The Economic Impact of Rhode Island's Forestry and Wood Products Sector: Technical Appendix

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CONTENTS

Data Collection

Data were collected from a variety of sources with the goal of generating a list of forestry-related businesses to determine the size of the sector. Business listings were obtained from a survey, from consultation with Dick Went (of the RI Forest Conservators Organization) and Marc Tremblay (of Land Management Services), and also from directory listings maintained by the RI Department of Environmental Management (DEM). Further potential businesses were then pulled from a variety of sources including the RI Secretary of State (RISOS) business database and the marketing/business information database of AtoZ Databases (AZ) and Manta. These businesses were eliminated or added to our final list in consultation with Mr. Went and Mr. Tremblay, in an attempt to ensure that we only included businesses active in 2016, the year of our study (businesses closing before 2016 or opening after 2016 were explicitly excluded). In total, we identified 513 firms engaged with the forestry and wood products sector within Rhode Island. Of note, we exclude lumber dealers as a category due to their almost exclusive sale of non-RI forest products. We include RI woodland owners as a category, but we are forced to estimate them from non-primary sources, including the "Intent-to-cut" reports managed by DEM, the US Forest Service's (USFS) Forest Inventory and Analysis (FIA) Report for Rhode Island, and various conversion factors for lumber, firewood and chips.

Mr. Went and Mr. Tremblay also assisted with categorizing the non-woodland owner businesses into eight subsectors. The subsectors are: Arborists, Christmas Tree Farms, Forest Consulting, Logging, Milling and Manufacturing, Mulch and Materials Dealers, and Woodworking. The divisions between subsectors are fairly straightforward, with a few points bearing discussion:

1. *Arborists vs. Logging.* Firms were categorized as loggers according to their registration with RI DEM as licensed woods operators. Exceptions to this rule were determined on a case-by-case basis according to whether businesses were self-described as belonging to another category. For example, some arborists hold woods operator licenses and some loggers hold arborist licenses, so we relied on businesses' websites and/or the expertise of Mr. Went and Mr. Tremblay to make these distinctions.
2. *Milling and Manufacturing vs. Woodworking.* The woodworking category contains primarily finish woodworking, and wood products manufacturing including furniture and custom cabinetry. The milling and manufacturing category includes larger businesses such as sawmills, pallet manufacturers, and firms specializing in finish millwork including custom architectural millwork and flooring.
3. *Woodland owners and managers.* This category includes stumpage payment estimates from intent to cut reports, covering both lumber

and firewood cuts. In addition, since we are unable to include them elsewhere, it includes revenues from wood chips that might accrue due to land clearing. These revenues are estimated from indirect sources based on the rate for firewood (to landowners, not retail), and the corresponding jobs are estimated using IMPLAN multipliers.

Economic data (revenues *aka 'gross sales"*, employees) were collected via an online survey distributed by URI and by a variety of forestry-related organization in the state, and these survey data (6 observations) were supplemented by economic data available through atozdatabases.com and manta.com. In the aggregate we have revenue observations for 165 firms and employment observations for 168 firms.

Subsector Data Summary

Our dataset for the forestry and wood products subsectors are described in Table 1 below. Note that woodland owners revenues are not the result or primary, business-level data collection, and jobs are estimated from the revenues via IMPLAN. For each subsector we note the total number of firms, the number for which we have economic data, and the remaining number for which economic data need to be imputed.

Table 1A. Raw Data for Forestry and Wood Products Subsectors (Revenues)

Subsector	Firms w/ Economic Data	Firms w/out Economic Data	Total Firms
Arborists	83	266	349
Christmas Tree Farms	13	35	48
Forest Consulting	4	7	11
Logging	9	36	45
Milling and Manufacturing	25	2	27
Mulch and Materials Dealers	7	1	8
Woodland Owners	--	--	--
Woodworking	24	1	25
Total	**165**	**348**	**513**

Table 1B. Raw Data for Fisheries Subsectors (Jobs)

