COMPETITION CONTROL IN SLASH PINE (*PINUS ELLIOTTII* ENGELM.) PLANTATIONS

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Abstract—Harvesting intensity impacts the composition of the post-harvest recolonizing community and thereby influences the method and quality of post-harvest site preparation and resultant slash pine (*Pinus elliottii* Engelm.) response. Knowledge of the composition of the competitor community, growth state of the competition, and the efficacy and duration of the treatment contributes to appropriate treatment selection. A variety of chemical or mechanical treatments are available for pre-plant, post-plant or midrotation slash pine competitor control. Slash pine responds to weed control, bedding, and fertilization with significant increases in basal area, and total and merchantable volume per acre on many spodosols and nonspodosols. These treatments are the standard for contemporary slash pine plantation management. Control of arborescent, woody shrub, and herbaceous species is a vital part of increased slash pine plantation productivity.

INTRODUCTION

The South leads the United States in production forestry, but on a global scale, growth rates and yields of southern pines are moderate. To meet the challenge of foreign competition in markets, southern forests must be managed more efficiently and productively. Research indicates intensive and cost-effective management can potentially increase growth 50 to 70 percent (Pienaar and Rheney 1996) or more (Stanturf and others 2003) when compared to current conventional plantation management. Vegetation management, specifically chemical site preparation, plus woody shrub and herbaceous weed control, has an important role in increased plantation productivity.

Within the South, slash pine (*Pinus elliottii* Engelm.) is a major contributor to overall fiber production with more than 1.5 million seedlings planted annually (McKeand and others 2003). Slash pine plantation establishment commonly includes either or both mechanical and chemical site preparation. Post preparation sites are typically planted with genetically improved seedlings, fertilized, and treated for herbaceous weeds.

Slash pine responds to competition control (Swindel and others 1988; Shiver and others 1990). Cognoscience of species composition of the competitor community, growth state of the competition, the efficacy of the treatment, and duration of treatment effect contributes to wise treatment selection and justification.

HARVESTING CONSIDERATIONS

The best competition control often begins with utilization of both the crop and weed species on any given harvesting site. Thus, harvesting intensity, subsequent site preparation alternatives, revegetating plant community, and resultant slash pine seedling performance are all related. Increasing harvesting intensity can impact the method of post-harvest preparation, the quality of post-harvest treatments, and seedling response. However, harvesting intensity does not reduce the need for good site preparation if aggressive species occupy the site (Miller and Zhijuan 1994). For example, hard-to-control competitors such as gallberry (*Ilex glabra* (L) Gran), sawpalmetto (*Serenoa repens* (Bartram) Small), vacciumium (*Vaccimium* spp.), waxmyrtle (*Myrica cerifera* L), fetterbursh (*Lyonia lucida* (Lam) K.Koch) staggerbush ((*Lyonia ferruginea* (Walter) Nutall), sweetbay (*Magnolia virginiana* L.), and titi (*Cyrilla racemiflora* L.) commonly occupy poorly drained slash pine sites and will not be controlled by harvesting activities. An appropriate site preparation method addresses these competitors, else they will persist into the rotation, complicate midrotation control, and reduce pine growth. The importance of selecting the appropriate site preparation treatment cannot be overstated. The growth gain associated with site preparation can be detected 20 years later (Shiver and Harrison 2000).

HERBICIDE TREATMENTS

When applied prior to planting, Arsenal® AC, Chopper® EC, Tordon® K, Garlon® 4, Accord® concentrate, Accord® SP, Tordon® 101M, Escort® XP and Velpar® L may be used for the control of labeled grasses, broadleaf weeds, vines and brambles, and woody brush or trees on forest sites (BASF 2000, 2001; Dow AgroSciences 1999, 2001a-b, 2003; DuPont 2003a, 2003c). Slash pine seedlings may exhibit damage symptoms if planted too soon after certain chemical site preparation treatments. Minimum intervals between treatment and planting include: one month after Garlon® 4 at less than 4 quarts per acre, two months after Garlon® 4 at 4 to 8 quarts per acre (Dow AgroSciences 2001a), and six months after Tordon® K or Tordon® 101M (Dow AgroSciences 1999, 2003). If a Velpar® L treatment is to be followed with a second mechanical, chemical, or burning treatment, the second treatment should be delayed until competitors exhibit two complete defoliations (DuPont 2003c). Efficacy of specific herbicide stand-alone and tank mixtures are presented in Minogue 1985, Shiver and others 1991, and Minogue and Zutter 1986.

