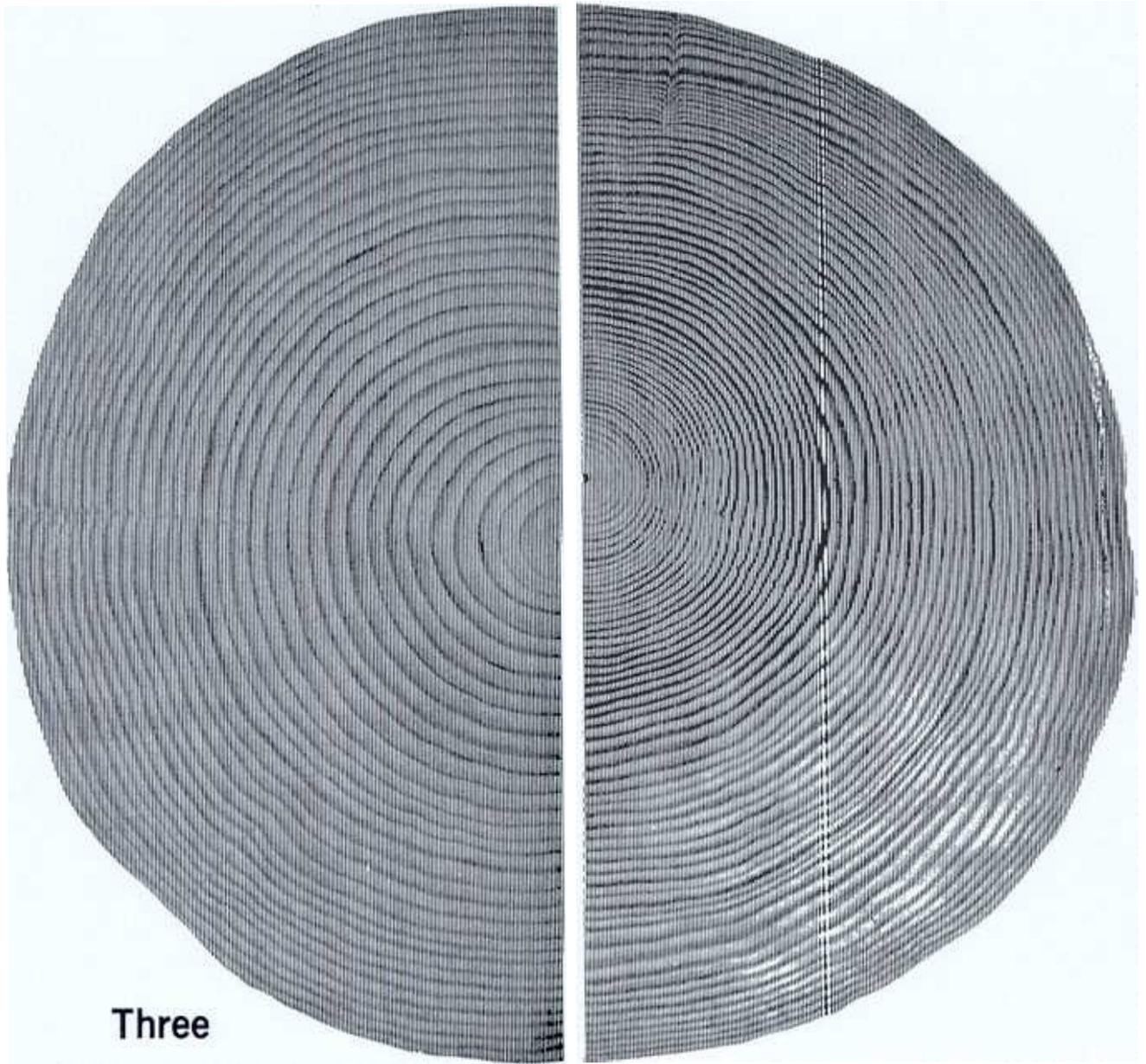


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Three

Rings Per Inch

Southern Pine

# Three Rings-Per-Inch, Dense Southern Pine *—Should It Be Developed?*

Peter Koch



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**ABSTRACT**—*Three-rings-per-inch, dense southern pine is a debatable goal in forests managed for solid wood products, but possibilities are evident. The problems lie in product specifications, strength, attractiveness, paint retention, gluing characteristics and machinability. An interim goal for southern pine silviculturists is suggested.*

