PRESCRIBED FIRE AND BRUSH REMOVAL AFFECT VEGETATION, FUEL LOADS, AND ABUNDANCE OF SELECTED BEETLE POPULATIONS IN PINE STANDS

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Abstract--Three forest sites were selected in Louisiana in early 2001. On each site, three treatments were applied: (1) Check: no further management; (2) PF: prescribed fire was applied in May 2001 and June 2003; and (3) PF-MPC: between the two prescribed fires, midstory and understory woody vegetation was masticated with mechanical equipment in July 2002. Management did not change overstory composition, and basal area per ha increased on all treatments through February 2005. Percentage of understory arborescent cover also increased, although less so on PF and PF-MPC treatments than Checks. Herbaceous plant cover decreased on all treatments through August 2004, and increased shading and crowding were the likely reasons. Both PF and PF-MPC reduced 10-hour time-lag dead fuels but did not affect 1-hour or 100-hour fuels. Abundance of pine bark beetles, *Dendroctonus terebrans*, *Hylastes salebrosus*, *H. tenuis*, and *Ips* spp., and root-feeding weevils, *Hylobius pales* and *Pachylobius picivorous*, increased after each prescribed fire but not after mastication.

INTRODUCTION

Before European settlement, longleaf pine (*Pinus palustris* Mill.) forests occupied as much as 38 million ha across the southeastern United States and were the most extensive ecosystem in North America (Brockway and others 2005, Landers and others 1995). Across this extent, longleaf pine depended upon natural and anthropogenic fires for existence, because without fire, other pines and hardwoods would eventually succeed them (Brockway and others 2005, Haywood and others 2001, Wahlenberg 1946). Once longleaf pine forests were depleted for their many desirable commercial attributes, they failed to naturally recover because the species does not successfully invade open lands; livestock, especially feral hogs (*Sus scrofa*), destroyed established seedlings, and the natural fire regime was disrupted (Barnett 1999, Komarek 1983, Landers and others 1995). Fire protection implemented during the 1920s allowed invasive hardwoods and other southern pines to replace longleaf pine within its natural range (Barnett 1999). By 1996, only 1.2 million ha of longleaf pine forest remained (Outcalt and Sheffield 1996).

Currently, several state and federal agencies, non-governmental organizations, and private individuals are restoring longleaf pine to portions of its former range (Brockway and others 2005). The desired future condition is park-like longleaf pine grasslands with few midstory hardwoods except in riparian and other moist areas, and a rich and diverse ground cover of herbaceous and low woody plants that can be maintained by frequent surface fires; thus, prescribed fire is an essential element in these efforts (Barnett 1999, Brockway and others 2005, Haywood and others 2001, Landers and others 1995).

Forest managers, however, are faced with multiple challenges in planning and executing prescribed fires to minimize injury to the desired trees while removing unwanted vegetation. While fire may promote longleaf regeneration and facilitate restoration efforts, it may also weaken trees, making them susceptible to attacks by insects and pathogens (Hanula and others 2002, Sullivan and others 2003). Of prime concern is the increased attraction caused by resin flow and the reduced resistance to bark beetles such as the southern pine beetle (*Dendroctonus frontalis* Zimmermann), black turpentine beetle (*D. terebrans* Olivier), and *Ips* species. Root-feeding weevils are also attracted to fire-stressed stands (Bauman 2002, Hanula and others 2002, Sullivan and others 2003). Longleaf pine trees tolerate fire and have high resin flow rates that make them more resistant to bark beetle attack than other southern pines. Still, the effects of fire on the interaction of insect pests and longleaf pine health are largely unknown. This lack of knowledge is a major

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concern given the high fuel loads and mixed composition of many upland stands currently undergoing fire-aided restoration efforts.

Because prescribed burning is challenging, mechanical or chemical methods have been proposed as supplemental means for reducing woody vegetation (Brockway and others 2005, Drewa and others 2002, Haywood and Harris 1999, Haywood and others 2001, Provencher and others 2001). In fact, woody plant control may be required where managers must restore certain plant communities quickly (Brockway and others 2005, Haywood 2000). To study the relationship between fire, fire surrogates, and insects, two management schemes involving fire and mechanical treatment were evaluated in three upland pine forests in Louisiana to determine if management influenced fuel conditions, vegetation, and selected beetle populations.

