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Net Impact of the Proposed EITE Rate for Minnesota Wood Products Manufacturers

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1. BACKGROUND

In 2015, the Minnesota Legislature passed the "Competitive Rate for Energy-Intensive, Trade-Exposed Electric Utility Customer" bill (Minnesota Statute 216B.1696), which permits investor-owned electric utilities to propose alternative rate options for customers that qualify as energy-intensive trade-exposed (EITE). Qualifying customers include iron mining extraction and processing facilities, steel mills, paper mills, wood products manufacturers, sawmills, and oriented strand board (OSB) manufacturers. The purpose of the legislation is to ensure competitive electric rates for qualifying customers.

In a 2017 petition to the Minnesota Public Utilities Commission, Otter Tail Power (OTP) Company secured lower electricity rates for its EITE customers for a period lasting through November 2021. In this filing, OTP submits a new petition (the "Petition") to extend these lower electricity rates to their EITE customers for an additional four years. The EITE rate continuation is proposed for three wood product manufacturing facilities, including the Potlatch Deltic stud mill at Bemidji, the Norbord OSB plant at Solway, and the Cass Forest Products sawmill at Cass Lake (collectively, "OTP-EITE"). Stoel Rives LLP, as counsel for OTP-EITE, has assembled corresponding legal and factual analysis supporting the Petition. Mason Bruce & Girard has been retained by Stoel Rives to provide an analysis of the potential net benefit to the State resulting from the proposed EITE rate.

We have been instructed to consider benefits with measurable economic impact, as well as benefits that are not as easily quantified. In this case, the proposed EITE rate extension is not expected to result in increased production at the three facilities. In other words, there will be no *additional* benefit to the state resulting from extending the EITE rate; rather existing benefits will have a greater chance of remaining at current levels. As will be discussed, the forest products manufacturing industry experienced a significant decline during the 2009 recession, suffered facility closures during the SARS-CoV2 (COVID-19) pandemic, and remains vulnerable to external market forces.

Each member of OTP-EITE occupies distinct segments of the broad yet intertwined forest products industry. These mills use wood sourced primarily from Minnesota forestlands, and their finished products are sold and utilized in Minnesota and around the upper Midwest. As such, the wood products industry is something of a rarity among global industries, considering that a product may be sourced, manufactured, and consumed regionally.

The question to be answered for the purpose of this study is whether the economic benefits conferred by the OTP-EITE outweigh electricity costs that are passed on to remaining OTP customers. The proposed electricity cost discount of 20%, as applied to all three facilities, will result in a total redistributed cost of $1,015,245, or an average increase of 0.41% if distributed equally across all OTP ratepayers.[1] The average residential customer will pay an additional $3.53 per year under the proposal. This report is organized as follows:

- Section 2 provides an overview of Minnesota's wood products industry and supporting sectors.
- Section 3 summarizes each of the three facilities included in the EITE rate proposal.
- Section 4 describes how the OTP-EITE members' facilities benefit the state of Minnesota and weighs those benefits against the cost of continuing the current EITE rate.
- Section 5 provides a summary and conclusion of our findings.

[1] Petition of Otter Tail Power Company at Attachment 1 (February 1, 2021) ("Petition").

2. MINNESOTA WOOD PRODUCTS INDUSTRY

The forest industry is the fifth largest manufacturing sector in Minnesota by employment.[2] Approximately 2.84 million cords[3] of wood are harvested annually in the state, consisting mainly of pulpwood (73%), sawlogs (22%), and fuelwood (5%).[4] According to data provided by Minnesota Employment and Economic Development, approximately 714 people were employed in the logging industry in 2019 and 2020, while the wood products manufacturing industry (sawmills, engineered products, paper) employed 20,189.

SARS-CoV2 (COVID-19) impact statement: Wood products manufacturers, including members of OTP-EITE, were designated as an "essential, critical infrastructure" businesses in 2020, and thus far through 2021 were able to avoid mill closures from COVID test-positives. The pandemic continues, however, with no guarantees that operations will not be impacted. Second-order effects on demand for forest products are unclear. Direct impacts to employees through, e.g., changes in family dynamics, child-care, etc. are likely to occur, but data are not available. Overall, economic impacts of the virus will not improve stability in the forestry sector and represent another risk factor for the industry. By maintaining successful and safe operation throughout the pandemic period, the OTP-EITE companies are still providing jobs to an economy that is otherwise suffering on many fronts. EITE rates that facilitate continued operation of these facilities were a factor in the companies' ability to continue operations, and therefore a positive contribution to limiting the pandemic's economic impact in Minnesota.

A. Wood Product Manufacturers

Following is a brief overview of the primary wood product manufacturing sectors in Minnesota.

1. Pulp and Paper Mills

The majority of wood harvested in Minnesota is used for the production of pulp and paper products at four primary facilities. Aspen trees are the primary wood source for these mills, although other species such as Balsam Fir, Basswood, Spruce, Birch, Tamarack, and Maple are also used. Finished products are also wide-ranging, consisting of magazine and publication papers, office paper, specialty printing grades, market pulp, and specialized cellulose. The production of cellulose from Aspen trees is a fairly recent development, with the Cloquet mill converting from paper to cellulose production in 2013. The product is mainly shipped overseas, where it is blended with cotton and used in clothing. Paper mill shutdowns across the Great Lakes region have been common in recent years, as newspapers and other paper publication circulation has declined, but remaining mills have continued infrastructure investments. In 2017, the Blandin paper mill shut down one paper-manufacturing machine in 2017,

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[2] Minnesota Department of Natural Resources Division of Forestry, and Resource Assessment, *Minnesota's Forest Resources* 2018, accessed January 2021: page 18.

[3] A "cord" of wood is a unit of measure of wood volume, generally applied to pulpwood and firewood. It occupies a volume of 128 cubic feet and corresponds to a stacked wood pile measuring 4 ft. x 4 ft. x 8ft.

[4]Minnesota Department of Natural Resources Division of Forestry, and Resource Assessment, *Minnesota's Forest Resources* 2018, accessed January 2021: page 6.

leading to 150 direct job losses in and around Grand Rapids, MN.[5] The Blandin plant retained approximately two thirds of its workforce and continues operations at this reduced level through the present. In May 2019, Sappi North America finished $25 million of investments at Cloquet mill, with capacity to process an additional 30,000 tons per year of pulp production.[6]

The owner of the paper mill in Duluth (Verso Corp.) filed for bankruptcy protection in 2016, but operations resumed in 2017. In May 2019, MN omnibus jobs bill included a $2 million forgivable loan from MN Investment Fund for Verso Corp's Duluth mill. In June 2020, however, in response to the economic downturn caused by regulatory responses to COVID-19, Verso Corp indefinitely idled the paper mill in Duluth, which had employed 220 people.[7] The status of Verso Corp's $2 million forgivable loan requires maintaining 190 employees; restart of mill operations is uncertain at the time of this writing.[8]

Using the annual Public Stumpage Price Review compiled by the Minnesota Department of Natural Resources (DNR) as a reference, pulpwood sold for about $22/cord in 2018.[9]

2. Sawmills

Sawmills are the second largest wood consumer by volume in Minnesota. As of January 2018, there were 329 sawmills operating in the state, which consume about 612,000 cords (306 MMbf) of wood annually. In comparison, there were over 500 sawmills as of 2005.[10] Many smaller mills ceased operation after the decline in housing starts during the Great Recession.

While it may be surprising that 329 sawmills currently operate in Minnesota, the majority of these mills are small, portable bandsaw mills. In 2018, the 39 largest mills that consumed at least 2,000 cords (1 MMbf) annually accounted for 97% of total sawmill wood consumption.[11] Minnesota sawmills produce lumber, veneer, poles, piling, and cants (partially sawn logs), as well as other specialty products. Many of these products are sold locally. For instance, approximately **[TRADE SECRET DATA BEGINS...** ■ **...TRADE SECRET DATA ENDS]** of studs produced at the PotlatchDeltic mill in Bemidji are consumed in Minnesota, according to mill manager Wade Semeliss. Sawmills

[5] http://www.businessnorth.com/daily_briefing/upm-blandin-to-shutter-one-grand-rapids-paper-machine-cut-150-jobs/article_0fac28e6-b8ca-11e7-8e91-bf2ad7428a24.html

[6] Minnesota Department of Natural Resources Division of Forestry, and Resource Assessment, *Minnesota's Forest Resources* 2018, accessed January 2021: page 21.

[7] https://www.duluthnewstribune.com/business/manufacturing/6605873-Verso-continues-to-explore-options-for-idled-Duluth-paper-mill

[8] https://www.bizjournals.com/twincities/news/2020/07/29/duluth-scrambles-to-find-future-to-verso-mill.html

[9] Minnesota Department of Natural Resources Division of Forestry, and Resource Assessment, *Minnesota's Forest Resources* 2018, accessed January 2021: page 21.

[10] Minnesota Department of Natural Resources Division of Forestry and Resource Assessment, *Minnesota's Forest Resources* 2015, accessed January 2021: page 7.

[11] Ibid. Accessed January 2021: page 22.

primarily process softwood sawtimber such as spruce, pine, and fir species. According to the Minnesota DNR, sawtimber sold by public agencies averaged about $145 per thousand board feet (Mbf)[12] in 2019.

3. Engineered Wood Products

The number of mills specializing in engineered wood products has also declined over the past 10 years. Norbord is the only OSB production facility remaining in operation in Minnesota, down from four OSB facilities operating in 2006. Ainsworth Lumber, headquartered in Vancouver, B.C., had operated three OSB facilities. They permanently closed their Cook, Bemidji, and Grand Rapids mills in 2008, moving operations to Canada.[13] Again, the decline in new home construction during the Great Recession is mostly to blame. Mills were either permanently shut down or converted to a different use such as the Two Harbors mill owned by Louisiana-Pacific, which now produces engineered siding. The production of OSB, engineered wood siding, and other engineered wood products utilizes generally the same species and grade of logs sought by pulp and paper mills, including Aspen, Birch, Maple, and various softwoods. As mentioned, pulpwood sold by public agencies averaged about $22 per cord in 2018.

4. Secondary Manufacturers

Minnesota is home to hundreds of wood products manufacturers that utilize milled and reconstituted wood products for production of window and door components, cabinets, millwork, furniture components, and several other specialty products. In 2015, Minnesota ranked as the second largest wood window and door manufacturer by employment and was the fifth largest producer of wood kitchen cabinets and countertops.[14]

B. Other Sectors of the Wood Products Industry

Wood processing facilities are part of a larger forest products economy made up of interdependent segments, beginning with the forest resource. Foresters, loggers, haulers, mills, and retail customers are closely linked, as discussed in this section.

1. Forest Resource

Approximately one-third of Minnesota's land area is classified as forestland, containing an estimated 14.9 billion trees on 17.7 million acres of private, state, county, Tribal, and federal timberland.[15] Most of the forestland is located in the northern and eastern parts of the state. According to the United States Department of Agriculture

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[12] Minnesota Department of Natural Resources Division. 2019 Minnesota Public Agencies Stumpage Price Review and Price Indices. August 5, 2020. Page 4. A "board foot" is a unit of measure for the volume of lumber. It is the volume of a one-foot length of a board one foot wide and one inch thick. This unit of measure may be applied to processed lumber or unprocessed logs. Units are often expressed in "thousand board feet" or "Mbf." One "Mbf" equals one thousand board feet, one "MMbf" equals one million board feet, and so on.

