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HERBICIDE TECHNOLOGY: ITS PRESENT AND FUTURE ROLE IN RE-ESTABLISHING SOUTHERN PINE PLANTATIONS

James H. Miller

This paper explores the benefits of competition control treatments in establishing plantations now and into the next rotation. More is known about the economic outcome of woody control treatments than about herbaceous control; thus, the former are given the most attention. But the early growth benefits of herbaceous weed control treatments are also reviewed, with the appropriate application methods and possible innovations. Application methods are explained, with emphasis on ideas leading to possible establishment savings.

THE PAYOFF OF VEGETATION CONTROL TREATMENTS

Why do we control competition when growing a crop? First, to increase seedling plant survival, and second, with weed control a larger crop can be grown sooner. Thus, by using weed control more fruit, grain, and fiber can be produced from less land. The cost benefits of competition control have been determined for most agricultural crops; however, the long-term investment returns for woody and herbaceous control with southern pine management have not as yet been verified.

Benefits of Hardwood Control

A recent model that draws upon 400 plots from across the South has estimated the losses in yield that occur in loblolly pine plantations with varying hardwood components in the main canopy (Burkhart and Sprinz 1984).

Discussion of herbicides in this paper does not constitute recommendation of their use or imply that uses discussed here are registered. If herbicides are handled, applied, or disposed of improperly, there is potential for hazards to the applicators, off-site plants, and environment. Herbicides should be used only when needed and should be handled safely. Follow the directions and heed all precautions on the container label.

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This model was based upon a critical relationship derived from a long-term study initiated by Whipple and White (1965) in Alabama, and more recently reported after 24 years of growth data by Glover and Dickens (1985). Periodic measurements of these site-prepared plots have shown that the proportion of hardwood basal area in a stand remained constant from age 11 to pulpwood rotation. That is, if a stand had 30-percent hardwood basal area at age 11, it still had 30-percent hardwood basal area at age 24. These data also suggest that hardwood basal area can displace a greater amount of softwood yield than an equivalent amount of pine basal area can add to yield (Figure 1). That is, a stand having 30-percent hardwood basal- area will reduce pine yield by SO percent. Thus, any hardwood species that can maintain equal height growth with the pines can displace a more than equal amount of softwood fiber production, This suggests that the elimination of even small amounts of hardwood competition from the main canopy can have real payoffs in pine yield; this has also been suggested in an earlier study (Langdon and Trousdell 19741.

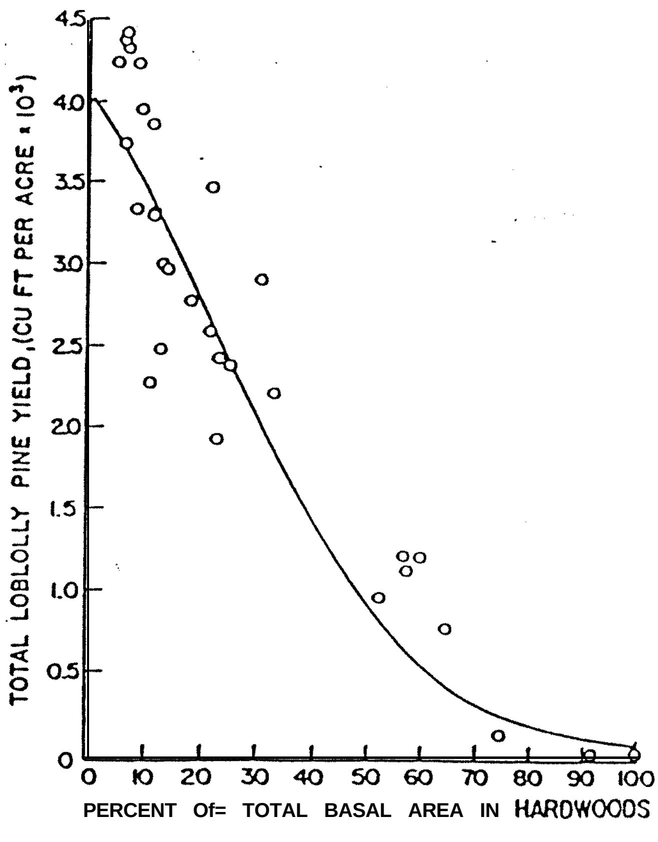

Figure 1. Total yeild of loblolly pine verses percent of total stand basal area in hardwood from plot observations in a hardwood competition/site preparation study in Fayette County, Alabama. The line represents predictions from the computer simulation HDWD (Burkhart and Sprinz 1984).

