Forest Trends, Timber Products Output, and Wood Chip Mill Harvest Area Impacts in North Carolina

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ABSTRACT

North Carolina forest area, timber volumes, and timber growth and removals increased from 1938 to 1990. Softwood harvests were approximately equal to growth as of 1990; hardwood growth still exceeded removals by about 30% in 1990. However, in 1990 more counties had removals that exceeded growth than in 1983, for both softwoods and hardwoods. Timber Products Output (TPO) analyses indicated that pulpwood harvests comprised about 40% of all timber removals in North Carolina. The 18 wood chip mills considered in the North Carolina wood chip mill study used about 88% hardwood timber and 12% softwood. In total, wood chip mills processed about 27% of all roundwood pulpwood production in North Carolina in 1997, and about 12% of all timber production. Roundwood pulpwood production was correlated with increases in wood chip mill capacity in both the eastern and western portions of the state. The greatest harvest volume increases associated with chip mills were found in the Piedmont region. New wood chip mills would add incremental new capacity and increase the area of forest harvested. Wood chip mills would average about 1000 acres per year of additional harvest area per 100,000 tons per year of chip mill.

INTRODUCTION

The contribution of wood chip mills to timber harvests has been an increasingly contentious issue in the South for at least three years. Environmentalists have called for bans of permits of wood chip plants, citing fears about adverse effects on local communities and on the forest environment. Firms have shifted more existing production and added new capacity via wood chip mills, which provide efficient roundwood processing capacity. This paper summarizes some of the findings of our study in North Carolina regarding trends in the forest resources, timber products output, and chip mill impacts on timber harvesting areas.

FOREST RESOURCE TRENDS, 1938-1990

The Forest Inventory and Analysis (FIA) data from 1938 to 1990 indicate that North Carolina has experienced generally increasing amounts of hardwood and softwood timber volumes, increasing timber harvest levels, and generally older forest stands.

Total North Carolina forest area rose from 1938 to 1964 and has been in a gentle decline ever since. Farmer-owned timberlands decreased 62% since 1955 and privately held (non-farmer) ownerships increased accordingly. Total forest industry ownership area has remained stable since 1955. As of 1990, North Carolina forest types consisted of 39% Upland Hardwood, 22% Natural Pine, 14% Oak-Pine, 14% Lowland Hardwood and 11% Pine Plantation. The western portion of the state is three-quarters hardwood and the eastern portion is roughly half hardwood, half softwood, with a gradient of change in-between. From 1974 to 1990, pine plantations were gaining acreage, while all other broad management classes remained relatively stable or declined slightly.

Since 1938, hardwood growing stock volumes are up 176%. Softwood growing stock volumes increased 69%. Accordingly, from 1938 to 1990, the hardwood volume to softwood volume ratio climbed from 1:1 to 1.7:1. The forests are becoming more balanced among different species. Perhaps more late successional (maple, beech) rather than early successional species (southern pine, oak) have contributed to this trend. Also, while pines have been the dominant species group, oaks have been accumulating volume faster, and should become dominant within 10 years.

The increase of wood volume and the decrease in timberland means the lands available were more productive in 1990 than in 1938. The total amount of growing stock volume (all species) has increased from about 1100 cubic ft/acre to 1800 cubic ft/acre.

Sustainable timber production for the state as a whole seems challenging according to the forest survey data reviewed here. As of 1990, we were still growing more...
timber than we were removing each year in total, for both softwoods and hardwoods. That surplus for softwoods had actually increased slightly since the 1984 forest survey. The hardwood surplus growth was declining rapidly as of 1990, however. Given increased timber harvests, for both industrial wood and urban expansion, continued increases in the hardwood inventory levels will slow, if not reverse, in the future. Softwood removals on private lands already exceeded net annual growth.

As of 1990, North Carolina averaged about 400,000 acres of timber harvest per year, with 295,000 acres of final harvest or clearcuts. Pine plantations are harvested at regular intervals, mostly as young stands. Other management types are not harvested at predictable ages. On all lands, use of site preparation, commercial thinning, and final harvests (clearcuts) has increased from 1984 to 1990, while use of partial harvests has decreased. A greater share of timber harvesting is being performed as final harvests, or clearcuts, and the reliance on partial harvests is declining. The only large amount of thinning occurs on pine plantations.