METHODS

Study Sites

The three study sites lie within the boundaries of the Kisatchie National Forest in central Louisiana at an average elevation of 45 m above sea level. All three sites are suitable for restoration of loamy dry-mesic upland longleaf pine forests (Turner and others 1999), which is the long-term management objective.

Study Site 1 is a mixed loblolly pine (*P. taeda* L.) and longleaf pine stand on a well-drained and moderately permeable Ruston fine sandy loam (fine-loamy, siliceous, semiactive, thermic, Typic Paleudults) (Kerr and others 1980). Site 2 is a loblolly pine stand on a Ruston fine sandy loam with Malbis fine sandy loam (fine-loamy, siliceous, subactive, thermic, Plinthic Paleudults) interspersed. Site 3 is a mixed loblolly and longleaf pine stand on Smithdale fine sandy loam (fine-loamy, siliceous, subactive, thermic, Typic Hapludults) and Kolin silt loam (fine-silty, siliceous, active, thermic, Glossaquic Paleudalfs). The Ruston and Smithdale soils form well-drained, moderately permeable uplands. The Malbis is moderately well drained and moderately to slowly permeable, and the Kolin is moderately well drained and slowly permeable. The Malbis, Ruston, and Smithdale soils have few limitations for growing pine trees, while soil drainage may limit growth on the Kolin soil. The site index (base age 50) at Sites 1 and 2 is 24 m for longleaf pine and 21 m at Site 3 (Kerr and others 1980).

Study Establishment and Measurements

Each site or block is about 10 ha and was divided into three treatment areas: (1) Check: management was discontinued; (2) PF: prescribed fire was applied to the plots in May 2001 and June 2003; and (3) PF-MPC: between prescribed fires, the understory and midstory vegetation was masticated to within 5 cm of the ground with a machine-mounted horizontal-shaft drum shredder (Woodgator®) as a mechanical plant control (MPC) treatment in July 2002.

Prescribed burning was by strip headfiring the treatment areas after baseline backfires were established. Rates of spread were estimated as best as possible from outside the burned area. Overall, the prescribed fires in 2001 averaged 342 kJ/s/m (table 1), which was higher than the 173 kJ/s/m intensity recommended by Deeming and others (1977) as a maximum for prescribed fires. However, the 2001 intensities were comparable to fire intensities reported for prescribed burning in longleaf pine-grassland fuels (Haywood 2002). Fire intensities were lower in 2003 than in 2001 but still above the 173 kJ/s/m intensity recommended by Deeming and others (1977). In addition, fire intensity between the PF and PF-MPC treatments were comparable in both years.

Table 1—Fire intensities by treatment and time of burning

Treatments	May 2001	June 2003
	------------*kJ/s/m*------------	
PF[a]	345	258
PF-MPC[a]	338	192

[a]PF = prescribed fire; MPC = midstory and understory woody vegetation, masticated in July 2002

For the MPC treatment, it was argued that mastication of the woody plants had to precede the second prescribed fire by about a year. The woody debris would have enough time to deteriorate so that the prescribed fire in June 2003 would not be too severe and injure the overstory pine trees. However, the next prescribed fire could not be delayed longer than a year after treatment or the understory brush would regain its pre-masticated stature.
Within each treatment area, a 0.10-ha plot was established for making fuel and vegetation measurements. We inventoried and took the diameter at breast height (d.b.h.) of overstory trees (stems > 10 cm d.b.h.) in April 2001 and

total height and d.b.h. of the overstory trees in February 2005. The 2005 measurements were used to calculate a volume per tree with Baldwin and Feduccia's (1987) formula for loblolly pine, Baldwin and Saucier's (1983) formula for longleaf pine, and Clark and others' (1985) formula for mixed hardwoods.

Four 10-m^2 subplots were randomly selected and established within each main plot. In August 2004, all understory trees and shrubs > 1.4-m tall with a d.b.h. < 2.5 cm were inventoried on the 10-m^2 subplots, and d.b.h. was measured. Initially, we attempted to study midstory vegetation changes using the 10-m^2 subplots; however, the midstory trees were too scattered and the mastication treatment eliminated the midstory on the PC-MPC plots, nullifying this plan.