[13] https://www.hbsdealer.com/news/ainsworth-permanently-closes-minnesota-mills

[14] Woodworking Network. "Where's the wood work? Top 10 states." http://www.woodworkingnetwork.com/wheres-wood-work-top-10-states (accessed March 21, 2017).

[15] United States Department of Agriculture, *Forests of Minnesota, 2019*, January 2021: page 1. Forestation increased from 14.5 billion trees on 17.4 million acres in 2014.

(USDA), only 0.97% of available timberland is harvested in Minnesota annually. The amount of forestland has been increasing since the early 2000s.[16]

Sustainable yet productive use of forestland is supported in several ways. In 2001, the Minnesota legislature passed the Sustainable Forest Incentive Act, which provides a financial incentive for forestland owners to practice long-term sustainable forest management. In addition, the Minnesota DNR offers the Forest Stewardship Program, providing advice and long-term forest management planning to landowners. National certification programs such as the Forest Stewardship Council and Sustainable Forestry Initiative are also available. All are aimed at conserving forest acres while encouraging sustainable use of the resource.

Wood products manufacturers are also well aware that helping to ensure a reliable local supply of wood amounts to an investment in the mill as well as the local economy and overall forest health. For example, all of PotlatchDeltic's Minnesota holdings (approximately **[TRADE SECRET DATA BEGINS...** [redacted] **...TRADE SECRET DATA ENDS]** acres of forestland) are certified by the Forest Stewardship Council.

According to the United States Department of Agriculture (USDA), 89% of wood processed by Minnesota mills in 2014[17] was harvested from forests within the state; this fraction appears stable through at least 2017 (Pers. Comm. Ron Piva, USDS USFS, January 2021).

2. Forestland Owners

Approximately 41.5% of Minnesota forestland is privately owned, 51% is owned publicly at the federal, state, county, and municipal levels, and the remaining 7.5% is owned by timber industry interests.[18]

Management of these forestlands varies by ownership. Lands may be managed for various forms of recreation, wildlife habitat, timber production, or not managed at all. Harvest levels are highest on state and county lands, which combine for 39.2% of total forestland but contribute 48% of the total harvest.[19]

Managing forestland for timber production benefits owners in many ways. Revenues create a dependable return on investments. Harvest revenues from public land are used to finance infrastructure, education, services, etc. Others rely on commercial timber harvest to help finance forest restoration or recovery after catastrophic failure. There are many trades that support forest management, such as planters, foresters, accountants, lenders, etc.

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[16] Ibid.

[17] United States Department of Agriculture, *Minnesota Timber Industry, 2014: Resource Update FS-156,* accessed January 2021: page 1.

[18] Minnesota Department of Natural Resources Division of Forestry, and Resource Assessment, *Minnesota's Forest Resources 2018*, accessed January 2021: page 13.

[19] Ibid., pages 13, 43.

3. Timber Harvest

Loggers carry out the harvest and rely on consistent markets for employment and investment. As of 2019, there were 714 loggers working in Minnesota, with total wages of $31.9 million.[20] In 2018, loggers harvested about 2.8 million cords of wood; preliminary 2019 harvest data suggest between 2.7 and 2.9 million cords were harvested.[21] OTP-EITE members together spend approximately $57 million annually to purchase timber.

4. Log Transportation

Logs are a product with a high weight to value ratio and must be transported to the mill with specialized log trucks. The 2019 harvest of 2.8 million cords equates to 420,000 truckloads of logs.[22] Hauling logs employs truck drivers, mechanics, fuel retailers, equipment dealers, etc.

5. Wood Products Processing Facilities

The logs are processed into a multitude of products at Minnesota facilities (as discussed in Section II.A), which employ roughly 20,378 people and pay $1.28 billion in wages.[23]

6. Product Transportation

Once the logs have been processed at sawmills, pulp mills, and reconstituted wood products plants, primary products are shipped for further processing, retail sales, or secondary manufacturing. Once again, the weight to value ratio is high and many of these products never leave the Midwest. In 2017, 37% of wood products manufactured in Minnesota were utilized in-state.[24] Products are shipped domestically by truck and rail, again employing truck drivers, engineers, mechanics, etc.

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[20] Data obtained through Quarterly Census of Employment and Wages (QCEW) data tool provided by the Minnesota Department of Employment and Economic Development at http://mn.gov/deed/data/data-tools/qcew/. Preliminary 2020 data suggest a decline to 856 loggers, though comparable wages; likely COVID-19 has impacted these figures.

[21] Minnesota DNR, Div. of Forestry, *Minnesota's Forest Resources 2018*, accessed January 2021.: page 2.

[22] Using conversion factor of 2.25 tons per cord, and assuming an average of 15 tons per load.

[23] Minnesota Employment and Economic Development, *wood product manufacturing* and *paper manufacturing* industries, as of 2015.

[24] Result computed from data downloaded from the Census Bureau Commodity Flow Survey: https://www.census.gov/programs-surveys/cfs.html. Accessed January 2021.

3. OVERVIEW OF WOOD PRODUCTS FACILITIES INCLUDED IN EITE RATE PROPOSAL

Continuation of the EITE rate is proposed for three wood product manufacturing facilities: the PotlatchDeltic sawmill, the Norbord OSB plant, and the Cass Forest Products sawmill in Northwestern Minnesota – OTP-EITE. Table 3-1 summarizes key elements of OTP-EITE.

Table 3-1. Contemporary operational data from PotlatchDeltic, Norbord, and Cass Forest Products facilities relevant to computing economic impacts and benefits of EITE rate. Note MMSF refers to area measure of OSB production, million square feet.

Mill Owner	Potlach	Norbord	Cass Forest Products	Total
Mill Type	Sawmill	OSB	Sawmill, Dimension	
County	Hubbard	Beltrami	Cass	
General Location	Bemidji	Solway	Cass Lake	
Employees	110	134	30	274
[TRADE SECRET DATA BEGINS...				
...TRADE SECRET DATA ENDS]				

† Excludes cost of raw materials

A. PotlatchDeltic Mill

The PotlatchDeltic sawmill is a softwood stud mill[25] located outside of Bemidji and currently employs 108 people. The mill consumed approximately **[TRADE SECRET DATA BEGINS...** [redacted] **...TRADE SECRET DATA ENDS]** of wood in **[TRADE SECRET DATA BEGINS...** [redacted] **...TRADE SECRET DATA ENDS]** and is by far the largest sawmill in the state. According to mill manager Wade Semeliss, approximately **[TRADE SECRET DATA BEGINS...** [redacted] **...TRADE SECRET DATA ENDS]** of the studs produced at the mill are consumed in Minnesota, with big-box retailers such as Home Depot, Menards, and Lowes serving as primary customers. The mill has been in operation for almost 30 years and is currently the only stud mill in Minnesota. The mill consumes sawlogs, with Red Pine accounting for about **[TRADE SECRET DATA BEGINS...** [redacted] **...TRADE SECRET DATA ENDS]** of all logs processed at the mill. The remaining species used in production include Balsam Fir, Jack Pine, and White Spruce.

Over the previous three years, the PotlatchDeltic mill has produced an average of **[TRADE SECRET DATA BEGINS...** [redacted] **...TRADE SECRET DATA ENDS]** of lumber annually. For perspective, the average single-family home requires about 12,000 board feet of lumber, meaning that every year, the mill produces the

[25] A "stud mill" is a sawmill specializing in the production of stud lumber.

equivalent amount of lumber required to build **[TRADE SECRET DATA BEGINS...** [redacted] **...TRADE SECRET DATA ENDS]** homes.[26]

The mill is owned by PotlatchDeltic Land & Lumber, LLC, which is a diversified forest products company based in Spokane, Washington. The company operates four sawmills and one plywood mill and has land holdings in Idaho, Wisconsin, Arkansas, and Minnesota. PotlatchDeltic currently owns about **[TRADE SECRET DATA BEGINS...** [redacted] **...TRADE SECRET DATA ENDS]** of timberland in Minnesota, which is managed as productive forestland and is also leased to the general public for recreation. These lands supplied only **[TRADE SECRET DATA BEGINS...** [redacted] **...TRADE SECRET DATA ENDS]** of the volume delivered to the PotlatchDeltic mill in 2020.

B. Norbord OSB Facility

The Norbord OSB facility is Minnesota's last remaining OSB plant. Producers of OSB are typically quite large entities, and the Norbord facility is no exception. The facility is located west of Bemidji and employs 134 people. Annual production during 2020 was **[TRADE SECRET DATA BEGINS...** [redacted] **...TRADE SECRET DATA ENDS]** of OSB on a 3/8" basis. With the average single-family home requiring approximately 9,800 square feet of structural panels, the Norbord facility produces enough wood paneling annually to build **[TRADE SECRET DATA BEGINS...** [redacted] **...TRADE SECRET DATA ENDS]** homes.[27]

Aspen is the primary species used in the production of OSB, while other species such as Birch, Maple, and various softwoods are also used. The Norbord facility consumed approximately **[TRADE SECRET DATA BEGINS...** [redacted] **...TRADE SECRET DATA ENDS]** in 2020. Finished products are shipped throughout the Upper Midwest and compete with OSB products manufactured in the Great Lakes Region, as well as eastern Canada and the U.S. South.

The mill is owned by Norbord Minnesota, LLC, which is an international producer of wood-based panels, with 15 plant locations in the U.S., Canada, and Europe. In contrast to PotlatchDeltic, Norbord does not own land in Minnesota outside of the OSB facility and depends entirely on public and private Minnesota forestland for wood.

C. Cass Forest Products Mill

The Cass Forest Products sawmill and dimensional lumber plant is located in Cass Lake and employs 30 people. The sawmill produces timbers, lumber, squares, finger jointed cut stock parts, heat treat squares, and lumber, among other custom products. Over the past three years, the sawmill has averaged **[TRADE SECRET DATA BEGINS...** [redacted] **...TRADE SECRET DATA ENDS]** of annual production and consumes about **[TRADE SECRET DATA BEGINS...** [redacted] **...TRADE SECRET DATA ENDS]** of logs. Cass Forest Products is structured as an employee-owned company through an employee stock ownership plan, and the company has owned and operated the Cass Lake mill for over 30 years. Finished products are sold primarily in-state, and the mill uses wood sourced entirely from Minnesota forestland.

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[26] McKeever, David and Joe Elling. "Wood products and other building materials used in new residential construction in the United States, with comparison to previous studies 2012" PDF File. *USDA Forest Service, Forest Products Laboratory*. June 2015. https://www.fpl.fs.fed.us/documnts/pdf2015/fpl2015mckeever001.pdf (accessed March 27, 2017).

[27] Ibid.