The southern pines are the most important softwood timber species in the United States. It is estimated that, by the year 2000, 51 percent of the softwood used in this country will come from the South. Occupying about 20 percent of the commercial forest land, the southern pineries now furnish material for about 15 percent of the softwood plywood manufactured in the United States, 23 percent of the particleboard, 25 percent of the softwood lumber, 36 percent of the fiberboard, 40 percent of the market dissolving pulp, 41 percent of the groundwood pulp, a major share of the kraft pulp, over 75 percent of the poles and nearly all the turpentine and rosin. And some of these commodities—notably kraft pulp and naval stores—are important in international markets.

Six rings per inch is a fairly usual growth rate for southern pine today. What if this growth rate could be doubled, so that wood of the future would average only three rings per inch, with ring width constant at 1/3-inch from pith to ring 30? What if such fast-grown wood could occur in a range of specific gravities from 0.4 to 0.6 (basis of green volume and oven-dry weight), as it does now? Under this assumption, entire stems would average about 0.5 in gravity; but diameter inside bark would be 6.7 inches at ten years, 13.3 inches at 20 years, and 20 inches at 30 years.

Because of the commercial importance of the southern pines, it is useful to consider the possible effects such accelerated growth could have on their utilization. Evaluation of the economic effects of doubling wood production by harvesting two crops during the time span now required for one has been omitted from the following discussion. Obviously though, many patterns of distribution would be altered.

## Poles

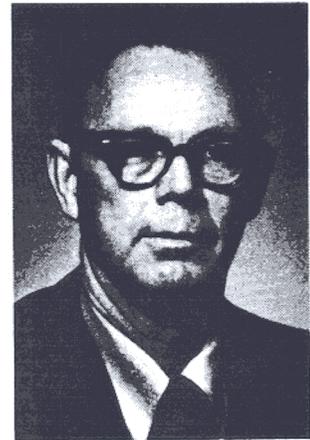
Straightness, little taper, high strength, absence of damaging spiral grain, ease of drying and treating, and ready availability under standardized grading rules all contribute to the widespread use of southern pine poles in the U.S.

Although straightness and taper should not be adversely affected by rapid growth, fast-grown small poles would likely have inferior strength. For example, a 30-foot Class 9 pole measuring about 7 inches in diameter at the butt would show only ten or 11 growth rings; such a pole—comprised almost entirely of juvenile wood—should be relatively weak. Poles 14 inches and larger in diameter would show more than 20 rings at the butt; if the mature outer wood had at least 50 percent latewood, such poles should have adequate strength.

No data are published that correlate grain spirality with rings per inch; in this country the outer wood of fast-grown southern pines appears to have little spiral grain. The effect of ring width on the permeability of the wood is also in doubt, but the data so far available indicate that wood showing three rings per inch can be dried and treated readily. Fast-grown southern pines in

# Three Rings-Per-Inch, Dense Southern Pine —Can It Be Developed?

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**ABSTRACT**—It will take the best sites, intensive silviculture, intensive selection and breeding, correct geographical area and rotation ages no greater than 25 years to produce three-rings-per-inch, dense southern pine. A major difficulty will be to maintain constant ring growth throughout the rotation. A specific gravity of 0.50 or greater cannot now be provided; the normal growth pattern of low gravity near tree center and higher gravity near the outside will be difficult to change.

Peter Koch has described possible usage of fast-growth, high-density southern pine. But can such trees be developed with three rings to the inch and still maintain an average specific gravity of 0.50 or greater? Koch particularly stresses the need for uniform growth rate—not the normal pattern of wide rings near the tree center followed by narrower rings as the trees become older and larger.

The answer involves both silviculture and genetics and depends largely on species and rotation age. The biggest factor is time available to develop information and skills necessary to produce wide-ringed, high-gravity southern pines. Remember that in calling for a doubling of diameter growth one is asking for a 400 percent increase in basal area and an even greater increase in volume production. Further, the biology of tree growth makes uniform density from pith to bark a difficult goal. Let us examine briefly some of the controlling factors, using the basal, high-value logs of loblolly pine (*Pinus taeda*) as the example.

