Montana Forest Lands Valuation Report

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Introduction

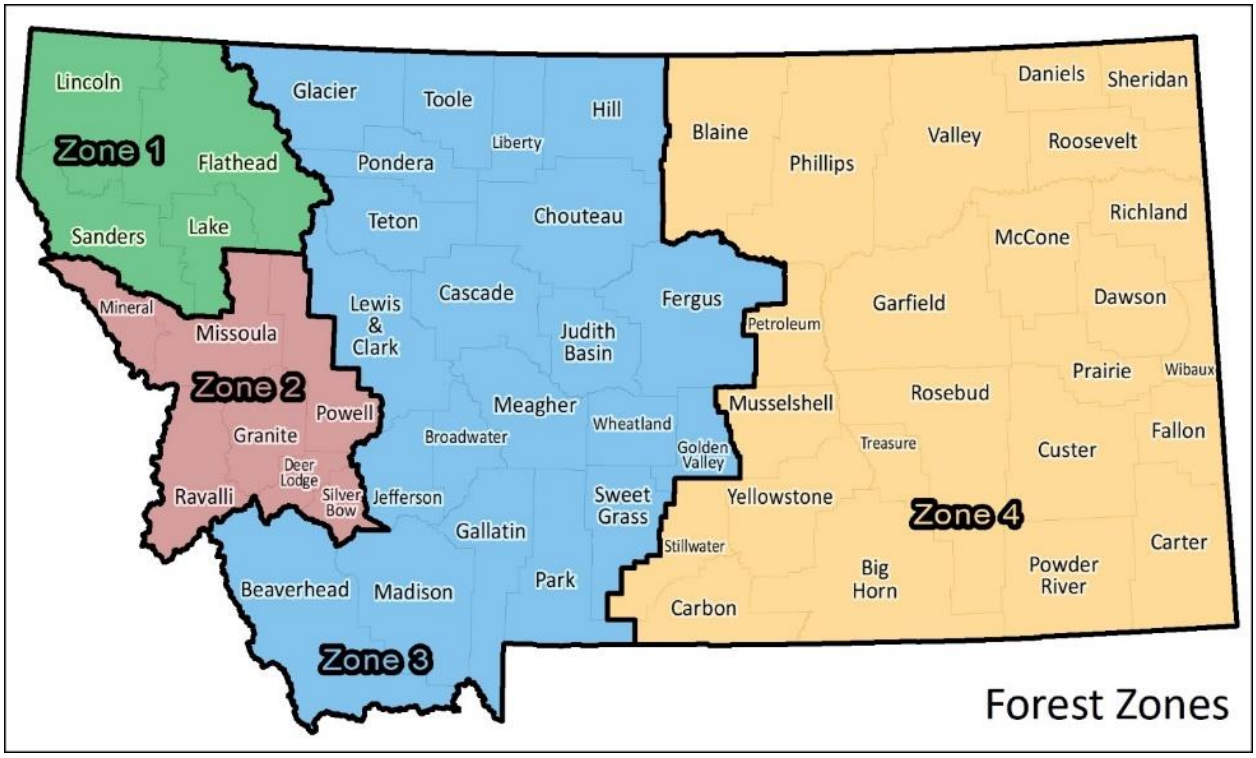
This report explains the data and methodology used by the Department of Revenue's Tax Policy and Research Division to value private forest land in Montana. It is a continuation of the work done by Dr. David Jackson of The University of Montana. Many of the ideas, methods, and phrasing of this report come from his original 2019 report, and significant portions of this writeup are dedicated to comparing his model against our work. One of the main goals of this process was for the department to internally develop a valuation method that can be updated regularly and used in perpetuity. Secondarily, we attempted to create a transparent method with industry-informed variables that explain as much of the variation in stumpage value as possible. Ultimately, our estimation yields stumpage values lower than that estimated by Dr. Jackson's 2019 methodology for the Northwest, Southwest, and Central regions and a higher stumpage value in the East. The ten-year average price per thousand board feet for each zone are:

