REFORESTING DISTURBED SITES IN THE SOUTH WITH PINE SPECIES[1]

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Abstract.--Methods of reforesting disturbed sites with pine species in the southern United States are reviewed. With proper planning and reclamation, disturbed soils can be at least as productive as the original sites. Control of competing vegetation is necessary for adequate seedling survival and early growth. The potential of agroforestry that would combine animal grazing and tree production is also discussed.

Pines are well suited for reforestation of disturbed sites in the southern and southeastern United States. They are subclimax species ecologically adapted to open, bare sites that usually result from disturbance. In fact, most of the vast southern pine resource comes from reforestation of old fields that had lost more than half their top soil to erosion (Wahlenberg 1960). Pines then provide one of the best opportunities for quickly and economically putting disturbed land back into production. Even on many of the infertile and highly erodible sites across the South, reforestation with pines can both stabilize the soil and provide a significant economic return to the landowner.

Southern pines are not the best species for reforestation on some disturbed sites in the South (calcareous overburdens, coal mine dumps at altitudes above 3,000 feet, and some of the bituminous spoils in Kentucky). Nevertheless, in most cases, certain southern pine species are the fastest-starting, highest-yielding tree species producing pulpwood, sawlogs, quick cover, and soil stabilization in the forested Coastal Plain, Piedmont, and Cumberland Plateau.

CHOICE OF SPECIES

Only four native pines have widespread potential for reforesting disturbed sites across a wide range of difficult conditions. These species are loblolly (*Pinus taeda* L.), slash (*P. elliottii* Engelm.), longleaf (*P. palustris* Mill.), and shortleaf (*P. echinata* Mill.) pine. The question is, then, which is best? From Texas to Georgia, the choice is usually loblolly or slash pine. Longleaf pine regeneration is usually rejected due to establishment difficulty and its slow early height growth during "grass stage". However, recent advances have improved the capabilities of longleaf pine to compete favorably on drier sites in the South (Kais 1985, Barnett and Kais 1987, Shoulders 1985). Shortleaf pine usually grows more slowly than loblolly and slash pines, and its best relative performance is in the mountainous areas of the interior South.

Comparisons of the performance of the four species on a wide range of sites indicate that loblolly pine will outperform other species on the drier sites that are typical of reclamation areas (Shoulders 1983, Plass and Burton 1967). Loblolly is generally considered the preferred species for most sites. Slash pine is better suited to flat, wet sites near the coast.

SOIL/MINESOIL ENVIRONMENTS

Surface mining in the South mainly extracts lignite in the West Gulf, coal in the lower Appalachian Mountains, and phosphates in Florida. To illustrate expanse of mining, lignite mining alone could disturb about 2 million acres in six states (Hossner and O'Shay 1985), the majority of which are now producing pines.

Before open pit mining, most woodland soils are siliceous and acid, and have low organic-matter contents (Pettry and Furst 1985). The soils being disturbed range from Vertic Hapludalfs in Texas and Louisiana to Aeric Halaquods in Florida. These soils must be limed and fertilized before they can be used for

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agriculture. Most of the soils will produce a commercial stand of pines without amendments, but phosphorus will increase the wood production substantially (Tiarks 1983). With proper planning, overburden that is a better plant growth medium than the original soil can be placed near the surface (Feagley 1985). For example, in Mississippi simulated disturbance of a heavy clay soil increased the site productivity by improving aeration, porosity, and water-holding relationships (Pettry and Wood 1986).

The main soil-related problems of regeneration are caused by low water-holding capacity of the reclaimed spoils (Darfus and Fisher 1984), low pH (Plass 1969), and low nitrogen availability (Burton and Tiarks 1986). Annual rainfall is relatively high, ranging from 36 to 56 inches. Periods of high intensity rainfall followed by long periods of drought are common (Hossner and O'Shay 1985). This, combined with the low water-holding capacity of the soil, can lead to seedling failures on most sites in some years. Irrigation (Burton and Tiarks 1986), mulching (Dyer and others 1984), and weed control have all been used to improve the availability of water to seedlings. However, selection of a drought-resistant species such as longleaf pine over the less resistant slash pine may be sufficient (Darfus and Fisher 1984). Acidity of the spoils is usually not a serious problem because of the availability of spoil material that is low in acid-forming minerals. After the phosphate mining, high pH may be a problem if carbonate-containing materials are placed near the surface (Erwin and Bartleson 1986). Because of the low organic matter content of these spoils and leaching of nitrates, trees can become nitrogen-deficient within a year after fertilization (Bengtson and Mays 1978). Nitrogen-fixing plants such as sericea lespedeza (*Lespedeza cuneata* [Dumont] G. Don) reduce the need for frequent nitrogen applications, but most nitrogen-fixing plants require high initial applications of lime and phosphorus. Replacement of the original surface horizon of soil is probably the best source of nitrogen.