Natural disturbances occurred at the rate of about 350,000 acre per year as of 1990. However, they seem to have increased their impact on North Carolina forests more than timber harvesting in the 1990s, also prompting needs for forest management responses. The trends discussed here all occurred before the frequent hurricanes of the 1990s, including Bertha, Fran, Bonnie, and Floyd, which caused substantial damage to forest lands in the state. Fire, pests, and pathogens continue to affect forest health.

We experienced declines in the total forest area in the state, with a loss of more than one million acres of timberland from 1964 to 1990. The natural pine management type, in particular, has seen substantial decreases in area. Timberland area declines and timber harvesting has been particularly heavy in the Piedmont region. In 1990, forest industry and public ownerships maintained a 2:1 growth to removal ratio. Private owners had a 0.97 ratio for softwood and 1.3 ratio for hardwood. Timber harvests have increased as state and regional population has increased, and demands for forest products have increased accordingly. Our continued timber inventory growth has attracted more forest industry expansion to the state and is increasing harvests. Sustained levels of timber production in some counties will face increasing pressures from those increased timber harvests, as well as from urbanization.

**TIMBER PRODUCTS OUTPUT**

Softwoods provide the principal component of North Carolina's timber products output (TPO), accounting for two thirds of NC TPO volume in 1997. Softwood sawtimber is the largest single component, and for much of the 1990s, this one softwood product category has accounted for almost as much timber volume as all hardwood categories combined. Domestic hardwood pulpwood harvest volumes have increased from about 44% of hardwood TPO in the late 1980s to about 50% by 1997. Inclusion of international export volumes would further increase this percentage.

In recent years, hardwood roundwood pulpwood volumes have increased, while softwood roundwood pulpwood volumes have declined slightly. In combination, these two trends have resulted in roundwood pulpwood volume retaining a roughly 40% share of overall North Carolina TPO, but hardwoods comprise an increasing percentage of the product mix. The quantity of hardwood as a percentage of total North Carolina domestic pulp production has increased from 33% in 1980 to 42% in 1997.

Comparing the last (1984-1989) and the present (1990- ) FIA reporting periods, average annual roundwood softwood pulpwood volumes are 24% higher than averages for the prior period. The average annual roundwood hardwood pulpwood volumes are 17% higher. Overall average roundwood pulpwood removals are 21% higher than during the prior FIA inventory cycle. For purposes of FIA reporting, North Carolina is divided into four survey units: (1) the Southern Coastal Plain, (2) the Northern Coastal Plain, (3) the Piedmont, and (4) the Mountains.

The two Coastal Plain regions accounted for 74% percent of average total roundwood softwood pulpwood production over the period 1980 to 1997. In contrast, the Piedmont and Mountains together produce only slightly more than a quarter of the average softwood volumes for 1980 to 1997. The two Coastal regions are also the largest hardwood roundwood pulpwood producers. However, this pattern is changing, as the Coastal Plain regions provided only 59% of North Carolina's roundwood hardwood pulpwood production in 1997, compared with 74% in 1990. This shift is due principally to a 66% increase in hardwood roundwood pulpwood production in the Piedmont between the average of the last FIA inventory period and the average over the decade of the 1990s.

Roundwood pulpwood production in North Carolina has shown rates of increase which exceed the rates of increase for North Carolina pulp mill capacity. Based
on all mills included in the Southern Pulpwood Production reports, North Carolina has an average of 6.5% of the South’s pulping capacity (averaged over the period 1980-1996), but has provided 9% of the region’s pulping capacity, and 11.3% of the region’s hardwood pulping capability over the same period.

Accordingly, North Carolina has been a net exporter of both hardwood and softwood roundwood pulping every year from 1980 to 1997. More than 95% of net exports go to South Carolina and Virginia. In 1997, the last year for which data are available, North Carolina was a net domestic exporter of 629,000 cords of softwood roundwood pulping and 577,000 cords of hardwood roundwood pulping. In 1997, North Carolina exported about 25% of its pulping production to other states, and about 6% to international markets. Hardwoods comprised 15.3 million cubic feet (73%) of North Carolina’s international export chip production.

In 1998, North Carolina’s 18 satellite chip mills reported an aggregate capacity of 4.1 million tons per year. The Mountain region has 4 chip mills, the Piedmont has 9, and the combined Coastal regions have 5 mills. Table 1 shows the distribution of processing capacity among North Carolina’s FIA regions for selected years.

