# RESOLVING THE PULPWOOD CANVASS WITH INVENTORY HARVEST INFORMATION

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## ABSTRACT

The Resource Use section of the Forest Inventory and Analysis (FIA) Program has done a canvas of wood processing mills for timber product output (TPO) throughout the southern United States. Pulpmills in the South are canvassed on an annual basis, while all other mills (e.g., sawmills, veneer mills, etc.) are canvassed every two years. Attempts have been made to graph and map the amount of pulpwood harvested compared to the acres of forest treated (cut) in order to provide more information on harvesting rate or intensity (i.e., volume harvested per acre). It appears that one county's worth of plots is not enough data to accurately estimate the cutting rate in a county. The authors advocate smoothing the apparent cutting rate, with one suggested model being logistic regression based on forest density and ownership patterns in a county.

**Keywords:** Timber Products Output (TPO), Forest Inventory and Analysis (FIA), logistic regression, pulpwood harvest, harvesting rate.

## INTRODUCTION

Each year since at least 1953, the Timber Products Output (TPO) section of the Forest Inventory and Analysis (FIA) unit, or their predecessor programs, has conducted a canvass of pulpwood mills in the Southern United States. The data have been reported tabularly, by county, and by a variety of maps. Maps have included dot density maps, starting with Cruikshank (1954) to Bertelson (1972). Bertelson (1975) experimented with some type of contouring for the 1974 report. Dennis May (1986) used raw choropleth maps (polygon maps with varying patterns to indicate the level of the response variable) for the 1984 report then experimented (1988) with a choropleth map based on acres of timberland. Johnson et al. (1997) used a choropleth based on acres of land, then used a choropleth based on acres of timberland (2010).

FIA field crews collect data on survey plots—including whether trees were harvested or not. Another variable that field crews collect is: TRTCDx, where x = 1, 2, or 3, as appropriate. This is the "treatment code" that field crews believe a plot has received. For example, TRTCDx = 10 indicates some type of cutting. Theoretically, a plot may be cut twice, or even three times, in a cycle. In practice it will rarely happen more than once. In the Southern Research Station, if a condition of a plot receives TRTCDx =10, field crews will further classify that code into clearcut harvest, partial harvest, shelterwood harvest, commercial thinning, or timber stand improvement. In this study, all field calls of TRTCDx = 10 were used and weighted equally.

Pulpwood production represents about 43 percent of overall harvesting (Johnson et al. 2009). However it would still be useful to see how the pulpwood canvass matches the Phase 2 survey.

The traditional calculation of acres treated per year is this one:

$$A = \sum_{i=1}^{C} \frac{EXPCURR_i \times ADJ\_EXPCURR_i \times CONDPROP_i}{REMPER_i} (I_1 + I_2 + I_3) \quad [1]$$

where

$EXPCURR_i$ is the current expansion factor for condition *i*,
$ADJ\_EXPCURR_i$ is the adjustment factor for condition *i*,
$CONDPROP_i$ is the condition proportion of the plot in forest,
$I_x$ is an indicator function for condition *i*; if $TRTCD_x = 10$, then $I_x = 1$, and 0 otherwise,
$REMPER_i$ is the remeasurement period for condition *i*.

*ADJ_EXPCURR* is an adjustment factor that compensates for inaccessible portions of otherwise accessible plots. *REMPER* is the time since the previous plot visit. In the case of a new plot, *REMPER* is assumed to be 5 years in the eastern United States and 10 years in the western United States (in the South, this restriction includes only western Texas and Western Oklahoma). See Rudis et al. (2008) and Harper (2010) for boundaries. Further details on the FIA database may be found in USDA (2007).

In standard pulpwood reports, softwood and hardwood are broken out separately, however in the interest of brevity they have been combined for this analysis. Figure 1 shows a map of pulpwood harvest per treated acre.

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## A CLOSER LOOK AT PHASE 1

There are 98 counties (parishes in Louisiana, but often called counties hereinafter) with pulpwood harvest data but no treated acres identified by the P2 FIA plots. 25 of these counties have less than 100 cords of production, but another 25 counties show more than 10,000 cords of production. According to the FIA Database, there were about 357 billion cubic feet of wood on forestland on 257 million acres in the south. The average yield, then, is 19 cords per forested acre. Among 1227 forested counties, the median value is 20.6 cords per forested acre, with the 95th percentile being 35.4 cords per acre. The highest is Hampton City, VA at 127 cords per acre, based on one plot, followed by Carlisle County, KY with 4 plots at 66 cords per acre and Fayette County, KY and then several counties at 52 cords per acre. So, some of the 15 counties in the 32 – 569 cords per acre range should be considered suspect as well.