A 1-m^2 subplot was randomly nested within each 10-m^2 subplot; therein, cover of nine understory vegetation classes were estimated to the nearest percent. The nine classes were trees, shrubs, blackberry (*Rubus* spp.), ferns, forbs, grasses, grass-likes, legumes, and woody vines. Cover estimates were made in July 2001, June 2003, July 2003, and August 2004.

Fuel load was measured on four randomly established 2- by 5-m fuel-sample plots within each 0.10-ha main plot. The fuel-sample plots were distinct from the subplots used to inventory vegetation. Each fuel-sample plot was divided into 10 1-m^2 subplots. On each sample date, a 1-m^2 subplot was randomly selected for sampling fuel load without replacement. Fuel samples were collected before and 6 weeks after each prescribed fire on all three treatments. The sampled fuels were separated into five fuel classes considered available for burning based on Deeming and others (1977) fire-danger-rating system. The five fuel classes were as follows: (1) living foliage of all trees, shrubs, vines, grasses, and forbs within 2 m of the ground; (2) living blackberry canes, woody stems, and vines no more than 6 mm in diameter within 2 m of the ground; (3) 1-hour time-lag dead fuels (surface litter and duff to a 0 to 6 mm depth and small roundwood and stubble no more than 6 mm in diameter); (4) 10-hour time-lag dead fuels (litter from a 7 to 25 mm depth and roundwood and stubble between 7 and 25 mm in diameter); and (5) 100-hour time-lag dead fuels (litter from a 26 mm to 100 mm depth and roundwood between 26 and 75 mm in diameter). In addition, in the post-burn samples, two additional fuel classes were collected--(6) needlecast after the prescribed fire; and (7) regrowth of vegetation--to keep these classes from biasing how much fuel was consumed in the fires. The sampled fuels were oven dried at 80 ^{o}C for 72 hours in a forced-air oven and weighed. The differences in pre-burn and post-burn fuel samples (not including needlecast or regrowth immediately after the prescribed fire) were used with a best estimate of rate of spread to calculate Byram's fire intensity as described by Haywood (1995).

Insects were collected over the entire treatment area and not just in the 0.1-ha main plot. Flight interception and pitfall traps were used to sample insects after Klepzig and others (1991). Flight interception traps were placed at 0.5 m above ground, and pitfall traps were placed in the ground with openings drilled at intervals around the circumference to allow crawling insects to enter. The traps were baited with ethyl alcohol (95 percent) and Klean Strip® turpentine, general attractants for pine-infesting insects (Chénier and Philogène 1989, Hunt and Raffa 1989, Phillips and others 1988, Schroeder and Lindelöw 1989), and placed in pairs of two-dram vials that were secured to the interior of the traps. The baited vials were refilled at each collection period. A 5- to 8-cm long and 1- to 2-cm diameter segment of loblolly pine stem was placed in the bottom of the pitfall trap as a substrate for insect attack/breeding. Ten pitfall and ten flight interception traps were deployed yearly in the check and PF-MPC treatments and on the PF treatment in 2001 and 2003. The traps were spaced 30 to 50 m apart and near pine trees. Initially, insects of interest included pine bark beetles, ambrosia beetles, and root-feeding weevils, which were collected, identified to species (Wood 1982), and counted weekly. Voucher specimens were stored with the USDA Forest Service, Forest Insect Research Unit at Pineville, LA. Trapping was conducted 3 to 4 weeks pre-treatment and 6 to 8 weeks post-treatment for the prescribed fires in 2001 and 2003 and for the mastication treatment in 2002.

It was ascertained from related, concurrent studies at nearby sites that six beetle taxa regularly occurred in longleaf pine stands after prescribed burning (Bauman 2002). These were pine bark beetles, *Dendroctonus terebrans* Olivier, *Hylastes salebrosus* Eichoff, *H. tenuis* Eichoff, and *Ips* spp. (Coleoptera: Scolytidae) and the root-feeding weevils, *Hylobius pales*

Herbst and *Pachylobius picivorous* Germar (Coleoptera: Curculionidae). These beetles do not cause major damage in healthy longleaf pine stands and mostly reproduce in the lower boles and roots of damaged or stressed pine trees. However, they are attracted to burned stands, which benefit these beetles by permitting location and exploitation of host trees made susceptible by fire injury. Data from other insects collected, mostly ambrosia beetles (Coleoptera: Scolytidae and Platypodidae), were not included in the analyses because of their unknown association with longleaf pine and their irregular distribution.