Northwest: $222.96 Southwest: $203.90 Central: $172.56 East: $46.07

Data

The necessity of performing regression analysis to value forest land arises because of a lack of data for private timber sales. These private sales do not disclose to the state the value of timber sold. Therefore, the best available data for determining forest land value is governmental entities that make timber sales. We agree with Dr. Jackson's assessment that the Montana Department of Natural Resources and Conservation (DNRC) is the best source of comparable sales data for what a private landowner could expect to receive for their timber. The DNRC has a fiduciary responsibility to maximize profit through the sale of timber on state lands. Based on price differentials across different government agencies that manage and sell timber from public forest land, it appears not all institutions act as a fiduciary in this way. We consider the DNRC sales to be at market prices, unlike sales by other federal institutions. The DNRC sales data includes information needed to determine bid price per thousand

board feet of each sale as well as important determinants of the bid price, such as the location of the sale and the cost of logging and hauling. In recognition that location of forest land influences its value, the state is split into four zones: Northwest, Southwest, Central, and East. The classification of these zones was performed by Dr. Jackson in his 2019 analysis and generally conform with cost zones utilized by the DNRC in their land management. The map below lays out the zones and counties.



In fiscal years 2014 through 2019, the DNRC facilitated 149 timber sales. Of these, 30 were either noncompetitive, salvage, or both. These sales did not meet criteria for market pricing and were therefore excluded. Additionally, one sale from the East zone was determined to be an outlier and was dropped from the analysis. The geography of Montana means most forest sales take place in the Northwest and Southwest zones. Table 1 sums the total number of sales in each zone for the six-year period that was used.

Table 1. Total Sales by Year and Zone				
	NW	SW	Cent	E
FY14	9	6	2	0
FY15	11	5	2	0
FY16	13	6	2	0
FY17	7	6	3	3
FY18	11	3	2	3
FY19	18	6	0	0
Totals	**69**	**32**	**11**	**6**

Methodology

Because some years had no sales in some zones and others had very few, a regression model was created to reach a stumpage value in every zone for every year rather than relying on simple averages. The following formula represents the regression, followed by an explanation of the variables and the reasoning behind them.

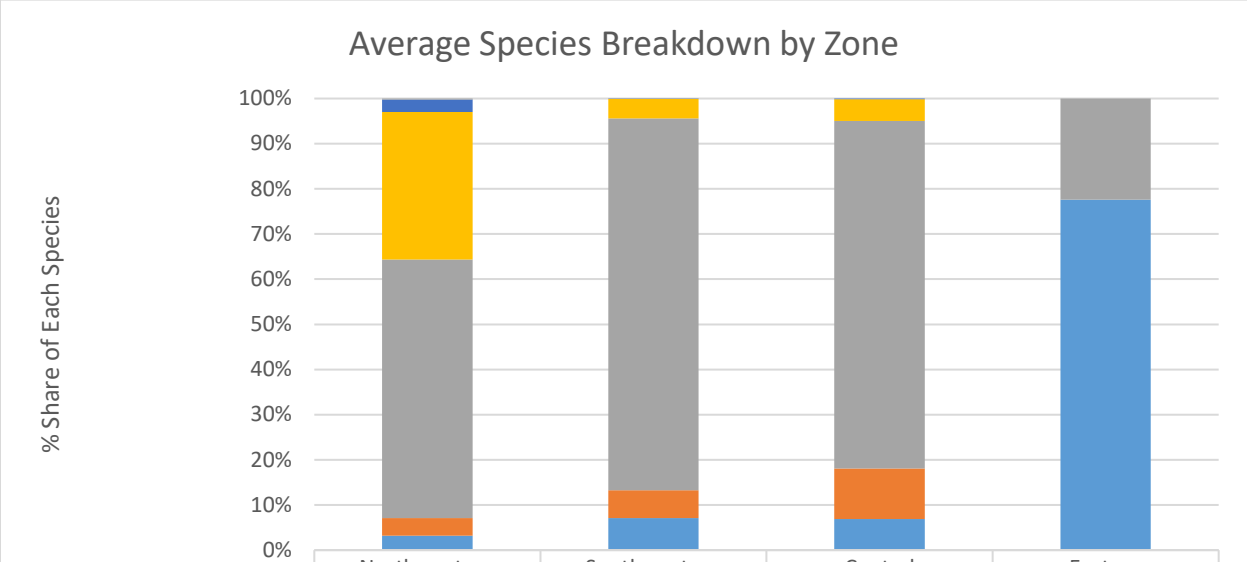
$$Bid18\$/MBF_i = \alpha + z_1 NW + z_2 SW + z_3 E + \beta_1 BBER100_i + \beta_2 BBERSQ_i + \beta_3 TotalAcres_i + \beta_4 VolSky\%_i + \beta_5 PavHaul_i + \beta_6 UnPavHaul_i + \beta_7 YardDisSky_i + \beta_8 YardDisGrnd_i + \varepsilon_i$$