4. WOOD PRODUCTS MANUFACTURING BENEFITS TO LOCAL ECONOMY AND THE STATE

Our task is to compare the benefits to the state provided by the PotlatchDeltic, Norbord, and Cass Forest Products facilities to the cost that will result from the EITE rate. According to the OTP filing, the proposed electricity cost discount of 20%, as applied to all three facilities, will result in a total redistributed cost of $1,015,245.[28]

In the following sections, we first quantify the total economic benefits provided by OTP-EITE. We then compare those benefits to the redistributed cost. Finally, we provide a qualitative evaluation of additional benefits provided by the three facilities.

A. Economic Benefit Calculation

The combined PotlatchDeltic, Norbord, and Cass Forest Products facilities produce about $248 million in gross sales, directly provide 274 jobs, and pay $4.3 million in state and local taxes (Table 3-1). These figures constitute the direct economic contribution of these three companies to the economy of Minnesota.

The total economic impact that can be attributed to these three mills also includes indirect and induced economic activity. For procedures to estimate indirect and induced effects, we refer to:

1. A 2010 study conducted by the University of Minnesota Duluth Labovitz School of Business, hereafter the Labovitz study, used originally in the EITE filing from 2017.[29]
2. A 2020 Economic Contribution Study of Minnesota Agriculture and Forestry, by Decision Innovation Solutions, hereafter the DIS study,[30] providing contemporary multiplier values.

In theory, we could use the IMPLAN input-output model from either the Labovitz study or the DIS study to estimate the direct contribution from the subject mills. The three subject mills have reported actual direct contributions, however, so we will use these more accurate figures in this analysis.

We adopt the methodology from the Labovitz study, updated with new output data from the three facilities and IMPLAN multipliers from 2018 from the DIS study, to estimate the indirect and induced impacts associated with the direct impacts directly reported by the subject mills. Since we are only using multipliers, there is no need to account for inflation.

We reviewed multipliers from the DIS study for three kinds of economic activity, and confirmed that these values are in line with the Labovitz study, allowing for macroeconomic shifts that occurred between 2007 and 2018:

> **Value added** – a measure of the contribution to the local community that includes wages, rents, interest, and profits. We use the value-added Type SAM multiplier for Sawmills and Wood Preservation (2.99) for

[28] Petition at Attachment 1.

[29] UMD Labovitz School of Business and Economics, 2010, *The Economic Impact of Minnesota's Forestry Related Industries on the State of Minnesota,* Bureau of Business and Economic Research, August 2010.

[30] AgriGrowth, 2020, 2020 Economic Contribution Study of Minnesota Agriculture and Forestry, September 2020. Prepared by Decision Innovation Solutions.

PotlatchDeltic and Cass Forest Products, and the Reconstituted Wood Product Mfg (2.02) for Norbord. (These multiplier values were received via email communication from Decision Innovation Solutions, January 21, 2021; the IMPLAN version was downloaded in 2020, and represents multipliers released originally in 2018). The analogous multipliers are found on page 30 of the Labovitz Study, but those values derive from a 2007 version of IMPLAN. We apply the most contemporary 2018 IMPLAN multipliers against the actual Total Wages shown in **Table 3.1** above. We consider the result to be a conservative estimate of total value added as we are not including taxes paid by the subject companies in the calculation.

Output – a measure of the value of local production required to sustain the current economy. We use the 2018 IMPLAN output total Type SAM multiplier for Sawmills and Wood Preservation **[TRADE SECRET DATA BEGINS...** [redacted] **...TRADE SECRET DATA ENDS]**. We apply these multipliers against the actual Total Sales shown in **Table 3.1** above.

Employment – the number of jobs. **Table 3.1** reports jobs in terms of Full-Time Equivalents (FTEs) for the subject companies. We use the Type SAM multiplier for Sawmills and Wood Preservation (3.69) for PotlatchDeltic and Cass Forest Products, and the Reconstituted Wood Product Mfg (3.05) for Norbord (Pers. Comm. DIS, January 21, 2021). We apply these multipliers against the actual Employment shown in **Table 3.1** above.

Table 4.1 shows the actual employment, value added, and output as reported by the subject companies, along with the IMPLAN-based estimate of statewide impacts.

Table 4-1. Economic impact of PotlatchDeltic, Norbord, and Cass Forest Products facilities in the state of Minnesota, calculated using IMPLAN multipliers from 2018.

Mill Owner	Actual	Multiplier	Total
Value Added Total	$ 26,132,435	2.48	$ 64,749,981
[TRADE SECRET DATA BEGINS... [redacted] ...TRADE SECRET DATA ENDS]			
Output Total	$ 248,216,400	1.87	$ 463,120,408
[TRADE SECRET DATA BEGINS... [redacted] ...TRADE SECRET DATA ENDS]			
Employment Total	274	3.38	926
Potlatch	110	3.69	406
Norbord	134	3.05	409
Cass	30	3.69	111

B. Comparison of Benefits to Costs

This is the second time that OTP seeks favorable EITE rates for the three wood-processing facilities. In its 2017 ruling, the Commission found that OTP's analysis was sufficient to demonstrate a net benefit to the utility. That ruling identifies the difficulty of demonstrating the certainty that the benefits will occur and sets a standard of reasonable likelihood that the net benefits will occur:

> *The Commission concludes that Otter Tail has identified the relevant potential benefits and costs to the utility and has quantified them to the extent practicable. The Company estimated that, if the EITE Customers were to shut down and leave its system, it would experience an annual revenue shortfall of $2,571,126 (derived from expected EITE Customer sales net of avoided EITE Customer costs). In the short run, this cost would be borne by Otter Tail; in the longer term, it would be redistributed among the Company's remaining customers in a rate case.*
>
> *It is impossible to say with certainty that a 20 percent discount—or any other amount—will keep the EITE facilities open. However, the parties agreed that the relevant standard is whether the identified net benefit is reasonably likely to occur, not whether it is certain. The Commission concurs, and finds that under the circumstances of this case, there is a reasonable likelihood that the discount will more likely than not increase the probability that the EITE facilities will continue to operate at current or high levels, remain on Otter Tail's system, and realize the net benefit identified by Otter Tail.*[31]

We use the reasonable likelihood standard for our analysis of benefits to the state.

The benefit of the rate reduction for the OTP-EITE companies is that with lower rates, the firms are more likely to be able to stay in business. The wood products industry is very susceptible to economic downturns and many companies shut down operations during down cycles, some to never reopen. Our analytical approach, therefore, compares the benefits and costs to establish the likelihood that the continued power cost savings would contribute to keeping the subject mills open.

For our calculation, we consider cost to be the power costs transferred from the OTP-EITE members to the rate payers. This is $1,015,245 annually, or an average increase of 0.57% distributed equally across all OTP ratepayers. This equates to an annual increase of $3.53 per residential customer, on average. To estimate the direct, indirect, and induced economic impacts, we multiply the total cost of $1,015,245 by 1.87, the average output multiplier shown in Table 4-1 above. Applying the multiplier to the redistributed rate yields a total cost of $1,898,508. Note that the 1.87 multiplier probably overestimates the multiplier for residential customers – basic industries typically have a higher multiplier than secondary or support sectors. Use of the 1.87 multiplier therefore makes our analysis conservative.

For the benefit side of our calculation we rely on the total output of the OTP-EITE members, as shown above in Table 4-1. This is the direct, indirect, and induced economic activity in the state of Minnesota that can be attributed to OTP-EITE, and totals $463,120,408. Were these mills to shut down, the IMPLAN model indicates that the State's economy would decline by this amount.

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[31] Minnesota Public Utilities Commission, 2017, *Order Approving EITE Rate and Establishing Cost-Recovery Proceeding,* Docket No. E-017/M-17-257, November 17, 2017.

The economic benefit associated with continued operations of the OTP-EITE members outweighs the cost of re-distributing the rate, and if there was a 100% chance that the OTP-EITE members would disappear without the lower rate, the wisdom of granting the petition would be indisputable.

Unfortunately, such certainty is not present in this case. The OTP-EITE members are still in business with the current EITE rate. The real question is whether there is a reasonable likelihood that continuation of the EITE rate would increase the probability that the OTP-EITE members could remain viable in the long term. Clearly, lower electric rates would lower costs for the three mills, and *ceteris paribus*, make these three mills more competitive, leading to a better chance that they would survive in a downturn.

We cannot answer how much the probability of a successful outcome would increase as a result of continuation of the EITE rates. But we can calculate a threshold value delineating at what probability the benefits outweigh the costs.

The ratio of benefits to costs yields a probability that can be tested against the "reasonable likelihood" standard. In this case, the ratio of cost to benefit (or $1,898,508:$463,120,408) is 0.0041 or 0.41%. In other words, the benefits of keeping mills open will exceed the cost if there is at least a 0.41% chance that the rate reduction will keep the OTP-EITE mills in business. In our view, a 0.41% threshold certainly meets the "reasonable likelihood" test.

This part of our analysis is based entirely on economic benefits that can be quantified, and that can be derived from the IMPLAN input-output model. The subject mills provide many other benefits. Some can be quantified but could not be included in the above calculation. Others are quantified and are included in the above calculation, but merit further discussion. Finally, there are some benefits that can be identified but not quantified. The remainder of this section discusses these additional benefits.

C. Qualitative Evaluation of Benefits

In the section above, we compared the total economic output for the Forest Product Group to the total economic output that might be associated with the cost of the rate reduction. There are other economic impacts that merit discussion. Some of these are perhaps included in the economic output but are highlighted because we believe that they should be considered beyond the simple dollar contribution to outputs. Others are included because they have an impact that may not be included, or fully included, in the contribution to economic output.

1. Employment Benefit

The PotlatchDeltic, Norbord, and Cass Forest Products facilities directly employ 274 people. According to the methodology from the Labovitz Study, updated using 2018 IMPLAN multipliers from the DIS study, the economic impact to the state in terms of employment is quite large. Applying the multipliers to the three mills indicates that 926 jobs are impacted by these facilities.

The PotlatchDeltic, Norbord, and Cass Forest Products operations offer living-wage manufacturing jobs in the local community. Located within 25 miles of one another, the three mills reside in Beltrami, Cass, and Hubbard Counties. According to data obtained from Minnesota Employment and Economic Development, these counties combined for 2,450 total manufacturing jobs as of 2019, including 542 wood products manufacturing jobs overall (including other facilities beyond the three analyzed in this petition). As such, the three mills represent 11% of all manufacturing jobs and half of the wood products manufacturing jobs in the three-county area. If these mills were

to shut down, it is highly unlikely that the other facilities could absorb the laid-off workers or sustain the timber harvest levels necessary for responsible management of the regional forest resource.

As shown in Table 4-2, manufacturing jobs (especially wood product manufacturing jobs) pay higher wages on average. From Table 3-1, we calculate that the payroll and benefits for these three OTP-EITE customers average $93,665 per year, which is substantially more than the sector as a whole. The loss of these particular jobs would have disproportional economic consequence not only on these families, but on the communities in which they reside. Again, if these three mills shut down, it is unlikely that the displaced workers could earn as much in other jobs in the wood products manufacturing sector, where the average annual wage is $58,091, and in all manufacturing industries where the average annual wage is just $37,476 (Table 4-2).