Data Analysis

The statistician reviewing this paper suspected that there were site-by-treatment interactions, which nullified the block effect and would leave no degrees of freedom for Error Mean Squares in the analyses. Therefore, we do not present statistical results, although we will discuss trends in the data based on prior, albeit inappropriate, analyses. In those earlier analyses, the overstory stocking and basal area measurements in April 2001 and February 2005 were compared as was volume per ha in 2005. Number of stems and basal area per ha and average d.b.h. of understory trees and shrubs > 1.4-m tall in August 2004 were compared. Percent cover of understory vegetation were compared on the following dates, post burn in June 2001, preburn in June 2003, post burn in July 2003, and post burn in August 2004. Besides percent cover of all understory vegetation, we compared the cover of arborescent vegetation (trees, shrubs, and blackberry) and the other taxa (ferns, forbs, grasses, grass-likes, legumes, and woody vines).

The ovendried mass of live stems and foliage both followed the same pattern of treatment response throughout the study. Therefore, the two classes of live fuels were combined. Fuel loads (kg/ha) in May and June 2001, June and July 2003, and August 2004 were compared for live fuels, 1-hour time-lag dead fuels, 10-hour time-lag dead fuels, and 100-hour time-lag dead fuels. The beetle counts were combined for all taxa. Means were based on pooled weekly trap catches over the 8-week sampling period from 10 sampling points per study site and treatment. For 2001 and 2003, beetle counts on all three treatments were compared. For all 3 years, beetle counts on the check and PF-MPC treatments were likewise compared.

RESULTS

Overstory Vegetation

The number of overstory trees per ha did not change much from April 2001 to February 2005, although the average number of trees decreased from 205 to 185 trees per ha over this period (table 2). Average basal area per ha greatly increased during this period from 19.8 to 20.9 m^2/ha across all treatments. In 2005, total volume for all species averaged 267 m^3/ha across all three treatments but was similar among treatments.

Loblolly and longleaf pine trees dominated the overstory, comprising 81 percent of the trees, 94 percent of the basal area, and 95 percent of the total volume per ha in February 2005. Loblolly pine was the more common pine species comprising 87 percent of the pine trees, 88 percent of the pine basal area, and 89 percent of the total pine volume per ha. The minor overstory species were flowering dogwood (*Cornus florida* L.), sweetgum (*Liquidambar styraciflua* L.), blackgum (*Nyssa sylvatica* Marsh.), black cherry (*Prunus serotina* Ehrh.), southern red oak (*Quercus falcata* Michx.), blackjack oak (*Q. marilandica* Muenchh.), and post oak (*Q. stellata* Wangenh.).

Understory Vegetation

The number of understory trees and shrubs ≥ 1.4-m tall with a d.b.h. < 2.5 cm ranged from

Table 2—Number of overstory trees, basal area, and volume per hectare

	----------April 2001----------		----------------February 2005---------------		
Treatments	Stocking	Basal area	Stocking	Basal area	Volume
	trees/ha	*m^2/ha*	*trees/ha*	*m^2/ha*	*m^3/ha*
Check	203	20.0	200	21.1	269.0
PF[a]	183	19.8	173	21.4	274.1
PF-MPC[a]	230	19.6	183	20.2	256.4

[a]PF= prescribed fire; MPC = midstory and understory woody vegetation, masticated in July 2002.

2,833 to 14,500 stems/ha on the PF-MPC and check plots, respectively, 40 months after the first prescribed fire (table 3). D.b.h. and basal area per ha of the understory plants were likewise affected by treatment with checks having the greatest d.b.h. and basal area and PF-MPC having the least d.b.h. and basal area per ha. Prescribed burning also affected stocking and plant stature but not as much as the PF-MPC treatment.

After the first prescribed fire, percent cover of all of the understory vegetation was not much affected by burning, although cover on the PF and PF-MPC treatments averaged 54 percent and was 87 percent on the checks (fig. 1, top graph). However, after the mastication treatment and before the second prescribed fire, vegetation cover varied among treatments: 111, 91, and 63 percent on the check, PF, and PF-MPC treatments, respectively, because mastication of the woody material and vehicle trafficking destroyed a part of the understory plant community on the PF-MPC plots. Following the second prescribed fire, both of the PF and PF-MPC treatments had less understory cover than the checks. In August 2004, the understory vegetation on the PF and PF-MPC treatments had not fully recovered, and there were still treatment differences at the last measurement.