This regression model follows the same basic logic of Dr. Jackson's 2019 model. The terms α and ε are constant and error terms, respectively. The dependent variable, Bid18$/MBF, is the winning bid of each sale plus the amount paid to the forest improvement fund and the cost of building permanent forest roads, adjusted to 2018 dollars. The forest improvement fee and road fees are known at the time of bid, so it is reasonable to expect that rational bidders adjust their willingness to pay accordingly. This information is expressed in $/ton in the DNRC data, so it is converted to $/MBF using the tons/MBF estimated for each sale by the DNRC. It is then converted to 2018 dollars using the U.S. Bureau of

Economic Analysis' GDP Price Deflator. The Bid18$/MBF variable is calculated for each sale and represents the amount a buyer is willing to pay for each thousand board feet of stumpage adjusted to 2018 dollars.

The explanatory variables are split into three categories: zones, index, and stump-to-mill estimators. The zones (NW, SW, and E) are dummy variables whose coefficients (z_1, z_2, and z_3) only apply to sales when they take place in that respective zone. The Central zone was used as a baseline and therefore has no coefficient. The Bureau of Business and Economic Research (BBER) at the University of Montana publishes a quarterly log price by species and zone, which was used to express lumber value. This data was collected from a survey of mills. The BBER index splits Montana into a West zone and East zone, which match almost exactly with Jackson's Northwest/Southwest and Central/East zones, respectively (Silver Bow and Deer Lodge counties are in Jackson's Southwest zone and the BBER's East zone; no sales took place in these counties from FY2014 to FY2019 so there is no issue in this analysis, but this may need to be addressed in the future). The BBER index breaks down timber prices by region, species type, and quarter, yielding a high level of specificity and generating a unique index value for each sale. That value is also converted to 2018 dollars and then divided by 100 to make it easier to work with, resulting in the variable BBER100. This variable is also squared in the regression to reflect the curval linear relationship between market prices and stumpage value (BBERSQ). The BBER index and its square measure the expected price a logging company will receive for the timber harvested from the sale. Figure 1 displays the average species breakdown of each zone as well as the total timber in thousand board feet (MBF) sold per region from FY 2014-2019. For more BBER data visualization, Appendix A contains average BBER Index values by species, Appendix B contains average index values by zone, and Appendix C contains average index values over time.

Figure 1.



	Northwestern	Southwestern	Central	Eastern
Whitepine (MBF)	418	7	-	-
Cedar (MBF)	5,029	51	25	-
Whitewood (MBF)	59,869	2,857	979	-
Larch/Douglas Fir (MBF)	104,761	54,235	15,538	794
Lodgepole Pine (MBF)	7,235	4,043	2,253	-
Ponderosa Pine (MBF)	5,801	4,683	1,396	2,755

The final group of explanatory variables estimates the cost of logging and hauling timber, otherwise known as stump-to-mill costs. Jackson's model combines these into one variable – we chose to leave them separate. They include the total acres of the sale, the percent of the land that will be logged by skyline (vs. tractor), hauling distance in miles on paved and unpaved roads, and the average distance in feet of skyline and tractor yarding for each sale.

Results

Table 2. Regression Results

Linear Regression Results

Model: Linear_Regression_Model
Dependent Variable: bid18$/MBF`

Number of Observations Read	118
Number of Observations Used	118

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	11	648813	58983	23.19	<.0001
Error	106	269574	2543.15525		
Corrected Total	117	918388			

Root MSE	50.42971	R-Square	0.7065
Dependent Mean	240.63751	Adj R-Sq	0.6760
Coeff Var	20.95671		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	2071.68227	746.83525	2.77	0.0065
nw	1	97.25662	18.28445	5.32	<.0001
sw	1	51.42093	19.75349	2.60	0.0106
e	1	-104.46746	40.56716	-2.58	0.0114
BBER100	1	-1072.93808	374.31272	-2.87	0.0050
BBERSQ	1	152.52625	46.53615	3.28	0.0014
Total Acres	1	0.04230	0.02329	1.82	0.0722
Vol Sky (%)	1	-0.64502	0.29926	-2.16	0.0334
Pav Haul (miles)	1	-0.06722	0.11527	-0.58	0.5610
Un Pav Haul (miles)	1	-0.39280	0.42538	-0.92	0.3579
Yard Dis Sky (ft)	1	-0.07231	0.02236	-3.23	0.0016
Yard Dis Grnd (ft)	1	-0.03027	0.02291	-1.32	0.1893