Table 1. Cumulative chip mill capacity by region within North Carolina (thousands of tons)

<table>
<thead>
<tr>
<th>Region:</th>
<th>Mountain</th>
<th>Piedmont</th>
<th>Coastal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HW SW</td>
<td># mills</td>
<td>HW SW</td>
</tr>
<tr>
<td>Year:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1980</td>
<td>0 0</td>
<td>0</td>
<td>286 50</td>
</tr>
<tr>
<td>1985</td>
<td>354 186</td>
<td>2</td>
<td>361 125</td>
</tr>
<tr>
<td>1989</td>
<td>434 206</td>
<td>3</td>
<td>672 338</td>
</tr>
<tr>
<td>1994</td>
<td>459 206</td>
<td>4</td>
<td>897 413</td>
</tr>
<tr>
<td>1998</td>
<td>459 206</td>
<td>4</td>
<td>1612 448</td>
</tr>
</tbody>
</table>

Historical data that relate chip mill throughput volumes to harvest removals within FIA survey units are available only for one year, 1997. Alternatively, we performed a correlation analysis, comparing chip mill capacity and pulpwood production volumes for each of North Carolina’s four FIA regions for the years 1980 through 1997. The Piedmont region and the Mountains showed strong positive correlations between chip mill capacity and production volumes, the individual Coastal Plain regions did not. When comparing the western and eastern sections of the state along Timber Mart-South boundaries, we found positive correlation between the eight chip mills in western North Carolina and hardwood pulping production as well as overall pulping production. The correlation of capacity for the ten chip mills in the eastern portion of the state and pulping production volumes are also well correlated for hardwoods, softwoods, and for combined production. Table 2 reports the correlation coefficients between chip mill capacity increase and hardwood and softwood roundwood pulping production increase in North Carolina from 1980 to 1997 (significance levels: p=0.10*, p=0.05**, p=0.01***).

HARVEST AREA IMPACTS

Our TPO analysis indicated that wood chip processing comprised an increasing amount of the total hardwood pulping production ranging from the eastern to western parts of the state. In the Coastal Plain, independent wood chip mills processed from 15% to 16% of the total pulping production in 1997. In the Piedmont, wood chip production was 49% of pulping production; in the Mountains it was 75%. State-wide it was 27%. These findings, in conjunction with the correlation analysis, suggest a relationship between chip mill operations and increasing areas of harvest in North Carolina.

To analyze whether wood chip mills would affect forest harvest area, we utilized data on (1) the varying
Table 2. Correlation between roundwood pulp production and chip mill capacity in North Carolina 1980-1997

<table>
<thead>
<tr>
<th>Region</th>
<th>Hardwood</th>
<th>Softwood</th>
<th>All Pulpwood</th>
</tr>
</thead>
<tbody>
<tr>
<td>S. Coastal Plain</td>
<td>--</td>
<td>.75**</td>
<td>--</td>
</tr>
<tr>
<td>N. Coastal Plain</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Piedmont</td>
<td>.77***</td>
<td>--</td>
<td>.48**</td>
</tr>
<tr>
<td>Mountains</td>
<td>.55*</td>
<td>--</td>
<td>.53*</td>
</tr>
<tr>
<td>Eastern TMS</td>
<td>.55**</td>
<td>.84***</td>
<td>.77***</td>
</tr>
<tr>
<td>Western TMS</td>
<td>.77***</td>
<td>--</td>
<td>.58**</td>
</tr>
</tbody>
</table>

size of wood chip mills and the species mix that they used; (2) estimates of the harvest volumes per acre; (3) estimates of the working circles around wood chip mills; and (4) estimates of the residual wood volume that could be harvested on chipped versus non-chipped sites.

**Woody Debris vs. Chip Mill Capacity**

A woody debris study was performed as part of the North Carolina wood chip mill study (Hess 2000). That study examined woody debris residual volumes on sites which had been harvested both with and without chip mill product components. The mean residual volume per acre including tops, limbs, and residual growing stock volume for sites harvested without wood chips was found to be 1288 cubic feet per acre; with a wood chip component, residual volume was 834 cubic feet per acre. The difference of about 450 cubic feet per acre (about 18 tons), may be thought of as the incremental wood fiber utilization attributable to chip mills.

We compared these site specific data with the statewide data available from the 1990 FIA analysis (Brown 1993). These data show that on average 428 million cubic feet of hardwood growing stock volume were harvested annually from 184,000 acres during the period 1984-1989. This is an average hardwood growing stock volume of 2320 per acre. About 34% found its way into higher value products, and about 31% was processed as pulpwood. Roughly 21% of total hardwood harvest, about 490 cubic feet per acre, was not used for products, but was classified as residual growing stock volume or other removals. Acknowledging that some removals represent reserved lands, but knowing also that chip mills can process material too small to be classified as growing stock, our estimate of 450 cubic feet per acre of incremental volume seems to tally pretty well with historical data.