The mastication treatment kept understory arborescent vegetation suppressed until the second prescribed fire (fig. 1, middle graph), in which the second fire reduced woody cover on both the PF and PF-MPC treatments to a similar percentage. The overall pattern of responses for understory arborescent vegetation was similar to the pattern for all understory vegetation, because woody plants dominated in the understory.

Table 3--Number of stems, d.b.h., and basal area per hectare of understory trees and shrubs > 1.4 m tall with a d.b.h. < 2.5 cm in August 2004, which was 40 months after the first prescribed fire

Treatments	Stocking	D.b.h.	Basal area
	stems/ha	*mm/stem*	*m^2/ha*
Check	14,500	11	1.58
PF[a]	5,417	6	0.21
PF-MPC[a]	2,833	2	0.03

[a]PF = prescribed fire; MPC = midstory and understory woody vegetation, masticated in July 2002.

Average percent cover of ferns, forbs, grasses, grass-likes, legumes, and woody vines was not affected by treatment until after the second prescribed fire, when there was less cover on the PF-MPC plots (11 percent) than on check and PF plots (an average of 24 percent) (fig. 1, bottom graph). The mastication treatment doubtlessly changed the structure of the fuel bed although it did not increase the amounts of 1-hour or 10-hour time-lag dead fuels (fig. 2). The difference in fuel bed structure may have influenced how the fire spread, and therefore, there was an immediate, adverse effect on the cover of ferns, forbs, grasses, grass-likes, legumes, and woody vines after the second prescribed fire (fig. 1). By August 2004, however, the percent cover among treatments was less on the checks (15 percent) than on the PF and PF-MPC treatments (22 percent).

Fuel Loads

Before the first prescribed fire, the mass of live stems and foliage averaged 1486 kg/ha across

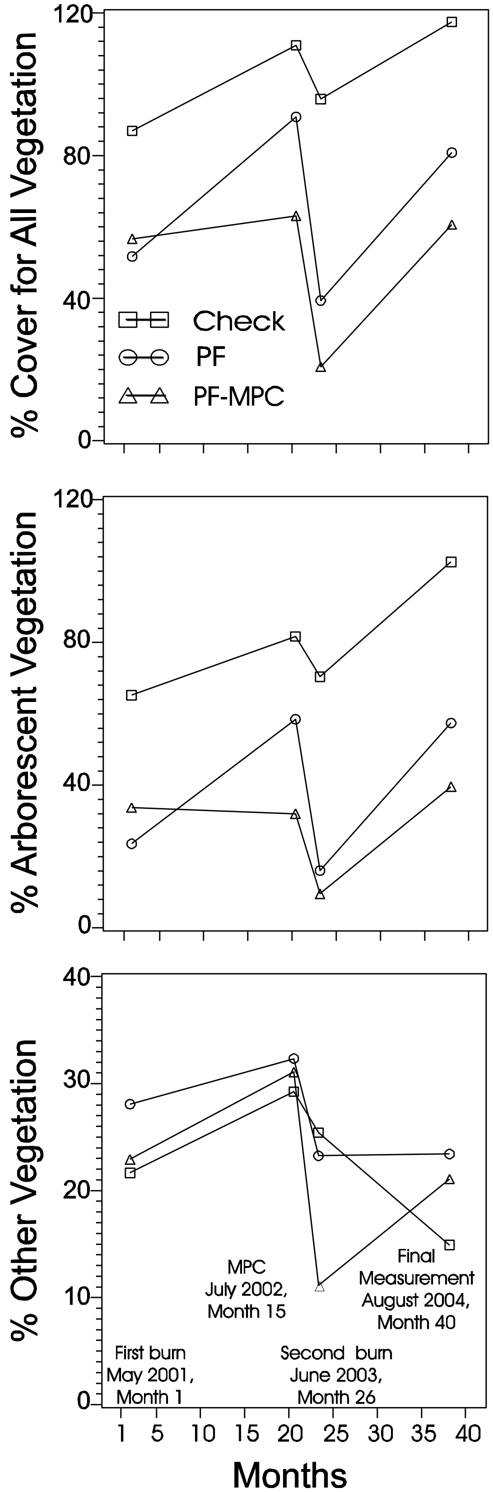

Figure 1—Percent cover of all understory vegetation (top); arborescent vegetation only (middle); and ferns, forbs, grasses, grass-likes, legumes, and woody vines (bottom) that were measured post burn in June 2001, preburn in June 2003, post burn in July 2003, and post burn in August 2004: PF-prescribed fire was applied in May 2001 and June 2003, and MPC-midstory and understory woody vegetation was masticated in July 2002.