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The regression results describe some important trends of the model and are used to estimate stumpage values. First, the adjusted R-squared of .6760 indicates that the model explains about 67.6% of the variation in stumpage values. Given the number of factors that contribute to forest land value we believe this is a reasonably good fit. Comparing the dummy variables, stumpage in the Northwest and Southwest zones is more valuable and stumpage in the East zone is less valuable than the Central zone, which was used as a baseline. This is consistent with Dr. Jackson's model and geographical expectations. Regarding the stump-to-mill variables, increasing the acreage of a sale area also increases the bid price. This is expected due to economies of scale and fixed mobilization costs. The other stump-to-mill

explainers – percent skyline, haul distance, and yard distance – increase the cost of logging and hauling, so they decrease the stumpage value with every increase in percentage point, mile, or foot, respectively. Interpreting the effects of the BBER index is not as straightforward because it is also squared. The BBER index drives a highly significant portion of the variation in price because it represents an expected return on investment of the logging bid. However, the index is a poor explainer of bid price when the index is comparatively low for the data set. In particular, the depressed prices that mills paid for sawlogs in the early recovery years from the Great Recession cause inconsistent estimates of bid price by the model for those years. For this reason, and in deference to Dr. Jackson's 2019 report, we have kept his old appraisal values for 2010-2013. The Covid-19 pandemic may have also introduced powerful price variations and the model is unfortunately susceptible to price shocks. Careful consideration will be necessary when updating the model in coming years.

Table 3 displays estimated stumpage values for each zone and year using the regression coefficients and variable averages for each zone. BBER index data was averaged by fiscal year and species breakdown in each zone. Table 4 breaks down the calculations by revealing the specific values for coefficients and explanatory variables. The results were readjusted to nominal figures based on the year of the sale to reflect actual prices and to ensure that the base year does not affect the valuation.

Table 3. Estimated Annual Stumpage Values, Split Methodologies

Year	NW	SW	Central	East
2019	$246.69	$205.44	$210.43	$79.86
2018	$259.40	$214.62	$197.54	$63.38
2017	$226.70	$193.16	$173.99	$55.78
2016	$227.90	$200.60	$173.80	$56.55
2015	$300.87	$301.28	$317.41	$98.19
2014	$257.12	$237.42	$206.28	$53.35
2013	$230.63	$222.29	$169.10	$13.77
2012	$171.77	$165.81	$104.78	$13.53
2011	$156.06	$150.85	$87.89	$13.26
2010	$152.48	$147.55	$84.33	$13.01
10-year Average	**$222.96**	**$203.90**	**$172.56**	**$46.07**

