Biomass **20** (1989) 145–153

Potential Residual Biomass in Mature Pine Stands of the Midsouth, USA

J. F. Rosson, Jr

Southern Forest Experiment Station, PO Box 906, Starkville, Mississippi 39759, USA

ABSTRACT

*The extent, location, and ownership of residual woody biomass available on mature pine timberland prior to the harvest of log-size pine was determined for the Midsouth States. Most of this residual is on non-industrial private timberland. Sweetgum (*Liquidambar styraciflua *L.) and loblolly pine (*Pinus taeda *L.) are the dominant species in the residual. Stems of all species < 25 cm in diameter comprise most of the residual (66%). A preharvest biomass operation may be the most efficient way to take advantage of these substantial levels of woody biomass.*

Key words: forest inventory, forest ownership, woody biomass, mature pine.

INTRODUCTION

Many biomass harvests are coordinated around traditional timber harvests in the southern US. These biomass harvests often take place after timber harvesting is complete, when much of the potential biomass has been knocked down by skidding machinery or felling equipment, making it unusable or difficult to gather. Preharvest biomass operations may increase the efficiency of harvesting by gathering potential woody biomass before it is knocked down. Such an operation poses no threat to the mature pine targeted for harvest, as it is believed these stems would be large enough to withstand any accidental contact by harvesting equipment. Soil compaction would not increase over that of a post harvest operation but nutrient depletion may be higher due to the efficiency of removing more material from a particular site.

The extent of the potential residual biomass resource available on mature pine sites in the Midsouth States (Alabama, Arkansas, Louisiana, Mississippi, Oklahoma, Tennessee and Texas) is defined in this paper. It

Biomass 0144-4565/89/$03.50 — © 1989 Elsevier Science Publishers Ltd, England.
Printed in Great Britain

is not the intention of this paper to suggest that all timberland sites can sustain such total tree harvests indefinitely. Each site should be evaluated separately for negative impacts. This requires a detailed soil analysis.

METHODS

Data from continuous forest inventory (CFI) plots collected by the USDA Forest Service Forest Inventory and Analysis (FIA) work unit in the Midsouth were examined to determine the extent of residual woody biomass in mature pine forests. The primary criterion used to identify mature pine stands in the data set was a minimum pine saw-log volume of 75 m^3 ha^{-1}. This is equivalent to approximately 8000 board feet per acre (International 1/4-in rule). Maximum pine saw-log volume on the mature pine stand plots was 395 m^3 ha^{-1}, average for all plots was 142 m^3 ha^{-1} (approximately 12 500 board feet per acre). The minimum pine volume is based on sites of various productivity and comes primarily from Walker's synthesis of the southern pine region.[1] Much subjectivity was used in establishing this threshold. Based on this criterion, of $\approx$ 17 000 CFI plots, 1268 were identified as being mature pine stands. Most of these plots were located in the southern belt of the Midsouth States on the Coastal Plain, exclusive of the Mississippi Embayment (Fig. 1). Biomass weights were obtained by applying individual tree measurements to allometric equations developed by the Utilization of Southern Timber work unit of the Forest Service, Southeastern Forest Experiment Station.[2-4] Woody biomass dry weights were computed for two components of each tree: (1) the total tree weight (above a stump height of 30 cm to the twig tips) and (2) the stem weight (above a stump height of 30 cm to a stem terminus of 10 cm in diameter outside the bark). A third tree component, crown weight, was derived by subtracting stem weight from total tree weight.

Woody biomass is defined as the oven-dry weight of wood and bark in the tree component in question. Fruits, flowers, leaves and roots were excluded. Potential residual woody biomass includes all hardwood trees $\geq 2{\cdot}5$ cm in diameter and all softwood trees $\geq 2{\cdot}5$ and < 23 cm in diameter. It is understood that there are many potential uses of material in the size ranges defined. No attempt is made to separate other potential end products. This can be done by consulting the tables. The crown portion of pine saw logs was not included in the residual biomass in these computations because it is not considered accessible in a first-pass biomass harvest (preharvest operation).