The benefits from controlling understory hardwood competition have been studied in only a very few stands (McClay 1955, Russell 1961, Langdon and Trousdell 1974, Clason 1978, D'Anieri et al. 1986, Boyer 1987). Removal of sapling hardwoods and shrubs has often, but not consistently, increased yeild. These variable findings suggest that the impacts of understory competition'on pine growth are probably site dependent, Surviving deep-rooted trees can eventually obtain moisture and nutrients on deep soils, regardless of competition. Where soils are poor and shallow and rooting depth is restricted, competition can be severe.

Current economic anlayses of investments in hardwood control have predicted substantial rates or return, with the added benefit of increasing yields per land area (Anderson and Hickman 1986, Kline and Kidd 1986). Thus wood production can be increased from a fixed land base. These analyses indicate that with competition control, growth and investment returns greatly increase as site' quality increases, Thinning is almost essential in capturing the rapid growth (Langdon and Trousdell 1974, Clason 1987). Therefore, highly productive lands and lands near mills can be made even more productive with shortened rotations.

In. these economic analyses, hardwood control is 'considered' to occur at the time of establishment. Early hardwood control is logical because less herbicide is required to control small woody plants, and young plantations are easier to treat with current application methods. Less is understood about the returns from hardwood treatments applied for timber stand improvement. A growing data base and enhanced understanding are accruing regarding preharvest hardwood treatments, those made 1 or 2 years before harvest. Some preharvest control treatments can be expensed as a harvesting aid and thus have a benefit for taxing the investment. The tax savings are over and beyond the actual benefits from easier harvests, reduced haulage rates due to reduced wood water content, shortened'regeneration times, and possibly improved competition control.

Benefits of Herbaceous Control

Pine growth benefits from herbaceous weed control have been increasingly reported during the past 10 years (Nelson et al. 1981, Michael 1985, Metcalfe 1986, Zutter et al. 1986). Benefits of increased survival and enhanced diameter growth are well documented, These studies are usually performed on areas that have nearly complete woody control as a concurrent condition.. Studiesacross the South have been under way for up to 12 years, involving investigations of loblolly, slash, and longleaf pine- -Much research has been conducted by the members of the Auburn University Silvicultural Herbicide Cooperative (Knowe et al. 1986, Glover et al. 1986, Creighton 1987a, 1987b, 1987c). Current results show that: a) the same wood yield can be reached 1.5 to 3 years soon&r with herbaceous and woody control, b) herbaceous weed control in a band along the planting row is as effective as broadcast control, and c) 1 year of weed control in a band often yields growth comparable to 2 years of banded or broadcast weed control, This points to large savings in application costs by using banded application, which treat'only 40 to SO percent of a tract and for only the first year of establishment.

A region-wide study performed cooperatively at 16 locations by the USDA Forest Service, universities, and industry shows that during the first 2 yesrs, herbaceous competition significantly limits growth more than woody competitors (Miller et al. 1987). In this ongoing study, complete weed control for four growing seasons has yielded loblolly pines that commonly range in size from 12 to 20 feet tall and 3 to 4 inches in d.b.h. (Miller, unpublished data). Thus, these dramatic growth gains with total weed control show the promise that herbicide technology holds for southern forestry.