Table 4. Calculations of Estimated Annual Stumpage Value

Year	Zone	Zone Coeff	Constant	BBER100	BBERSQ	Total Acres	Vol Sky %	Pav Haul	Un Pav Haul	Yard Dis Sky	Yard Dis Grnd	$/MBF 18	**$/MBF**
			2071.68227	-1072.93808	152.52625	0.0423	-0.64502	-0.06722	-0.3928	-0.07231	-0.03027		
	NW	97.25662											
2019				3.816942111	14.56904708	307.035942	26.2173913	38.83768116	8.705797101	361.4347826	593.3478261	$241.71	**$246.69**
2018				3.9709092	15.76811988	307.035942	26.2173913	38.83768116	8.705797101	361.4347826	593.3478261	$259.40	**$259.40**
2017				3.667108605	13.44768552	307.035942	26.2173913	38.83768116	8.705797101	361.4347826	593.3478261	$231.43	**$226.70**
2016				3.765162885	14.17645155	307.035942	26.2173913	38.83768116	8.705797101	361.4347826	593.3478261	$237.38	**$227.90**
2015				4.275675469	18.28140071	307.035942	26.2173913	38.83768116	8.705797101	361.4347826	593.3478261	$315.75	**$300.87**
2014				4.059738565	16.48147722	307.035942	26.2173913	38.83768116	8.705797101	361.4347826	593.3478261	$272.90	**$257.12**
											Average	**$259.76**	**$253.11**
	SW	51.42093											
2019				3.835180879	14.70861238	399.2221875	26.78125	21.0546875	8.665625	362.5	625.3125	$201.29	**$205.44**
2018				3.951353212	15.6131922	399.2221875	26.78125	21.0546875	8.665625	362.5	625.3125	$214.62	**$214.62**
2017				3.789612843	14.3611655	399.2221875	26.78125	21.0546875	8.665625	362.5	625.3125	$197.19	**$193.16**
2016				3.906167792	15.25814682	399.2221875	26.78125	21.0546875	8.665625	362.5	625.3125	$208.95	**$200.60**
2015				4.441504338	19.72696079	399.2221875	26.78125	21.0546875	8.665625	362.5	625.3125	$316.18	**$301.28**
2014				4.175643927	17.43600221	399.2221875	26.78125	21.0546875	8.665625	362.5	625.3125	$252.00	**$237.42**
											Average	**$231.70**	**$225.42**
	C	-											
2019				4.04056468	16.32616294	323.2727273	4.272727273	87.72727273	7.781818182	40.90909091	640.9090909	$206.18	**$210.43**
2018				3.9833337	15.86694736	323.2727273	4.272727273	87.72727273	7.781818182	40.90909091	640.9090909	$197.54	**$197.54**
2017				3.811634	14.52855375	323.2727273	4.272727273	87.72727273	7.781818182	40.90909091	640.9090909	$177.63	**$173.99**
2016				3.847397046	14.80246403	323.2727273	4.272727273	87.72727273	7.781818182	40.90909091	640.9090909	$181.03	**$173.80**
2015				4.568887242	20.87473063	323.2727273	4.272727273	87.72727273	7.781818182	40.90909091	640.9090909	$333.10	**$317.41**
2014				4.115176716	16.9346794	323.2727273	4.272727273	87.72727273	7.781818182	40.90909091	640.9090909	$218.94	**$206.28**
											Average	**$219.07**	**$213.24**
	E	104.46746											
2019				3.140670861	9.863813457	251.8333333	0	176.0833333	31.66666667	0	333.3333333	$78.25	**$79.86**
2018				3.306700937	10.93427109	251.8333333	0	176.0833333	31.66666667	0	333.3333333	$63.38	**$63.38**
2017				3.470889587	12.04707453	251.8333333	0	176.0833333	31.66666667	0	333.3333333	$56.95	**$55.78**
2016				3.63968522	13.2473085	251.8333333	0	176.0833333	31.66666667	0	333.3333333	$58.91	**$56.55**
2015				4.068933636	16.55622093	251.8333333	0	176.0833333	31.66666667	0	333.3333333	$103.05	**$98.19**
2014				3.512581549	12.33822914	251.8333333	0	176.0833333	31.66666667	0	333.3333333	$56.62	**$53.35**
											Average	**$69.53**	**$67.85**

Table 5 compares stumpage value estimations from our new methodology with Jackson's 2019 methodology and the actual averages for each zone.

