department of Labor, but those totals must be distributed. It is not enough to say that Coos County has 2,042 jobs in the FPI, we need to know what specific industries those jobs are in. Similarly, it is not sufficient to say that Oregon has 3,627 timber tract operators, we need to know where they are operating in the state. These totals are useful but provide an incomplete picture of timber operations in each county. Once these employment figures are appropriately distributed to industries and counties we can begin to build and assess the impacts the FPI has on each county and the state.

Total employment in the FPI was calculated by the Oregon Employment Department (OED) to be 60,020. Employment in the FPI by the constituent industries are provided in Table A13 along with assumed proportion of the industry being allocated to the FPI. For example, it is assumed that 100% of the logging industry employment is attributable to the FPI, whereas only 18% of the Transportation industry is attributable to the FPI. Table A14 provides total FPI employment by county. However, 658 jobs could not be allocated because of state and federal disclosure rules.

Before distributing the total employment to the county-industry matrix, County Business Pattern data, produced by the U.S. Census Bureau, was collected and used to verify the totals. CBP data was also used to derive estimates, or seed data, for the county-industry matrix to be populate. Standard statistical discrepancies, data disclosure rules, and differing types of employment measures, always result in data sets from different departments being slightly dissimilar. However, the totals were within acceptable tolerances.

Table A13: ***Industry Description, Code, and Employment for the Oregon FPI***

Industry Name	NAICS	Total	Assume 100%
Primary Forest Products		*19837*	
Hardwood veneer and plywood	321211	2012	100%
Sawmills and wood preservation	3211	6450	100%
Paper manufacturing	322	4255	100%
Softwood veneer and plywood	321212	4390	100%
Reconstitued wood products	321219	1245	100%
Engineered wood member (except truss)	321213	895	100%
Truss manufacturing	321214	590	100%
Forestry Support		*12826*	
Logging	1133	7453	100%
Support activities for forestry	11531	4144	100%
Sawmill, woodworking, and paper machinery	333243	1061	100%
Forest nurseries and gathering forest products	1132	122	100%
Vocational rehabilitation services	62431	46	100%
Secondary Forest Products		*11963*	
Millwork	32191	5331	100%
Wood kitchen cabinets and countertops	33711	3445	100%
Manufactured and mobile homes	321991	994	100%
Wood containers and pallets	32192	810	85%
All other miscellaneous wood products	321999	387	50%
Custom architectural woodwork and millwork	337212	408	85%
Nonupholstered wood household furniture	337122	321	70%
Prefabricated wood buildings	321992	203	85%
Wood office furniture	337211	64	75%
Forestry Management		*6946*	
Timber tract operations	1131	3627	100%
Administration of conservation programs	924120	2294	0%
Corporate, subsidiary, and regional managing offices	551114	725	2%
Colleges, universities, and professional schools	6113	225	2%
Business associations	813910	26	2%
County government foresters and support staff	9211	27	100%
Additional private certified foresters/consultants	-	22	100%
Forestry-Dependent Industries		*3128*	
Lumber, plywood, millwork, and wood panel merchant wholesalers	42331	2366	100%
Printing and writing paper merchant wholesalers	42411	364	100%
Industrial and personal service paper merchant wholesalers	42413	398	85%
All other identified forestry sector firms	-	*582*	*0%*
Transportation	*484*	*4738*	*18%*
Total		**60020**	

Source: OED

Oregon FPI Employment by County

County	Total Gross Employment	Average Annual Wage
Baker	381	$47,432
Benton	1,380	$57,284
Clackamas	3,263	$54,604
Clatsop	1,430	$67,790
Columbia	813	$50,770
Coos	2,042	$49,192
Crook	718	$45,000
Curry	620	$49,812
Deschutes	1,982	$50,117
Douglas	5,561	$52,369
Gilliam	-c-	$0
Grant	579	$48,496
Harney	101	$47,657
Hood River	224	$49,230
Jackson	5,121	$44,979
Jefferson	823	$38,754
Josephine	1,675	$41,789
Klamath	2,374	$50,553
Lake	361	$47,682
Lane	7,172	$57,724
Lincoln	924	$69,216
Linn	3,321	$54,898
Malheur	116	$40,898
Marion	4,347	$54,977
Morrow	195	$53,754
Multnomah	4,368	$70,545
Polk	1,103	$37,209
Sherman	-c-	$0
Tillamook	856	$50,893
Umatilla	992	$44,564
Union	953	$50,810
Wallowa	254	$49,561
Wasco	223	$41,512
Washington	3,821	$56,690
Wheeler	-c-	$0
Yamhill	1,269	$50,892
Oregon	**60020**	**53518**

Source: OED

Assumptions

Several assumptions needed to be made before distributing the employment totals to the county-industry employment matrix. It was necessary to ensure that the total county

employment and total industry employment matched between the two data sets provided by the OED. The method of distribution required row and column totals to be equal so that convergence could be achieved.