Table 4-2. Employment and average wages in Beltrami, Cass, and Hubbard Counties (private industry 2019).[32]

Category	2019	
	Employment	Average Wage
Total, All Industries	26,313	$ 37,476
Manufacturing	2,450	$ 45,135
Wood Product Manufacturing	542	$ 58,091

Statewide, the reconstituted wood products manufacturing sector, which includes manufacturers like the Norbord Mill, support approximately 425 direct jobs in Minnesota. Using methodology from the Labovitz study and updated IMPLAN multipliers from the DIS study, these jobs support a further 870 jobs for a total employment impact of 1,295 jobs (representing the average of 2019 and 2020). By analogous methods, the value-added contribution of this manufacturing sector to Minnesota's economy averaged $65.8 million in 2019 and 2020.

2. Benefit to Forestland Owners

The three facilities that are the subject of this analysis are situated near the western edge of the northern Minnesota wood basket. In 2016, the mills consumed more than a half-million cords of wood, which constitutes a significant share of wood demand west of the Arrowhead Region. The price of stumpage[33] is directly impacted by demand for logs attributed to these mills. For instance, sawlogs sell at a premium over pulpwood logs as they are made into higher value products at sawmills such as PotlatchDeltic and Cass Forest Products. Using the annual Public Stumpage Price Review compiled by the Minnesota DNR as a reference, sawlogs sold for $147/Mbf ($73.60/cord) in 2019; pulpwood sold for $22/cord in 2019. If not for the sawmill industry, Red Pine and other softwoods would be valued and purchased as pulpwood, at a substantially reduced price. PotlatchDeltic estimates

[32] Data obtained through Quarterly Census of Employment and Wages (QCEW) data tool provided by the Minnesota Department of Employment and Economic Development at http://mn.gov/deed/data/data-tools/qcew/. Average wage is calculated by dividing total wage by total employment.

[33] Stumpage value is the value of standing timber, prior to being harvested and transported. It is the price a timber buyer will pay a landowner, with consideration given to costs such as logging and hauling.

that nearly **[TRADE SECRET DATA BEGINS...** [redacted] **...TRADE SECRET DATA ENDS]** of Red Pine sold by public agencies is destined for its Bemidji stud mill.[34]

Norbord is the only large user of pulpwood located in northwest Minnesota and one of only **[TRADE SECRET DATA BEGINS...** [redacted] **...TRADE SECRET DATA ENDS]** large mills in a 100-mile radius that buy **[TRADE SECRET DATA BEGINS...** [redacted] **...TRADE SECRET DATA ENDS]**. The value of pulpwood in northwest Minnesota is dependent on these three mills. Further, the Norbord facility is located furthest to the west and buys wood from areas that would otherwise require long haul distances to competing facilities. Without the Norbord facility, the price for pulpwood in northwest Minnesota would decline. For instance, we estimate that only the Norbord and Blandin facilities can economically buy pulpwood from an area of about 1.2 million acres to the southwest of Bemidji. (Note: Blandin's recently reduced capacity makes Norbord's fiber demand even more important.) Norbord's shorter haul distance creates a better market for forestland owners interested in selling pulpwood in this area. Figure 4-1 identifies all the major users of Aspen trees in Minnesota, which is the primary source for pulpwood. There are five total mills, consisting of one OSB plant (Norbord), three paper/pulp mills (Blandin, Boise, Sappi), one engineered siding facility (Louisiana Pacific), and one proposed siding facility (Louisiana Pacific). As of June 2020, the Verso mill at Duluth has been idled indefinitely, leaving five operational mills in this region.

[34] PotlatchDeltic 2021 Affidavit.

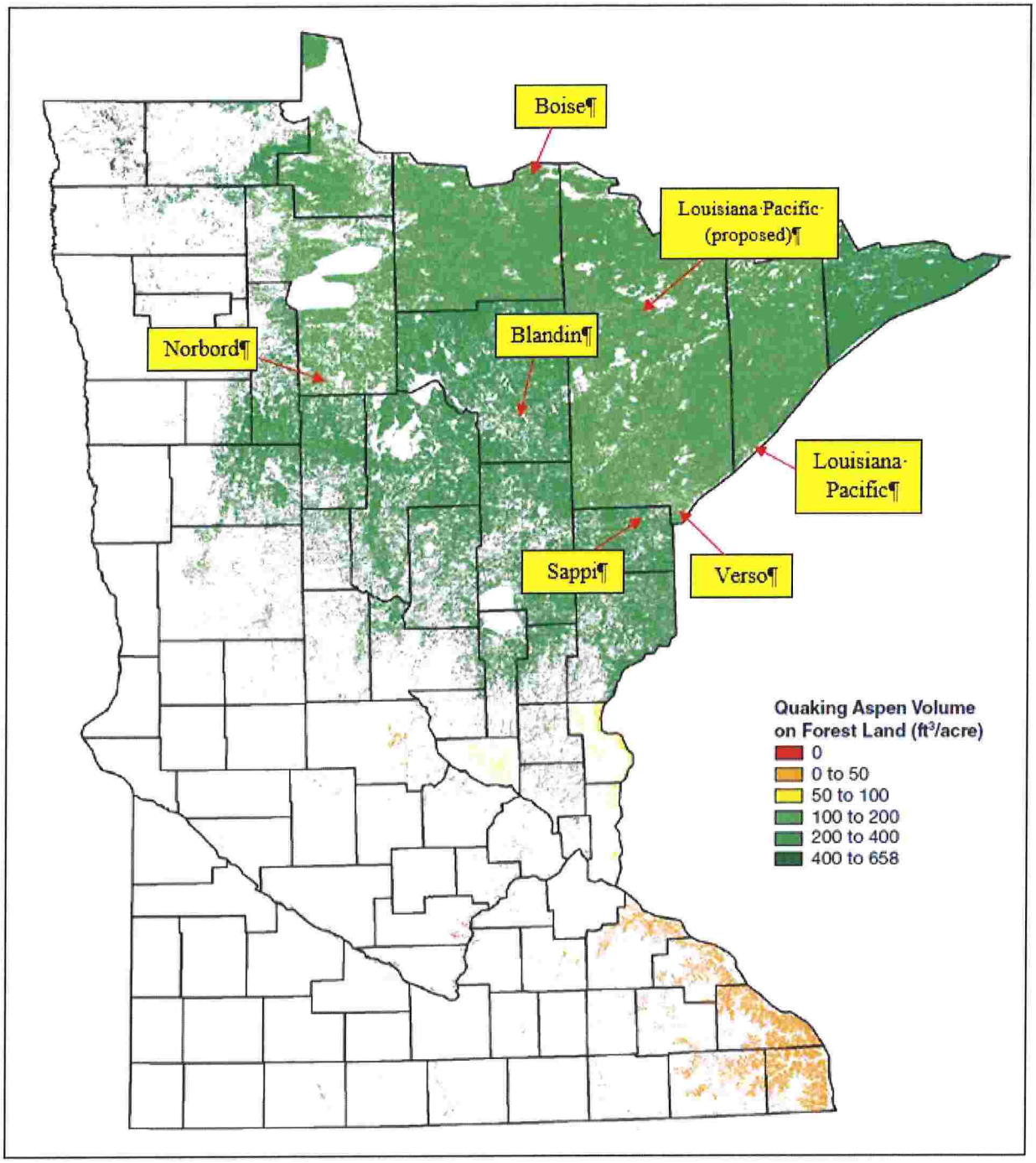

Figure 4-1. Minnesota Aspen forest map, locations of large pulpwood mills indicated with red arrows.

OTP-EITE members source wood from private lands, as well as public lands under federal, state, and county control. Below, we discuss the impacts on each group in more detail.

Private Timberland Owners

As of 2017, and filed in our 2017 report, private timberland supplied 34% of the wood consumed by OTP-EITE. Private timberland owners in Minnesota may choose to sell standing trees for a variety of reasons. Timber harvest allows landowners to shape their property toward management goals - for example, creating a mix of young and older forest to support a variety of wildlife species. Timber sales help to offset costs associated with these forestland management activities. In addition, income from timber sales may be applied toward annual property taxes. Some private timberland owners regard their timber resource as an economic asset that can be used to finance a college education, retirement, etc.

Were the Forest Product Group mills to drop out of the log market, private timberland owners would face a market with lower prices. There would be a direct reduction in the value of their assets, and they would have fewer options for managing their lands.

State-Owned Timberland

Timberland managed by the state is the second largest source of wood at the PotlatchDeltic and Norbord mills. Approximately 4.2 million acres[35] of forestland is managed by the Minnesota DNR Forestry Division. The land is spread out among 59 State Forests, and also includes 1.5 million acres of forested School Trust Lands. State land is well managed, certified under two different systems. In 2019, stumpage sales from DNR lands were $18.7 million.[36] Beginning in 2017 the DNR more than tripled sawtimber harvest by volume, from 2,711 Mbf in 2016 to 8,435 Mbf in 2017, with most of the increase in sales of red and white pine. Higher sawtimber sales correspond to the time period during which the first EITE utility rate came into effect, underscoring the positive impact of this rate on timber management. Net revenue from timber sales conducted on School Trust Lands is given to the Permanent School Fund. Interest and dividends from the fund are distributed to Minnesota school districts biannually, which amounted to $25.39 million per year in 2019.[37] In 2019, net timber revenue from School Trust Lands was $3.77 million.[38]

Without the subject mills, a portion of the State timberlands would face lower prices–sawtimber would be sold at lower prices as pulpwood, and haul costs would increase on some acres, resulting in a lower net return to the State.

County-Owned Timberland

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[35] Minnesota Department of Natural Resources. "Division of Forestry." http://dnr.state.mn.us/forestry/index.html (accessed January 14, 2021).

[36] Minnesota Department of Natural Resources, *2019 Minnesota Public Stumpage Price Review and Price Indices*, accessed January 2021: page 30.

[37] Minnesota Department of Natural Resources. "School Trust Lands." http://www.dnr.state.mn.us/aboutdnr/school_lands/revenue.html (accessed March 12, 2017).

[38] Minnesota's School Trust Lands: FY18-19 Biennial Report. Accessed January 2021. Page 20.

County-owned timberland is also a major supplier of wood for the EITE mills. Northern Minnesota counties benefit substantially from timber sales. For example, Beltrami County manages 147,500 acres of forestland[39] and conducts timber sales consistent with their long-term forest management plan. Table 4-3 lists the top counties benefiting from the sale of timber in 2015, according to the Minnesota DNR.[40]

For perspective, we have expressed timber revenue as a share of total revenue from all sources for each of the counties (property taxes, federal grants, state aid, etc.), as reported by the Minnesota State Auditor.[41] Revenue from timber sales as a percent of total revenue ranges from 0.42% to 8.23% and averages 1.74 (Table 4-3)%. Timber revenue is instrumental to providing services, especially in Hubbard County and nearby Aitkin County, where timber sales account for 8.1% and 5.4% of total county revenue, respectively. As with state-owned timberland, much of the county-owned timberland is certified under one or both of the certification systems.