### Specific Gravity Pattern

Near the center of a southern pine a “cylinder” of

wood is formed, often wide-ringed with low specific gravity. This “juvenile wood” is produced for the first seven to ten annual rings, after which normal mature wood is formed. In loblolly pine the juvenile wood has a specific gravity of 0.36 to 0.45, whereas mature wood in the same trees can vary from 0.42 to 0.68. Additionally, the tree usually produces juvenile wood with wide annual growth rings while it has room to grow freely. Thus wide rings and low density are associated near the center of the tree. Juvenile wood formation is not restricted to young trees—it is formed relative to the number of rings from the tree center or pith at all levels. The ring formed at the thirtieth year in a tree's life thus has wood with all mature characteristics at the base of the tree, but has juvenile wood characteristics near the top of the tree.

Even if a uniform growth rate could be maintained, the density of the wood is usually less in the juvenile than in the mature wood zones. It is possible to counter this tendency by using parent trees with high-gravity juvenile wood to produce similar progeny. Although the possible increase in specific gravity of these improved young trees is considerable (over the average by 0.02 to 0.03), it would take several generations of intensive selection and breeding to develop juvenile wood with a specific gravity at or near 0.50. Occasionally we find trees with juvenile wood specific gravity of 0.52 to as high as 0.60, but the inheritance pattern permits only a portion of the high gravity of the parent to be “captured” by a selection program. If an all-out effort were made and tree form and growth rate given low priority, trees that average 0.50 juvenile wood could probably be produced by two generations of breeding.

## Koch: Three Rings-Per-Inch—Should It Be Developed?

pole sizes contain less heartwood, and should therefore be more easily treated than slow-grown trees of the same diameter. The American Standards Association requires that the outer wood zone at the butt show at least six rings per inch, although poles having four rings per inch are acceptable if they contain 50 percent or more latewood. Obviously, the grading rules would require revision if poles with three rings per inch were to be marketed.

### Timbers

By current rules of the Southern Pine Inspection Bureau, timbers for structural use (*i.e.*, stress-rated) must average on one end not less than four annual rings per inch. Thus the three-rings-per-inch timber would require specification revisions. If latewood content could be maintained at 50 percent or more, fast-grown wood should be usable in most structures. But timbers containing boxed heart, if 7 inches square or smaller, would contain virtually no wood older than ten years and, therefore, could not be expected to show a high latewood content. Like poles, timbers having three rings per inch should be easily treated; boring and machining should not be unduly difficult.

### Lumber

Southern pine finds wide use as non-stress-rated framing, structural and finish lumber. For most framing purposes that do not require stress-rated lumber, fast-grown wood can serve adequately. Under present grading rules, however, wood having less than four rings per inch is excluded from the important structural grade of Number 1 Common dimension lumber. These rules could be revised to permit inclusion of faster grown wood having a sufficient percentage of latewood. For structural lumber, the wide rings become objectionable only if earlywood is placed so that it is highly stressed or so that mechanical connectors rely only on earlywood for holding power. Compression wood can be particularly damaging, however, in boards or planks showing only a few rings.

Users of clear finish lumber prefer slow-grown wood. Lumber with three rings per inch has a bold look that

most consumers find objectionable. Fast-grown wood is difficult to machine into complex patterns (*e.g.*, finger joints), and wide bands of latewood receive nails with difficulty and are likely to split. When painted, fast-grown dense southern pine frequently develops raised grain that is visible through the coating; moreover, paint retention is notably poor.

Because of the widespread adoption of the chipping headrig in the South, a significant portion of all southern pine lumber is now cut from logs measuring 7 to 12 inches in diameter. Since fast-grown logs of this diameter show only ten to 18 rings, it is evident that much of the lumber would contain pith-associated wood. Such wood may warp excessively unless it is dried under mechanical restraint.

Not all uses for southern pine are best served by slow-grown wood, however.

Steam bending, for example, is best accomplished with fast-grown, low-density wood. And wooden boxes are most easily nailed if the wood has wide rings and low density.