However, the benefits from herbicide applications are not risk free. Treatment success, with the currently labeled herbicides and management latitudes, is never assured, There is a risk of ineffective control due to known and ambiguous factors. Chief among these factors is weather conditions. It is rarely possible for operations to schedule application to coincide with ideal weather conditions. Also, the correct herbicide is not always prescribed for controlling the specific species present. Many additional variables are yet to be studied, . including the quality of water used in mixing, surfactant interactions, plant status for receptivity, and others that ultimately contribute to poor control, Too, it is painfully obvious that if one set of competitors is successfully controlled, another set can become established from a multitude of hardwood, shrub, and herbaceous propagules that reside or migrate into forested lands. However, as broader spectrum forestry herbicides become labeled and more research and experience are brought into play, the risk of failure will be decreased but never nullified.

The economics of herbicide treatments are dictated mainly by herbicide .and application costs. Interestingly enough, herbicide costs of the commonly used broadcast treatments for woody control do not vary much by product and usually range from $55 to $80 per acre for site preparation and $20 to $30 per acre for release. Unless lower cost herbicides become available, there is little latitude for cost savings from the selection process. There are, however, great cost benefits from selecting the most effective herbicide for the species present, selecting a herbicide that gives both herbaceous and woody control, and applying that herbicide at the optimum time, This paper focuses on application alternatives because most savings can be realized by application efficiency,

HERBICIDE APPLICATION TECHNOLOGY - PRESENT STATUS

For an application method to be most efficient, it should be geared toward a specific distribution of competition. Simply stated, broadcast treatments are the most expensive, with per acre expenses decreasing as treatment area decreases. Broadcast treatments are easily prescribed and can be applied to all acreage, but they are wasteful'if the competition is not spread across the entire acreage. When competition is scattered or in patches, other treatment patterns may be more efficient and economical. Although alternative treatment methods are currently available, in the near future there will probably-be a number of alternatives from which to choose.

Hardwood Control Applications

Most existing plantations have been established with some type of hardwood control treatment, e.g., chopping, shearing, rootraking, and/or burning. The interplay of the degree of control from that initial treatment, the preharvest distribution of woody vegetation, and the re-encroachment by shrubs and hardwoods determines the distribution of woody competition in a plantation. Windrows will concentrate hardwoods in strips, while other treatments result in other patterns, Also the terrain., which influences the frequency of minor swells and minor and major drainages, strongly influences the control and re-establishment of woody component. In general, although not consistently, hardwood regrowth is more dominant on the lower terrain, and control treatments are less effective in lower areas, Competition is usually more severe on sites of higher quality, which is also the moist lower ground. Thus, great gains are possible on lower lands if effective control strategies are applied.

The two basic patterns that result from the interplay of past treatment and regrowth are; one that is uniformly distributed *across* the area, either dense or scattered, and one that is grouped into patches around the lower terrain or along windrows. The prescriptionist should identify areas with these different distributions to gain application savings.

Aerial Methods

When woody competitors are greater than 800 stems per acre and are evenly distributed across a tract (over 80 acres), then the first alternative to consider is aerial broadcast applications, For these applications to be successful, adequate preparation'of the tract is imperative. To assure good and complete coverage by a helicopter sprayer or spreader, the area should be outlined by a bladed line, a ground-sprayed buffer, or a tree-injected buffer to enable the pilot to easily determine the boundaries of the tract. Flagging stations need to be surveyed accurately around the boundary to assure accurate swath placement and appropriate overlaps. Determination of proper overlap and swath placement is critical in release applications. Unexpected mortality from excessive overlap can easily nullify any growth benefits.

Heliports should be planned and established in compartments and maintained permanently for this purpose. A heliport should be on a high area with cleared approaches and take-offs relative to the prevailing winds. Heliports should be maintained with a grass *cover,* so that dust will not hinder ship operation, visibility, and ground crew efficiency.