Table 5. Jackson, TPR, and Actual Value Comparison

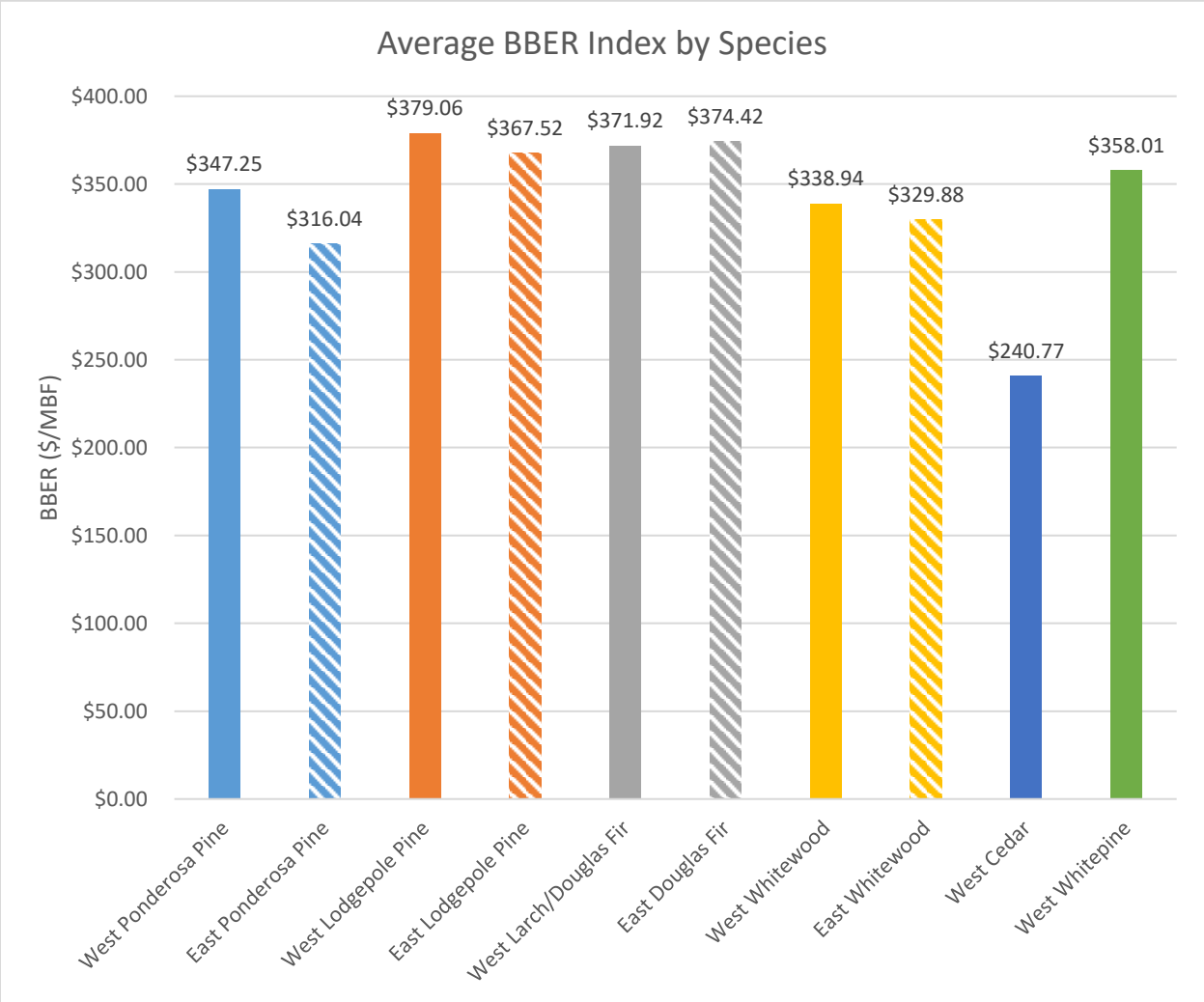
Year	Zone	Jackson 2019	TPR	% difference	Average Bid18$/MBF	N
	NW					
2019		$350.60	$241.71	-31.06%	$265.95	18
2018		$363.15	$259.40	-28.57%	$251.40	11
2017		$356.14	$231.43	-35.02%	$214.21	7
2016		$332.83	$237.38	-28.68%	$246.35	13
2015		$354.31	$315.75	-10.88%	$291.61	11
2014		$361.70	$272.90	-24.55%	$303.61	9
Average		**$353.12**	**$259.76**	**-26.46%**	**$262.19**	
	SW					
2019		$396.39	$201.29	-49.22%	$223.66	6
2018		$408.94	$214.62	-47.52%	$251.96	3
2017		$401.93	$197.19	-50.94%	$134.21	6
2016		$378.62	$208.95	-44.81%	$190.48	6
2015		$400.09	$316.18	-20.97%	$293.39	5
2014		$407.49	$252.00	-38.16%	$306.96	6
Average		**$398.91**	**$231.70**	**-41.94%**	**$233.44**	
	C					
2019		$333.72	$206.18	-38.22%	n/a	0
2018		$346.27	$197.54	-42.95%	$128.66	2
2017		$339.26	$177.63	-47.64%	$151.91	3
2016		$315.95	$181.03	-42.70%	$151.33	2
2015		$337.43	$333.10	-1.28%	$363.05	2
2014		$344.82	$218.94	-36.51%	$338.57	2
Average		**$336.24**	**$219.07**	**-34.88%**	**$226.70**	
	E					
2019		$42.39	$78.25	84.60%	n/a	0
2018		$54.94	$63.38	15.37%	$83.74	3
2017		$47.92	$56.95	18.84%	$58.56	3
2016		$24.61	$58.91	139.32%	n/a	0
2015		$46.09	$103.05	123.58%	n/a	0
2014		$53.48	$56.62	5.88%	n/a	0
Average		**$44.90**	**$69.53**	**64.60%**	**$71.15**	

We believe these comparisons show that our model is a better predictor of stumpage value than the model produced by Dr. Jackson in 2019. His regression produced stumpage value estimates significantly higher for the Northwest, Southwest, and Central zones and lower for the East zone. When comparing actual averages to the model-predicted prices, our model has a lower margin of error.