COMPETITION CONTROL

One of the significant problems in establishing stands of trees on reclamation sites is the heavy grass competition that develops from requirements to quickly control any potential erosion (Vogel 1973, Fung 1986). Grass species such as bahiagrass are fierce competitors of pine and are usually well established before trees are planted. These grasses reduce both tree survival and growth (Fisher and Adrian 1981). The nutrients added to reclamation sites to encourage grass establishment also increase growth of both grasses and trees more than that on undisturbed sites. However, competition from the grasses--rather than nutrient deficiencies--most often limits the growth of pines (Shoulders and Tiarks 1984, Bengtson and Mays 1978). Additional increments of fertilizer will not increase tree growth unless some of the competition is removed.

First-year growth of slash pine in a native bluestem rough was unaffected by fertilization with nitrogen, phosphorus, and potassium at rates of 100, 87, and 58 lb per acre applied at planting (Tiarks and Haywood 1981). When herbaceous growth was eliminated in a strip 5 ft wide on both sides of the row style of trees, the fertilizer produced a five-fold increase in total aboveground biomass of the pines (fig. 1). In the experiment, competition was removed from a wedge-shaped area that increased in width from 0 to 10 ft over a distance of 150 feet. Response to the fertilizer was proportional to the width of the controlled strip. By age 4, the fertilized pines had overtopped the uncontrolled herbaceous vegetation and were equal in total ovendry weight to the unfertilized trees that were given complete release from herbaceous competition (fig. 1). But trees that were fertilized and completely released weighed 163 percent more than either the unfertilized-released trees or the unreleased-fertilized trees.

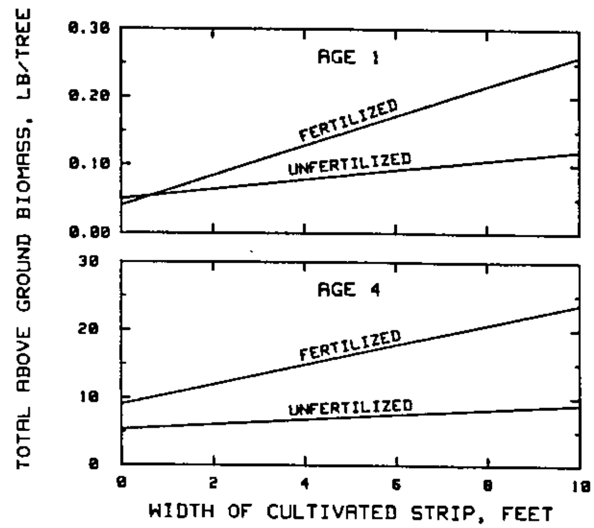

Figure 1.--Effect of fertilization and cultivation on aboveground biomass of young slash pine (from Tiarks and Haywood 1981).

Delayed response of pines to fertilization at planting is not unusual on sites occupied by herbaceous plants. For example, response to a preplanting application of 88 lb per acre of phosphorus was delayed three years, until pines began to dominate the site (Tiarks 1983). The response that followed was still evident at age 13.

Spot or band applications of herbicides are effective techniques to reduce competing vegetation and stimulate pine growth. Hexazinone as Velpar L® and sulfometuron methyl as Oust® can be used either as pre- or post-plant treatments for control of competing vegetation. Wittwer and others (1986) reported that loblolly pine seedling heights were increased 23 percent in the second year by Velpar L treatments. Diameter appeared to increase rapidly as biomass of competing vegetation decreased below 1500 lb/acre (fig. 2). Michael (1985) obtained similar growth response with Oust.

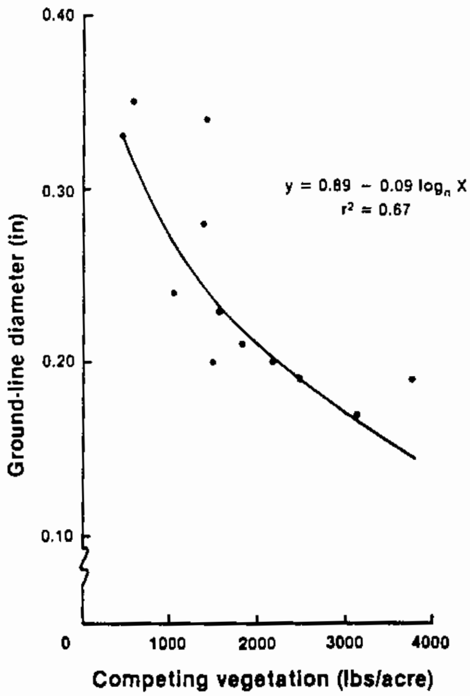

Figure 2.--Relationship of seedling ground-line diameter to biomass of competing vegetation at the end of first growing season. Each point is the plot mean for diameter measurements on 50 seedlings and vegetation biomass measurements on six, 10.8 ft^2, subplots (from Wittwer et al. 1986).