With aerial applications, -and somewhat with ground applications, an operations foreman must be on site to determine when to start and stop treatment relative to the prevailing conditions. This is often a difficult decision because weather conditions quickly change in the morning hours when applications usually occur, Consideration must be given to the wind at various altitudes, temperature inversions, and prognosis of pending rain storms, only to specify a few. It is a judgement call at best, a management decision not to be made by the applicators. With ideal weather, proper layout, and good supervision, one helicopter can treat hundreds of acres in a single day,

Ground Methods

Broadcast treatments can also be performed with tractor-mounted sprayers and spreaders on certain tracts (Sage et al. 1984, Miller et al. 1985, Miller 1985). Ground machines and backpack crews can also treat buffer areas around aerially treated tracts. Skidder- or crawler-mounted equipment can be efficient if the terrain, stand conditions, and utilization permit consistent operating speeds of 1 to 3 mph. Ground sprayers can presently apply foliar-active herbicides to woody competition up to about 16 ft tall with a 30-to 40-ft swath. Spreaders and sprayers can apply soil-active herbicides and treat hardwoods greater than 16 ft tall if uniform coverage of the soil is possible. The Omni Spreader (Miller 1985) currently has an 85-ft swath, and some high-mounted sling spreaders can treat a 40-ft swath. Average productivity for tractor-mounted applicators is 4 to 18 acres per hour.

Individual hardwood stem treatments: As densities of hardwoods drop to below 800 stems per acre, broadcast treatments become inefficient, and individual stem treatments become comparable or less in cost per acre. Application and herbicide efficiency also improve for certain crew-applied methods when stem sizes decrease. Individual stem treatments include directed foliar sprays, streamline basal sprays, tree injection, and soil spots (Williamson and Miller 1986). Directed foliar sprays are used to treat woody plants up to 6 ft tall. Basal streamline applications and soil spot applications can control many species of hardwoods up to 6 inches in d.b.h.. Injection treatments are capable of controlling trees 2 to 30 inches in d.b.h. With streamline treatments, the juvenile bark is treated in one or two streaks with a mixture of herbicide and diesel fuel. Apparently, backpack crews are effective at densities of 500 to 4,000 stems per acre. Productivity ranges from 0.2 to 0.5 acre per hour for injection and 1.0 to 1.5 acre per hour for directed sprays. Applicators on all-terrain vehicles (ATV's) can apply foliar and basal sprays. ATV's permit rapid movement among scattered stems. ATV and backpack methods have terrain limitations for safe operations, but the future use of ATV sprayers for flat to rolling terrain appears feasible.

Patch distribution of hardwoods: Skidder-mounted sprayers will probably be most effective for traveling from patch to patch and along old windrows to apply pellets, granules, or sprays. Application can be directed to one side of a tractor to treat along old windrows, and handgun attachments can be used to spray very tall hardwoods. ATV's or small skidders may be more efficient for higher speed travel between patches, although backpack crews may be effectively trucked between large patches where access is possible.

Herbaceous Weed Control Applications

The same application options are available for herbaceous weed control as presented for woody treatments: helicopter sprayers and spreaders, tractor sprayers and spreaders, ATV sprayers, and backpack sprayers. Also, a prototype spreader mounted on an ATV, patterned after the Omni air-blown spreader, is just appearing on the market and offers yet another option.

Aerial Methods

Because of the soil erosion potential and the extra expense, broadcast applications are not totally desirable or warranted for herbaceous control. More preferred are banded and spot (small patch) treatments along planting rows and over individual seedlings. In the spring-flooded flatwoods, however, broadcast by helicopter is presently the only choice in application. This has been determined through extensive but unsuccessful trials of various tractor-mounted equipment, including elevated levee sprayers.

Ground Methods

For first-year planting, a 4- to 5-ft wide band results in approximately the same pine growth as broadcast treatments and at lower costs (Knowe et al. 1985). Banded sprays are now being applied post-plant by tractors, ATV's, and backpack crews. Planting machines have also been equipped with small sprayers to apply banded treatments simultaneously with planting (White 1962, Gilbert 1972, Garner and Olinger 1982, Miller 1985); this lowers application costs even further. However, herbicide rates must be increased, often doubled, and/or herbicides with more residual activity used for preemergent applications in the early planting season. Even with some banded treatments, accelerated erosion can still occur because all acreage cannot be treated with bands parallel to the contour, and minor gulleys can cut across bands, channeling water and soil. However, inspection of the terrain and soil during the prescription process should result in wise application to minimize erosion.

