# TPO Data: Recent Trends and County-level Variation

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## ***Background & History of TPO survey***

The Timber Products Output (TPO) survey program began in 1948 as a way to determine industrial and non-industrial utilization of harvested roundwood in the United States. As part of the program, mills and wood processing facilities submit their total annual roundwood consumption data, identifying supplying counties, and what percentage of that consumption was harvested within each of those counties. A measure of total roundwood production by county is computed by summing up a county's harvest across mills. These total roundwood figures are classified by roundwood type, based on the type of mill that consumed the wood.

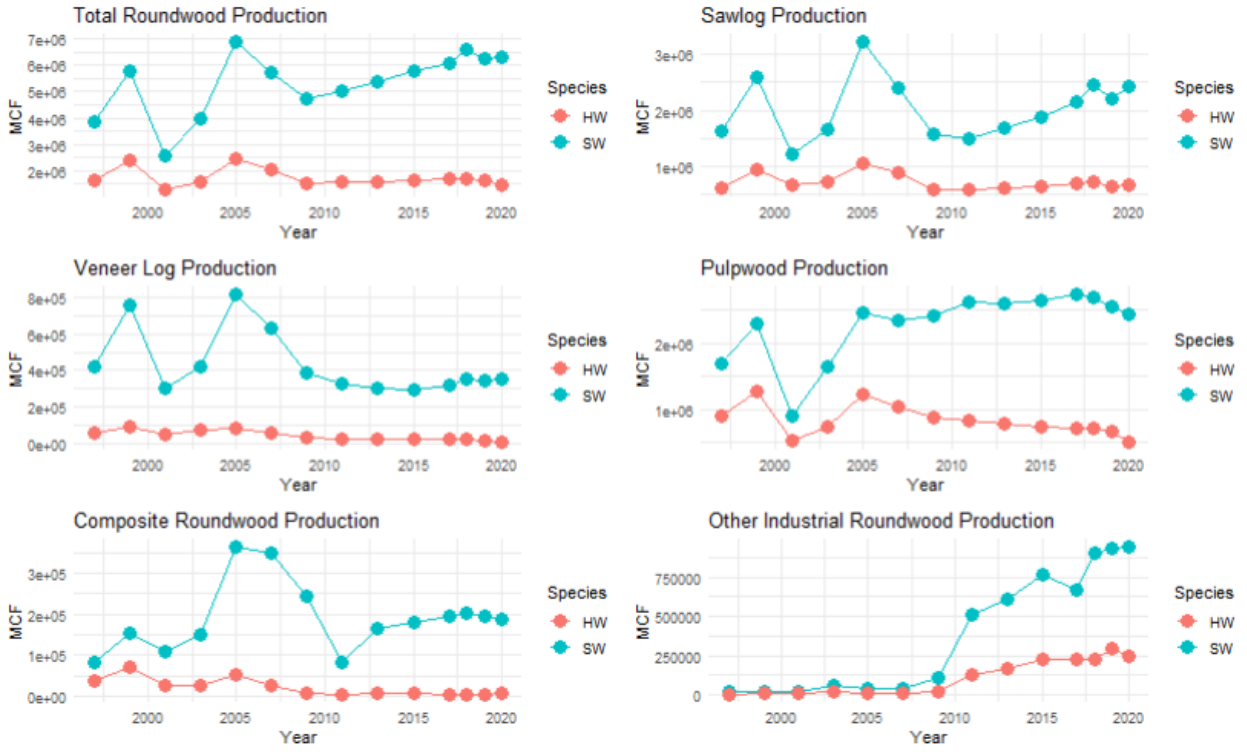
Historically, the TPO studies had a staggered design across states where only some states were surveyed each year. In more recent years the TPO program attempted a complete biannual census of all primary wood products facilities across all states in the southern U.S. region. However, the TPO data for some states was not collected for each year reported in the public TPO data release and the regular collection of survey data in the southern states has improved over time. This is evident in Table 1, where we see the coverage of the TPO survey from 1997 to 2020. Notice that the data for Arkansas, Louisiana, Mississippi, and Oklahoma was collected in 2002, but not in 2001 or 2003, so the TPO tables contain missing information for these states in both 2001 and 2003. The TPO survey coverage for Texas (not shown in Table 1) includes only roundwood delivered to pulp & paper mills and is unavailable for year 2017. Any available information on other roundwood production in Texas is obtained from an annual survey administered by Texas A&M University, not the TPO program. Beginning in 2018, the TPO program moved to an annual sampling design [1].