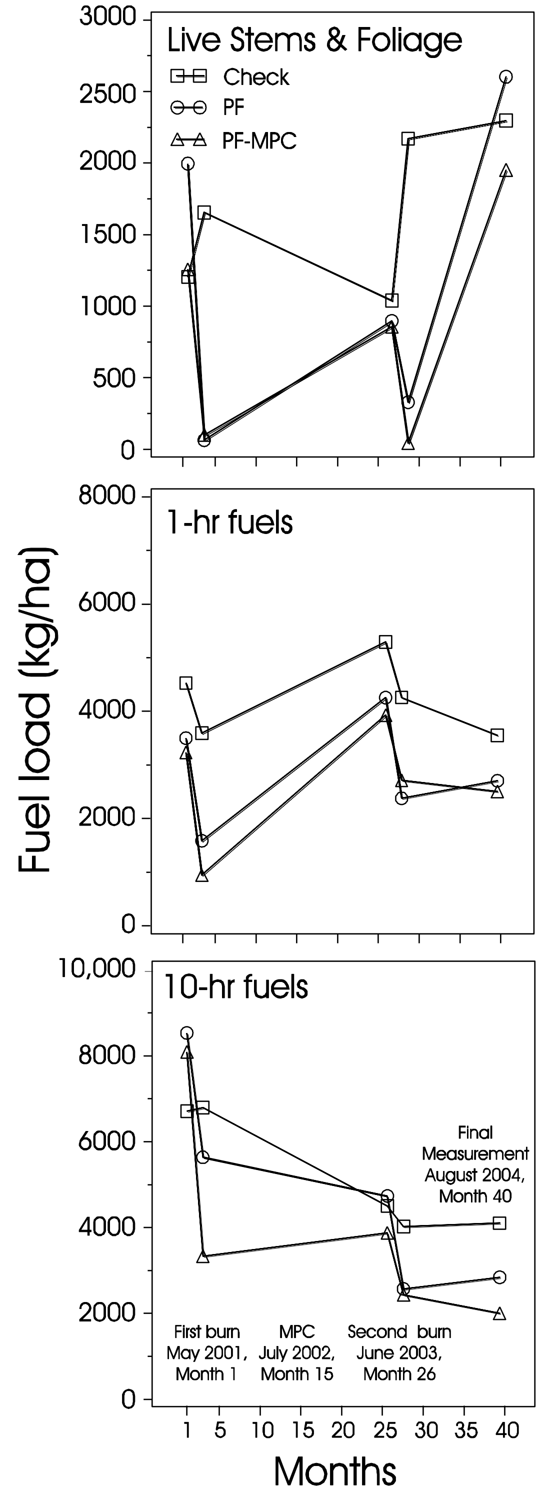

Figure 2—Fuel loads (kg/ha) for the live stems and foliage (top), 1-hr time-lag dead fuels (middle), and 10-hr time-lag dead fuels (bottom) that were measured preburn in May 2001, post burn in June 2001, preburn in June 2003, post burn in July 2003, and post burn in August 2004: PF-prescribed fire was applied in May 2001 and June 2003, and MPC-midstory and understory woody vegetation was masticated in July 2002.

all three treatments (fig. 2, top graph). The first prescribed fire reduced the amount of live stems and foliage, while they continued developing on the checks. Before the second prescribed fire, the mass of stems and foliage was again similar on all three treatments averaging 664 kg/ha, and the post-burn pattern of response was the same as after the first prescribed fire. On the checks, the mass of live stems and foliage ranged from 1204 kg/ha in May 2001 to 2298 kg/ha in August 2004 (fig. 2). The mass of stems and foliage on the PF and PF-MPC treatments averaged 2278 kg/ha in August 2004.