### Laminated Wood

Systems have been developed for placing wood in laminated beams so that the strongest wood is in the outermost, highly stressed laminae. These systems permit complete utilization of batches of lumber of variable strength. If selective placement of laminae is to achieve maximum effect, however, a

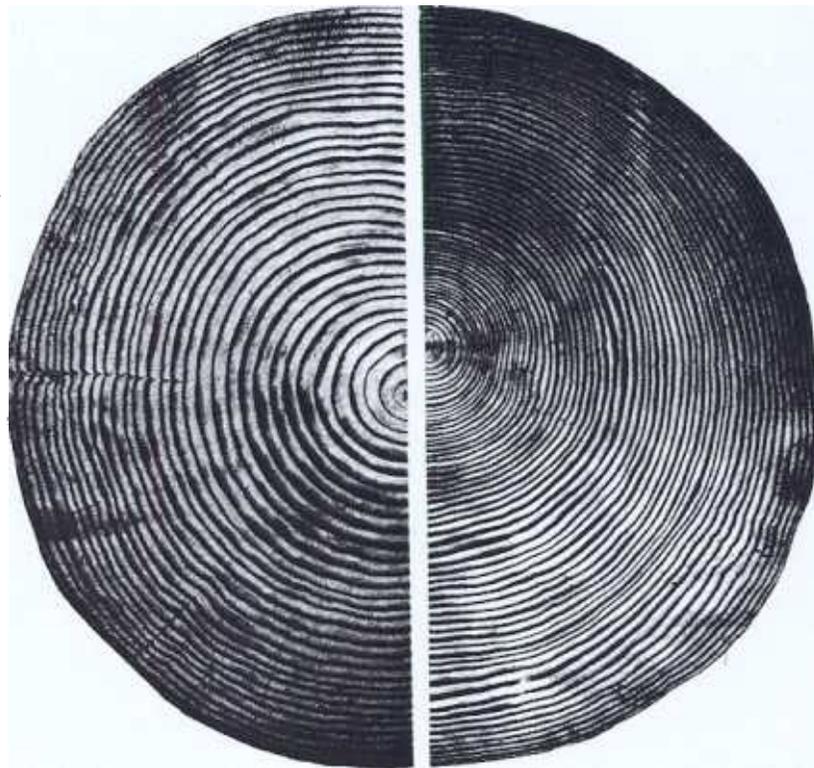
portion of the lumber should have a modulus of elasticity in excess of 3,000,000 p.s.i., and a tensile strength of more than 10,000 p.s.i. Such high-strength values are infrequently reported for lumber showing only three rings per inch.

### Plywood

Southern pine veneer bolts must have a certain minimum density for veneer cut from them to be comparable in strength to Douglas-fir veneer. If latewood content sufficient for this density is attainable in bolts showing three rings per inch, the veneer will display wide patches of latewood as well as wide patches of earlywood. Veneer from dense, fast-grown bolts tends to be rougher, less uniform and much more difficult to glue into plywood than veneer cut from slow-grown bolts. The gluing problems arise primarily

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Comparison of 3- and 6-rings-per-inch growth rates. The cross sections are from moderately dense loblolly pine logs with fairly uniform ring spacing from pith to bark. Section at left shows 31 rings, that at right 57 rings. Both logs measure 20 inches in diameter, inside bark.



### **Growth Rate Pattern**

Foresters are in the habit of assessing growth rate by ring width. This can be misleading; as tree diameter becomes greater, an equal volume of wood per year will be represented by narrower and narrower rings. As trees become quite large it is nearly impossible to maintain uniform width of ring because the tree would be required to produce an increasingly greater volume of wood. However, for short rotations of 20 to 25 years and under well managed conditions, it is quite possible for a tree to have uniformly wide rings throughout its life.

Another biological fact of tree growth is that under normal forestry conditions the tree starts out early life essentially free grown; but soon root and crown competition occur, and the width of the annual ring being formed declines. To develop uniform rings, tree spacing and stocking must be maintained in such a way that optimal growth can be sustained throughout the rotations. Such stringent stand management is easy to describe but difficult to achieve.

### **Geographical Source**

No matter how desirable a specific gravity of 0.50 might be, it would be nearly impossible in certain parts of the species range. For example, the upper Piedmont and northern and inland portions of the loblolly range have an average specific gravity well below Koch's desired 0.50, especially in younger trees. It would be most difficult to increase the gravity in this region, whereas in north-central Florida the average is already well above 0.50.

### **What Can Be Done**

No one expects to develop a universal three-rings-per-inch tree with high specific gravity in the near future. But the goal is at least approachable.

The problem in the past has been that foresters felt fast growth was always accompanied by low specific gravity. This is not true, and although widespread tests of wild stands usually show a negative correlation of growth rate and specific gravity of about  $-0.15$ , this is so small as to be practically negligible. The negative relationship often disappears when competition among trees is encountered. In fact, two of our latest studies have shown a positive correlation; the faster growing families had the most dense wood. Because our tests show specific gravity and growth rate are not closely related genetically, it should be possible to have both in the same tree if care is exercised in selection.