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[39] Beltrami County, Minnesota. "Forest Management." http:/www.co.beltrami.mn.us/Departments/NRM/Forest%20Mgmt.html (accessed March 12, 2017). http://www.co.beltrami.mn.us/Document%20Center/Documents%20Forms/NRM/Forest%20Management%20Plan.pdf, accessed January 2021: pages 1, 10.

[40] Minnesota Department of Natural Resources, *2019 Minnesota Public Stumpage Price Review and Price Indices*, accessed January 2021: pages 14-26.

[41] State of Minnesota Office of the State Auditor, *Minnesota County Budgets, 2020 Summary Budget Data Together With 2019 Revised Summary Budget Data, accessed January 2021*: Appendix 1, pages 13-30.

Table 4-3. Summary for 2019 of timber sale revenue and share of total revenue for thirteen northern Minnesota counties.

County	Timber Sale Revenue	Total Revenue	Share of Total Revenue
Aitkin	$1,020,699	$31,501,320	3.24%
Becker	$255,257	$52,020,158	0.49%
Beltrami	$935,126	$82,828,813	1.13%
Carlton	$267,854	$63,972,327	0.42%
Cass	$2,169,772	$59,449,100	3.65%
Clearwater	$338,635	$27,510,645	1.23%
Crow Wing	$886,502	$84,819,556	1.05%
Hubbard	$1,163,911	$38,895,426	2.99%
Itasca	$3,108,272	$141,792,404	2.19%
Koochiching	$2,522,230	$30,639,956	8.23%
Lake	$336,985	$29,112,733	1.16%
Pine	$596,736	$45,708,466	1.31%
St. Louis	$4,033,511	$323,661,681	1.25%
Total	**$17,635,490**	**$1,011,912,585**	**1.74%**

Timber sales in the 13 northern Minnesota counties totaled $17.6 million in 2019 (Table 4-3). Should any of the subject sawmills close, declining timber sales would be further reduced.

Again, without the subject mills, a portion of the County timberlands would face lower prices–sawtimber would be sold at lower prices as pulpwood, and haul costs would increase on some acres, resulting in a lower net return to the Counties.

4. Contribution to Forest Health

Timber sales provide funding for forest management activities that may be tailored to benefit wildlife by creating a balance of young and old forests and/or creating forest conditions that are favorable to various wildlife species.

Furthermore, Minnesota wood products manufacturers in general, and OTP-EITE in particular have played an important role in salvage operations after wildfire and blowdown events. According to a study by the University of Minnesota, timber salvage accounted for 11% of all timber sales conducted by the state from 2010-2014.[42] A recent example is the Palsburg Fire of 2015. The fire occurred in Beltrami Island State Forest in northwest Minnesota and burned about 4,500 acres of primarily Red Pine and Jack Pine forest.[43] Approximately 40,000 cords of wood were salvaged, with most of the wood being purchased by the PotlatchDeltic and Norbord facilities. Pulp mills cannot accept wood with any char, so mills such as these are the only ones that can process fire-damaged

[42] University of Minnesota, and Department of Natural Resources, "A Characterization of Timber Salvage Operations on Public Forests in Minnesota and Wisconsin", October 27, 2016: page 6.

[43] Dokken, Brad. "After April 2015 fire, MN's Beltrami Island Forest on the rebound." *Grand Forks Herald*, October 17, 2016.

timber. The cleanup paved the way for DNR foresters to implement a replanting plan, and also minimized the potential for pine bark beetles to populate the area and spread into neighboring pine forests.

In 2011, a severe storm event in east central Minnesota with wind speeds as high as 80 to 100 miles per hour damaged 97,000 acres of state forests in the St. Croix River Valley, including 13,000 acres of St. Croix State Park.[44] As noted by the DNR, the damaged trees would eventually become a wildfire hazard and a breeding ground for forest pests and disease. Instead, sales of timber salvage provided "the most efficient method to mitigate blow-down hazards."[45] The DNR completed timber sale contracts with loggers to harvest the trees on 5,303 acres within the state park, in addition to salvage operations in nearby state forests. OTP-EITE participated along with several other mills by purchasing this salvaged wood and making economic use from an otherwise disastrous event.

5. Value to the Community

The mills also provide other benefits to the community that are not easily measured by conventional economic metrics. All three mills engage in charitable donations. Employees are active in the community, performing various civic duties and filling volunteer positions. While these benefits to the local community cannot be measured in dollars, they are real, nonetheless.

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[44] Minnesota DNR. "The St. Croix Valley Blowdown" PDF File.
http://www.dnr.state.mn.us/state_parks/st_croix/slideshow_storm.html (accessed March 16, 2017).

[45] Ibid.

5. SUMMARY AND CONCLUSION

OTP-EITE accounts for at least $463 million in economic output in the state of Minnesota. The proposed rate reduction will transfer about $1 million of direct costs to other ratepayers. After cycling through the economy, the cost accounts for about $1.9 million of economic output.

Comparing total benefits to total costs suggests that if there is more than a 0.41% chance that the rate change would keep the OTP-EITE facilities economically viable, then the proposal is reasonably likely to provide a net benefit to the state of Minnesota, as required by the EITE statute and Commission precedent.

As part of the larger forest products sector, OTP-EITE provides benefits that go beyond the calculation above. The long-term survival of OTP-EITE mills provide additional economic benefits that may not be fully incorporated into the analysis above, but ought to be considered in the decision. These additional benefits include:

1. Providing above-average-wage jobs for 274 employees. These employees contribute time, energy, and commitment to their communities.
2. Providing superior log prices to forestland owners that include, families, state, municipal, and Tribal timberland owners. These revenues fund government programs and services, and help private landowners manage their lands and provide funding for college, retirement, etc.
3. Providing state and local taxes that support programs and services important to the citizens of Minnesota.
4. Providing for forest health through active management of forest stands, and salvage of catastrophic mortality.

Appendix A

CV for Mark Rasmussen

CV for Tom Baribault

Mark Rasmussen

Senior Forest Planning Economist / Principal

Mark heads MB&G's Forest Planning and Economics Group, which consists of economists, planners and modelers. He directs the company's work related to forest economics, forest land management planning, timber and product market analysis, timberland acquisition and public land management policy. Over the last 25 years, Mark has been involved with long-term planning and/or appraisal on nearly 240 timberland properties totaling more the 78 million acres of private, federal, state and tribal timberlands. Mark also serves on the Oregon Governor's Council of Economic Advisors.

Education

M.S., Forest Science/Economics, (Thesis: Two conceptual approaches to land allocation in NFMA forest planning), Utah State University

B.S., Environmental Studies (Minor in Economics), Utah State University, Graduated Valedictorian of the College of Natural Resources, Nominee Robins Scholar of the Year

Years of Experience

41

Certificates and Memberships

- Member of the Society of American Foresters.
- President of Western Forest Economists, Inc., 1989. Member of the Board of Directors, 1989 to present
- Member of Oregon Governor's Council of Economic Advisors
- Western Forestry and Conservation Association Board Member

Proficiencies

- Forest Valuation
- Timber Harvest Scheduling
- Land Management Planning
- Forest Economics and Market Analysis
- Forest Policy Analysis
- Expert Witness

MB&G Project Experience

Project Manager, 2019 to present, Forest Plan Modeling for Michigan Department of Natural Resources. Design and build forest management modeling software to assist MDNR in strategic and operational planning for 4 million acres of state timberland.

Project Manager, 2020 to present, Chelan County Economic Development. Assist the County in identifying and evaluating proposals to develop new wood product manufacturing opportunities located in the County.

Project Manager, 2020, Financial and Economic Impacts of Washington DNR HCP for Marbled Murrelet. Identify the local economic impacts on Counties and Taxing Districts of DNR's efforts to comply with the Endangered Species Act.

Consultant to the Council of Forest Trust Land Counties, 2000 to present. Provide County Commissioners with insight and advice about management of 600,000 acres of State Forest Trust Lands.

Project Manager, 2018-2020, Economic Analysis of OSU Proposal for the Elliott State Forest. Project costs and revenues of proposed research activities to be conducted by OSU after its acquisition of the 80,000 acre Elliott State Forest.

Supervising Principal, 2020, Analysis of Forest Restoration Lake Tahoe Areas, The Nature Conservancy. Project economic costs and benefits of increased forest management activity designed to address forest health issues on 1.5 million acres around Lake Tahoe.

Lead Investigator, 2019, High Hazard Fuels Availability Study. Evaluate the supply and cost of biomass fuel available to seven BioRAM powerplants in California. Identify obstacles to fuel supply and forest restoration.

Supervising Principal, 2017 Analysis of Forest Restoration, The Nature Conservancy. Estimate the volume, value and costs of harvest designed to address TNC's Eastern Washington forest health initiative.

Expert Witness, 2017 US Lumber Coalition. Estimated the market value of Canadian timber harvested in British Columbia and Alberta as part of the counter-vailing duty petition.

Supervising Principal, 2017 Sustained Yield Calculation for Minnesota Department of Natural Resources. Analysis of harvest opportunities and tradeoffs for 4 million acres of timberland managed by Minnesota DNR.

Project Manager, 2015 Tongass NF Forest Plan Revision, US Forest Service. Using the information developed for TNC (see below) we built a new forest management model for the Tongass National Forest, including both Young Growth and Old Growth acres. We did the analysis required to support evaluation of six forest plan alternatives.

Project Manager, 2014 Tongass NF Young Growth Sustainable Harvest, The Nature Conservancy. MB&G is calculated the sustainable yield from the TNF young growth resource under a set of management scenarios designed by TNC.

Project Manager, 2014 Western Oregon BLM Forest Plan Revision, BLM. MB&G supported BLM's efforts to revise its Plan by performing the long term timber harvest scheduling analysis for five plan alternatives on six separate Districts covering 2.5 million acres in Western Oregon. MB&G complied and stratified inventory data, made yield projections under a large number of different timber management regimes, projected a variety of forest condition descriptors, and built the timber harvest scheduling models and did the analysis to support the planning effort.

Project Manager, 2014 Montana Department of Natural Resources and Conservation Sustained Yield Calculation, MT DNRC. MB&G made the sustained yield calculation (SYC) for DNRC's 750,000 acres of forest trust land. MB&G will compile inventory data, stratify the land base, project yields and forest conditions and build a timber harvest scheduling model for each of DNRC's 13 Units. MB&G performed a similar project for DNRC in 2004.

Indian Forest Management Assessment Team, 2013. Served as a member of a team tasked with reporting to Congress about the condition and needs on 18.6 million acres of Indian forest land on 334 reservations. Visited 20 reservations, conducted surveys, collected and analyzed resource and financial data. This was the third such report to Congress, required by the National Indian Forest Resource Management Act.

Project Manager, 2012 Forest Report, Oregon. MB&G led the team that analyzed and reported on the economic contribution of Oregon's forest and wood products manufacturing sector. The 193-page report addressed forest resources and conditions, employment and income in the forest sector, trend, opportunities and challenges facing Oregon's forest sector.