***Table 1: TPO survey years by state (1997-2020)***

| State | 1997 | 1999 | 2001 | 2002 | 2003 | 2005 | 2007 | 2009 | 2011 | 2013 | 2015 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **AL** | X | X | | | X | X | X | X | X | X | X | X | X | X | X |
| **AR** | | X | | X | | X | X | X | X | X | X | X | X | X | X |
| **FL** | X | X | | | X | X | X | X | X | X | X | X | X | X | X |
| **GA** | X | X | X | | X | X | X | X | X | X | X | X | X | X | X |
| **KY** | X | X | X | | X | X | X | X | X | X | X | X | X | X | X |
| **LA** | | X | | X | | X | X | X | X | X | X | X | X | X | X |
| **MS** | | X | | X | | X | X | X | X | X | X | X | X | X | X |
| **NC** | X | X | X | | X | X | X | X | X | X | X | X | X | X | X |
| **OK** | | X | | X | | X | | X | X | X | X | X | X | X | X |
| **SC** | X | X | X | | X | X | X | X | X | X | X | X | X | X | X |
| **TN** | X | X | X | | X | X | X | X | X | | X | X | X | X | X |
| **VA** | | X | X | | X | X | X | X | X | X | X | X | X | X | X |

To facilitate an understanding of demands on the resource base over a region of interest, the SOFAC team will provide members who submit an inventory request with a file summarizing basin-level TPO data over time. This data can be used to understand historical or potential trajectories of demand within a basin or to verify historical information on mill capacity. When SOFAC provides members with basin-level TPO history, we aggregate county-level production volume into 5 categories of timber products: 1) sawlogs, 2) veneer logs, 3) pulpwood, 4) roundwood used for the manufacturing of composite wood products, and 5) roundwood used for the manufacturing of "other industrial" materials. Figure 1 below shows the production history by timber product across the entire southern region as measured by the TPO data.

***Figure 1: Trends in timber production volume (southern U.S. region, 1997-2020)***




The SOFAC definition of sawlog production includes utility poles in years after 2011 where the TPO survey began to separate pole volume from a broader "poles/posts/pilings" category of roundwood. Prior to 2011, all roundwood volume utilized for utility poles is incorporated into the "other industrial" product category. The "other industrial" product also includes bioenergy/fuelwood, roundwood used for posts and pilings, as well as "miscellaneous" roundwood volume. The "miscellaneous" category also includes any logs not used by pulp mills, sawmills, veneer mills, composite materials facilities, or bioenergy facilities as well as the "re-classified" volume described above. An increase in fuelwood reporting, including the use of roundwood in pellet production began in 2009, which explains part of the rising trend in both softwood and hardwood production of "Other Industrial" roundwood. Note that TPO collects

only roundwood information. Pellet mills have been captured from 2009 forward because of newer and larger pellet mills that utilize roundwood. The survey has been capturing fuelwood, more generally, for much longer.

In Figure 1, we notice a spike in total south-wide softwood roundwood production in year 2018, corresponding to a sharp increase in sawlog production. This spike dampened again in 2019 and seems to maintain the pre-2017 trend through 2020. We also see that, beginning in 2018, softwood pulpwood production began to decline after a rise from 2015 to 2017. A short drop in the production of "other industrial" hardwood is noticeable in 2018, but the long-term increasing trend is maintained again by 2019 and through 2020.

The SOFAC team will typically provide basin-level history of TPO production data alongside a member's basin-level inventory request. However, county-level TPO production history is also available. Due to ***re-classified mill volume***, ***variation in survey response rates***, and ***changes in sampling methodologies over time***, the county-level TPO data may have missing or inconsistent data across survey years. It is important for analysts using the county-level data or looking at basin-wide trends to be aware of these potential anomalies.