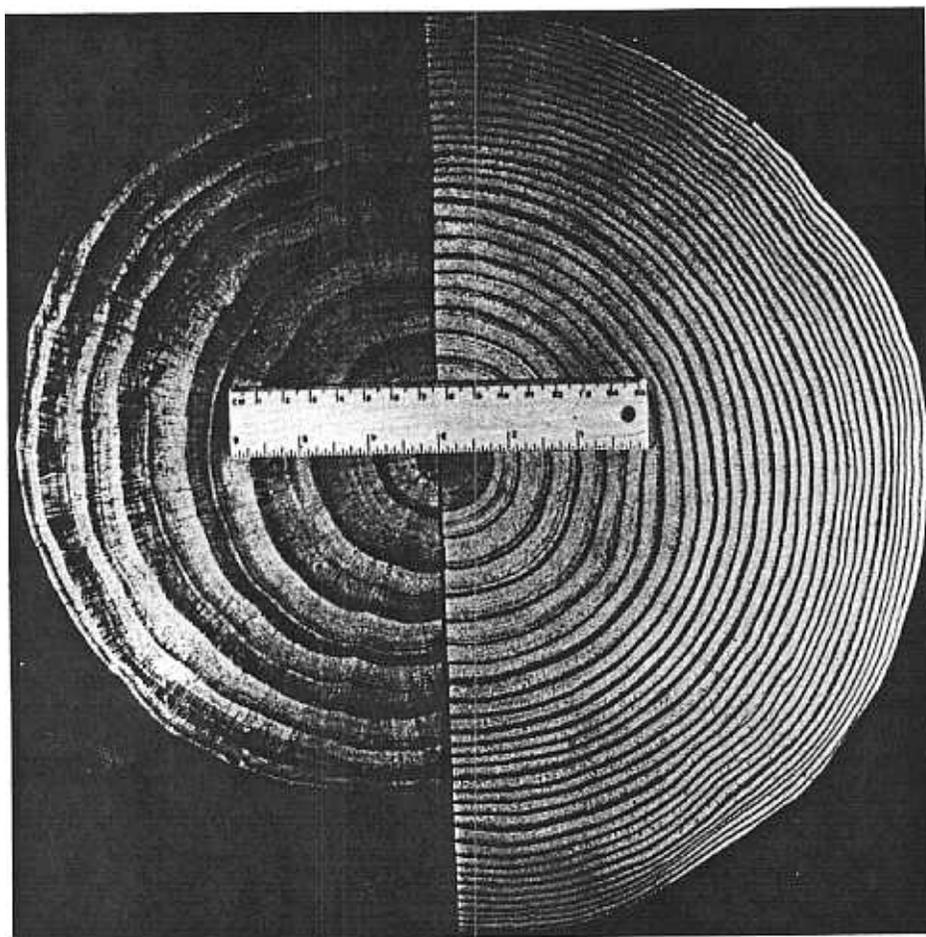
It is feasible now to produce trees that grow three rings per inch for relatively short rotations of about 25 years. This will require the best sites, technical skill and expensive management practices such as selective thinning. Mass methods such as row thinning will be much less successful. Utmost care must be taken to thin at the proper time because a delay of only one or two years will result in a reduction in ring width.

Fertilizers such as phosphorus will not materially affect the wood, but on some soils a heavy nitrogen

fertilization will produce very wide rings with essentially no summerwood. Infrequent heavy nitrogen fertilization sometimes causes production of bands of strong and weak wood, making it undesirable for certain products.

It is not now possible to mass-produce trees with high specific gravity in the juvenile wood, although research data show that considerable progress can be made. With more intensive breeding it may be possible to have juvenile wood gravities of 0.50 on a commercial scale; but if so, the gravity of the mature wood of the same trees will be considerably greater than 0.50. Tying together the desired growth and density can be done, but it will take time, money and considerable skill. □

Photograph showing contrast between fast-growth and slow-growth loblolly pine, and showing high density in the fast-growth tree.



Koch *continued*

because latewood-to-latewood bonds are difficult to achieve with normal spreads of phenol formaldehyde resins.