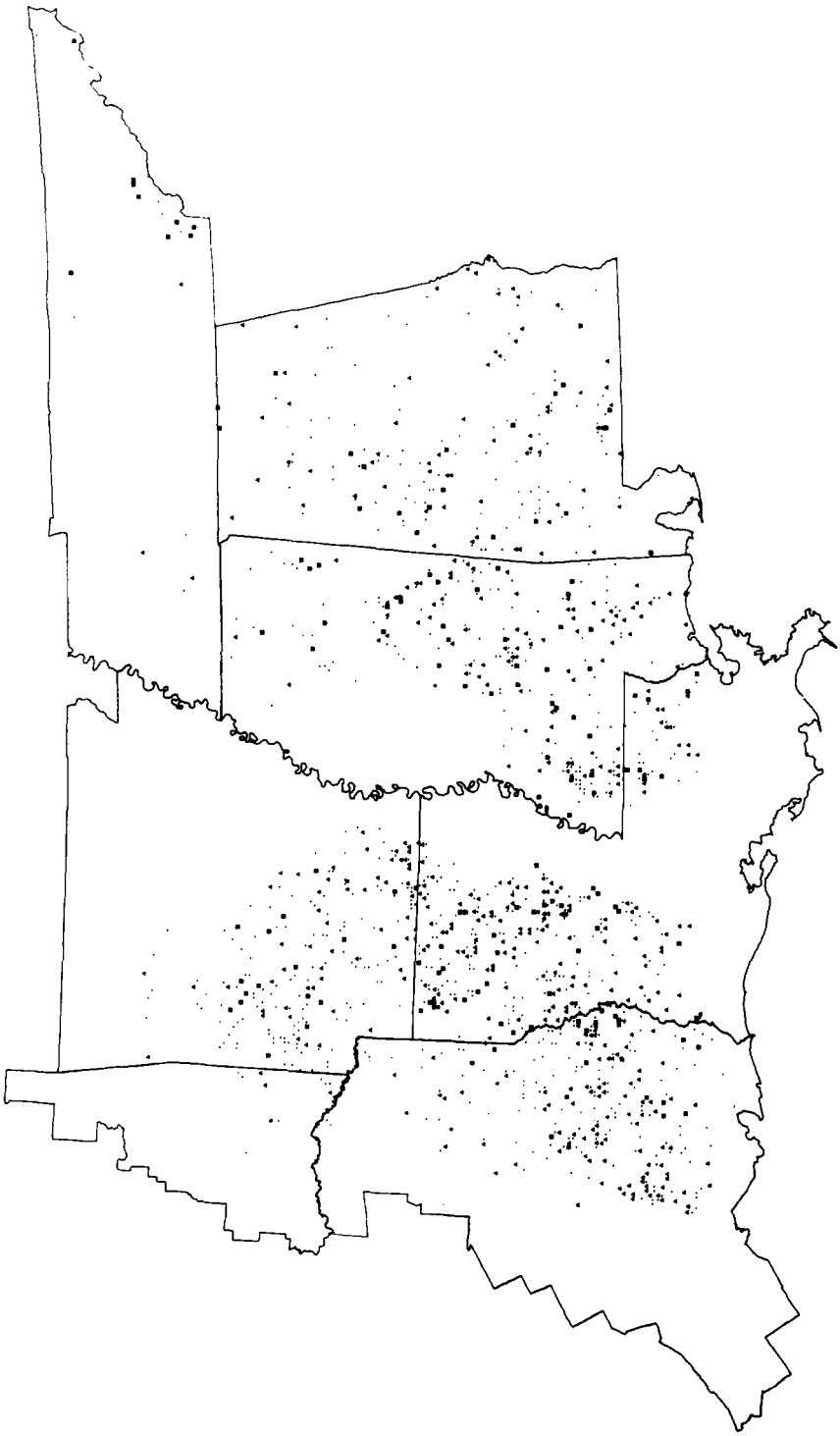

Fig. 1. *Mature pine sample plot locations in the Midsouth, USA. Each location is indicated by a symbol representing the yield of potential residual woody biomass.* ▲ $< 4{\cdot}00 \times 10^{1}$ tonnes ha^{-1}; ● $= 4{\cdot}00 \times 10^{1}$–$1{\cdot}00 \times 10^{2}$ tonnes ha^{-1}; ■ $\geq 1{\cdot}00 \times 10^{2}$ tonnes ha^{-1}.

Dry weight biomass estimates for individual sample trees were computed by the following equations:

Trees ≥ 2·5 cm and ≤ 13 cm in diameter

$$Y = a'(D^2)^b$$

Trees ≥ 13 cm and < 22·5 cm in diameter (softwoods)
Trees ≥ 13 cm and < 28 cm in diameter (hardwoods)

$$Y = a'(D^2 TH)^b$$

Trees ≥ 22·5 cm in diameter (softwoods)
Trees ≥ 28 cm in diameter (hardwoods)

$$Y = a''(D^2)^b(TH)^c$$

where Y is the oven-dry weight, D is the tree diameter, TH is the total height of tree, and a', a'', b and c are the regression coefficients.