There were 35 jobs that were unallocated in the FPI industry data provided by the OED. These jobs represented tribal employment and it was not clear which industries they belonged in. The assumption was made that allocating these jobs to the logging industry (the largest single industry in the FPI) would distort the overall distribution of employment the least. Even if these jobs were misallocated, they represented less than 0.05% of total FPI employment. FPI employment in Gilliam, Sherman, and Wheeler Counties were suppressed. A total of 658 jobs in FPI needed to be allocated to these counties and was done so based on the relative size of these counties to the overall size of the state.

Lastly, in order to derive the seed matrix (see description in the following section) the CBP data for Oregon counties was used. When actual employment counts were provided, they were used, otherwise prespecified ranges were provided and the midpoint of the range was used as a proxy. This gave us industry level employment by county. Those figures were then multiplied by the assumed values provided in Table A13. This calculated data represented the bulk of the seed matrix. Three industries, with FPI employment, were not captured by CBP data. Two were government industries; Administration of Conservation Programs and County Government Foresters and Support Staff. The third "industry" was a catch all identified by OED as "All Other Identified Forestry Sector Firms." Employment in those industries were distributed uniformly to counties with forestry employment.

Distribution Technique

Iterative Proportional Fitting (IPF), sometimes referred to as RAS in economics and Bi-proportional in data science, is a process for ensuring row and column totals are preserved while distributing values within an array. In our case we have a two-dimensional array, or matrix, with counties on the vertical axis and industries on the horizontal axis. Figures A1 and A2 show the general objective of IPF.

Notice that in Figure A1 the row and column totals on the margin of the table do not perfectly match the sum of the row or column values in the table (seed values).

Figure A1: ***Seed Table and Margin Totals***

	11	9	8
5	1	2	1
15	3	5	5
8	6	2	2

Figure A2: ***Fitted Table and Margin Totals***

	11	9	8
5	1.51	2.31	1.18
15	4.2	5.35	5.45
8	5.28	1.34	1.37

Step 1: Each element in a row is divided by the actual sum of the row and then multiplied by the row margin. This proportionately adjusts the rows.

Step 2: Each element in a column is divided by the actual sum of the column and then multiplied by the column margin. This proportionately adjusts the columns.

Thus, iteration 1 is over. However, now the rows are "off" again. Steps 1 and 2 are repeated according to a specified number of times or until the difference between the actual row and column totals are within a specified distance from the margin totals. Different seed values often result in slightly different final tables, though the main advantage to well described seed matrix is that the time it takes for the process to converge is greatly reduced. Typically, the IPF process will not *exactly* converge to the originally specified margins.

Results

In order to conduct the IPF process the seed matrix and margin data was loaded into R and the software package MIPFP was used. The process iterated 10,000 times. The sum of the column

errors, difference between the stated margins and the fitted column totals, was 1.64×10^{3} and the sum of the row errors was 9.09×10^{13}.

The diversity in FPI employment by county is stark. For example, Benton County has 1,380 jobs in FPI, nearly the same as Clatsop County's 1,430. However, 19% of the jobs in Benton County are in Primary Forest Products, while 72% of Clatsop County FPI jobs are in Primary Forest Products. This different mix in employment will result in a different mix of earnings by county and ultimately a different mix in expenditure patterns. This heterogeneity will cause the impacts by county to differ in terms of their multiplier effects. Table A15 synthesizes the data by major FPI sector and ranks the data by total employment.

The three counties with the largest volume of FPI employment are Lane, Douglas, and Jackson. These three counties compose 30 percent of the state's total FPI employment. Though all three are heavily weighted towards the Primary Forest Products sector they differ in the remainder of the employment. Lane has 18% of its FPI employment in Forestry Support and 10% in Secondary Forest Products. Douglas, on the other hand has 36% of its FPI employment in Forestry Support and only 4% in Secondary products. Compare this to Jefferson County, which only has 823 FPI jobs but 96% of them are in Secondary Products. Tables A16-A20 provide the distribution of employment for each county and major FPI sector.

