STACKING THE LOG DECK, OR SOME FALLACIES ABOUT NATURAL PINE MANAGEMENT

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Abstract—The increasing use of intensive plantation management in the South has led to inferences that natural pine stands are unacceptably inferior in terms of fiber production, rotation length, wood quality, and regeneration. In this paper, we have compiled information from studies of different silvicultural practices in southern pine stands of natural origin to provide a more meaningful comparison with plantations. Research has shown that aggressive precommercial and commercial thinning regimes in stands of natural origin and the careful retention of high-quality residual stems dramatically closes the productivity gap. In addition, natural-origin pine stands often provide other products and compositional, structural, and esthetic values that exceed those of plantations. Although plantations have become an increasingly important element of silviculture, most southern pine forests will remain in stands of natural origin and must be managed appropriately to help ensure future timber supplies and environmental integrity.

INTRODUCTION

Since the 1960s, plantation management has become the standard practice for most industrial timberland owners in the Southern United States. This is especially true for loblolly (*Pinus taeda* L.), slash (*P. elliottii* Englem.), and other southern pines. Recently, there has been considerable effort to maximize the productivity of pine plantations (Rogers and Munn 2003, Rousseau and others 2005, Siry 2002). Genetic improvement, site preparation, competition control, and manipulation of stand density are some of the principal treatments for greater growth and yield. Careful implementation of these techniques has produced some spectacular results (e.g., Allen and others 2005, Borders and Bailey 2001, Miller and others 2003). However, this effort comes at a high price: Borders and Bailey (2001) placed the cost of their most productive experimental treatment at $600 per acre. In addition, intensive plantation management has significant environmental and social consequences that are not traditionally incorporated in the economic evaluation of this practice.

From an industrial perspective, pine plantations have distinct advantages over stands of natural origin (Allen and others 2005, Siry 2002). Well-managed plantations can produce more fiber in less time than naturally seeded pine stands and are often more easily treated to control density and non-pine competition. However, few outside of forest industry or investment management organizations can invest $200 to $400 (or more) per acre for plantation establishment at the start of a rotation, especially when pulpwood and fiber markets are limited.

Naturally regenerated stands offer a viable alternative to many landowners. Unfortunately, positive descriptions of southern pine stands of natural origin are rare in the silvicultural literature, and several recent papers have portrayed these forests unfavorably. To counter this impression, we have compiled research on the potential of well-managed natural pine stands to provide a basis for more realistic comparisons with pine plantations. In addition, we suggest a different philosophy for considering whether to manage forest stands using planted stock or natural regeneration.

METHODS

We critically reviewed statements made about aspects of naturally regenerated pine stands. In particular, we focused on three papers (Allen and others 2005, Stanturf and others 2003, Yin and Sedjo 2001) that made claims for the economic advantages of plantations over stands of natural origin. These papers suggest that natural pine stands have unacceptably low productivity. Additionally, we discuss published reports of South-wide studies that deal with factors such as rotation length, wood quality, and regeneration consistency of natural pine stands on sites of varying quality.

RESULTS AND DISCUSSION

Low Fiber Production

Yin and Sedjo (2001) compared the economic viability of silvicultural options in the Georgia Piedmont. As their control, they chose natural-origin stands of mixed pine and hardwoods originally described in Shiver and Brister (1996) and Martin and Brister (1999). Yin and Sedjo (2001) compared these stands to pine plantations on cutover and old field sites. By age 35, natural-origin stands were decidedly less productive than the plantations. Yin and Sedjo (2001) reported average pine diameters of 8.7 inches for the natural stands and 9.4 to 10.2 inches for the plantations. In addition, natural-origin stands yielded only 30 to 67 percent of the sawtimber and pulpwood produced by plantations (table 3 in Yin and Sedjo). However, there were several critical flaws in these comparisons.

First, only the pine component of the natural stands was included in the growth-and-yield data. Thus, yield of the natural pine-hardwood stand was based on only 300 trees per acre (no hardwood data were reported), whereas the planted stands averaged slightly > 500 stems per acre. It would have been more appropriate to compare the productivity of the plantations with that of better stocked natural pine

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stands thinned to 500 trees per acre (with competition control) at a very young age, since the plantations had been planted to approximately 600 trees per acre and received periodic postestablishment herbicide applications. Furthermore, Martin and Brister (1999, p. 180) acknowledged that shortleaf pine (*P. echinata* Mill.) was "treated as loblolly pine" in their study. This was not a trivial assumption, as shortleaf constituted an average of 5.4 percent (range: 0 to 37.6 percent) of the pines in these natural stands. Since shortleaf pine has long been recognized as slower growing and less productive than loblolly pine under most conditions (Mattoon 1915, Walker and Wiant 1966), its incorporation will also negatively bias the results of Yin and Sedjo (2001).