West Texas has 4 of 10 panels processed; West Oklahoma has no data processed at all. All other states have a full cycle of data. A cycle is a full set of plots. In general, there is one plot for every 5937 acres. Plots are divided into 5 to 7 panels in the Eastern United States, and one panel is done in roughly one year. In the Western United States, the plot list is divided into 10 panels, with one panel done roughly each year. At the end of one cycle, the next cycle begins.

Only three counties stood out in the 2008 canvass in terms of infinite production per acre of timberland: Johnston County, OK is in west Oklahoma. Dallas County, TX shows a small amount of production but no timberland according to the Phase 2 survey. Orleans Parish, LA shows no forestland, let alone any timberland; it too shows a small amount of production.

Potentially small amounts could be due to landowners or utility companies cutting down trees and sending them to a pulpwood mill. However, FIA's understanding of urban forestry is too weak to model this sort of activity.

A rigorous examination of the Phase 1 data shows that there just might be some forestland present in Orleans Parish. Phase 1 is the first phase of forest inventory. It involves taking a classified satellite scene, totaling the pixels, and overlaying the plots on the scene. *EXPCURR* is equal to the stratum size within a survey unit divided by the number of plots in the stratum. Results for the South Delta of Louisiana are shown in Table 1.

Survey unit lines were established because FIA believed contiguous counties to be ecologically similar. If we apply these correction factors to the results specifically for Orleans Parish, we get the result shown in Table 2.

The phase 1 map of Orleans Parish is shown in Figure 2.

The water layer was not used for plot stratification but it is included to give the reader context. One can see there are areas of likely forest in New Orleans East, between Interstate 510 and Bayou Sauvage National Wildlife Refuge, as well as on the West Bank of the Mississippi River near English Turn, and then a small amount along the intracoastal waterway.

While the method described in Table 2 gives the same number of acres in each survey unit as the current method, it distributes acres among counties differently. However there are no forested plots in Orleans Parish among which to distribute these acres. The current problem requires only calculation of forested acres rather than volume or biomass, but there are still no treated acres for Orleans or any of the other 97 county-equivalents with no observed cutting.

## A CLOSER LOOK AT TRTCDx

It would appear then, that one county's worth of plots is not enough to accurately determine the cutting rate. The data need to be smoothed. There are many ways to accomplish this task.

Reams and McCollum (1999) found that important factors in probability of harvest were geographic region and ownership. Other factors were trees per acre and stand diameter.

It occurs to the authors that percent forest is a relevant factor as well, at least for privately owned forests. In most states the data appear to bear that out. For instance, in Louisiana, Figure 3 shows a graph of percent forest in a county to percent cut.

The regression line is a logistic regression, weighted by the number of plots, determined by the equation

$$Y = logit\left(b_0 + b_1 X\right),$$

where Y is the percent of privately held acres treated and X is the proportion of acres in private forest, as a percent of total area of the county. The one severe outlier is St. Bernard Parish, based on two forested plots. Possibly there is particularly heavy cutting in this parish, but the cost of increasing the estimate in parishes with no observed cutting is reducing the high estimate of the high outliers as well.

The results for public lands in Louisiana are shown in Figure 4. These results are quite a bit noisier. Grant Parish, home to the Kisatchie National Forest, is the one over 40 percent publicly forested. The parishes with the highest

observed rates of public cutting are: Sabine (Ft. Polk), West Feliciana (Cat Island National Wildlife Refuge), Caddo (County/Municipal lands), and St. Landry (Other federally owned lands).

Most other states have fairly similar graphs for private land. One notable exception is Kentucky; the regression line is nearly flat. Georgia's and Mississippi's graphs are somewhat less steep as well. Table 3 has coefficients for all the southern states. One can see that management patterns on public lands are relatively diverse. There may be some accessibility issues in Kentucky. There would appear to be too much cutting in lightly forested counties for all to be flukes.
Another special case is Texas. Ordinarily, FIA processes Texas as though it were two separate states. From Figure 6, one can see that there is valid reason for doing that. Open circles represent counties in East Texas, open squares represent counties in West Texas that did not appear on the TPO canvass, and filled circles represent counties in West Texas that appeared on the TPO canvass. Only the counties that appeared on the canvass were used to compute the regression.