Table A15: Percentage of Gross Employment by Major FPI Sector and County

County	Primary Forest Products	Forestry Support	Secondary Forest Products	Forestry Management	Forestry-Dependent Industries	All other	Truck Trans.	Total FPI Jobs
Lane	50%	18%	10%	14%	4%	1%	3%	7,172
Douglas	50%	36%	4%	4%	0%	3%	4%	5,561
Jackson	35%	29%	9%	15%	2%	1%	7%	5,121
Multnomah	15%	13%	19%	8%	20%	0%	26%	4,368
Marion	15%	20%	48%	2%	2%	0%	13%	4,347
Washington	36%	10%	23%	8%	17%	0%	5%	3,821
Linn	47%	17%	12%	16%	1%	1%	6%	3,321
Clackamas	25%	16%	17%	3%	25%	1%	13%	3,263
Klamath	59%	9%	27%	1%	0%	1%	2%	2,374
Coos	27%	30%	1%	36%	1%	2%	3%	2,042
Deschutes	3%	14%	63%	0%	8%	0%	12%	1,982
Josephine	10%	22%	65%	0%	1%	1%	1%	1,675
Clatsop	72%	24%	0%	0%	0%	2%	2%	1,430
Benton	19%	32%	1%	44%	0%	1%	3%	1,380
Yamhill	41%	16%	26%	5%	8%	2%	2%	1,269
Polk	0%	85%	3%	0%	2%	2%	8%	1,103
Umatilla	25%	8%	21%	0%	4%	0%	43%	992
Union	76%	21%	0%	0%	0%	0%	3%	953
Lincoln	72%	22%	0%	0%	0%	3%	3%	924
Tillamook	33%	40%	16%	0%	0%	3%	8%	856
Jefferson	0%	1%	96%	0%	0%	0%	2%	823
Columbia	30%	46%	14%	0%	0%	4%	6%	813
Crook	0%	15%	71%	0%	0%	0%	13%	718
Curry	71%	28%	0%	0%	0%	0%	1%	620
Grant	0%	25%	75%	0%	0%	0%	0%	579
Baker	0%	7%	84%	0%	0%	0%	9%	381
Lake	50%	0%	39%	0%	0%	0%	11%	361
Sherman	0%	0%	0%	100%	0%	0%	0%	278
Gilliam	0%	0%	0%	100%	0%	0%	0%	255
Wallowa	26%	64%	0%	0%	0%	0%	10%	254
Hood River	27%	22%	17%	0%	0%	0%	35%	224
Wasco	59%	41%	0%	0%	0%	0%	0%	223
Morrow	64%	31%	0%	0%	0%	0%	5%	195

Wheeler	0%	0%	0%	100%	0%	0%	0%	125
Malheur	0%	1%	0%	11%	0%	0%	88%	116
Harney	0%	100%	0%	0%	0%	0%	0%	101
Oregon	***34%***	***22%***	***20%***	***9%***	***5%***	***1%***	***8%***	***60,020***

Table A16: ***Primary Forest Products Gross Employment Distribution by County***

	Total	**Hardwood veneer and ply**	**Sawmills and wood preservation**	**Paper Mfg.**	**Softwood veneer and ply**	**Reconstituted wood products**	**Engineered wood member**	**Truss Mfg.**
Baker	***0***	0	0	0	0	0	0	0
Benton	***258***	0	229	29	0	0	0	0
Clackamas	***819***	0	215	564	0	0	0	39
Clatsop	***1,034***	0	124	910	0	0	0	0
Columbia	***241***	0	187	55	0	0	0	0
Coos	***558***	0	258	0	301	0	0	0
Crook	***0***	0	0	0	0	0	0	0
Curry	***442***	0	181	0	261	0	0	0
Deschutes	***50***	0	0	0	0	0	0	50
Douglas	***2,764***	0	1,382	0	1,117	173	42	49
Gilliam	***0***	0	0	0	0	0	0	0
Grant	***0***	0	0	0	0	0	0	0
Harney	***0***	0	0	0	0	0	0	0
Hood River	***60***	0	60	0	0	0	0	0
Jackson	***1,812***	384	31	0	869	325	165	38
Jefferson	***0***	0	0	0	0	0	0	0
Josephine	***171***	148	23	0	0	0	0	0
Klamath	***1,404***	510	311	0	0	582	0	0
Lake	***180***	0	180	0	0	0	0	0
Lane	***3,599***	1,004	1,231	138	762	18	323	123
Lincoln	***665***	0	92	572	0	0	0	0
Linn	***1,560***	23	309	327	773	100	0	28
Malheur	***0***	0	0	0	0	0	0	0
Marion	***657***	0	43	317	0	0	297	0
Morrow	***125***	0	125	0	0	0	0	0
Multnomah	***648***	0	0	648	0	0	0	0
Polk	***0***	0	0	0	0	0	0	0
Sherman	***0***	0	0	0	0	0	0	0
Tillamook	***279***	0	279	0	0	0	0	0
Umatilla	***246***	0	246	0	0	0	0	0
Union	***720***	0	270	0	389	60	0	0
Wallowa	***67***	0	67	0	0	0	0	0
Wasco	***131***	0	78	0	0	0	53	0
Washington	***1,389***	0	318	815	0	22	0	234
Wheeler	***0***	0	0	0	0	0	0	0
Yamhill	***520***	0	393	0	42	0	40	46