Table 3 shows the calculations by forest survey unit for potential residual volume in tons that would be available to chip mills at 1990 levels of harvest.

As Table 3 indicates, there appears to be more than enough harvest area times the residual volume in the Coastal Plain to provide all the wood chip mill harvest. However, removing pine acres from consideration reduces the residual volumes by almost 2 million tons and implies that Coastal chip mill production, which is principally hardwood, would need to utilize virtually all available hardwood acres to meet volume requirements without increasing harvested acres. Harvesting all the residual volume in the Piedmont and the Mountains would not provide enough volume to feed all the chip mill capacity as of 1997. Conclusions about acre effects must be tempered by the observation that some chip mill volume substitutes for volumes previously processed through concentration yards and chipped at pulp mills. The most pertinent factor to consider here would be reductions of wood chipping at pulp mills. While this has certainly occurred, particularly in western North Carolina, these effects were not quantified within the present study. Taken into account, they would reduce our estimates of wood volumes required.

Other components of the North Carolina study support the premise that wood chip mills induce additional harvest acres. Our field visits and efforts to sample harvest sites found more sites that did not have wood chip component than those that did. Our study of nonindustrial private forest owners showed that economic and market factors would prompt more harvests. Cointegration statistical tests indicated that North Carolina timber markets were well integrated; wood chip markets contribute to this status.
Table 3. FIA Final Harvest Areas, Potential Wood Chip Volumes, and Chip Mill Capacity

<table>
<thead>
<tr>
<th></th>
<th>1990 Final Harvest (Acres)</th>
<th>Residual Available (Tons)</th>
<th>1997 Chip Capacity (Tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coastal Plain</td>
<td>194,834</td>
<td>3,500,000</td>
<td>1,413,000</td>
</tr>
<tr>
<td>Piedmont</td>
<td>72,161</td>
<td>1,300,000</td>
<td>2,060,000</td>
</tr>
<tr>
<td>Mountains</td>
<td>27,991</td>
<td>500,000</td>
<td>665,000</td>
</tr>
<tr>
<td>State Total</td>
<td>294,986</td>
<td>5,300,000</td>
<td>4,138,000</td>
</tr>
</tbody>
</table>

In order to estimate the range of potential impacts of a wood chip mill, we assumed that the maximum areal impact would result if a wood chip mill consisted of entirely new processing capacity in an area. For this analysis, we assume a hardwood harvest of 2500 cubic feet per acre. These numbers are well within the acreage volume range of harvests in North Carolina, but slightly above the average volume of 2320 per acre reported by FIA. The FIA 1990 average includes some high-graded acres that reduce the volume estimate, and considers only growing stock volume. In our theoretical analysis, we assume harvest is entirely for wood chips and all available material from the site is processed. At a conversion rate of 25 cubic feet per ton, this analysis results in an estimate of 100 tons per acre, or 1000 acres of forest consumed for each additional 100,000 tons of chip mill capacity. Therefore, if all chip mills in North Carolina were supplied entirely from dedicated wood chip harvest sites and no substitution effects occurred, the upper bound on the number of acres harvested would be 41,000 acres of hardwood harvest to meet chip mill capacity of 4.1 million tons in 1997.

In addition to upper and lower theoretical bounds, we also considered data which might provide evidence of average effects during the decade of the 1990s. One approach used was to consider the average annual hardwood pulpwood increase of roughly 23,000,000 cubic feet per year which marks the difference between the last FIA inventory cycle and hardwood pulpwood removals averages during the 1990s. This average annual increment of 920,000 tons is a conservative estimate of the volume effect of chip mills, because it does not include international export volumes, and it does incorporate the impacts of concentration yard substitution as chip mills came on line during the 1990s. This annual increment would translate to 9200 acres of additional harvest each year during the 1990s.

Projecting these estimates into the future, with the increased capacity of chip mills added during the 1990s fully operational, leads to significantly higher area impacts. Our TPO analysis showed that pulpwood harvest levels in North Carolina were substantially higher in the 1990s than in the prior decade. Consistent with this historical data, if we assume that substitution effects are captured by changes prior to 1990, and chip mill expansion after 1990 represents new processing capacity, the area required to support the cumulative gain of the 2.4 million tons of chip mill capacity that has come on line in North Carolina since 1990 would be 24,000 acres chipped per year. Applying the historical average of roughly 1000 cubic feet per acre utilized as higher value TPO or fuelwood (Brown 1993), that would leave about 15,000 cubic feet of pulpwood furnish per acre, and imply an annual harvest impact of 40,000 acres harvested, allowing for 16,000 acres utilized for higher value products and 24,000 acres as pulpwood. Extending these utilization ratios to new chip mill capacity would suggest that each 100,000 tons of additional capacity would result in about 1700 acres of additional harvest, or that a high capacity 400,000 ton chip mill would induce about 6700 acres of additional harvest per year.