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REVEGETATION

Following site preparation, lower Coastal Plain flatwood sites rapidly revegetate (Conde and others 1983a, 1983b, 1986; Miller and Zhijuan 1994). Relationships between pre- and post-preparation communities have been noted (Schultz and Wilhite 1974; Conde and others 1983a, 1983b, 1986; Miller and Zhijuan 1994). First, with minimum preparation, the most abundant pre-preparation species may also be the most abundant post-preparation species (Conde and others 1986). Second, woody shrubs and herbaceous species differ in their response to site preparation treatments. Mechanical bedding disturbs roots and slows the re-establishment of woody shrubs (Schultz 1976, Conde and others 1986). Treatments with increased root disturbance provide slow recovery of woody shrubs and decrease the resultant density of the shrubs (Schultz 1976; Conde and others 1983a, 1983b, 1986; Miller and Zhijuan 1994). Thus, shrub recovery following a double bed operation is slower than following a single bed (Lauer and Zutter 2001). In each example, herbs proliferate in the absence of woody shrubs (Schultz 1976, Conde and others 1986, Miller and Zhijuan 1994, Lauer and Zutter 2001). Third, post-mechanical recolonizing herb communities may shift from grass towards forbs and blackberry (Miller and Zhijuan 1994). Collectively, this information suggests that a pre-harvest woody shrub and herb inspection can be used as an indicator of the post-harvest competitor communities yet to develop. Accordingly, the manager can prescribe a preparation method, timing, and sequence for woody shrub and herb control based on the impact each has on subsequent slash pine growth.

PRE-PLANT VEGETATION CONTROL

Herbicide Treatments

Pre-plant herbicide applications are less restrictive than post-plant applications because they can accommodate a broader array of rates and products. With proper herbicide selection and application, pre-plant treatments can potentially provide broader control than post-plant treatments (Lauer and Zutter 2001). However, timing of pre-plant applications is critical for overall efficacy and the planting restrictions associated with some herbicides.

Pre-plant, fall-applied (Oct and Nov) herbicide treatments following early bedding improve control of woody shrubs over that of a double bed and provide some first-year herbaceous vegetation control (Lauer and Zutter 2001). Examples of herbicide treatments and per acre rates successfully used as pre-plant fall applications with 20 gallons per acre of total spray volumes are: Garlon® 4+Arsenal® AC+ Accord® concentrate+Timberland 90 (2qt+10oz+24oz+0.75 percent v/v), Garlon® 4+Arsenal® AC+Escort®+Kinetic (1qt+8 oz+2 oz+0.1 percent v/v), Garlon® 4+Arsenal® AC+ Timberland 90 (2qt+8 oz+0.96 percent v/v), Garlon® 4+ Chopper®+Escort® (2qt+24oz+1oz) (Lauer and Zutter 2001). The planting delay restrictions apply in this example (Dow AgroSciences 1999; 2001a,b; 2003; DuPont 2003a,c). The improved competition control from early bedding followed by pre-plant, fall-applied herbicide versus early bedding alone results in better pine growth (4.9 ft versus 4.0 ft after two growing seasons) (Lauer and Zutter 2001).

Pre-plant treatments may be a manager's last opportunity to focus on specific weed problems prior to the midrotation thinning. If not controlled early, difficult-to-control weeds may increase in the early stand, reduce growth, and increase the difficulty of midrotation control. To reduce total costs, managers should combine pre-plant treatments with herbaceous weed control. Managers may select between a band on beds and a broadcast application for the herbaceous control treatments.

Mechanical Treatments

Slash pine is commonly managed on poorly drained sites, thus, bedding is the most common mechanical treatment used. Bedding is either single pass or double pass and rarely conducted without the use of herbicides. Thus, what becomes critical is the proper selection of herbicides and application timing if the land manager is to optimize the benefit of the bedding operation. On single bedded sites, vegetation control can be enhanced with a pre-plant or post-plant herbaceous treatment. Post-plant Arsenal® AC+Oust® (4+2 ounces per acre) controls herbs and suppresses shrubs (Lauer and Zutter 2001). Escort® mixtures (correctly timed) are appropriate if bracken fern, woody vines, or blackberry are issues. Timing is critical for herbaceous treatments that are used also for the control or suppression of woody shrubs. Good herbicidal coverage of foliage prior to the first flush of growth is essential. May or June applications will likely provide poor control (Kline and others 1994).

Shrub cover is reduced more with a double bed than with a single bed treatment (Lauer and Zutter 2001). Controlled shrubs are rapidly replaced by herbs. Double bedding without post-plant herbaceous control may not result in enhanced seedling performance because the short-term impact of woody shrub and herbaceous vegetation on seedling growth is similar (Lauer and Glover 1998).