Table A17: ***Forestry Support Gross Employment Distribution by County***

	Total	**Logging**	**Forestry Support Activities**	**Sawmill, Woodworking, and Paper Machinery**	**Forest Nurseries***	**Vocational Rehabilitation Services**
Baker	***28***	28	0	0	0	0
Benton	***435***	233	201	0	0	1
Clackamas	***520***	140	190	188	0	2
Clatsop	***347***	346	0	0	0	2
Columbia	***374***	370	0	0	0	4
Coos	***603***	492	110	0	0	1
Crook	***111***	111	0	0	0	0
Curry	***172***	172	0	0	0	0
Deschutes	***277***	88	186	0	0	2
Douglas	***1,987***	1,555	340	90	0	2
Gilliam	***0***	0	0	0	0	0
Grant	***143***	143	0	0	0	1
Harney	***101***	36	65	0	0	0
Hood River	***49***	48	0	0	0	1
Jackson	***1,498***	400	1,067	0	29	2
Jefferson	***12***	12	0	0	0	0
Josephine	***368***	200	166	0	0	2
Klamath	***212***	201	10	0	0	2
Lake	***0***	0	0	0	0	0
Lane	***1,297***	605	266	327	96	3
Lincoln	***203***	203	0	0	0	0
Linn	***569***	489	79	0	0	1
Malheur	***1***	0	0	0	0	1
Marion	***858***	227	624	0	0	6
Morrow	***60***	60	0	0	0	0
Multnomah	***576***	17	122	428	0	9
Polk	***933***	341	592	0	0	0
Sherman	***0***	0	0	0	0	0
Tillamook	***341***	341	0	0	0	0
Umatilla	***76***	76	0	0	0	0
Union	***204***	162	42	0	0	0
Wallowa	***162***	154	8	0	0	0
Wasco	***92***	92	0	0	0	0
Washington	***376***	157	159	57	0	3
Wheeler	***0***	0	0	0	0	0
Yamhill	***203***	166	35	0	0	2

* Forest Nurseries and Gathering Forest Products

Table A18: ***Secondary Forest Products Gross Employment Distribution by County***

	Total	Millwork	Wood Kitchen Cabinets and Countertops	Mfg. and Mobile Homes	Wood Containers and Pallets	All other Miscellaneous Wood Products	Custom Architectural Woodwork and Millwork	Non-Upholstered Wood Household Furniture	Prefabricated Wood Buildings	Wood Office Furniture
Baker	***319***	319	0	0	0	0	0	0	0	0
Benton	***15***	0	6	0	0	0	9	0	0	0
Clackamas	***567***	308	200	0	24	23	12	0	0	0
Clatsop	***0***	0	0	0	0	0	0	0	0	0
Columbia	***113***	0	54	0	36	23	0	0	0	0
Coos	***21***	13	0	0	0	8	0	0	0	0
Crook	***510***	488	0	0	0	0	22	0	0	0
Curry	***0***	0	0	0	0	0	0	0	0	0
Deschutes	***1,255***	761	307	0	0	0	53	134	0	0
Douglas	***222***	131	45	27	0	19	0	0	0	0
Gilliam	***0***	0	0	0	0	0	0	0	0	0
Grant	***436***	436	0	0	0	0	0	0	0	0
Harney	***0***	0	0	0	0	0	0	0	0	0
Hood River	***37***	0	0	0	0	37	0	0	0	0
Jackson	***480***	199	161	0	42	61	0	0	18	0
Jefferson	***794***	794	0	0	0	0	0	0	0	0
Josephine	***1,082***	230	841	0	0	0	11	0	0	0
Klamath	***648***	633	0	0	0	0	15	0	0	0
Lake	***143***	143	0	0	0	0	0	0	0	0
Lane	***740***	63	503	0	19	10	68	64	12	0
Lincoln	***0***	0	0	0	0	0	0	0	0	0
Linn	***406***	0	108	192	17	65	0	24	0	0
Malheur	***0***	0	0	0	0	0	0	0	0	0
Marion	***2,105***	557	428	466	454	13	21	0	165	0
Morrow	***0***	0	0	0	0	0	0	0	0	0
Multnomah	***814***	59	254	0	97	103	207	80	13	0
Polk	***29***	0	11	0	0	18	0	0	0	0