Project Manager, Eastside Oregon Forest Restoration, 2012. Prepared at the request of Governor Kitzhaber and Legislative leaders, this report assessed current forest restoration efforts of the US Forest Service in Eastern Oregon, and estimated the economic cost and benefits of doubling the pace. The Legislature subsequently appropriated funds to help increase the restoration effort.

Project Manager, Support to Governor's Panel on O&C Lands, Western Oregon. MB&G led the analysis team supporting the Panel's effort to evaluate alternatives for managing the 2.5 million acres of BLM O&C trust land. MB&G provided quick turnaround of eight different policy alternatives designed by the Panel.

Project Manager, Valuation of O&C Lands, Feasibility Analysis of O&C Trust Proposal, Western Oregon. MB&G worked with Dr. John Sessions to provide the O&C Counties with a market value for the younger half of the 2.5 million acres of BLM forest land in Western Oregon. On a subsequent project, worked with Dr. John Sessions and Dr. John Gordon to

evaluate the financial feasibility of managing the 2.5 million acres as a public trust under a relaxed set of management objectives.

Project Manager, Bureau of Land Management (BLM) Western Oregon Plan Revision, Oregon. MB&G provided the BLM with an ID Team Leader, socioeconomic impact analysis, and a Writer/Editor for the EIS supporting the forest plan for 2.5 million acres in Western Oregon. Mark managed MB&G's efforts and led the team of scientists responsible for the socioeconomic impact analysis. That analysis provided estimated sector level employment and income impacts in each of 18 counties.

Project Manager, Idaho Department of Lands (IDL), Asset Management Planning, Idaho. Mark designed the timber harvest scheduling analysis tools used by IDL to create, evaluate and select forest management plans that meet the Agency's fiduciary responsibility to state forest trust beneficiaries. MB&G builds the models, does the analysis and helps foresters on each the 13 supervisory areas to explore management opportunities.

Project Manager, Oregon Department of Forestry (ODF) Forest Management Plan, Western Oregon. Mark served on the ODF Core Team, charged with designing and building a long-term forest management model reflecting ODF's commitment to structure-based management. MB&G helped ODF in planning process, such as designing silvicultural regimes, projecting yields to analyzing model results, and identifying policy issues for the Department and its stakeholders. MB&G assisted with the final report for the Board of Forestry.

Project Manager, Forest Plan for the Umatilla Indian Reservation Forest, Confederated Tribes of the Umatilla Indian Reservation (CTUIR), Eastern Oregon. MB&G helped CTUIR prepare a long-term forest management plan consistent with the Bureau of Indian Affairs forest planning regulations. MB&G built the forest management model, did all of the analysis of forest vegetation conditions, prepared the Environmental Assessment, the Forest Inventory Analysis and the Forest Management Plan.

Project Manager, US Forest Service Forest (USFS) Plans, Nationwide. Over the past five years, MB&G has assisted the USFS on preparing revisions to the National Forest Management Act (NFMA) forest plans on 16 national forests and on the Savannah River Site. In total, these forests cover over 20 million acres.

Project Manager, Wahkiakum County Sustained Yield Calculation, 2003 to 2006, Wahkiakum County, Washington. MB&G has assisted the County Commissioners in their effort to obtain a favorable result from the Washington Department of Natural Resources' sustained yield calculation for the County's Forest Board Transfer Lands. As part of that ongoing project, MB&G provided the Commissioners with an independent valuation of those lands. MB&G has also helped the County work through the Habitat Conservation Plan (HCP) strategies for the marbled murrelet.

Project Manager, Sustained Yield Calculation and Habitat Conservation Plan (HCP), 2004-2010. Montana Department of Natural Resource and Conservation (DNRC), Statewide Montana. Mark prepared the legislatively required Sustained Yield Calculation (SYC) for Montana's 726,000 acres of state-managed trust forest lands. Working with a State team of specialists, MB&G prepared the inventory data, built a long term forest management model that scheduled harvests while meeting all pertinent laws and regulations. He prepared the final SYC report and presented it to the State Land Board. Leveraging that work, he then projected future harvests, revenues and forest habitat conditions in support of DNRC's efforts to negotiate a Habitat Conservation Plan with the US Fish and Wildlife service. Mark served as

the forest vegetation work group leader and prepared portions of the Environmental Impact Statement (EIS) and HCP.

Experience Prior to Employment with MB&G

1987-1996, Timber Data Company, *Forest Economist.*

Collected, edited, analyzed and reported data about timber sold from public lands. Prepared a variety of standard and special reports about public timber sale activity. Edited and published the monthly *Stumpage Price Report*, quarterly *Contract Activity Reports*, and the *Annual Purchaser Summary*. Clients included the timber industry, financial institutions, federal and state government agencies, trade associations, environmental organizations and other consultants. Served as a consultant on issues regarding public timber sale programs and timber sale contracts. Helped clients understand public timber sale policies and procedures, define data needs and properly use available data. Clients included government and industry attorneys, academic researchers, state and federal government agencies and other consultants. Served as a consultant on public timber supply issues. Analyzed, for example, the impact on public and private lands of proposed schemes for managing spotted owl habitat. Specialized in evaluating US Forest Service timber harvest scheduling models and analyses. Prepared extensive written reports, oral presentations and testimony as needed. Clients included various industry trade associations, private companies and government agencies.

1983-1987, National Forest Products Association, *Policy and Programs Analyst.*

Served simultaneously as the Policy and Programs Analyst and the Manager of Federal Forest Planning. Duties included: (1) analyzing the impacts of federal policies affecting supplies of timber from federal lands; and (2) helping the industry formulate and accomplish its public timber supply objectives. Work ranged from writing draft testimony for Congressional hearings, to preparing persuasive arguments supporting industry's position on various issues, to informing and educating Congressional staff about industry's position to staffing NFPA member committees. Also served as an ad hoc computer consultant. Developed NFPA's computerized membership database application. Involved extensively in the following issues:

- The Federal Timber Contract Payment Modification Act of 1984.
- Annual appropriations for the US Forest Service and Bureau of Land Management.
- NFMA forest planning standards for analysis. Implementation of NFMA forest plans.
- Below-cost timber sales and the Timber Sale Program Information Reporting System (TSPIRS).

1980-1983, USFS, *Operations Research Analyst.*

Served as the Operations Research Analyst first on the Targhee National Forest, and then the Salmon National Forest in Idaho. Helped interdisciplinary teams of specialists build forest planning models, interpret results, and develop and analyze NFMA forest plan alternatives. Responsible for the development, maintenance and use of several FORPLAN models.

Publications/ Presentations

Most of Mark's work is confidential and related to specific clients. Following is a list of reports in the public domain.

NFMA Forest Plan Reviews

- Review of the Wallowa-Whitman National Forest FORPLAN model, October 1987.

- Review of the Willamette National Forest FORPLAN model, January 1988.
- Review of the Mt. Hood National Forest FORPLAN model, March 1988.
- Evaluation of the implementation of the Targhee National Forest NFMA plan, July 1988.
- Review of the Payette National Forest Plan timber sale economic analysis, August 1988.
- Review of the Boise National Forest Plan timber sale economic analysis, October 1988.
- Review of the Plumas National Forest FORPLAN model, January 1989.
- Review of the Willamette National Forest final FORPLAN model, October 1990.
- Review of the Tongass National Forest FORPLAN model, October 1991.
- Review of the Kisatchie National Forest timber supply and demand analysis, April 1994.
- Review of the Pisgah National Forest FEIS, June 1994.
- Review of the Francis Marion National Forest DEIS, September 1994.
- Review of the National Forests of Texas DEIS, November 1994.
- Review of the Sumter National Forest AMS, March 1995.
- Review of the Southern Appalachian Assessment timber supply analysis, October 1995.
- Review of the National Forests of Mississippi timber supply and demand analysis, October 1995.

Analysis of Public Timber Sale Programs

- A review of Region 2 transaction evidence appraisal system, November 1989.
- Analysis of alternative mechanisms for triggering increased financial security requirements, September 1990.
- Timber output impacts of the northern spotted owl conservation strategy proposed by the Interagency Committee of Scientists, June 1990.
- Timber output impacts of the northern spotted owl critical habitat proposed by the US Fish and Wildlife Agency, June 1991.
- Timber output impacts of the US Forest Service Spotted Owl Management Plan, February 1992.
- Timber output impacts of the USDI Draft Recovery plan for the Northern Spotted Owl, April 1992.
- Evaluation of the Draft Washington Timber Supply Study, September 1992.
- Future timber outputs in Oregon: Implications for county budgets, May 1992.
- Impacts of timber supply restriction on wood products and stumpage markets. Chapter included in the industry's April 2, 1993 Forest Conference briefing book.
- Public timber sales in Western Oregon: CY 1982-1990, October 1990. (Analysis used by the USDA Pacific Northwest Research Station to prepare the BLM analysis of the management situation.)
- Public timber under contract: Volume and Distribution. Written and oral testimony prepared for a hearing on an injunction on new USFS timber sales before Judge William Dwyer, May 1991. Subsequently updated June 1992.
- Public timber under contract: Response to questions posed by the Endangered Species Committee. Written and oral testimony prepared for the Endangered Species Committee hearing on whether to exempt 44 BLM "jeopardy" timber sales from the requirements of the Endangered Species Act, January 1992.
- Timber, Economic and Financial Impacts of the Draft Plan for Northwest Oregon State Forests: A Prospective Analysis, April 1999.
- Timber Harvest Levels in the May 2001 Draft Implementation Plans for the State Forests in Northwest Oregon: A Report to the Council of Forest Trust Land Counties. January 2002.
- 2004 Sustained Yield Calculation, State of Montana Department of Natural Resources. November 2004.
- Socio-economic analysis for the BLM's 2008 Western Oregon Plan Revision

Testimony

- Testified as an expert witness before the Endangered Species Committee regarding economic impacts of listing the spotted owl, February 1992.
- Testified as an expert witness in US District Court regarding spotted owl impacts, May 1991 and June 1992.
- Testified as an expert witness in federal court in a criminal trial, July 1993. (*US v. Paul Knapp*).
- Testified before Congress on several occasions regarding national forest policy.
- Testified as an expert witness in federal tax court, July 1995. (*Pope & Talbot v. US*).
- Testified as an expert witness before the USDI Board of Contract Appeals, July 1998. (*Superior Lumber v. US*).
- Testified as an expert witness before the US Court of Claims, September 2001. (*Mescalero Apache Tribe v. US*).
- Testified as an expert witness in US District Court, April 2003. (*Confederated Tribes of Siletz Indians of Oregon et.al. v. Weyerhaeuser Company*).
- Testified as an expert witness in US District Court, May 2004 (*Washington Alder v. Weyerhaeuser Company)*.
- Testified as expert witness in *Merrill & Ring v. Government of Canada*, North American Free Trade Agreement Chapter 11 Arbitration, January 2008.
- Testified as an expert witness in The Yakama Nation, et al. vs. Sally Jewell, 2012
- Testified as an expert witness in fire damage cases:
    - *Timber Products v. Redd Ranch* – fire damages
      Isleta Pueblo v. US – forest mismanagement
      Various plaintiffs v. PG&E – fire damages (Pendola Fire)
    - Various plaintiffs v. Calpine – fire damages (Geysers Fire)
    - *US v. PG&E and WEC* – fire damages (Sims Fire)
    - *US v. SPI et.al.* – fire damages (Moonlight Fire)
- Testified as an expert witness in a forest trespass case, *Zeitz v. Raymer*, 2018
- Testified as an expert witness in a forest mis-management case, *Linn County v. State of Oregon*, 2019
- Testified as an expert witness in a forest valuation case, Save Our Gallatin Front v. Montana Department of Natural Resources, 2019

Tom Baribault, Ph.D.
Forest Analyst

Tom specializes in forest growth and yield modeling, economic analysis, and forest management planning. His technical skills include biometry and inventory analysis, yield projections, and familiarity with a variety of statistical methods applicable to common problems in forestry. Since joining MB&G in 2015, Tom has completed economic impact assessments for the State of Oregon and the Washington Forest Protection Association, and regional timber supply studies for Pacific Northwest industrial clients and The Nature Conservancy. He has written successful management plans for national and international forestry programs, including for the Forest Legacy Program, USDA NRCS EQIP, and the Forest Stewardship Council. Tom's background includes working as a research forester and planner in Hawaii from 2011 to 2015, where he worked for multiple private clients, the Hawaii Department of Land and Natural Resources, Department of Hawaiian Homelands, and the Office of Hawaiian Affairs.