## ***Re-classified mill volume***

To accommodate privacy concerns, some of the TPO data may be re-classified as "Miscellaneous" if there are fewer than 3 mills of a certain type across an entire state (although sawlog production is unaffected through 2020). For example, if a state has fewer than 3 veneer mills, then the roundwood volume utilized by those mills that is sourced from a particular county gets lumped into the "Miscellaneous" category of volume for that county (which in our summary of the data will show up under the "Other Industrial" category of roundwood). In Table 2, we have summarized the percentage of *mill types* that have some of their reported volume re-classified as "Miscellaneous" volume. The set of all mill types are: 1) sawmills, 2) veneer mills, 3) pulp/paper mills, 4) utility pole facilities, 5) pole/posts/pilings facilities, 6) post facilities, 7) bioenergy/fuelwood facilities, 8) composite panel facilities, 9) "Miscellaneous" (which includes mulch and other types unlisted above). The re-classified volume is incorporated into this last "Miscellaneous" category of roundwood.

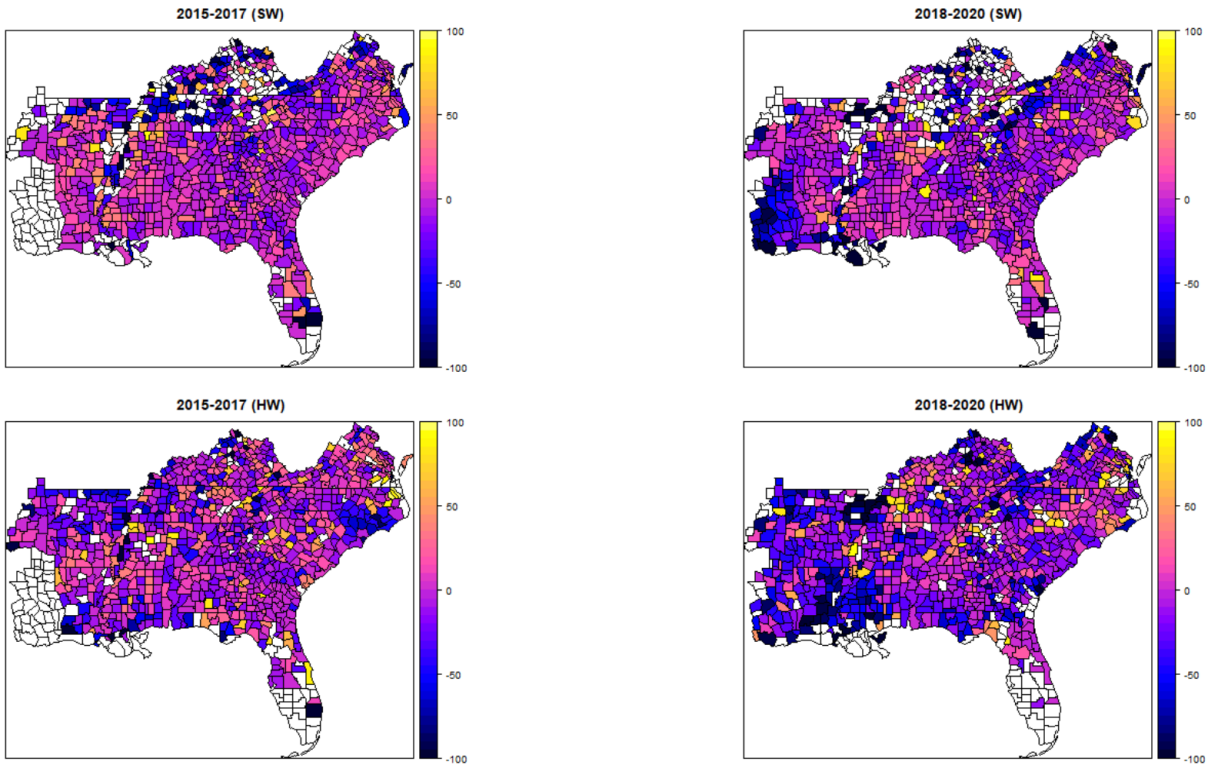
***Table 2: Proportion of active mill types with volume re-classified as "Miscellaneous" in the publicly available TPO data (2011-2020)*** [+++]