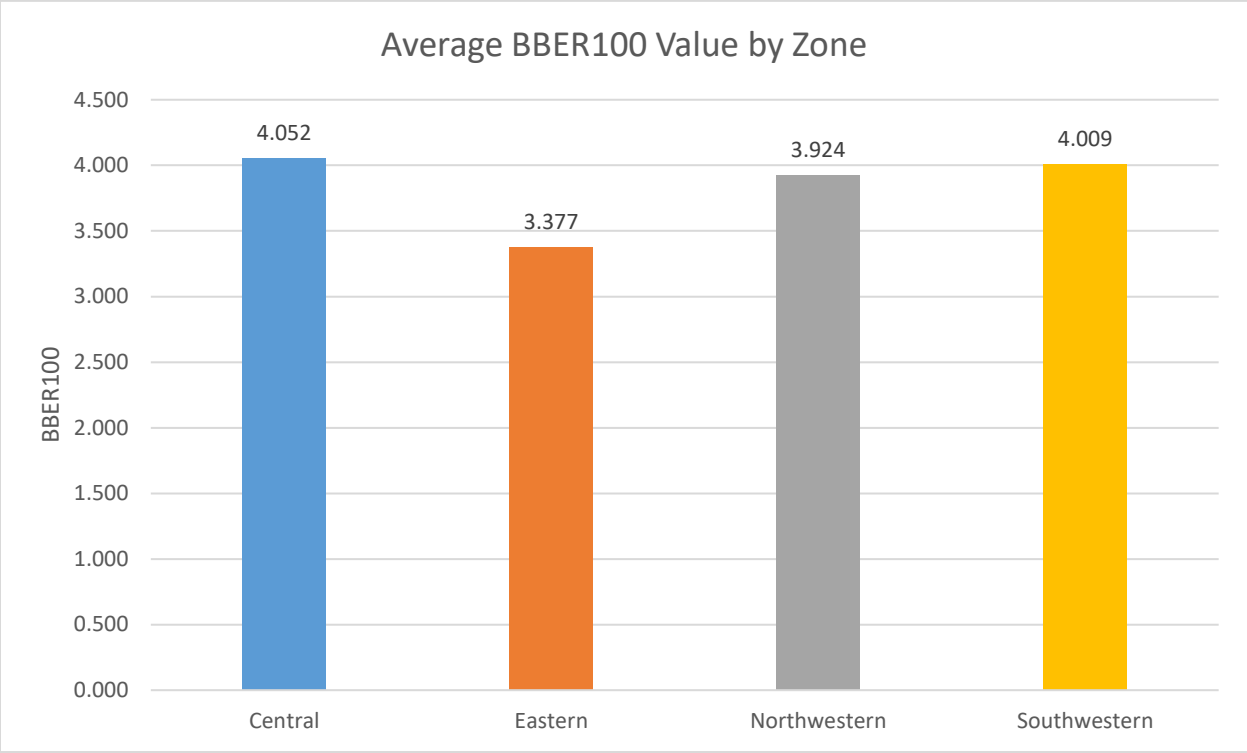
Conclusions

The stumpage value estimation model created at TPR is very closely based on Dr. Jackson's 2019 methodology and would have been impossible to complete without the logical processes contained in his work. The core model structure remains the same; the dataset and observations used, the calculation of the dependent variable, the separation of zones, the use of a price index, and the inclusion of stump-to-mill costs are instituted in both models. The main changes are the use of a different index (BBER vs. Framing), earlier conversions to $/MBF (vs. $/ton), a separation of explanatory variables (vs. one complicated, all-inclusive stump-to-mill calculation), and readjusting the results to nominal figures. We believe the specificity of the BBER index more accurately tracks differences between regions and years. Converting key variables to $/MBF from the start (instead of the end) removes significant rounding errors. The separation of stump-to-mill variables results in a more transparent model and captures the same information. Finally, returning the results to nominal dollars reflects expected value per board foot in the year of the sale. We believe our model's estimated average price per board foot for each zone and year closely represents what a private timber landowner could receive in exchange for logging their land.

Appendix A. BBER Index Values by Species



Appendix B. BBER Index Values by Zone



Appendix C. BBER Index Value Over Time