Species-specific coefficients were used to estimate dry weights of trees ≥ 2·5 cm in diameter at breast height (1·37 m above ground level). Coefficients were available for most of the commercial gymnosperm (softwood) species and several of the commercial angiosperm (hardwood) species.[2–4] When species-specific coefficients were not available for a particular species, general coefficients for softwood, soft hardwood (specific gravity < 0·50) and hard hardwood (specific gravity > 0·50) were substituted. It has been demonstrated that these general coefficients from grouped species produce reliable estimates for regional surveys.[5]

Plot locations were categorized into three ownership types: (1) public, (2) forest industry and (3) non-industrial private (NIPF). Public lands are under the administration of federal, state, county or municipal governments. Forest industry lands are owned by companies or individuals operating primary wood-using plants. The NIPF lands are owned by all other owners. These include farmers, non-farmers and corporations other than forest industry.

RESULTS

The majority of the $2{\cdot}98 \times 10^6$ ha of mature pine timberland in the Midsouth is on NIPF land (Table 1). Public and forest industry ownerships hold 21% and 27%, respectively. The availability of material from the large NIPF base is in question. Information relating ownership characteristics to disposition of timberland resources is insufficient at this time. It can only be assumed that owners will market their resources where net return is highest. Also, aestheticism regarding property plays

TABLE 1
Area of Mature Pine and Potential Residual Woody Biomass by Ownership Class in the Midsouth, USA

Ownership class	*Hectares ($\times 10^3$)*	*Tonnes ($\times 10^4$)*
Public	638·1	3 723·5
Foresty industry	816·5	4 520·5
Non-industrial private (NIPF)	1 529·0	8 931·6
All owners	2 983·6	17 175·6

TABLE 2
Area of Mature Pine Stands and Oven-dry Weight of Potential Residual Woody Biomass by Tree Component, Species Group and State in the Midsouth, USA

State	*Hectares ($\times 10^3$)*	*Total ($\times 10^4$ tonnes)*		*Stem ($\times 10^4$ tonnes)*		*Crown ($\times 10^4$ tonnes)*	
		Softwood	*Hardwood*	*Softwood*	*Hardwood*	*Softwood*	*Hardwood*
Alabama	453·3	686·5	1 886·7	560·0	1 473·8	126·5	412·9
Arkansas	478·7	731·4	2 120·6	604·2	1 644·8	127·2	475·8
Louisiana	761·0	863·6	3 369·7	704·3	2 572·6	159·3	797·2
Mississippi	584·4	694·3	2 934·3	563·5	2 250·6	130·8	683·8
Oklahoma	25·8	36·1	91·0	29·4	70·8	6·7	20·2
Tennessee	46·7	88·5	344·7	75·6	266·0	12·9	78·7
Texas	633·8	799·5	2 548·7	639·6	1 947·6	139·9	601·1
Midsouth	2 983·7	3 899·9	13 295·7	3 176·6	10 226·1	703·3	3 069·7

an important role in ownership decisions and may keep much material from the market.

Louisiana and east Texas, together, have 47% of the mature pine stands (Table 2). East Oklahoma and Tennessee contribute only a small amount of mature pine timberland to the Midsouth total (< 1%). Most of these mature pine stands are in the loblolly–shortleaf pine forest type ($2{\cdot}39 \times 10^6$ ha). The remaining 20% of the timberland area is in the oak–pine forest type ($4{\cdot}10 \times 10^5$ ha) and the longleaf–slash pine forest type ($1{\cdot}80 \times 10^5$ ha).