In the process of leveling, reshaping, and contouring mine spoils, considerable compaction usually occurs and adversely affects seedling performance. So, in addition to the use of herbicides, ripping can reduce seedling stress. Ripping improves soil conditions by loosening the soil to allow free drainage and provide channels to collect surface run-off (Wittwer et al. 1986, Josiah 1986, Philo et al. 1982). The ripping treatment alone increased loblolly pine seedling height and ground-line diameters 10 and 20 percent. However, when ripping was combined with the application of Velpar L, height and diameter were increased 49 and 83 percent after two growing seasons (Wittwer et al. 1986).

These data indicate that some modification of the typical reclamation site may be necessary to obtain aatisfactory pine seedling performance.

REFORESTATION OPTIONS

Reforestation options available for reclamation sites normally include planting of bare-root or container stock and direct seeding. What are the bases for selecting one technique over another? Direct seeding of pines was a promising reforestation technique for mine spoils prior to the recent legislation that required rapid establishment of herbaceous cover and restoration of the sites to their original contours (Biesterfeldt and Mann 1969, Wittwer et al. 1979). However, direct seeding has limited potential on current reclamation areas because of vegetative competition and compacted soils. Pine seeds must be in contact with mineral soil in order to germinate and become established.

Planting offers much better control of stocking, makes more efficient use of expensive genetically improved seeds, makes thinning and harvesting easier, and elminates need for precommercial thinning. Planting of container-grown seedlings is an artificial regeneration option that has become available in recent years. The use of containerized southern pine seedlings has not gained widespread popularity because bare-root stock is cost-effective, relatively easy to procure, and generally reliable. However, some situations involving bare-root seedlings will not provide the desired results and the use of container-grown seedlings should be considered. Container-grown seedlings can be used to: (1) improve survival and growth, particularly of species difficult to regenerate on adverse sites, (2) extend the planting season to allow regeneration to dry sites in the fall and wetlands that are subject to winter flooding in the spring, and (3) allow greater flexibility in seedling production to meet unexpected demands (Barnett 1983). If containerized seedlings are grown in sufficient quantities to take advantage of the economies of scale, they will be cost-competitive with bare-root stock (Guldin 1983).

Planting container-grown seedlings

Many aspects of planting container seedlings are the same as those planting bare-root stock. However, there are some important differences. Despite their bulk and weight, container seedlngs have the attractive feature of planting ease; the uniformly shaped root system makes them easy to plant by hand or machine.

Container seedlings can be hand planted using conventional bare-root planting tools or tools designed for specific container types. Such special tools have been used to plant container stock at twice the rate of hand planting bare-root stock (Appleroth 1971). These planting devices displace or dibble the soil to make room for the seedling root ball. Their effectiveness depends greatly on the soil type and soil moisture, and they work well on mid-range soil types such as sandy loam, loam, and silt loam. For clay soils, tools must be designed to avoid soil compression or case hardening of the side walls when the hole is opened (Barnett and Brissette 1986). For very sandy soils the tool must prevent the side walls from caving in before the seedling can be properly planted. Hand-held power augers can be used for planting stock grown in very large containers.

With only minor modifications, most mechanical planters designed for bare-root seedlings can be adapted for planting container stock. Conventional planting machines are either of the continuous furrow type or the intermittent furrow type and are usually fed manually. To modify continuous furrow machines to plant container seedlings may only require changes in operator technique. Intermittent planters may need some changes to the seedling holding mechanisms.

As with bare-root stock, planting container-grown seedlings to the proper depth is important to ensure good survival and growth after outplanting. Container seedlings should be planted deep enough to allow covering the top of the root plug with about 0.5 inch of soil. Covering the container reduces drying in the root zone caused by the wicking effect of the media or planted container. Planting below the groundline also reduces the frost-heaving of container stock planted in the fall or winter.

Planting bare-root seedlings

Detailed instructions for planting are available in Planting the Southern Pines (Wakeley 1954), which remains the most complete guide available. Key requirements for planting are selection of a suitable site, use of the best seedling quality and planting technology, and adequate control of competing vegetation.