Education

Ph.D., Forest Ecology and Ecology/Evolutionary Biology and Behavior, Michigan State University, East Lansing, MI

B.A., Chemistry, Vassar College, Poughkeepsie, NY, 2004

Years of Experience

10 years

Certificates and Memberships

- Spatial Analysis, ESRI, certificate UC-7B3DMQ67
- Remsoft
- Adult First Aid/CPR/AED, American Red Cross, March 2018 – 2020
- Society of American Foresters 2015-2020

Proficiencies

- Statistics: Maximum likelihood, hierarchical Bayesian spatial analysis, non-linear regression, model comparison.
- Inventory: USFS FIA Postgres and SQLite, MBGTools
- Growth and Yield: YTGTools, Forest Vegetation Simulator (FVS), openFVS, Forest Projection and Planning System (FPS), custom models
- GIS: MBG MobileMap, ArcGIS 10.3, ArcCollector, QGIS, GRASS, Geospatial Modeling Environment, geoR, mba, lidR
- Database: Postgres, SQLite, MS Access
- Communication: Microsoft Office, LibreOffice, LaTeX
- Scripting: R / R-Studio, Python, Jupyter Notebooks, R-Markdown

MB&G Project Experience

Economic Impacts Assessment

Marbled Murrelet Economic Impact Assessment, Washington State Association of Counties (WSAC) | 2020. Project in progress, substantially complete. Investigated management alternatives pertaining to Marbled Murrelet (endangered marine bird species) conservation goals and impacts to harvest revenues at State, County, and taxing district level. Imputed long-term yields derived from WA Department of Natural Resources (DNR) to discern the financial impact to total revenues and tax revenues across affected Western WA counties, and developed spreadsheet-based reporting tool to investigate consequences of rotation length.

Forest Industry Economic Impact Analysis, Washington Forest Protection Association (WFPA) | 2018, 2020 update in progress. Analyzed econometric data from assorted sources, including Federal (Bureau of Labor Statistics, Census Bureau) and State of Washington (Department of Revenue, Department of Natural Resources), to estimate the direct, indirect, and induced impact of the forest industry on the economy of the State of Washington. Computed indirect and induced economic impacts for the period 2017-2018 using the Bureau of Economic Analysis (BEA) Regional Input-Output Modeling System (RIMS II) to estimate changes to statewide industry impact since prior reporting period.

Sudden Oak Death (SOD) Economic Impact Assessment, Oregon Department of Forestry (ODF) | 2019. The fungal pathogen *Phytophthora ramorum* has caused extensive mortality in

tanoak (*Notholithocarpus densiflorus*) across California and southwest Oregon, impacting thousands of acres since 2001. During 2018 and 2019; served as project manager for an MB&G-led team contracted with ODF to estimate the 20-year term impact of SOD on the southwest regional economy. This project required estimates of current and future timber resource value, analysis of econometric data, and personal interaction with regional stakeholders, including timber industry, and private landowners. Final economic impact assessment available in the public domain.

Sustained Yield and Harvest Scheduling

Biomass Supply Assessment for Lake Tahoe Basin, Tahoe Central Sierras Initiative (TCSI) and The Nature Conservancy (TNC) | 2020. Adapted stand-level inventory from remotely sensed data (Source: USFS via SilviaTerra) to project growth and yield of sawtimber and biomass over 2.4 million acres in the Tahoe Basin. Collaborated with TNC and USFS silviculturists to develop forest restoration management regimes in the Forest Vegetation Simulator (FVS) compatible with agency strategic plans for USFS Region 4, including precommercial thinning, prescribed fire, and skips-and-gaps treatment. Regimes were consistent with agency and TNC objectives for forest restoration to improve resiliency to wildfire. Assessed economic implications for biomass stumpage price under four scenarios of forest restoration intensity, each with several cases of increasing infrastructure investments. Deliverables included spatial data, Woodstock model outputs, report, and content for presentation at American Geophysical Union (delivered by TNC).

Sustained Yield Calculation (SYC), Montana Department of Natural Resources & Conservation (MT DNRC) | 2019. MB&G conducted the first SYC for MT DNRC in 2015, stratifying statewide inventory data, generating timber yields from compatible silvicultural pathways, and computing a long-term sustainable harvest level for MT state lands with a Woodstock harvest scheduling model. MB&G updated this effort for 2019-2020 using improved inventory data (USFS FIA, MT DNRC) for 750,000 acres, a revised stratification, and new silvicultural regimes that better reflect harvest yields reported to DNRC over the last five years. Revised yields account for improvements to source inventory data, as well as changes to growth projection models (FVS Inland Empire and Eastern Montana variants) that have occurred since 2015. New yields are currently being incorporated into the Woodstock model to produce the 2020 SYC update.

Sustainable Timber Harvest Analysis, Minnesota Department of Natural Resources (MN DNR) | 2017. MB&G was selected to perform an independent analysis of the sustainable timber harvest levels on lands administered by the MN DNR. The MN DNR manages more than 5.6 million acres of land which provide ±28% of the wood products supplied to in-state processing industries and account for about 64,000 jobs and $16.2 billion of annual impact. MB&G conducted this study in two phases. For Phase 1, MB&G rebuilt the existing MN DNR harvest scheduling model, updated the inventory data, and assessed the potential timber harvest from MN DNR lands.

Timber Supply Assessment

Biomass Supply Analysis, High Hazard Zones: Forest Mortality Task Force (FMTF) and Pacific Gas and Electric (PG&E), California | 2019. MB&G constructed an in-place timber and forest biomass inventory for all forest land across the State of California, then used this inventory to calculate the 20-year supply of forest biomass. Work completed in the context of the Biomass Renewable Action Mechanism (BioRAM) power sale contract framework devised by the State of California to assist and facility public utilities with increasing the pace and scale of forest

restoration mediated by sales of biomass to power generating facilities. Project required generating supply assessment and biomass cost-of-acquisition curves for 23 active biomass power facilities, with source areas spanning 13 million acres.

South Willamette Valley Timber Supply Assessment, Confidential client | 2018. Estimated standing inventory and land ownership distributions, as well as annual net growth, harvest, timber consumption, and export levels in four Southwestern Oregon counties. Determined adequacy of current production to support expanded mill operations in the study area under several scenarios of increased timber consumption.

The Nature Conservancy (TNC) Central Washington Timber Supply Analysis | 2018. Forests in central WA are increasingly susceptible to destruction by wildfire; The Nature Conservancy contracted MB&G to estimate timber supply (biomass and saw volume) available in the region over a 20-year period from 2018 to 2028. Data sources included the Forest Inventory and Analysis program (FIA), the Landscape Ecology, Modeling, Mapping and Analysis (LEMMA), and simulated growth via the East Cascades variant of the Forest Vegetation Simulator (FVS). Timber volume and location were assessed for the region, with priority given to forests identified as most in need of restoration. Project deliverable included location optimization strategy for new sawmill infrastructure.

Northern California Timber Supply Study, Confidential client | 2016. Quantified sawtimber growth and inventory in the Northern half of CA, classified by landowner, forest type, age class, and site productivity class; estimated timber demand from domestic processors and international export. Developed translation databases linking USFS FIA sawtimber inventory, State of CA timber harvest plan data, and CA Board of Equalization prices to summarize current market supply and forecast log prices.

Northern and Central California Biomass Assessment, Confidential client | 2015. Adapted USFS FIA inventory and growth data from the Pacific Northwest dataset to perform merchandizing calculations in MBG Tools with the objective of assessing availability of top-wood biomass across 15 CA counties. Analyzed feasibility of opportunities to use timber harvest waste biomass as feedstock for alternative processing, including oriented strand board, laminated veneer lumber, and electricity cogeneration.

Eastern Oregon Biomass Supply Assessment, Oregon Department of Forestry, Subcontracted by The BECK Group | 2015. Recent legislation passed which required ODF to complete a biomass inventory. MB&G was contracted by The BECK Group to assess biomass inventory, growth, and harvest rates in Eastern Oregon regions outside of the ODF Regions 1-5. Responsibilities included review of timber sales contracts, and interviews with harvest contractors and area mills to determine biomass availability and current markets.

Forest Management and Harvest Planning

Forest Management Plans, Columbia County NRCS, Confidential clients | 2019. Developed forest stand improvement plans in 2019 for two properties, 36 acres and 26 acres, in Columbia County. Conducted property review with landowners, inventory of target management units, and developed planning documents that met requirements to receive funding from the Environmental Quality Incentives Program. Both plans accepted by Columbia County NRCS, securing cost share revenue for the two landowners to conduct improvement thinning and biomass removal, and providing a modular forest management plan that can be updated and upgraded as their land stewardship goals evolve over time.

Forest Plantation Harvest Planning, Willamette Valley, Confidential client | 2018. Developed six alternative scenarios for harvest scheduling and plantation establishment using Linear Programming (Woodstock, Remsoft) to optimize net present value for a landowner with circa 2500 acres of active timber production. Explored scenarios contrasting silvicultural alternatives, sensitivity analysis of timber prices, localized custom calibration of timber yield using a set of proprietary keyword multipliers for the Forest Vegetation Simulator yield generation software. Merchandized to Oregon Westside scaling standards.

Growth and Yield

Custom Calibration of Forest Vegetation Simulator (FVS), Confidential client | 2016. A timber management organization selected MB&G to calibrate a regional variant of the USFS software package FVS to match conditions on its ownership, approximately 700,000 acres. I worked with the client and a consortium of University and regional stakeholders to identify a stratification by geological attributers and forest type. Unique calibration keyword sets were developed for each stratum using data from permanent sampling plots, then validated by comparison to inventory. Calibrations were required to fall within a 90% confidence interval for critical variables including volume, diameter, top height, basal area, and trees per acre, both for existing stands and for regeneration pathways. This calibrated FVS variant is compatible with the MBG Tools inventory management software.