The preburn mass of 1-hour time-lag dead fuels averaged 3726 kg/ha in May 2001 and 4482 kg/ha in June 2003 across all three treatments (fig. 2, middle graph). Prescribed burning reduced the mass of 1-hour fuels, but there was also a decrease in 1-hour fuels on the checks in both years. In August 2004, 1-hour fuels averaged 2876 kg/ha across all three treatments.

In May 2001, the PF and PF-MPC treatments had more preburn mass of 10-hour time-lag dead fuels (an average of 8404 kg/ha) than the checks (6776 kg/ha) (fig. 2, bottom graph). However, prescribed burning reduced the amount of these fuels on the PF and PF-MPC plots. In June 2003, the preburn mass of 10-hour fuels was similar on all three treatments and averaged 4396 kg/ha. Prescribed burning again reduced the mass of 10-hour fuels, while the change in mass of 10-hour fuels on the checks was minor. In August 2004, there was more mass of 10-hour fuels on the checks (4121 kg/ha) than on the PF and PF-MPC treatments (an average of 2411 kg/ha). The mass of 100-hour time-lag fuels was unaffected by time or treatment, and the 100-hour fuels averaged 1983 kg/ha in May 2001 and 1672 kg/ha in August 2004.

Beetle Abundance

Both prescribed fires resulted in significant increases in abundance of beetles (fig. 3, top graph). The overall number of beetles appeared to be greater in 2001 than in 2003. The mastication treatment in 2002 on the PF-MPC plots did not directly influence beetle abundance perhaps because only minor damage to the overstory pine trees occurred, and therefore no chemical attractants were released from the trees to attract beetles (fig. 3, bottom graph).

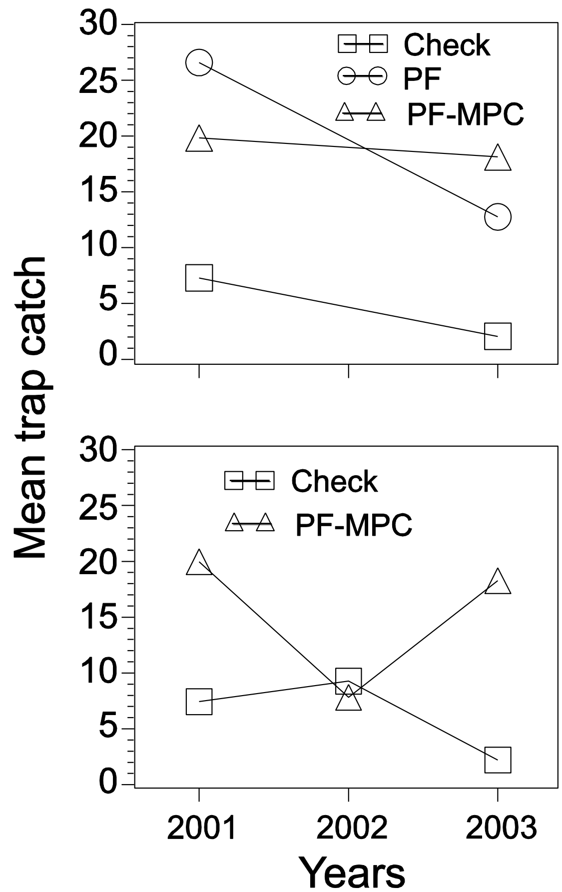

Figure 3—Abundance of six beetle taxa among all three treatments in 2001 and 2003 (top) and between the check and PF-MPC treatments in 2001, 2002, and 2003 (bottom): PF-prescribed fire was applied in May 2001 and June 2003, and MPC-midstory and understory woody vegetation was masticated in July 2002.

DISCUSSION

Prescribed burning, with or without the mastication treatment, did not change overstory composition; rather, basal area increased on all three treatments. The only pine tree mortality noted was associated with lightning strikes.

However, increasing fire intensities have been correlated with greater mortality within older longleaf pine stands where pine litter and duff are the primary available fuels (Sullivan and others 2003). For example, conditions favorable for fires that move too slowly at the base of trees where sloughed bark and needles accumulate can cause basal scarring, cambial death, root damage, and tree mortality (Wade and Johansen 1986). Presumably, because the stands in this study have a history of prescribed fire, litter and duff did not accumulate in large amounts, and longleaf pine mortality did not result.