Public land in Texas has an extremely low cutting rate, as shown in Figure 7. The one outlier is Upshur County (other public land).

## RESULTS

The next step is to fit these coefficients with the Phase 1 (not the raw Phase 2) derived area estimates, and divide the estimated treated acres into production. The combined result for softwood and hardwood is shown in Figure 6.

There are three counties with more than 32 cords per treated acre in the 2008 canvass, with Clay County, FL leading the way at 39 cords per treated acre.

There were five counties with more than 32 cords per acre in the 2009 canvass, with Washington County, TN leading the way.

## CONCLUSIONS

The plan for the 2009 Southern Pulpwood Report, to be published in Fiscal Year 2011, is to use a method similar to this one. It marks a drastic shift in the way pulpwood data and FIA Phase 2 data has been processed and visualized. The authors welcome suggestions for improving the model.

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**Table 1—Stratum statistics for the South Delta of Louisiana**

| Stratum | Acres | Plots | EXPCURR | Percent Forest |
|---|---|---|---|---|
| Nonforest | 10062566 | 1681 | 5985.955 | 0.53 |
| Nonforest Edge | 669614 | 99 | 6763.374 | 13.54 |
| Forest | 315246 | 46 | 6852.933 | 66.71 |
| Forest Edge | 370913 | 76 | 4880.275 | 27.56 |
| Bottomland Hardwoods | 2336656 | 333 | 7016.816 | 81.20 |
| Total | 13754994 | 2235 | | |

**Table 2—Stratum statistics for Orleans Parish, Louisiana**

| Stratum | Acres | Plots | Percent Forest | Forested acres |
|---|---|---|---|---|
| Nonforest | 201061 | 31 | 0.53 | 1070 |
| Nonforest Edge | 5381 | 1 | 13.54 | 729 |
| Forest | 3965 | 1 | 66.71 | 2645 |
| Forest Edge | 3243 | 0 | 27.56 | 894 |
| Bottomland Hardwoods | 10487 | 0 | 81.20 | 8516 |
| Total | 224137 | 33 | | 13853 |

**Table 3—Regression coefficients for southern states**

| State | Year | Private | | Public | |
|---|---|---|---|---|---|
| | | $b_0$ | $b_1$ | $b_0$ | $b_1$ |
| Alabama | 2008 | -4.1648 | 1.3859 | -3.7556 | -9.6544 |
| Arkansas | 2008 | -4.1318 | 1.7803 | -4.6951 | 1.5249 |
| Arkansas | 2009 | -4.1513 | 1.7245 | -4.5311 | 1.1438 |
| Florida | 2007 | -4.1368 | 1.0346 | -3.9876 | -3.0698 |
| Georgia | 2008 | -3.5806 | 0.4201 | -4.0208 | -1.8821 |
| Kentucky | 2007 | -3.6491 | 0.0664 | -3.9594 | -3.8556 |
| Louisiana | 2005 | -3.7813 | 1.1720 | -4.4667 | 2.3616 |
| Mississippi | 2006 | -3.6625 | 0.4711 | -4.317 | 0.6019 |
| North Carolina | 2007 | -3.9513 | 0.7585 | -5.1279 | -0.4179 |
| Oklahoma | 2008 | -5.2298 | 2.7946 | -5.6821 | 3.5580 |
| South Carolina | 2007 | -3.9947 | 1.1854 | -4.2465 | 0.2546 |
| Tennessee | 2007 | -4.7584 | 1.5121 | -5.3849 | -1.0712 |
| Texas | 2007 | -3.9199 | 1.1900 | -5.7037 | 7.3037 |
| Virginia | 2008 | -4.6398 | 1.5253 | -3.9773 | -5.3726 |