Subsector	Firms w/ Economic Data	Firms w/out Economic Data	Total Firms
Arborists	84	265	349
Christmas Tree Farms	14	34	48
Forest Consulting	4	7	11
Logging	10	35	45
Milling and Manufacturing	25	2	27
Mulch and Materials Dealers	7	1	8
Woodland Owners	--	--	--
Woodworking	24	1	25
Total	**168**	**345**	**513**

Estimation Procedure

To establish our final estimates, we imputed economic data for the firms without data available. We used log-linear regression models by subsector, following Sproul and Michaud (2018), who selected the log-linear model according to well-established information criteria (AIC, BIC) and other goodness of fit measures (R^2). Regression tables are shown below.

The regression results show we have a reasonably accurate estimate of the conditional mean (of log revenues, log jobs) for each subsector. Of note, raising the log-linear regression prediction to a power of *e* results in an estimated median if business revenues (and jobs) are assumed to follow a lognormal distribution. In this manner, we introduced conservatism into our imputations, attempting to model all missing businesses as being from the peak of the distribution and thus reducing the influence of larger observations in the tail. Given these regression estimates, we imputed the economic data for the missing firms, and added them to the observed economic data to generate a total estimate for each subsector.

For the woodland owners subsector, estimates were calculated according to distinct methods from the other subsectors. Lumber (MBF) and firewood (cords) were provided in the Intent-to-Cut reports by RIDEM and supplemented with quarterly price data from UMass Amherst Extension (masswoods.org). These were then supplemented with data from the United States Forest Service (USFS) Forest Inventory Analysis (FIA) reports for 2016

and 2011, indicating total harvests and total removals (Butler, 2017). Before further analysis, all FIA totals were adjusted downward by 30.85% for government owned forest land which must be excluded from economic impact estimates. The 2016 and 2011 years were averaged to remove noise in the data. Residual harvests not included as either lumber or firewood were attributed to firewood cuts that were exempt from filing an Intent-to-Cut report (less than 5 acre lots, and/or less than 25 cords per landowner per year). Other removals were attributed to land clearing (for development or otherwise) with the presumption that tons were converted to chips and sold for fuel at the same rate as firewood ($10/ton payments to woodland owners). This estimate is quite conservative given that the retail price for both chips and firewood is approximately 15-20x the rate paid to land owners. While those retail revenues are captured elsewhere in our study (specifically, in the logging subsector) for firewood, we do not capture them elsewhere for chips because we have no data sources for revenues of land-clearing firms (they are not required to register with RIDEM in the same manner as loggers).

Table 2A. Ordinary Least Squares Regression – Log-Linear Model (Revenues)

OLS Regression Results

Dep. Variable:	np.log(REVS)	R-squared:	0.353
Model:	OLS	Adj. R-squared:	0.329
Method:	Least Squares	F-statistic:	14.39
Date:	Tue, 15 Jan 2019	Prob (F-statistic):	4.68e-13
Time:	09:35:07	Log-Likelihood:	-251.92
No. Observations:	165	AIC:	517.8
Df Residuals:	158	BIC:	539.6
Df Model:	6		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
Category[Arborists]	13.0533	0.125	104.474	0.000	12.806	13.300
Category[Forest Consulting]	9.9084	0.569	17.410	0.000	8.784	11.033
Category[Logging]	12.3103	0.379	32.445	0.000	11.561	13.060
Category[Milling and Manufacturing]	14.1665	0.228	62.228	0.000	13.717	14.616
Category[Mulch and Materials Dealers]	13.6025	0.430	31.617	0.000	12.753	14.452
Category[Tree Farms]	11.6407	0.316	36.872	0.000	11.017	12.264
Category[Woodworking]	12.3655	0.232	53.219	0.000	11.907	12.824

Omnibus:	7.468	Durbin-Watson:	1.605
Prob(Omnibus):	0.024	Jarque-Bera (JB):	10.368
Skew:	0.250	Prob(JB):	0.00561
Kurtosis:	4.122	Cond. No.	4.56