Second, the natural-origin stands used by Yin and Sedjo (2001) had a large component of hardwoods, which further diminished the productivity of the pines. Martin and Brister (1999) reported that 71 percent of their natural-origin plots had at least 10 percent of their basal area in hardwoods, and that hardwood basal area exceeded 40 percent or more of the total in some plots. Yin and Sedjo (2001) did not report on the average hardwood stocking in these natural pine stands when they analyzed them, but presumably a significant amount remained. Both Shiver and Brister (1996) and Martin and Brister (1999) predicted sharp declines in pine sawtimber volume as hardwood basal area increased (see also Miller and others 2003). Martin and Brister (1999) forecast that a stand with minimal hardwood basal area at age 25 (0.01 percent of the total) would produce approximately 3,500 cubic feet of pine sawtimber at age 35, but that a stand with 20 percent of its basal area in hardwoods at age 25 would yield only 2,300 cubic feet of pine sawtimber 10 years later. Given that Yin and Sedjo assumed for their economic analysis that pine sawtimber was worth $94 per cord, and using their conversion (95 cubic feet = 1 cord), this particular scenario suggests that the hardwoods reduced pine sawtimber production by 12.6 cords, or $1,184, per acre.

Stanturf and others (2003) provided another unfavorable picture of natural stand productivity. They estimated that a natural-origin southern pine stand initiated in the 1920s produced 1 ton per acre per year, but did not explain how this number was determined. According to Miscellaneous Publication 50 (U.S. Department of Agriculture Forest Service 1929), a fully stocked natural loblolly pine stand on even the poorest site listed (SI_{50} = 60 feet) is capable of producing between 63 and 76 cubic feet (peeled) per acre per year over the first 6 decades of the stand. Assuming 1 cubic foot of loblolly pine weighs 53 pounds when green (Panshin and de Zeeuw 1970), this implies an annual production of between 1.5 and 2.0 tons per acre. On a better site (SI_{50} = 90), the annual production of fiber for a 35-year-old stand increases to 3.5 tons per acre. Other sources report even higher volume production from natural-origin stands. In a thinning study of a naturally regenerated loblolly pine-dominated stand arising after the clearing of the virgin forest, Burton (1980) reported periodic annual increments of 143 to 165 cubic feet per acre for these stands at age 45, or 3.8 to 4.4 tons per acre. Mean annual increments of young, thinned pine stands on a good site in southern Arkansas ranged from 139 to 153 cubic feet (3.7 to 4.1 tons) per acre (Cain and Shelton 2003). Even though these values still represent only about half of the 8 tons per acre per year claimed for the "fifth forest" of Stanturf and others (2003), they are much higher than the estimate of 1 ton per acre per year for natural stands.

Allen and others (2005) emphasized the productive capacity of intensively managed young (8- to 26-year-old) southern pine plantations, assigning them a potential of 12 to 15 tons per acre per year, compared to 1.8 to 2.8 tons per acre per year for natural stands of similar age. Once again, this understates the currently known productivity of well-managed stands of natural origin.

In terms of sheer merchantable volume, there is little doubt that naturally regenerated stands are less productive than plantations. If a forest landowner is determined to quickly maximize fiber yield, and capital is available to cover establishment costs in the first decade, plantations represent a good investment decision. However, if landowners have limited resources or no desire to invest in expensive stand re-establishment based on an intensive plantation model, many productive low-cost natural silvicultural alternatives are available to them (e.g., Baker and others 1996, Cain and Shelton 2001).

Rotation Length

Shorter rotations are one of the primary benefits of plantation management. In part, this is an argument of utilization, since comparing the rotation length of pulpwood or chips vs. large sawtimber is an unreasonable contrast. Assuming the same product goals, plantations generally have an advantage over stands of natural origin because of the degree of stocking control permitted by planting. In other words, it is much easier for an individual tree to quickly reach sawtimber size if stand density is 600 trees per acre at establishment, rather than allowing 10,000 or more stems to self-thin.