Sherman	***0***	0	0	0	0	0	0	0	0	0
Tillamook	***136***	118	0	0	0	18	0	0	0	0
Umatilla	***212***	0	0	212	0	0	0	0	0	0
Union	***0***	0	0	0	0	0	0	0	0	0
Wallowa	***0***	0	0	0	0	0	0	0	0	0
Wasco	***0***	0	0	0	0	0	0	0	0	0
Washington	***887***	232	418	0	144	0	0	27	0	66
Wheeler	***0***	0	0	0	0	0	0	0	0	0
Yamhill	***332***	0	207	125	0	0	0	0	0	0

Table A19: ***Forestry Management Gross Employment Distribution by County***

	Total	**Timber Tract Operations**	**Administration of Conservation Programs**	**Corporate, Subsidiary, and Regional Managing Offices**	**Colleges, Universities, and Professional Schools**	**Business Associations**	**County Government Foresters and Support Staff**	**Additional Private Certified Foresters/Consultants**
Baker	***0***	0	0	0	0	0	0	0
Benton	***613***	594	0	17	0	0	1	1
Clackamas	***83***	0	0	74	5	3	1	1
Clatsop	***3***	0	0	1	0	0	1	1
Columbia	***3***	0	0	0	0	0	2	1
Coos	***735***	730	0	0	0	1	2	2
Crook	***0***	0	0	0	0	0	0	0
Curry	***0***	0	0	0	0	0	0	0
Deschutes	***8***	0	0	6	0	2	0	0
Douglas	***205***	187	0	6	0	0	7	5
Gilliam	***255***	0	255	0	0	0	0	0
Grant	***0***	0	0	0	0	0	0	0
Harney	***0***	0	0	0	0	0	0	0
Hood River	***0***	0	0	0	0	0	0	0
Jackson	***786***	728	0	53	0	1	2	2
Jefferson	***0***	0	0	0	0	0	0	0
Josephine	***4***	0	0	2	0	0	1	1
Klamath	***26***	0	0	23	0	0	1	1
Lake	***0***	0	0	0	0	0	0	0
Lane	***983***	950	0	23	3	2	3	2
Lincoln	***4***	0	0	2	0	0	1	1
Linn	***545***	540	0	3	0	0	2	1
Malheur	***13***	0	0	13	0	0	0	0
Marion	***65***	0	0	25	32	8	0	0
Morrow	***0***	0	0	0	0	0	0	0
Multnomah	***329***	0	0	202	121	6	0	0

Polk	***2***	0	0	0	0	0	1	1
Sherman	***278***	0	278	0	0	0	0	0
Tillamook	***2***	0	0	0	0	0	1	1
Umatilla	***0***	0	0	0	0	0	0	0
Union	***0***	0	0	0	0	0	0	0
Wallowa	***0***	0	0	0	0	0	0	0
Wasco	***0***	0	0	0	0	0	0	0
Washington	***310***	0	0	290	15	4	1	1
Wheeler	***125***	0	125	0	0	0	0	0
Yamhill	***63***	0	0	6	55	0	1	1

Table A20: ***Forestry Dependent Industries, All Other Forestry Sector Firms, and Truck Transportation Gross Employment Distribution by County***