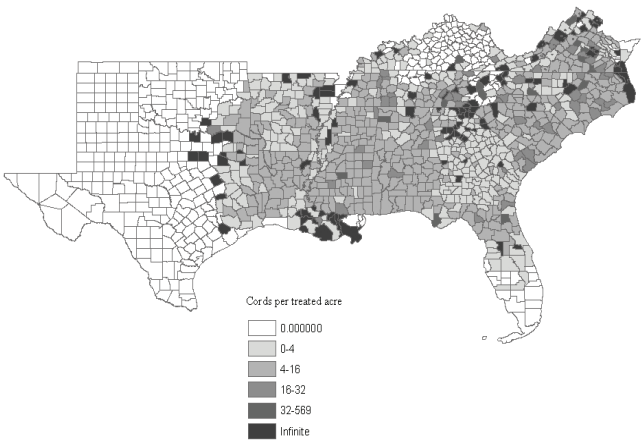


Figure 1—Choropleth map of pulpwood harvest per treated acre, 2008.

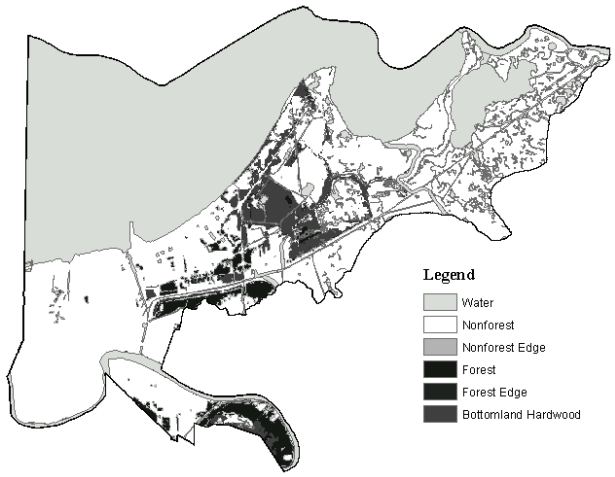


Figure 2—Phase 1 map of Orleans Parish, Louisiana.

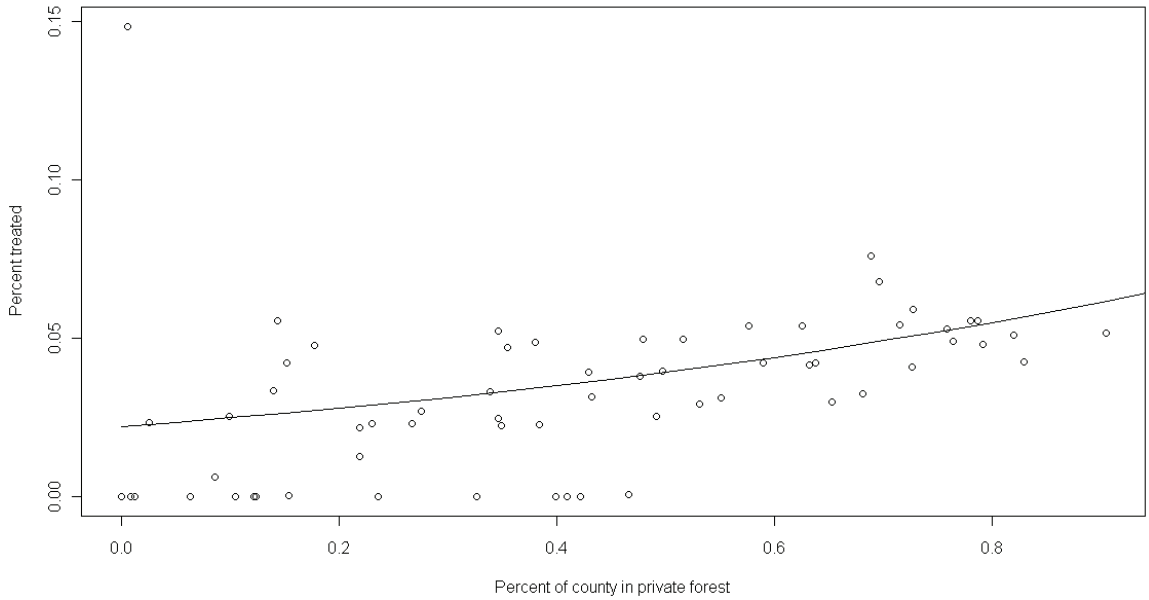


Figure 3—Percent of county in private forest versus percent treated, LA 2005.