| State | 2011 | 2013 | 2015 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|
| **Alabama** | 3/8 | 2/8 | 2/8 | 2/8 | 2/7 | 1/6 | 1/7 |
| | (38%) | (25%) | (25%) | (25%) | (29%) | (17%) | (14%) |
| **Arkansas** | 3/7 | 4/8 | 4/8 | 2/8 | 3/8 | 3/8 | 4/8 |
| | (43%) | (50%) | (50%) | (25%) | (38%) | (38%) | (50%) |
| **Florida** | 1/8 | 2/8 | 2/8 | 3/8 | 3/8 | 3/8 | 3/9 |
| | (13%) | (25%) | (25%) | (38%) | (38%) | (38%) | (33%) |
| **Georgia** | 0/8 | 0/8 | 0/8 | 0/8 | 1/8 | 1/8 | 1/8 |
| | (0%) | (0%) | (0%) | (0%) | (13%) | (13%) | (13%) |
| **Kentucky** | 4/6 | 6/8 | 3/7 | 4/7 | 5/8 | 3/6 | 3/6 |
| | (67%) | (75%) | (43%) | (57%) | (63%) | (50%) | (50%) |
| **Louisiana** | 2/7 | 2/7 | 1/7 | 1/7 | 2/7 | 2/7 | 2/7 |
| | (29%) | (29%) | (14%) | (14%) | (29%) | (29%) | (29%) |
| **Mississippi** | 2/6 | 3/6 | 2/6 | 2/7 | 2/7 | 2/7 | 2/7 |
| | (33%) | (50%) | (33%) | (29%) | (29%) | (29%) | (29%) |
| **N. Carolina** | 3/7 | 3/8 | 3/7 | 3/8 | 2/8 | 2/8 | 2/8 |
| | (43%) | (38%) | (43%) | (38%) | (25%) | (25%) | (25%) |
| **Oklahoma** | 3/4 | 4/5 | 5/6 | 5/7 | 5/7 | 5/7 | 5/7 |
| | (75%) | (80%) | (83%) | (71%) | (71%) | (71%) | (71%) |
| **S. Carolina** | 2/8 | 1/8 | 1/8 | 1/8 | 1/8 | 1/8 | 1/8 |
| | (25%) | (13%) | (13%) | (13%) | (13%) | (13%) | (13%) |
| **Tennessee** | 5/7 | 4/7 | 4/7 | 4/8 | 4/7 | 4/6 | 4/7 |
| | (63%) | (57%) | (57%) | (50%) | (57%) | (67%) | (57%) |
| **Virginia** | 2/7 | 3/7 | 2/8 | 3/9 | 4/9 | 3/9 | 3/9 |
| | (29%) | (43%) | (25%) | (33%) | (44%) | (33%) | (33%) |

[+++]***percent of active mill types re-classified is given in parentheses.***

One option for avoiding measurement error from the re-classified volume is to instead focus on "Total" roundwood products harvested. The "Total" roundwood production category incorporates all roundwood volume, including the re-classified volume lumped into the "Miscellaneous" and the broader category of "Other Industrial" roundwood production volume. The maps in Figure 2 show the annual average growth rate in total roundwood production observed at the county level from 2015 to 2017 and from 2018 to 2020. We have mapped these growth rates from -100% (indicating a drop to zero roundwood production over the defined time interval) to greater than or equal to 100%.

***Figure 2: Average annual percentage growth rate in roundwood production of softwood (SW) and hardwood (HW) species across counties in the southern U.S.***




In general, the average growth rate of softwood roundwood across counties from 2015 to 2017 was larger than it was from 2018 to 2020 (18.5% vs. 15.6%, respectively). Similarly, the

average growth rate of hardwood roundwood production across counties rose from an decrease of -21.0% per year over the 2015 to 2017 period to an increase of 12.6% over the 2018 to 2020 time period. With outliers are removed (counties with very little volume and growth rates greater than 100%), we get a much different picture. We find in this case that the growth rate of total softwood roundwood production over the 2015 to 2017 period declined by 1.7% on average, but over the 2018 to 2020 period it declined by 7.6% on average. Similarly, the growth rate of total hardwood production over the 2015-2017 period declined by 1.4% on average, but over the 2018-2020 period it declined by 12.6%, on average.