Spot treatments are less prone to erosion and still provide the weed control for growth *gains.* Presently, backpack crews apply most spot treatments. One full backpack can treat about 1.5 acres in 1 hour. In the future, spot or small-patch treatments should be possible with modifications to tractor, ATV, and planting machine sprayers- Also, a hand device has been developed in New Zealand for spot application of concentrated granular herbicides; this device should have promise in the United States.

A basic need of all programs using backpack methods is an available labor force of applicators that are well-trained and reliable, To build this labor force will require scheduled training *on* proper handling and application techniques, business practices, and safety equipment development. An effort is currently under way to coordinate ground applicator training in the 13 Southern States. through the Auburn University Herbicide Technology Transfer Cooperative. This effort will assist each state in developing training sessions on a recurring schedule, Each state has the responsibility to train, certify, and license applicators under the Federal Insecticide; Fungicide, and Rodenticide Act, but-not all have the capabilities to invest in the training of the forestry applicator sector.

HERBICIDE APPLICATION TECHNOLOGY - FUTURE POSSIBILITIES

If forestry applications continue at the present *or* expanded levels, if the public's "pesticide phobia" is not inflamed by the press, and if regulatory restraints are not tightened, broader spectrum herbicides will continue to appear in the silviculturist's tool box. These newer herbicides, or mixtures of herbicides, will permit up to complete control of the woody and herbaceous components for a limited time- Such treatments will allow the speedy and assured reforestation and reclamation of increased acreage, but the cost will be somewhat higher. The herbicide manufacturers will pass on the soaring costs of new product registration, which will certainly keep rising as our health and environmental concerns expand registration testing. Early plantation growth will be phenomenal, especially *as fertilizers* and insecticides are applied to genetically improved planting stock. Accelerated growth periods may need to be adjusted to yield wood of desirable quality for selected products.

Larger investments by industry and greater capabilities by the manager will necessitate more critical decisions on where and what treatment to apply. The prescription process will become even more detailed, requiring more specialized training for the prescriptionist, The prescriptionist will have to critically evaluate soil site, woody and herbaceous composition,' liability hazards, terrain, access, legal context, etc. With the increased investment in herbicide treatments on select lands, greater.savings will be possible through effective and efficient applications.

In the realm of herbicide application technology, many future scenarios are possible. Much hinges on the continued capability for treatment by helicopter as forest lands and homesites' become even more interspersed, Obviously, less acreage will be treatable by helicopter, and more acreage will be in sensitive zones, buffer areas, hardwood management zones, and wildlife management areas. This will require more efficient ground applications with tractors, ATV's, tree injectors, and backpack crews, With the increased utilization of hardwoods and better forest access, the possibilities for ground application by tractors and handcrews will increase and thus become profitable on more sites, As industry realizes the need for these alternative application systems, the development effort will increase to produce low-drift and electronically guided sprayers and spreaders on suitably balanced ground equipment. The components are presently available, but the' incentive for development appears to be lacking,

The one-pass minimum-tillage trend in agriculture can be brought into silviculture, Figure 2 shows an integrated regeneration train of equipment that can shear, rip, and cultivate while applying herbicides, silvicides, insecticides, and fertilizers. A savings in applications can be realized with the right system management of this one-pass approach.

Another innovation worthy of development is an herbicide applicator combined with a tree shear or saw-head (Vidrine 1984). Thus, hardwood stumps could be treated simultaneously with felling, and resprouting could be stopped, Application costs would be minimal.

CLOSING REMARKS

This is obviously the age of information and automation. Forest regeneration operations cannot remain in a vacuum for long because the costs and savings are too apparent. Integrated research and development is required that extends across proprietary bounds and individual piecemeal efforts. But with the government's current leaning towards privatization, the main effort will have to be shouldered by industry, Some Northern European countries and Canada, New Zealand, and Australia are leading the way in regeneration mechanization, We should learn from these countries and initiate our own integrated programs in forest regeneration research. This is a worthy area of research and development that requires a cooperative responsibility and jointly shared expense.