Avoiding this extended period of intense competition in natural stands would allow the young crop trees to more rapidly reach merchantable size. Cain (1996) and Cain and Shelton (2003) provided an example of the value of well-timed early thinnings of natural-origin pine stands. In this study on a good site in southern Arkansas, different thinning and competition control techniques were applied to regulate the density of naturally regenerated loblolly and shortleaf pine. Stands were precommercially thinned when 6 years old by mowing swaths to reduce initial densities, and some stands also received later commercial thinnings and prescribed burns. By the time they reached 20 years of age, the most intensively treated stands (precommercial thinning + commercial thinning + prescribed burning) produced pines that averaged 8.9 inches diameter at breast height (d.b.h.), compared to 7.4 inches for the unmanaged control. Most of these crop trees had reached minimum sawtimber size (9.6 inches d.b.h.) by age 25 (Cain and Shelton 2003) and would probably average at least 14 inches d.b.h. by age 35. This growth performance is only somewhat lower than that for well-managed plantations from the area (e.g., Wiley and Zeide 1992).

Wood Quality Issues

It is unlikely that future southern pine wood quality will ever approach that of the virgin forest, regardless of how much tree improvement can be done. Logs cut from old-growth are typically slow-grown, low in taper, and knot-free for many decades, whereas most contemporary well-managed forests are maintained to maximize production and are cut at relatively young ages (Davis 1931, Guldin and Fitzpatrick 1991). These factors combine to produce small-diameter logs with a high proportion of juvenile wood and abundant knots, both of which result in wood with less favorable mechanical properties and decreased lumber value (Bendtsen 1978, Patterson and others 2000). Note that low-density stands of any origin can quickly produce knot-free wood with a considerable investment in pruning.

Product-based economic analysis has repeatedly shown that natural, uneven-aged stands of loblolly and shortleaf pine produce higher quality logs. For instance, Groom and others (2002) reported that the percentage of premium veneer was greater in naturally regenerated stands than in plantations. In a comparison of log quality in southern Arkansas, Guldin and Fitzpatrick (1991) reported significantly better log quality from natural uneven-aged stands than from plantations, primarily because logs of a given size in natural stands were older, had grown in denser stands when young, and thus had fewer knots. There is value in log quality related to ring count (witness the supplement in value given to dense grades of lumber by the Southern Pine Inspection Bureau), a property sacrificed when the rapidity of growth drives stand management.

Regeneration Consistency

Since the time Gifford Pinchot first worked the mountains of North Carolina, foresters have been concerned about regenerating stands by natural methods, since relying on natural pine regeneration holds certain risks. Plantation culture has reduced the uncertainty associated with stand replacement but has by no means eliminated it. The challenges associated with natural propagation can be minimized by understanding the factors (and their interactions) affecting regeneration processes and applying appropriate silvicultural practices. For example, seed production and seedbed conditions affect the initial establishment of regeneration, while competition from retained trees and understory vegetation impact subsequent development by influencing the availability of light, water, and nutrients.

Much has been published about the art and science of regenerating natural pine stands (e.g., see Shelton and Cain 2000). Indications are that seed production—the factor under the least amount of silvicultural control—is adequate for successful natural regeneration within most of the core ranges of the southern pines, especially for loblolly-shortleaf pine stands in the west gulf region. The other major factors affecting natural regeneration—seedbed condition, light regime, and competing non-pine vegetation—are more responsive to manipulation. In addition, procedures exist to forecast the adequacy of upcoming seed crops so that an adequate seedfall can be timed to coincide with a receptive seedbed and low levels of competing vegetation (Shelton and Wittwer 2004). Regrettably, there is little Southwide quantitative information about the success of natural pine regeneration when the proper silvicultural procedures have been applied. However, one basic tenet is apparent: Successful natural pine regeneration requires more skill and patience than plantation culture.

The use of improved planting stock provides a degree of control over heritable tree properties. Natural populations of pine can have a wide range of genetic characteristics, some of which are favorable and others that are not. For instance, loblolly pine attributes such as specific gravity, the transition between juvenile and mature wood production, and fusiform resistance are at least partially a function of genetics and thus may be “improved” upon (Choong and others 1986, Loo and others 1984, Skoller and others 1983). However, the advantage of controlling genetics to improve pine growth or disease resistance may come at the expense of lower genetic diversity and increased vulnerability to other damaging agents (Schultz 1997).