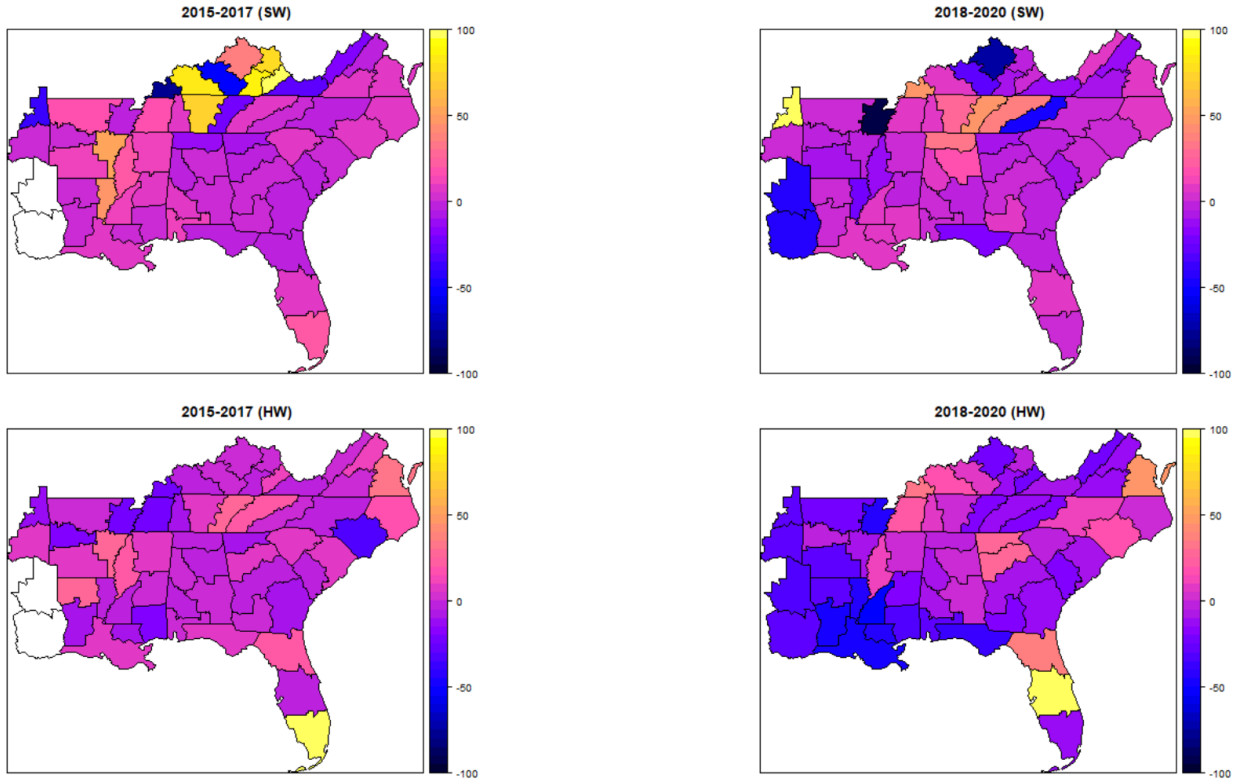
We note that softwood growth rates appear to be more steady across the two time periods, with some notably large decreases in counties within the western North Carolina region, the northeast Oklahoma region, the northeast Louisiana region, and the northeast Arkansas region. Hardwood production appears to display larger variation in the growth rate of roundwood production across counties, with large increases in southern Louisiana, the southern coastal plains of North Carolina, western Kentucky, northern Georgia, and the western parts of Tennessee. We also note that hardwood growth rates drop in parts of southern Mississippi and the northeast Florida regions, suggesting a shift from average annual increases in hardwood timber production over the 2015 to 2017 time period to average annual declines in hardwood timber production over the 2018 to 2020 time period.

When SOFAC provides TPO history aggregated to the level of a member-defined basin, counties with missing data are ignored so that basin-level statistics reflect only the production observable by the publicly released data across all counties within the basin. For these reasons, it is typically more reliable to observe TPO trends at the basin level when examining trends for a particular product type. When examining trends at the county-level for a specific product, there

may be large spikes or drops for some counties because of "re-classified" volume assigned to the "Miscellaneous" category.