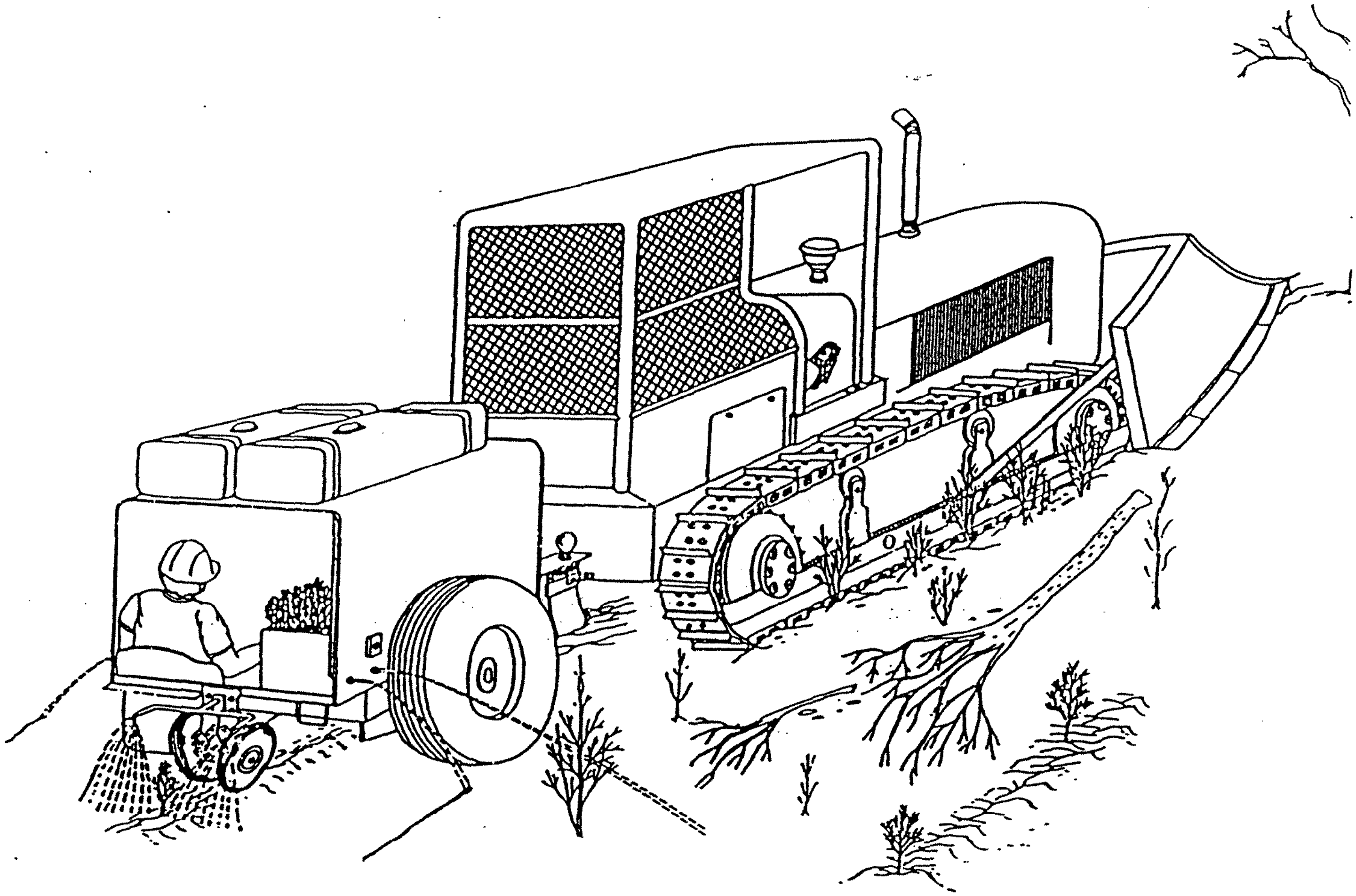

Figure 2. A conceptual integrated regeneration train of equipment having a shearing blade, ripping blade, cultivator, and tree planting machine. Fertilizers, insecticides, and herbicides for woody and herbaceous weed control can be simultaneously applied.

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