POST-PLANT VEGETATION CONTROL

Post-plant vegetation management takes the form of either herbaceous or woody release. Some treatments have the capacity to control herbaceous and woody competitors. Perhaps the best management strategy is to control the woody competition prior to planting and the herbaceous competition after planting. However, when one or both types of control are needed, release operations in slash pine increase growth. After five growing seasons, slash pine total height responses average 2.8, 5.4, and 6.7 feet due to first-year herbaceous control alone, shrub control alone, and both herbaceous and shrub control, respectively (Lauer and Glover 1998). Good first-year shrub control can eliminate the need for follow-up or annual shrub control treatments (Lauer and Glover 1998, Zutter and Miller 1998). Following initial control, woody shrubs do not respond to herbaceous weed control (Lauer and Glover 1998, Zutter and Miller 1998), remain suppressed for years (Zutter and Miller 1998), and do not rapidly recolonize from seed. Recolonization is of interest because woody vegetation has the potential to limit growth in midrotation stands (Pienaar and others 1983, Oppenheimer and others 1989). Therefore, managers should carefully select site preparation treatments for shrub control and

long-term pine growth. Lack of shrub control at the onset of the rotation (1) means reduced early pine growth, (2) allows shrubs to increase throughout early stand development, (3) complicates midrotation control, and (4) contributes to reduced late rotation growth. Although Lauer and Glover (1998) reported that pine response to shrub control was large compared to herbaceous weed control, it does not reduce the significant contribution of herbaceous weed control to slash pine seedling performance (Lauer and Glover 1998).

Herbaceous species will typically proliferate on prepared sites, especially if the woody shrubs are controlled. Accordingly, managers commonly select a herbicide treatment for herb control. When used properly, herbaceous release significantly enhances slash pine growth. For example, in a recent study, Ezell and Yeiser (2003) tested a number of herbaceous release treatments and found that 13 oz. Oustar® per ac provided the best overall competition control and growth response over a two-year period on sites in Alabama and Louisiana. Some trees were as much as nine feet tall after two growing seasons. By comparison, Lauer and Zutter (2001) noted that broad-spectrum control of herbs could be difficult with Oustar®. Thus, the species composition on the site is extremely important in determining final results. Arsenal® AC, Oust® XP, Oustar®, Escort® XP, and Velpar® (L or DF) are all used successfully to control herbaceous competition in slash pine plantations (BASF 2000; DuPont 2002a-b, 2003a, c). Proper use of herbicides includes a thorough familiarity with herbicide labels. Herbicide labels should always be consulted for any restrictions to applications or site conditions. Examples of application restrictions include the lack of an approved label for applying Arsenal® AC+Oust® XP and Arsenal® AC+Escort® XP tank mixtures over the top of slash pine seedlings. Interestingly, individual products (Arsenal® AC, Oust® XP, and Escort® XP), and a pre-mix blend of Oust® XP and Escort® XP (Oust® Extra) are labeled for use in slash pine (BASF 2000; DuPont 2002a, 2003a; DuPont 2003b). Furthermore, site conditions, such as water, can limit applications of Oust® XP, Escort® XP, or Velpar®. For specific details on water restrictions, see product labels (DuPont 2002a, 2003a-c).

VEGETATION CONTROL AND FERTILIZATION

Slash pine seedlings respond to bedding, vegetation control and fertilization (Colbert and others 1990, Shiver and others 1990, Shiver and Harrison 2000). At age 8, complete vegetation control in the flatwoods of southeast Georgia and Florida provided the most consistent improvement in slash performance (Shiver and others 1990). Bedding and fertilization provided significant growth improvement regardless of soil group. At age 20, bedding provided a total height gain of 1.50 feet. Total vegetation control increased total height 5.35 feet and d.b.h 0.9 inches. Fertilization enhanced total height 5.11 feet and d.b.h 0.6 inches. Projections from this study show intensified silvicultural practices can boost volume over conventional practices by 128 percent with a rate of return of 12 percent (Yin and others 1998). Slash pine responses to vegetation control and fertilization are additive (Baker 1973, Swindel and others 1988) although synergistic responses have been reported (Tiarks and Haywood 1981). In the latter case, vegetation control (hoeing) and fertilization together increased total biomass 347 percent, 207 percent more than expected if the two treatments had been additive (Tiarks and Haywood 1981). Although response to phosphorus commonly follows soon after application, it may not significantly affect pine growth for many years (Tiarks 1983; Haywood 1995).

MIDROTATION OPTIONS

Midrotation competition control treatments in slash pine are increasing across the South. Research shows slash pine responds very well to competition control in stands 10 to 15 years old. Oppenheimer and others (1989) controlled the vegetation in 9 to 15 year old slash pine plantations for 10 years. In response, height, basal area, total volume, and merchantable volume all increased significantly. While this type of control may not be operationally feasible, the results demonstrate that the species will respond to midrotation treatments.

Shiver (1994) examined the response of a slash pine plantation 14 years after it had received a midrotation competition control treatment. The plantations were 10 to 12 years old at the time of treatment and were located on a range of drainage categories. Overall, the worst results were generated on the poorly drained sites. However, on the sites with adequate drainage, volume was increased by 0.25 cords per acre per year.

Zutter (1999) noted similar results on a well-drained site. He studied slash pine plantations four years after an age 12 treatment of hexazinone at a rate of 1.4 lbs active ingredient per acre. Basal area, average d.b.h., and volume all increased. In his study, merchantable volume increased 0.33 cords per acre per year after the treatment.

Overall, it appears that midrotation competition control can be a cost-effective treatment in slash pine plantations. Applications will generate best results on better-drained sites and on those where the pre-treatment level of competition is restricting pine growth.

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