To display the improved regularity of basin-level trends, the following maps in Figure 3 display the same volume as in Figure 2 except aggregated to the level of the FIA survey units across the southern regions.

***Figure 3: Average annual percentage growth rate in roundwood production of softwood (SW) and hardwood (HW) species across FIA survey units in the southern U.S.***




Some trends are easier to observe when mapped at the basin or survey unit level. For example, we note there is a decrease in the growth rate of softwood timber production over the southern Arkansas region, suggesting that the large levels of annual production occurring across this region are beginning to slow down. However, annual production in 2020 was 177 million cubic feet, still 58% over the southwide average across survey units.

## ***Survey response rates***

Figure 2 shows several counties with missing TPO production information. This is due to several reasons. As mentioned above, some counties are recorded as having some roundwood production, but if there are fewer than 3 mills of a certain type within a state, this volume is reclassified as "Miscellaneous". In these cases, a county may contain missing production data for a particular roundwood product type. There also may be counties that do not display any production volume and counties without change in production volume because of a low response rate from the TPO survey (non-response is imputed using latest observed data). For these reasons, there may be cases where analyst-defined basins may omit production due to aggregations of the county-level TPO data. To better understand where low-response rates may contribute to this problem, and measurement error in general, Table 3 displays the TPO survey response rates over time at the state-level.

***Table 3: Actual and estimated TPO survey response rates (percent, 1999-2020)***

| State | 1999 | 2001 | 2002 | 2003 | 2005 | 2007 | 2009 | 2011 | 2013 | 2015 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Alabama** | 95 | - | - | 49 | 85 | 94 | 96 | 92 | 88 | 66 | 80 | 71 | 62 | 69 |
| **Arkansas** | 95 | - | 82 | - | 79 | 10 | 96 | 34 | 30 | 34 | 73 | 38 | 27 | 45 |
| **Florida** | 46 | - | - | 40 | 20 | 87 | 61 | 54 | 46 | 76 | 62 | 74 | 62 | 74 |
| **Georgia** | 76 | 59 | - | 95 | 78 | 98 | 99 | 99 | 80 | 92 | 89 | 70 | 65 | 62 |
| **Kentucky** | 95 | 26 | - | 78 | 25 | 87 | 85 | 96 | 72 | 82 | 95 | 72 | 65 | 56 |
| **Louisiana** | 91 | - | 34 | - | 29 | 25 | 100 | 79 | 49 | 69 | 90 | 86 | 94 | 100 |
| **Mississippi** | 100 | - | 84 | - | 68 | 39 | 97 | 52 | 33 | 61 | 63 | 67 | 46 | 53 |
| **N. Carolina** | 32 | 61 | - | 45 | 53 | 52 | 78 | 50 | 26 | 22 | 45 | 80 | 81 | 77 |
| **Oklahoma** | 100 | - | 65 | - | 43 | 100 | 81 | 46 | 73 | 36 | 100 | 83 | 85 | 74 |
| **S. Carolina** | 97 | 88 | - | 79 | 93 | 95 | 100 | 100 | 93 | 99 | 88 | 91 | 81 | 74 |
| **Tennessee** | 99 | 15 | - | 100 | 97 | 94 | 99 | 95 | - | 60 | 76 | 80 | 97 | 73 |
| **Virginia** | 29 | 98 | - | 91 | 41 | 34 | 70 | 40 | 30 | 60 | 87 | 85 | 92 | 62 |

## ***Changes in sampling methodology***

Starting in 2018, the TPO program adopted an annual stratified simple random sample [1], in lieu of an attempt at a complete census of all mills conducted every 2 years. This shift in sampling strategy allows for better coverage and an increased ability to measure roundwood utilization in emerging markets. However, a critical question remains as to whether or not the pre-2017 and post-2017 measurements of roundwood production are comparable and if so, at what spatial scale?