Table 2B. Ordinary Least Squares Regression – Log Linear Model (Jobs)

OLS Regression Results

Dep. Variable:	np.log(JOBS)	R-squared:	0.268
Model:	OLS	Adj. R-squared:	0.241
Method:	Least Squares	F-statistic:	9.833
Date:	Tue, 15 Jan 2019	Prob (F-statistic):	3.15e-09
Time:	09:35:11	Log-Likelihood:	-213.97
No. Observations:	168	AIC:	441.9
Df Residuals:	161	BIC:	463.8
Df Model:	6		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
Category[Arborists]	1.5271	0.096	15.844	0.000	1.337	1.717
Category[Forest Consulting]	-0.3466	0.442	-0.785	0.434	-1.219	0.526
Category[Logging]	0.5416	0.279	1.939	0.054	-0.010	1.093
Category[Milling and Manufacturing]	1.8748	0.177	10.612	0.000	1.526	2.224
Category[Mulch and Materials Dealers]	1.5330	0.334	4.591	0.000	0.874	2.192
Category[Tree Farms]	0.5035	0.236	2.133	0.034	0.037	0.970
Category[Woodworking]	0.7346	0.180	4.074	0.000	0.379	1.091

Omnibus:	3.862	Durbin-Watson:	1.883
Prob(Omnibus):	0.145	Jarque-Bera (JB):	3.433
Skew:	0.279	Prob(JB):	0.180
Kurtosis:	3.422	Cond. No.	4.58

Table 3A. Revenue Estimates for Forestry and Wood Products Subsectors

Subsector	Firms	Observed Revenues, $M	Imputed Revenues, $M	Total Revenues, $M
Arborists	349	55.94	124.12	180.06
Christmas Tree Farms	48	2.16	3.98	6.14
Forest Consulting	11	0.12	0.14	0.26
Logging	45	3.33	7.99	11.32
Milling and Manufacturing	27	187.79	2.84	190.63
Mulch and Materials Dealers	8	8.26	0.81	9.07
Woodland Owners*	--	--	--	0.85
Woodworking	25	9.48	0.23	9.71
Total	**513**	**267.08**	**140.11**	**408.04**

Table 3B. Jobs Estimates for Forestry and Wood Products Subsectors

Subsector	Firms	Observed Jobs	Imputed Jobs	Total Jobs
Arborists	349	522	1220	1,742
Christmas Tree Farms	48	27	56	83
Forest Consulting	11	3	5	8
Logging	45	22	60	82
Milling and Manufacturing	27	439	13	452
Mulch and Materials Dealers	8	46	5	51
Woodland Owners*	--	--	--	14
Woodworking	25	63	2	65
Total	**513**	**1,121**	**1,361**	**2,496**

*Woodland owners revenues and jobs estimated as described above and detailed below in Table 3C. Business counts were unavailable for this category.

Table 3C. Estimates for the Woodland Owners Subsector

Estimate	Lumber (ITC)	Firewood (ITC)	Firewood (Other)	Chips (Other)	Total
Revenues	$415.3K	$60.6K	$93.2K	$283.4K	$852.5K
Jobs	--	--	--	--	14.46

Confidence Intervals

In addition to estimating the revenues in the overall forestry and wood products sector, it is also important to address the degree of (un)certainty in our estimates. Namely, we estimate a 95% confidence interval, assuming that the total estimate comes from a normal distribution. There are two sources of uncertainty in our estimates, which we assume to be independent of one another (and therefore additive, in terms of variance). First, sampling uncertainty relates to the potential variation over which businesses appear in our data set, and thus which businesses are used to impute the remaining businesses for which economic data are unobserved. To address sampling uncertainty, we estimated the variance of our imputation procedure over 1,000 bootstrapped replications of our data (sampled with replacement). Imputed revenues across all subsectors were $140.11 million with a bootstrapped standard deviation of $23.69 million. Imputed jobs across all subsectors were 1,361 with a bootstrapped standard deviation of 223.