Moisture stress is the most widespread cause of low initial survival (Wakeley 1954). Probably the greatest loss of planted pine seedlings occurs when they have not re-established good soil-root contact within five days after planting. Seedling failure may result from poor planting, low initial soil moisture, prolonged rainfall deficiency following planting, and low seedling quality. We can improve on seedling quality and poor planting, but the other variables require methods that minimize environmental influences.

Another rather common reason for poor survival is root desiccation between the removal of the seedlings from the package and the actual planting. A healthy seedling placed into a dry planting machine box quickly loses its ability to survive. Exposure of fine rootlets to desiccating conditions predisposes the seedling to severe shock, slow recovery, or death. Ideally the moisture film covering the roots should never be allowed to evaporate, but drying for 10 or 15 minutes may be acceptable on overcast days. Many nurseries coat the seedling roots with a clay slurry to retard moisture loss.

Planting instructions often caution that J-rooting and other root malformation are to be avoided, but there is little conclusive evidence that malformed root systems are detrimental to survival. A too-shallow planting slit results in root deformation, but the real cause of mortality is probably shallow planting. However, root deformation does adversely affect height growth after planted pines become established (Harrington and others 1987).

APPLICATION OF OTHER TECHNOLOGY

We were asked to include in this paper new approaches that might be useful for consideration during reclamation. One concept that has been used widely in New Zealand and Australia is agroforestry. The term is of recent vintage and is broadly defined as growing an agricultural crop and a forest crop on the same land at the same time (Mosher 1984). The most common application of agroforestry is a combination of trees for timber and grass for animal grazing. Since most reclamation sites are seeded in grass and fertilized to quickly establish complete ground cover, agroforestry could have considerable merit, particularly in areas where cattle grazing is common.

A frequent area of concern among foresters is the adverse affect of livestock on young seedlings. However, there are several ways to limit animal damage to pine seedlings. One is to maintain a balance between forage and animals. Only heavy grazing (60 percent utilization) significantly reduced pine survival (about 20 percent) in planted slash pine stands (Pearson and Cutshall 1984). Another technique is to run a one-wire electric fence directly over the rows of pine seedlings. This is a very effective technique and normally is needed for only a couple of years (Pearson and Barnett 1986). Solar-powered electrical fencing now makes this practice more feasible.

Production of improved forage always decreases as the pine canopy begins to close. In order to optimize forage production and tree growth, some change in tree-spacing configuration should be considered. For example, instead of planting at conventional spacing of 6 X 8 ft with 908 trees/acre, or 8 X 12 ft with 454 trees/acre, the use of some wide-row spacings of 4 X 15 ft with 726 trees/acre, 4 X 20 ft with 544 trees/acre, or 5 X 18 ft with 484 trees/acre provides adequate stocking of trees while maintaining an open canopy for a longer period of time. Another approach would be to plant strips of double and triple rows of trees with even wider spacings between strips of trees (Pearson and Barnett 1986). Through age 13 there has been little difference in slash pine growth at these unusual configurations (Lewis 1986). The real value of these planting designs is an open canopy to promote growth of forage plants for livestock or hay throughout a pine rotation.

Obviously there are both advantages and disadvantages to growing trees and livestock together. First, the multiple use of land offers potentially more income per acre of land. There are ecological benefits too. A legume forage can add nitrogen to the system (Bengtson and Mays 1978). This will facilitate greater tree and forage growth, which could mean more livestock. It will make a more nutritious and highly digestible forage base. On reclamation sites where a heavy grass cover is present, grazing may reduce competition to pine seedlings and improve tree growth later.

However, agroforestry requires a higher level of management than do livestock alone and trees alone; and there is an increased investment in the new component added, whether it is trees or forage.

SUMMARY

Loblolly pine has the greatest potential for successfully reforesting disturbed sites in the southern and southeastern United States. Planting of container or bare-root grown stock are the best ways to establish new stands. However, reclamation sites with heavy grass cover present difficult conditions for seedling establishment. The survival and early growth can be markedly improved by the use of herbicides, either prior to or after planting. Performance of compacted soils can be helped by ripping of the soils prior to planting. If properly handled, disturbed sites can be as productive or more productive than the undisturbed sites for pines.

Agroforestry offers an opportunity to combine tree production with grass crops for animal grazing. Reclamation sites would provide appropriate agroforestry sites because of the heavy grass cover that is typically present.

DISCLAIMER

Discussion of pesticides in this paper is not a recommendation of their use. If pesticides are handled, applied, or disposed of improperly, they can harm humans, domestic animals, desirable plants, and pollinating insects, fish, or other wildlife, and may contaminate water supplies. Use pesticides only when needed and handle them with care. Store pesticides in their original container in a dry, well-ventilated, and secured building. Follow directions and heed precautions on the pesticide label.

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