We find some preliminary evidence that the average annual growth rate in total timber production across counties was different over the 2018 to 2020 period than it was over the 2015 to 2017 period. Using an unpaired two-sample t-test with unequal variances, we find enough evidence (at the 1% level of significance) to reject the null hypothesis that the average annual growth rate in total softwood log production from 2017 to 2020 was the same as it was from 2015-2017. We find similar evidence for the average annual growth rate in total hardwood log production, for pulpwood, and for roundwood used by composite facilities. We use Bartlett's K-test to verify our assumptions of non-equal variances in the growth rates across each time period. These tests find evidence at the 7% level (for total softwood production growth) and the 0.01% level (for total hardwood production growth) that the variances of growth rates in total log production are not equal across the two periods. We do not find enough evidence to suggest that the variances of pulpwood production are different across periods, so our test for equivalence in the means of pulpwood production growth rates assumes equal variances.

***Table 4: Two-tailed tests of mean and variance equivalence in the growth rate of log production across the 2015-2017 time period ("PRE") and the 2018-2020 time period ("POST").***[+++]

| Roundwood Product: | Unpaired t-test with unequal variances for equivalence in means ($H_0: \mu_{PRE} = \mu_{POST}$) | Bartlett's K-test for equivalence in variance ($H_0: \sigma^2_{PRE} = \sigma^2_{POST}$) |
|---|---|---|
| Total Softwood Production | $t^*_{df=1704.5} = 3.5904^{***}$ | $K^*_{df=1} = 3.4301^{*}$ |
| Total Hardwood Production | $t^*_{df=1778.9} = 6.6149^{***}$ | $K^*_{df=1} = 19.9350^{***}$ |
| Softwood Sawlog | $t^*_{df=1432.5} = 4.6183^{***}$ | $K^*_{df=1} = 50.0240^{***}$ |
| Hardwood Sawlog | $t^*_{df=1378.1} = 6.4521^{***}$ | $K^*_{df=1} = 89.0730^{***}$ |
| Softwood Veneer Logs | $t^*_{df=351.24} = -0.1583$ | $K^*_{df=1} = 108.880^{***}$ |
| Hardwood Veneer Logs | $t^*_{df=227.6} = -0.2175$ | $K^*_{df=1} = 22.9430^{***}$ |
| Softwood Pulpwood | $t^*_{df=1355} = 3.4462^{***}$ (assumption of equal variances) | $K^*_{df=1} = 1.4746$ |
| Hardwood Pulpwood | $t^*_{df=1301} = 3.2068^{***}$ (assumption of equal variances) | $K^*_{df=1} = 1.2468$ |
| Softwood Roundwood for Composite Facilities | $t^*_{df=226} = 1.7195^{*}$ (assumption of equal variances) | $K^*_{df=1} = 0.0077$ |
| Hardwood Roundwood for Composite Facilities | $t^*_{df=48} = -2.6852^{***}$ (assumption of equal variances) | $K^*_{df=1} = 0.4857$ |
| Softwood Roundwood for "Other Industrial" Facilities | $t^*_{df=1302.7} = 2.1356^{*}$ | $K^*_{df=1} = 5.6399^{**}$ |
| Hardwood Roundwood for "Other Industrial" Facilities | $t^*_{df=1161} = 5.5527^{***}$ (assumption of equal variances) | $K^*_{df=1} = 0.0300$ |

**p<0.1; **p<0.05; ***p<0.01*

[+++]*Counties with a production growth rate greater than 100% were dropped to satisfy test assumptions of normal distributions in the sample data. Counties where there are such large changes in production growth rates are typically counties with small amounts of production, so changes in this level appear large in percentage terms. Inferences made should refer to the population of counties with moderate levels of production.*

When examining trends at any scale, it is important to be aware of any changes in sampling methodology. A formal test of whether or not the changes in production trends after 2017 are attributable to actual, market driven events, changes in mill capacity, or to a difference

in the TPO survey methodology is a question we leave for further research. Overall, careful interpretation of the county trends can still be a useful way to examine recent harvesting activity within a basin. This is especially true for more recent years where there is more regular coverage of counties in the southern region. However, the TPO data may be best utilized alongside other sources to gain a complete picture of market activity, such as the FIA forest inventory data and any mill databases or information on wood processing capacity that may help explain the trends observed in the TPO data.

## ***References***

[1] Coulston, J., J. Westfall, D. Wear, C. Edgar, S. Prisley, T. Treiman, R. Abt, W.B. Smith. 2018. Annual Monitoring of US Timber Production: Rationale and Design. *Forest Science* 64(5): 533-543.