In southern pine plywood given exterior exposure, face checking is most severe, delamination most rapid, and paint failures occur soonest if veneers are cut from fast-grown dense bolts.

### Particleboard

Particleboard properties are strongly correlated with the density of wood from which the particles are derived; low-density wood is generally preferred. Board properties are also closely related to the specific surface of component particles (*i.e.* surface area per unit weight) and with the variation in specific surface among particles. Fast-grown, dense wood yields particles with a very wide range in specific surface. It is likely, however, that manufacturers would find no serious problems in producing board from wood with three rings per inch; most would prefer wood averaging 0.4 specific gravity over wood of 0.5 gravity.

### Fiberboard

McMillin<sup>1</sup> has shown the effects of gross wood characteristics on properties of fiberboards made from loblolly pine refiner groundwood. With high-density boards, stress at proportional limit in bending and modulus of elasticity were positively correlated with rings per inch, *i.e.*, fast-grown wood yielded somewhat weaker boards. Also, medium- and high-density boards from fast-grown wood had less dimensional stability parallel to the surface than boards from slow-grown wood; for medium-density board only, fast-grown wood yielded boards with less dimensional stability perpendicular to the grain.

McMillin concluded that most of the fiberboard properties he measured were improved by use of fibers refined from dense wood containing a low percentage of latewood. He forced stratification of samples from the core, middle and outer portions of the tree stem so that wood of high and low specific gravity and of slow and fast growth was considered at each position. Because of this forced stratification, the correlation between latewood content and unextracted specific gravity was low ( $R^2 = 0.66$ ) as compared to that in entire stems. Thus, proportion of latewood exhibited a range of values at all levels of chip specific gravity.

The data showed that fiber prepared from corewood of high unextracted specific gravity yielded boards of superior strength. Dense veneer cores therefore would appear to be a desirable raw material from a strength standpoint. In contrast, fiber refined from slabs and edgings of low density would be expected to yield boards of inferior strength.

<sup>1</sup>C. W. McMillin. 1968. Fiberboards from loblolly pine refiner groundwood: effects of gross wood characteristics and board density. *Forest Prod. J.* 18(8): 51-59.

### Pulp and Paper

The large body of literature relating pulp properties to fiber morphology leaves the impression, perhaps oversimplified, that pulp and paper makers will continue to use southern pine wood in whatever form it is grown as long as it is available in uniform, large quantities at a reasonable price. Most pulp company foresters appear to be primarily concerned with growing the maximum possible dry tonnage of wood per acre per year. Thus, three-rings-per-inch, dense southern pine would probably be acceptable to most manufacturers.

### Discussion

One might frame a specific objective for geneticists and silviculturists working on intensive plantation culture of southern pine:

To develop seed sources and silvicultural techniques that will yield plantations of southern pine trees averaging three rings per inch and 0.5 specific gravity (on the basis of green volume and oven-dry weight, unextracted).

From the preceding text it is evident that this objective is debatable in forests managed for solid wood products. In part, choice of objective must rest on this country's requirements for poles, timbers, lumber, laminated wood, plywood, particleboard, fiberboard, and pulp and paper. Since many economists forecast an increasing demand for timber products, as well as a decreasing land base from which wood can be harvested, it is my opinion that geneticists and silviculturists should press forward vigorously to develop southern pine plantations in which stems average 0.5 in specific gravity and show a uniform ring width of 1/3-inch from pith through ring 30. Even the most optimistic geneticist will probably concede that attainment of this goal will require numerous generations of tree breeding in addition to much basic research on manipulation of ring width and density.

In the meantime, I propose an interim, and more general, objective for southern geneticists and silviculturists:

*Over large areas, grow the maximum possible dry tonnage per acre per year, and grow it on the fewest possible straight stems of uniform size, taper and spacing.*

This would do more than increase the tonnage of pine production. Since uniformly spaced, large, straight stems of equal size and taper can be logged and processed more readily than smaller crooked stems of random size, taper and spacing, the cost of conversion would be reduced and the competitive position of pine wood would be enhanced.

The interim objective is applicable equally to unthinned stands grown on short rotations for pulpwood and to thinned plantations managed for longer rotations to yield saw logs and veneer bolts. In both cases, stands would be manipulated primarily to yield high tonnages, but with recognition that harvesting and processing costs are positively correlated with the number of stems per acre. □