Woody biomass in mature pine stands of the Midsouth States totals $4{\cdot}83 \times 10^8$ tonnes. Of this, $3{\cdot}50 \times 10^8$ tonnes are in softwoods and $1{\cdot}33 \times 10^8$ tonnes are in hardwoods. The majority of this biomass is in softwood stems, $2{\cdot}99 \times 10^8$ tonnes (62%); hardwood stems account for

$1{\cdot}02 \times 10^8$ tonnes (21%). Potential residual woody biomass of mature pine stands in the Midsouth is $1{\cdot}72 \times 10^8$ tonnes. Stems and crowns of softwood trees <23 cm in diameter make up 23% of the residual. The remaining 77% is found in the stems and crowns of hardwood trees (Table 2). Louisiana and Mississippi yield the highest amounts of potential residual woody biomass in mature pine stands (Table 2). Figure 1 illustrates the yield of potential residual woody biomass at sample locations. Louisiana's potential residual biomass is heaviest in the northwest and southeast portions of the State. Mississippi's concentrations are in the east-central and southern areas of the State. Southern Arkansas also has sizable concentrations of potential residual woody biomass, primarily in the southwest portion of the State. With the exception of total potential residual woody biomass, no State appears to be predominant in any yield category. The majority of residual woody biomass in the Midsouth is on mature pine land that yields $8{\cdot}00 \times 10^1$ tonnes ha^{-1}. Only small amounts (22%) of the Midsouth area yield potential residuals in excess of that level (Fig. 2).

Most of the potential residual woody biomass is in NIPF ownership (52%). Forest industry has 26% and public ownership has 22%. Densities of potential residual woody biomass are comparable for all ownerships. Forest industry has the lowest density, $5{\cdot}54 \times 10^1$ tonnes

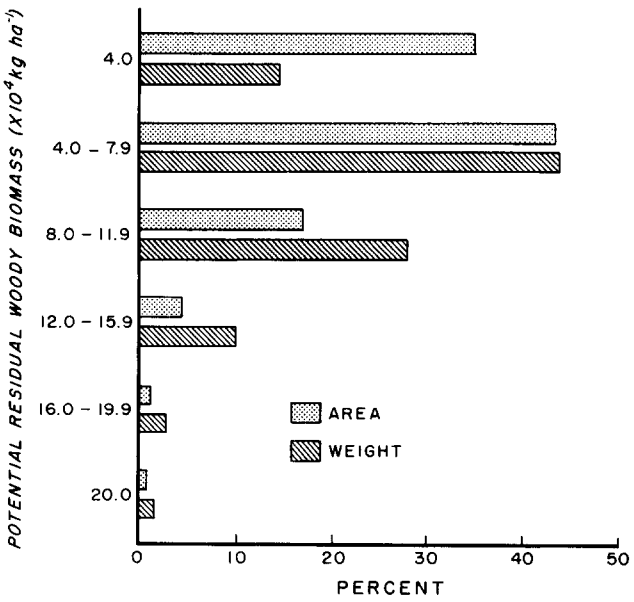

Fig. 2. Per cent mature pine timberland and per cent total potential residual woody biomass by kg ha^{-1} yield categories.

ha^{-1}, while public and NIPF ownerships each have $5{\cdot}84 \times 10^1$ tonnes ha^{-1}. The difference is not significant. No data are available to determine what effect understory vegetation control (or lack of control) has in the final potential woody biomass resource at harvest time.

Table 3 ranks the dominant species in the potential residual woody biomass of the Midsouth States by importance. The 17 species listed account for 87% of the biomass. Sweetgum (*Liquidambar styraciflua* L.) is dominant followed closely by loblolly pine (*Pinus taeda* L.). The three softwood species, loblolly pine (*P. taeda* L.), shortleaf pine (*P. echinata* Mill.) and slash pine (*P. elliottii* Engelm.) make up 21% of the potential residual woody biomass. Four species of oaks, southern red oak (*Quercus falcata* Michx.), white oak (*Q. alba* L.), water oak (*Q. nigra* L.) and post oak (*Q. stellata* Wangenh.) contribute 28% of the total residual woody biomass.

Table 4 illustrates the distribution of residual woody biomass by diameter class. Hypothetically, only softwoods $\geq 2{\cdot}5$ cm and < 23 cm in diameter are listed because larger softwoods would be removed as part of the pine harvest. Approximately one-half the softwood residual woody biomass is in the 20 cm diameter class. There are substantial

TABLE 3

Species Rank by Dominance for Potential Residual Woody Biomass in the Midsouth, USA