	Total	**Lumber, Merchant Wholesalers**	**Printing and Writing Paper Merchant Wholesalers**	**Other Paper Merchant Wholesalers**	***All other forestry sector firms***	***Truck Transportation***
Baker	***0***	0	0	0	***0***	***34***
Benton	***0***	0	0	0	***18***	***41***
Clackamas	***812***	674	0	138	***23***	***439***
Clatsop	***0***	0	0	0	***23***	***23***
Columbia	***0***	0	0	0	***34***	***48***
Coos	***12***	12	0	0	***46***	***67***
Crook	***0***	0	0	0	***0***	***97***
Curry	***0***	0	0	0	***0***	***6***
Deschutes	***162***	141	0	22	***0***	***229***
Douglas	***22***	22	0	0	***142***	***219***
Gilliam	***0***	0	0	0	***0***	***0***
Grant	***0***	0	0	0	***0***	***0***
Harney	***0***	0	0	0	***0***	***0***
Hood River	***0***	0	0	0	***0***	***77***
Jackson	***117***	101	0	16	***44***	***384***
Jefferson	***0***	0	0	0	***0***	***17***
Josephine	***16***	16	0	0	***21***	***12***
Klamath	***0***	0	0	0	***29***	***55***
Lake	***0***	0	0	0	***0***	***38***
Lane	***256***	246	0	11	***58***	***239***
Lincoln	***0***	0	0	0	***29***	***23***
Linn	***25***	13	0	12	***33***	***183***
Malheur	***0***	0	0	0	***0***	***102***
Marion	***107***	107	0	0	***0***	***554***
Morrow	***0***	0	0	0	***0***	***11***
Multnomah	***880***	438	264	177	***0***	***1,121***
Polk	***21***	21	0	0	***28***	***90***
Sherman	***0***	0	0	0	***0***	***0***
Tillamook	***0***	0	0	0	***27***	***70***
Umatilla	***35***	35	0	0	***0***	***423***
Union	***0***	0	0	0	***0***	***29***
Wallowa	***0***	0	0	0	***0***	***25***
Wasco	***0***	0	0	0	***0***	***0***
Washington	***652***	509	111	33	***18***	***190***
Wheeler	***0***	0	0	0	***0***	***0***
Yamhill	***99***	99	0	0	***27***	***25***

County Level Economic Base Analysis

County specific economic base contributions were calculated in a similar manner to how the state level economic contributions were calculated earlier. The county level estimates of employment by sector generated in the previous section were incorporated into an economic base SAM model (Watson el al. 2015). The aggregate results for county specific contributions to output, employment and state GDP of forest related sectors are presented in Table A21.

While some counties were larger than others, every county in the state of Oregon had some economic activity generated by forest related sectors. Lane County was the largest county in Oregon in terms of forest related sector contributions to output, employment, and GDP in the state, generating almost $2.5 billion in output, over 10,000 jobs, and $829 million in GDP (as measured by value added). Differences in relative size between output, jobs, and GDP is largely a function of the different forest sector mix that exists in the county. For example Coos County has a large contribution in terms of jobs, but a relatively low contribution in terms of output. This is due to a large proportion of the employment in that county in logging a relatively small proportion in wood products or paper manufacturing.

Table A21 - County Level Economic Contributions of Forestry in Oregon

County	Base Output ($1M)	Base Jobs	State GDP ($1M)
Baker	$101.8	454	$37.7
Benton	$249.2	1,659	$121.1
Clackamas	$807.9	3,263	$301.2
Clatsop	$1,046.0	1,689	$305.0
Columbia	$180.3	813	$59.4
Coos	$372.8	2,688	$150.7
Crook	$222.2	898	$64.0
Curry	$173.1	675	$46.3
Deschutes	$454.3	2,500	$170.9
Douglas	$1,498.6	6,595	$491.3
Gilliam	$22.0	289	$17.5
Grant	$164.8	716	$42.9
Harney	$3.3	101	$1.7
Hood River	$42.1	224	$14.3
Jackson	$1,268.0	6,192	$443.3
Jefferson	$240.6	998	$87.3
Josephine	$315.2	2,157	$96.8

Klamath	$904.2	3,149	$288.0
Lake	$98.4	421	$28.8
Lane	$2,468.7	10,404	$829.1
Lincoln	$770.3	1,140	$267.9
Linn	$1,138.3	3,522	$404.9
Malheur	$3.8	116	$1.5
Marion	$1,026.8	5,107	$384.2
Morrow	$52.5	212	$19.2
Multnomah	$1,363.2	5,273	$561.1
Polk	$66.9	1,103	$35.9
Sherman	$32.7	312	$32.7
Tillamook	$184.2	894	$73.2
Umatilla	$220.1	1,133	$80.8
Union	$317.5	1,139	$85.8
Wallowa	$34.5	304	$15.5
Wasco	$76.7	292	$23.4
Washington	$1,292.2	4,152	$477.6
Wheeler	$8.6	145	$8.6
Yamhill	$304.0	1,326	$100.0

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