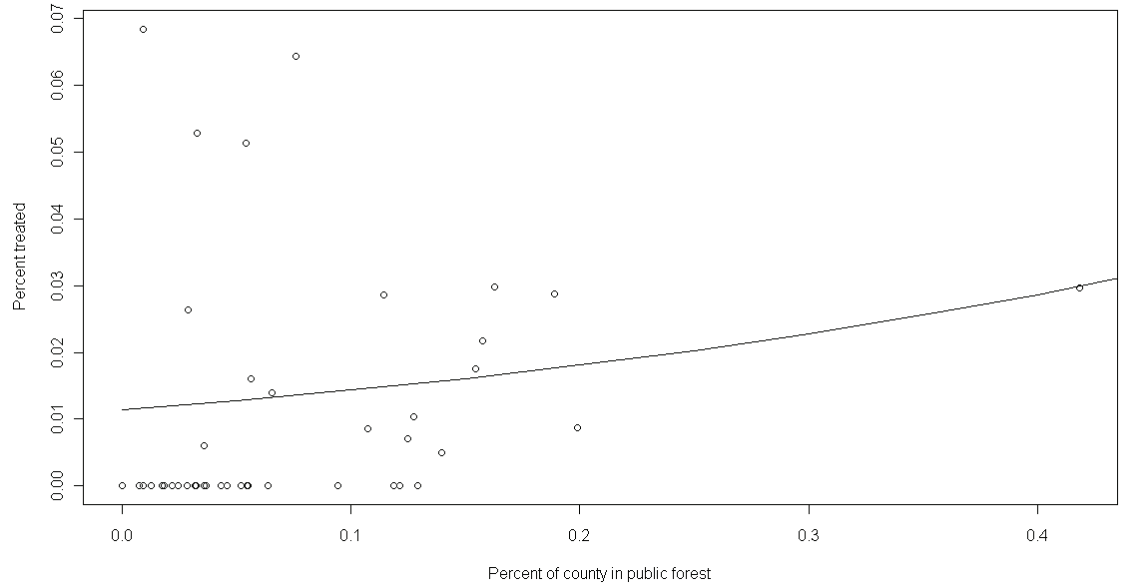


Figure 4—Percent of county in public forest versus percent treated, Louisiana 2005.

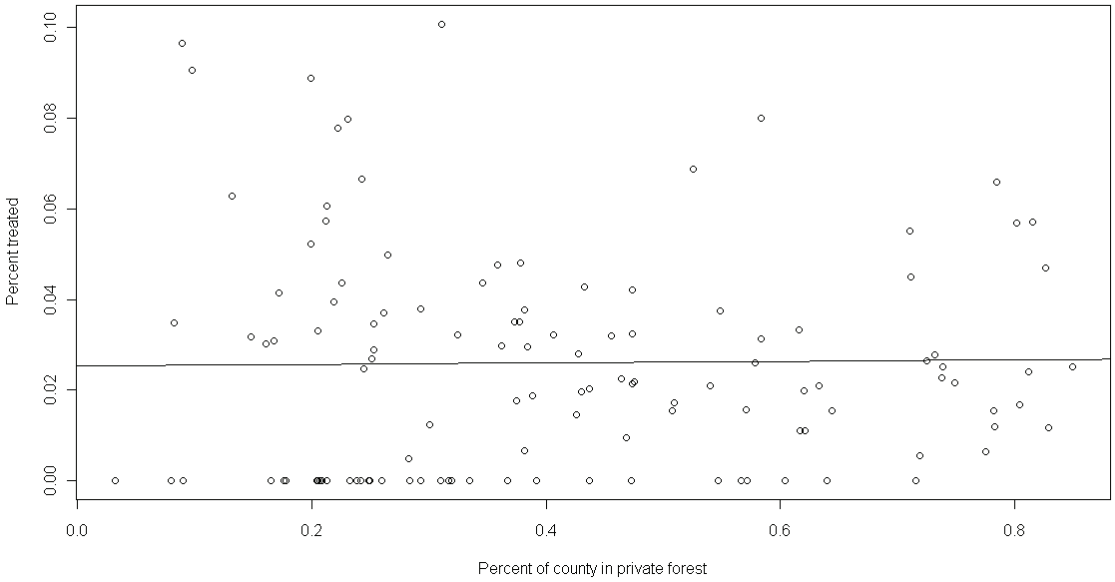


Figure 5—Percent of county in private forest versus percent treated, Kentucky 2007.