Rank	*Species*	*Oven-dry weight ($\times 10^4$ tonnes)*	*Tonnes ha^{-1} 10^4 tonnes*
1	*Liquidambar styraciflua* L.	2 518·4	8·4
2	*Pinus taeda* L.	2 232·2	7·5
3	*Quercus falcata* Michx.	1 376·9	4·6
4	*Quercus alba* L.	1 342·2	4·5
5	*Quercus nigra* L.	1 134·5	3·8
6	*Pinus echinata* Mill.	1 122·0	3·8
7	*Quercus stellata* Wangenh.	1 072·4	3·6
8	*Carya* sp. Nutt.	841·9	2·8
9	*Nyssa sylvatica* Marsh.	707·9	2·4
10	*Acer rubrum* L.	448·5	1·5
11	*Quercus falcata* var. *pagodifolia* Ell.	428·7	1·4
12	*Cornus florida* L.	401·1	1·3
13	*Quercus phellos* L.	339·4	1·1
14	*Ulmus alata* Michx.	244·8	0·8
15	*Liriodendron tulipifera* L.	229·9	0·8
16	*Quercus laurifolia* Michx.	228·0	0·8
17	*Pinus elliottii* Engelm.	207·8	0·7

TABLE 4
Oven-Dry Weight of Potential Residual Woody Biomass by Diameter Class[a] in the Midsouth, USA

Diameter class (cm)	*Softwoods ($\times 10^4$ tonnes)*	*Hardwoods ($\times 10^4$ tonnes)*
5	104·2	1 086·7
10	473·7	1 849·4
15	1 169·7	1 669·8
20	2 132·2	1 456·2
25	—	1 381·1
30	—	1 264·2
35	—	1 172·3
40	—	1 063·1
45	—	754·1
50	—	530·7
55	—	439·3
60	—	257·2
65	—	150·1
70	—	57·3
75	—	54·9
80	—	52·2
85	—	20·6
90	—	16·7
92·5	—	19·6

[a]In increments of 5 cm; for example, the 10 cm diameter class includes stems 7·5–12·4 cm in diameter.

amounts of hardwood residual woody biomass present up to the 40 cm diameter class. However, much of the hardwood residual above the 25 cm diameter class may be too large for certain types of biomass preharvest operations.

CONCLUSIONS

Substantial amounts of residual biomass exist on mature pine timberland to warrant further investigation into first-pass biomass harvests. Over $2{\cdot}10 \times 10^1$ tonnes ha^{-1} are available in all stems $\geq 2{\cdot}5$ cm and $< 17{\cdot}5$ cm in diameter, the classes of tree most likely to be knocked down in an over-story harvest. Previous studies show that, on average, after timber harvesting operations only $1{\cdot}10 \times 10^1$ tonnes ha^{-1} of standing live biomass residual remained on clear-cut timberland in Mississippi[6] and

$9{\cdot}00 \times 10^{1}$ tonnes ha^{-1} remained on clear-cut timberland in Alabama.[7] Examination of these stands was not done prior to harvest so it can only be hypothesized that many small stems were knocked down, thus accounting for differences in potential residual. Some hardwoods were also commercially logged.

REFERENCES

1. Walker, L. C., The southern pine region. In *Regional Silvicultural of the United States*, ed. J. W. Barrett. John Wiley, New York, 1980, pp. 231–76.
2. Clark, A. C., III, Phillips, D. R. & Frederick, D. J., Weight, volume, and physical properties of major hardwood species in the Piedmont. USDA Forest Service Research Paper No. SE-255. Southeastern Forest Experiment Station, Asheville, NC, 1986, 78pp.
3. Clark, A. C., III & Schroeder, J. G., Weight, volume, and physical properties of major hardwood species in the southern Appalachian Mountains. USDA Forest Service Research Paper No. SE-253. Southeastern Forest Experiment Station, Asheville, NC, 1986, 63pp.
4. Clark, A. C., III, Phillips, D. R. & Frederick, D. J., Weight, volume, and physical properties of major hardwood species in the Gulf and Atlantic Coastal Plains. USDA Forest Service Research Paper No. SE-250. Southeastern Forest Experiment Station, Asheville, NC, 1985, 66pp.
5. Freedman, B., The relationship between the above ground dry weight and diameter for a wide size range of erect land plants. *Can. J. Bot.*, **62** (1984) 2370–4.
6. Rosson, J. F., Jr., Residual woody biomass on harvested timberland in Mississippi. *Proc. 9th Ann. South. For. Biom. Workshop*, 8–11 June 1987, Biloxi, MS, Mississippi State University, Starkville, MS, 1988.
7. Rosson, J. F., Jr. & Thomas, C. E., The woody biomass resource of Alabama. USDA Forest Service Research Paper No. SO-228. Southern Forest Experiment Station, New Orleans, LA, 1986, 31pp.