Cumulative Area Effects

The cumulative effects of these annual wood chip harvests would obviously be many times greater than the effects for one year. The principal effect would be the tendency to convert increasing areas of North Carolina’s hardwood forests over time into increasingly younger stands. Our calculations suggest that supplying the capacity of one 400,000 ton chip mill would shift an additional 80,000 to 134,000 acres of hardwood into stands 20 years and younger, during its first two decades of operation. Similarly, supplying the 2.4 million ton capacity of the chip mills which have become operational since 1990 could shift an additional 480,000 to 800,000 acres of hardwood into the 20 year or younger age class over a 20 year period. This represents an area of roughly 4% to 6.5% of North Carolina’s total 1990 hardwood timberland.

The effect of the average volume of annual harvest is most apparent in the growth and removal ratios.
Assuming 100 percent hardwood consumption, the total state-wide effect of all 18 chip mills harvesting 100 percent hardwood maintains a 222 million cubic feet of annual surplus growth over removals within their assumed 50 mile radius procurement area. If the mills were to utilize only softwood, the net annual growth surplus in the 50-mile radius around mills would be only 30 million cubic feet. In fact, growth should still exceed removals for years around most new chip mills. They were located in areas of surplus wood, rather than scarcer wood baskets around existing pulp and paper mills.

CONCLUSIONS

Total timber net annual growth exceeds removals in North Carolina, and the state has more timber inventory volume now than at any time since the FIA began to track these data. However, private forest land growth to removal ratios are less favorable. Private softwood removals exceeded growth in 1990.

Estimated harvest levels in North Carolina have increased significantly for both hardwoods and softwoods during the decade of the 1990s, increasing 17% for hardwoods, 24% for softwoods, and 21% overall. Our study projected that hardwood removals will begin to exceed growth within about a decade, and hardwood inventory volume will begin to decline. Without the silvicultural advances associated with pine plantations, softwood inventories would show substantial declines. In any case, natural pine inventories are declining, as are natural pine acres; a condition that is worrisome for the nontimber, ecological values associated with these forest types.

Wood chip mills do contribute to the increasing harvest levels in North Carolina. North Carolina’s timber inventory volumes exceed those of many other southern states, yet stumpage prices remain comparatively low. This makes the state’s timber economically attractive, and chip mills provide a means to efficiently transport the fiber to other markets. Chip mills were correlated with increased timber harvest production in both the eastern and western regions of the state during the period 1980 to 1997, and chip exports from North Carolina have shown corresponding growth during the period. North Carolina has been a net exporter of both hardwood and softwood pulpwood during each year from 1980 to 1997, and in 1997 the state exported about 25% of its pulpwood production to other states and an additional 6% abroad. Transportation efficiencies associated with chip mills continue to make these exports viable and economically attractive.

Chip mills could take some, but not all, of their wood requirements from existing sites. Findings from our study suggest that chip mill furnish is most likely a combination of more intensive harvest from existing sites, resulting in about 18 tons of additional removals per average acre, and expanded harvest area within the state. The effect of the 2.4 million tons of capacity expansions in the 1990s was estimated to be the direct consumption of perhaps 9200 acres of hardwood annually, with a potential to induce a cumulative hardwood harvest increase of 40,000 acres annually in the years ahead. As a very generalized rule of thumb, each additional 100,000 tons of chip mill capacity will likely consume 1000 acres of hardwoods per year, and induce a total clearcut harvest for chips and other products of about 1700 acres annually.

These extensive and intensive impacts have different ecological implications for the state’s forests. Extensive effects have the potential to create fragmented forests, as a result NIPF harvest decisions in North Carolina’s highly fragmented forest ownerships. Cumulatively, these effects will also result over time in more area in younger hardwood stands, with resulting wildlife habitat effects. Intensive harvest, resulting in cleaner stands, will provide economic and soil stability benefits on artificially regenerated acres, but will reduce woody debris habitat and increase mineral soil exposure and the likelihood of erosion on naturally regenerating stands.

LITERATURE