Custer Gallatin National Forest Management Plan, Growth and Yield, USFS | 2017. Built FVS keyfiles using the Suppose interface to represent distinct silvicultural pathways, augmenting Python scripts from HLC 2016 to extend keyfiles and generalize batch processes to automatically produce 36,000 yield tables at less than 50% cost of prior efforts. Yields used as input to CGNF SPECTRUM model.

Helena and Lewis & Clark National Forest Management Plan, Growth and Yield, USFS | 2016. Built 480 FVS keyfiles using the Suppose interface to represent distinct silvicultural pathways. Developed automated Python scripts to revise keyfiles and batch processes to generate 42,000 stand-level yield tables and 3,800 summary yield tables as input to a SPECTRUM model. Modeling effort will support forest plan revision for Helena and Lewis & Clark National Forests.

Tetra Tech/The Nature Conservancy Tongass National Forest Young Growth Analysis 2014-2015. The Nature Conservancy asked MB&G to build a timber harvest scheduling model for 350,000 acres of young growth and 700,000 acres of old growth to evaluate and formulate different strategies for accelerating the transition of the Tongass National Forest from a timber sale program dominated by old growth harvest, to one more reliant on harvest of second growth stands. As analyst, responsibilities included quality control review for Woodstock harvest scheduling model output to ensure reconciliation of proposed and output acreage, as well as internal consistency of timber yields, harvest costs, and model constraints. Completed QC process for seven modeling alternatives.

Inventory and Biometry

Lidar-Derived Canopy Cover and Stand Age Inference, Oregon State University (OSU) | 2019. Oregon State University proposes to take over management of Oregon's Elliott State Forest in combined a research and production role. OSU contracted with MB&G to update stand age in the obsolete Oregon Department of Forestry Stand Level Inventory (ODF SLI). MB&G proposed using the publicly available Lidar coverage for this area to compute stand age. We segmented the raw Lidar point cloud into over 54 million individual tree approximate objects (TAO) and computed height and canopy cover metrics for each TAO, both for point clouds and for projected canopy polygons converted to raster objects. We computed the analytical

solution to King and Wiley site index equations to express age as a function of height rather than the usual inverse formulation, then calculated the age of each rasterized TAO. The management strategy adopted by OSU is to devise stand treatments that depend on stand age, for which we calculated the fraction of canopy cover exceeding 60, 100, and 160 years old, representing management decision points. Results presented at the 3rd annul Operational Lidar for Inventory conference, Olympia, WA, 2020.

Taper Function Validation from National Volume Estimation Library (NVEL), Confidential client | 2018, updated 2020. The NVEL provides a framework for calculating volume and value of sawtimber in the inland Northwest. The Flewelling function is a common taper estimation method and was developed in the 1970's using a dataset from trees ranging up to 150 years old or more. The client was concerned that current silvicultural practices yield trees that are different in significant dimensions from those used to parameterize the original Flewelling function. MB&G analyzed individual tree height and diameter datasets collected from 2016 to 2018 to provide a statistical analysis of contemporary Douglas-fir stem taper profile versus taper predicted by the Flewelling equation.

Projects with Hawaiian Focus

Expert Witness for Koa Financial Model, Confidential client | 2019. Estimated growth and yield outcomes, net present value, and rate of return on investment for *Acacia koa* plantations on windward Hawaii Island to assess veracity of investment prospectus and lost revenue claims for confidential client. Conducted extensive literature review regarding koa growth, yield, extraction, valuation, and market prospects. Completed deposition regarding background investigative work and interpretation of koa plantation investment value; arbitration terminated in favor of client.

Sandalwood Volumetric Equation Development, Confidential client | 2019. Developed volumetric equations for *Santalum paniculatum* suited for local use on Hawaii Island. Analyzed data from 120 individual trees and 480 tree fragments, including individual logs, branch mass, and root mass. Employed a model testing framework (BIC) to identify models with greatest empirical support. Resulting equations predict total, heartwood, and sapwood volume; total, heartwood, sapwood, root, and branch mass. Data analysis and final equations delivered to client as HTML output from R-Markdown notebook.

Sandalwood Inventory Analysis and Management, Confidential client | 2017. Developed inventory protocols and a custom inventory management database to measure *Santalum paniculatum* populations for a 2,500-acre parcel located on the leeward side of Hawaii Island. Inventory techniques included hierarchical 3P sampling combined with a scalable database tool for inventory of sandalwood heartwood volume, tree population, assessment of surrounding vegetation. The inventory database can be reused by the client for their other inventory needs related to native Hawaiian species (e.g. *Acacia koa*), particularly in field conditions where conventional forest inventory methods are too costly to implement. Developed proprietary set of allometric equations to compute volume sandalwood heartwood and sapwood specific to Hawaii Island species. Parameterized volume equations from confidential biometric data.

Koa (*Acacia koa*) allometric equation library development, Confidential client | 2014-present. Using data provided by several confidential clients[1], developed a set of koa biomass

[1] Data confidential. Permissions retained by T. Baribault to publicize resulting allometric equations in the form of published manuscript; currently unpublished / in preparation.

and sawtimber equations specific to unique combinations of land use history and bioregion for Hawaii Island. Equations estimate individual tree saw timber volume (board feet Scribner, cubic meters) and biomass for three (3) Windward locations (Hamakua, North Hilo, Volcano) and four (4) Leeward locations. Equations suitable for datasets with limited input (diameter) through more complex inventory (diameter, height, log count, dimensions). **Unpublished manuscript.**

Experience Prior to Employment with MB&G

2011 to 2015, Forest Solutions, *Forest Analyst*

Growth and yield modeling

- Developed Eucalyptus and Acacia yield models using maximum likelihood methods to forecast probability density functions of stand diameter distributions
- Applied probability density model to generate yield tables for plantations in Hawaii and Malaysia, formatted for implementation in Remsoft (in collaboration with MB&G).
- Drafted forest management proposals based on financial analyses of Remsoft model output for Eucalyptus plantations in Hawaii.
- Tested an adapted coefficient set in FVS to model Hawaii Eucalyptus plantation growth.

Forest inventory and GIS

- Designed and implemented forest inventory on scales from 50 to 30,000 acres using variable radius methods and plot 3P with both remote sensing and ground-based estimates.
- Generated comprehensive reports and checked inventory quality control for clients including New Forests, Cambium Asset Management, Hu Honua Bioenergy, and Kamehameha Schools Land Assets.
- Evaluated economic and silvicultural potential for timber production in West Hawaii, including appraisal of standing timber resources and future valuation. Secured contract values totaling $65,000.
- Managed GIS data for concurrent forest inventory programs in Eucalyptus plantations, native Hawaiian timber species in plantation, and natural forests.
- Constructed allometric equations for the high value Hawaiian timber species Acacia koa and Santalum paniculatum, producing biometric libraries for a range of growing conditions.
- Publicized silvicultural methods developed by Forest Solutions using multiple media, including technical papers, online publications, conference presentations, and field events open to the public.
- Developed insect pest and invasive weed control procedures for A. koa plantations; secured special local need label for spirotetramat insecticide (Bayer, Movento) for control of acacia psyllid.
- Implemented controlled release fertilizer trial in A. koa. Result: one publication under peer-review.

Management planning

- Developed forest management plans for the State of Hawaii Forest Stewardship Program; value of funded plans exceeded $1.75 million, and value of contracts approached $50,000.
- Maintained annual certification (2011 – 2014) by the Forest Stewardship Council of the 30,000 acre Hōnaunau Forest; improved analysis of invasive species policy.
- Conducted feasibility analysis for carbon market options related to native forest restoration on 33,000 acres in Ka'ū District, Hawaii Island. Result: one report.
- Secured two land management contracts valued at $150,000 and $800,000 per annum, FY 2011-2013, and FY 2013-2015; managed budgeting, field operations, and monthly reporting 2011 – present.
- Completed economic analysis for hardwood and biomass plantation performance in Hawaii, and agroforestry systems on Oahu (Waimānalo Forest Reserve).
- Project manager, supervising team of three foresters and two field crews (12 laborers) in implementation of forest management contracts. Required adherence to budgets and schedules, with operations including planting, silviculture, inventory, and invasive species control in native forest.
- Prepared more than 25 successful management and inventory proposals for the State of Hawaii, Kamehameha Schools, Office of Hawaiian Affairs, corporate clients, and individual landowners.

Research and Silviculture

- Constructed allometric equations for the high value Hawaiian timber species *Acacia koa* and *Santalum paniculatum*, producing biometric libraries for a range of growing conditions.
- Publicized silvicultural methods developed by Forest Solutions using multiple media, including technical papers, online publications, conference presentations, and field events open to the public.
- Conducted literature searches and drafted literature reviews for inventory, yield, silviculture, ecology, land management, soil resource analysis, and invasive weed control documents.
- Developed insect pest and invasive weed control procedures for *A. koa* plantations; secured special local need label for spirotetramat insecticide (Bayer, Movento) for control of acacia psyllid.
- Implemented controlled release fertilizer trial in *A. koa*. Result: one publication under peer-review.

2004 to 2011, Michigan State University, East Lansing, MI, *Graduate Research Assistant*

- Assessed tree competition neighborhoods using maximum likelihood methods in a Metropolis simulated annealing algorithm. Result: one first author peer-reviewed publication.
- Coordinated two long-term field studies to quantify seedling regeneration and mature tree growth. Result: two first author peer-reviewed publications.

2008, Michigan State University, East Lansing, MI, *Silviculture Instructor*

- Developed undergraduate laboratory exercises using forest dynamics simulators (SORTIE and FVS) and field exercises to teach forest management techniques.
- Created and delivered lectures covering topics in basic forest ecology, abiotic disturbance regimes, thinning, regeneration, and harvesting methods.

Publications/ Presentations

Tom Baribault, Jessica Desrocher, Brandon Kaetzel, Sarah Navarro, Winston Oakley, Mark Rasmussen, Barbara Wyse. 2019. Sudden Oak Death: Economic Impact Assessment. https://www.oregon.gov/ODF/Documents/ForestBenefits/sudden-oak-death-economic-impact-assessment.pdf

Tom Baribault, Andrew Finley, and Richard K Kobe. 2012. Tropical tree growth is correlated with soil phosphorus, potassium, and calcium, though not for legumes. 2012. Ecological Monographs.

Tom Baribault, Richard Kobe. 2011. Neighbour interactions strengthen with increased soil resources in a northern hardwood forest. Journal of Ecology.

Tom Baribault, Richard Kobe, David Rothstein. 2010. Soil calcium, nitrogen, and water are correlated with aboveground net primary production in northern hardwood forests. Forest Ecology and Management.

Kyle M. Earnshaw, **Tom Baribault**, Douglass Jacobs. 2016. Alternative Field Fertilization Techniques to Promote Restoration of leguminous Acacia koa on Contrasting Tropical Sites. Forest Ecology and Management. pp. 126-134.

Richard Kobe, **Tom Baribault**, Ellen Holste. 2013. Tree performance across gradients of soil resource availability (chapter in Forests and Global Change). Cambridge University Press.