A second source of uncertainty in our estimates was measurement error. Since we received only limited surveys with revenue and jobs data, this discussion applies primarily to the data obtained from public sources. While we used multiple public sources, only 12 observations contained data from multiple sources, making it difficult to precisely estimate measurement error from the current data set. We therefore rely on the measurement errors calculated during our previous study for the Rhode Island composites sector.

Namely, the standard deviation of measurement errors on revenue is 27% of the true value, and 22% for jobs. These errors correspond to a standard deviation of $21.42 million for observed total revenues of $267.08 million, and a standard deviation of 38 jobs for observed total jobs of 1,121.

A confidence interval was calculated only for total revenues and total jobs of the overall forestry and wood products sector. As stated above, we assume measurement error to be an independent source of variation from sampling error, and therefore the variances add. We also assume that the effect of measurement error on our imputation process is sufficiently well captured by the bootstrapping procedure as to not require a further adjustment. Finally, we expanded the confidence interval proportionally (0.21% for revenues, 0.58% for jobs) to account for uncertainty in the woodland owners category, to which our other methods of measuring uncertainty do not apply. As is well known, the 95% confidence interval of a normal distribution corresponds to 1.96 standard deviations on either side of the mean. Thus, we estimate total revenues for the forestry and wood products sector of $408.04 million, +/- $62.73 million (15.4%), and total jobs at 2,496, +/- 446 (17.9%).

Economic Impact Estimates

Economic impact estimates were generated using the industry-standard IMPLAN input-output model (Lindall and Olson, 2008). All effects are

estimated for the 2016 calendar year. The IMPLAN codes used for each subsector category and economic impact estimates are listed below.

Table 4A. IMPLAN Codes by Subsector Category

Category	IMPLAN Code	IMPLAN Description
Arborists	469	Landscape and horticultural services
Christmas Tree Farms	6	Greenhouse, nursery and floriculture production
Forest Consulting	460	Marketing research and all other miscellaneous professional, scientific, and technical services
Logging	16	Commercial logging
Milling and Manufacturing	134	Sawmills
Mulch and Materials Dealers	399	Retail – Building material and garden equipment and supplies stores
Woodland Owners	16	Commercial logging (no data available for correct category "Timber tract production")
Woodworking	145	All other miscellaneous wood product manufacturing

Table 4B. Economic Impact Estimates

Impact Type	Employment	Value Added, $M	Output, $M
Direct Effect	2,496	158.77	402.14
Indirect Effect	1,220	88.90	158.30
Induced Effect	1,127	95.64	155.97
Total Effect	**4,844**	**343.31**	**716.41**
(+/-)	**(865)**	**(61.32)**	**(127.95)**

Direct effect impacts are calculated net of interactions between firms in the subsectors in question. Indirect effects are downstream demand effects on suppliers to the firms in our study, and induced effects are further downstream effects in the economy arising from increased wages, proprietor

income, etc. The top-line value of interest is the Output, with a $716.41 million total effect. The Output value represents the hypothetical economic cost to the state if all of these businesses were to disappear. It should also be noted that we report the conservative "output multipliers" which discount retail sales by a margin factor (0.349, applied only to Mulch and Materials Dealers in this study), as discussed in Jeong and Crompton (2015). The Value-Added column is also useful, as this number is most directly comparable to GSP (Gross State Product, the state-level version of GDP). The total jobs impact includes a direct effect of 2,496 jobs in the forestry and wood products sector and 4,844 total jobs across the state arising from the economic activity in forestry and wood products.

We generate confidence intervals for our IMPLAN results by adjusting them according to the largest (percentage-wise) confidence interval among revenues and jobs in our study. In this case the jobs estimate has the largest uncertainty (+/- 17.9%). Our IMPLAN confidence intervals of +/- $127.95 million of output, $61.32 million of value added and 865 jobs thus err on the side of conservatism, since they are the worst-case 95% intervals that would arise under perfect rank-correlation of estimation errors, and under an assumption of uncertainty in the jobs estimates carrying through fully into the revenue-based impacts.

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