Other Benefits of Natural Stands

Because stands of natural origin require less intensive effort (and therefore lower expenditures) to establish and maintain, the economic viability of managing for larger logs is less burdensome to the landowner. It is therefore possible to grow bigger trees at a slower rate, producing higher quality sawtimber and veneer that can bring extra revenues. Premium prices for prime logs can significantly impact which management actions are best for a given stand, although finding buyers willing to reward pine log quality is becoming increasingly difficult (Huang and Kronrad 2004).

Well-managed natural-origin stands have other noncommodity benefits not supplied by the pine plantations that often replace them. Almost by definition, natural-origin pine stands have more genetic diversity, greater overstory richness, and more structural complexity than plantations. Rarely are intensively managed southern pine plantations allowed to grow beyond 35 to 40 years old (some are cut at less than half this age), making them poor habitat substitutes for mature natural-origin forests and the species dependent upon them. As an example, young loblolly pine plantations are inadequate nesting habitat for the red-cockaded woodpecker (RCW) (*Picoides borealis* Vieillot), but at least two active RCW colonies can be found in the Good Forty Demonstration Area of the Crossett Experimental Forest, managed using single-tree selection for the past 70 years. In addition, even-aged natural-origin pine stands are often allowed to reach older ages and larger sizes, which have greater esthetic appeal to many people than young, tightly spaced plantations (Hull and Buhyoff 1986, Rudis and others 1988).

Furthermore, when considering the total land base, debates about which method is best from the rather narrow perspective of growth, yield, and financial return are myopic. For example, are there any circumstances for which a forest industry landowner who devoutly practices plantation silviculture would, or should, consider the use of natural regeneration? Clearly there are, and those opportunities lie in the large percentage of commercial timberlands found in streamside management zones, roadside buffers, or other locations in which special considerations apply (see also Rousseau and others 2005). When examined carefully, one finds that these areas are often the most productive sites in forested landscapes. And yet, the prevailing harvest strategy is often just high-grading. A better tactic would be to practice natural stand management in sensitive portions of an ownership.

One of the best arguments for intensifying plantation management is that the same volume of wood fiber can be produced on fewer acres, thereby allowing larger areas of natural forests to be retained in a less intensively managed state

(Allen and others 2005, Rousseau and others 2005). This is a logical argument for capturing the full potential of a given piece of ground through a well-regulated treatment regime. However, from a broader perspective, this assertion is only true if the regional volume production is fixed and the rest of the land base is allowed to adjust accordingly. In other words, if all landowners (or even just a large portion of them) convert their holdings to intensive plantations, and no areas revert to lesser management, then the preservative benefits of intensive plantations for forests of natural origin will not be realized.

CONCLUSIONS

Several recent publications have compared growth and yield from unmanaged even-aged loblolly pine stands with that from more intensively managed plantations. Not surprisingly, these natural stands (often regarded as a "control") produce noticeably less fiber and sawtimber-sized material at an older age than the better regulated plantations, and this negatively affects economic evaluations. Natural stand management rarely applies the entire suite of silvicultural treatments used on intensively managed pine plantations, and therefore fiber yields will never match those from plantations. However, more aggressive precommercial and commercial thinning regimes, the careful retention of high-quality residual stems, fertilization, and other interventions have the potential to noticeably improve natural stand growth and yield performance (Cain 1999, Ruark and others 1991).

Arguments over which silvicultural system (natural vs. plantation) is most appropriate need to be based on legitimate comparisons of well-managed systems and not on neglected natural stands vs. intensively cultured plantations. With the acreage of southern pine plantations predicted to increase 33 to 100 percent over the next few decades and significant decreases expected for natural pine forests (Prestemon and Abt 2002, South and Buckner 2003), decisions to convert from one silvicultural system to another based even partially on productivity must avoid biased evaluations if southern pine-dominated forestlands are to maintain their full range of economic, ecologic, and social values.

Both Siry (2002) and Rousseau and others (2005) note that many aspects of intensive management are harder to implement and more expensive on smaller parcels of land, and that increasing landscape fragmentation in the South has contributed to the reduction of management options. The multitudes of small tracts held by many owners with highly variable resource goals provide a myriad of opportunities for natural stand management. Finally, we are concerned that philosophical approaches to forestry that claim the superiority of plantations over natural stands may discourage foresters from considering silvicultural and ownership situations, even in an intensively managed land base, for which natural stand management is better than the current practice.

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