There are no comparable studies to utilize in making valid comparisons of the number of beetles in our study responding to these treatments. However, Bauman (2002) and Sullivan and others (2003) found that prescribed burning resulted in peak trap captures 2 to 3 weeks after burning, which was similar to our results. We found consistently higher captures of bark beetles and root-feeding weevils after prescribed burning although the insect collections were conducted during the growing season and after the peak activity for *Hylastes* beetles (Bauman 2002). Further, their and our data indicate that the local population increases were the result of immigration (attractiveness) and not to increased breeding.
Fire intensity is positively correlated with post-fire insect abundance (Sullivan and others 2003), and the insects of interest are attracted to fire-injured pine trees where they may be able to reproduce in the lower boles and roots. Fire intensities were above the maximum intensity for a “safe” winter backfire (Deeming and others 1977) but about half the intensity expected when burning heavy grass rough (Haywood 2002) (table 1). *Hylastes* beetles and root-feeding weevils might be vectors for stain fungi (Eckhardt and others 2004, Hanula and others 2002, Klepzig and others 1991), and increasing degrees of crown thinning and foliage discoloration after prescribed burning have been associated with greater prevalence of stain fungi in longleaf pine (Otrosina and others 1999) and red pine (*P. resinosa* Soland.) (Klepzig and others 1991). A decline in tree vigor was not seen on our study sites, possibly because the pine trees were not seriously injured by the fires and were healthy enough to withstand insect attack. Regardless, insect abundance increased in recently burned stands, and this is of particular concern to land managers when and where the southern pine beetle is active.

Prescribed burning is often used as a way to open forest stands, remove litter, and create conditions where herbaceous productivity can increase (Grelen and Epps 1967, Haywood and others 2001). However, in this study, the percent cover of non-arborescent understory vegetation on the checks decreased from 22 percent to 15 percent from 2001 to 2004 and decreased from 26 percent to 22 percent over the same period on the PF and PF-MPC treatments (fig. 1). Both understory arborescent vegetation and overstory basal area adversely affect herbaceous plant productivity (Haywood and Harris 1999, Wolters 1982). Understory arborescent cover increased by 17 percentage points on the PF and PF-MPC treatments and 31 percentage points on the checks from 2001 to 2004. Therefore, the increased shading from a developing overstory and understory reduced herbaceous plant cover regardless of treatment. A possible solution would be to apply herbicides to reduce woody plant cover to levels that can be maintained by prescribed fire (Brockway and others 2005, Drewa and others 2002, Provencher and others 2001), and possibly favor herbaceous plant development (Grelen and Epps 1967, Haywood and others 2001).

The mass of live fuels increased by 91 percent on the checks from May 2001 to August 2004 but only increased by 40 percent on the PF and PF-MPC treatments (fig. 2). This trend was similar to the one for percent cover of understory arborescent vegetation (fig. 1). Fire initially affected live available fuels, but prescribed burning has not arrested plant growth.

None of the dead fuels accumulated on any of the treatments (fig. 2). Mass of 1-hour fuels decreased by 23 percent from 2001 to 2004 across all three treatments; the 10-hour fuels decreased by 71 percent on the PF and PF-MPC treatments and by 39 percent on the checks; and the 100-hour time-lag fuels decreased by 16 percent across all three treatments. On the checks, the decrease in fuel loads was either due to decomposition or sampling error, although the same personnel collected the fuel samples throughout the study. Rather, since all three available dead-fuel classes are decreasing on all three treatments, the decrease in surface fuels may be truly occurring, but whether this is a short-term or long-term trend is not certain. Nevertheless, the two prescribed fires initially reduced available fuel load by 49 percent on average (fig. 2), and this reduction temporarily lowered the risk of catastrophic wildfire.

The mastication treatment cost $337/ha U.S. while prescribed burning was $30/ha U.S. in 2002 (Personal communication. 2002. Daniel McDonald, Fire Management Officer, Calcasieu Ranger District, Kisatchie National Forest, 9912 Highway 28 West, Boyce, LA 71409). Given the cost differential and the limited effect of mastication, its extensive use seems unwarranted except in specific circumstances such as where midstory removal is needed beneath red cockaded woodpecker (*Picoides borealis*) colonies or at the wildland-urban interface.

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