Effects of Two Site Preparation Techniques on Biomass of Forage Plants for White-tailed Deer in Eastern Louisiana

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Abstract: Recently, concern has arisen regarding possible effects of site preparation treatments, particularly herbicide use, on availability and quality of browse for white-tailed deer (*Odocoileus virginianus*). To examine this concern, we quantified species-specific plant biomass of browse for deer in clearcuts site prepared with either prescribed fire ($N = 5$) or a combination of imazapyr with triclopyr and prescribed fire ($N = 5$) in eastern Louisiana during 2003–2005. Total biomass of quality browse did not differ between treatments, but was higher in years 1 and 2 post-treatment. However, stands site prepared with fire and herbicides were dominated by herbaceous vegetation, legumes, and *Rubus* spp. during the first growing season following site preparation, whereas stands prepared with fire were dominated by woody and vine species. Differences diminished across years with sites becoming structurally similar by the third year. Annual differences were reflective of successional changes more so than site preparation treatments. Yaupon (*Ilex vomitoria*), an understory species of concern for silvicultural operations in eastern Louisiana because of its competition with young pine seedlings, dominated (>30% of total biomass) stands site prepared with fire only by the end of our study. Our findings suggest that site preparation techniques have temporary effects on vegetation and that judicious use of herbicides can improve browse for deer and may improve habitat conditions for other early successional species in eastern Louisiana.

Key words: browse, early succession, forestry, herbicide, Louisiana, *Odocoileus virginianus*, prescribed fire, site preparation, white-tailed deer

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White-tailed deer (*Odocoileus virginianus*; hereafter, deer) are an ecologically and economically important wildlife resource throughout North America, and there is substantial interest in deer hunting throughout most of their geographic range (U.S. Fish and Wildlife Service and U.S. Department of Commerce, Bureau of the Census 1993). Populations and harvest of deer have increased dramatically throughout most areas of the southeastern United States during the latter part of the 20th century (Porter 1992, deCalesta and Stout 1997) and deer hunting continues to increase in popularity. In Louisiana, deer hunters represent 70%-75% of licensed hunters (Louisiana Department of Wildlife and Fisheries, unpublished data) and deer hunting has an estimated total economic effect of > US$340 million on Louisiana's economy (Southwick Associates 2005). Total economic impact of deer hunting in adjacent Mississippi during 2003 was recently estimated at over $900 billion (2005 dollars; S. Grado, Department of Forestry, Mississippi State University, unpublished data).

Likewise, the forest products industry is an important economic factor in the southeastern United States (U. S. Department of Agriculture 1988). Within the southeastern United States, intensively-managed pine forests are a primary forest type occurring on 12.9 million ha in 1999 (Wear and Greis 2002) and projected to remain an important component of the southern U.S. landscape (National Commission on Science for Sustainable Forestry 2005). Additionally, many commercial and private forest landowners are diversifying economic revenues on forested lands through leasing for sport hunting, of which deer hunting is most prominent in the southeast (Jones et al. 2004).

Intensive management of southern pinelands for wood production frequently uses herbicide and/or prescribed fire for site preparation prior to planting, which typically improves pine yield (Glover and Zutter 1993). Site preparation intensity may increase to improve tree yields on managed properties as demand for wood products increases (Miller and Miller 2004, Miller and Wigley 2004). Concern has arisen over possible negative impacts of intensive site preparation on wildlife and plant communities (Guynn et al. 2004), including possible impacts on deer. As the influence of site preparation techniques on floristic diversity has been examined in only a few areas, Miller and Miller (2004) encouraged additional research quantifying effects of site preparation on plant communities throughout the southeast. Given the importance of deer in the southeast and possible impacts of site preparation on this valuable resource, our objectives were to characterize deer browse in recently harvested stands subjected to two different site preparation techniques. Specifically, we measured plant response following site preparation with prescribed fire and a combination of prescribed fire and selective herbicide application.

Study Area

We conducted our study on the 5,607-ha Ben's Creek Wildlife Management Area, a tract of intensively-managed loblolly pine (*Pinus taeda*) forest owned and silviculturally managed by Weyerhaeuser Company located in Washington Parish, west of Bogalusa and east of Franklinton, Louisiana. The Louisiana Department of Wildlife and Fisheries manages wildlife resources on the area. Ben's Creek was managed primarily for wood production, and clearcutting was used for stand harvest and regeneration. Soils on the area were fine, sandy soils (e.g., Angie series) that were well drained. We selected 10 stands harvested and replanted during 2002 for this study; these stands were the only available stands within the study areas at the beginning of our study. Stand size averaged 8.1 ha (range = 4.2–16). Although we did not randomly select these stands, we assumed they represented plant community response to the site preparation techniques we studied in our area. No stands were juxtaposed to each other, and all stands were separated by >500 m. Five stands had previously been site prepared with prescribed fire only, whereas the remaining five stands had received a combination of prescribed fire and herbicide application for site preparation. We chose these two site preparation techniques for our study because they were the only two techniques practiced by the landowner during our study. Stands were broadcast burned as logging debris was not piled after harvest. After the prescribed fire, sites were bedded on rows 5.7–6.6 m apart by shearing and plowing by using an 8.5-m wide v-shear and a two-disk combination plow. Subsequent to burning and bedding, herbicide treated sites received an application of 1.89 L (2qts) of triclopyr (Garlon, Dow AgroSciences, Indianapolis, Indiana) with 0.82 L (28oz) of imazapyr (Chopper, BASF Corporation, Research Triangle Park, North Carolina) in a volume of 93.5 L/ha with a surfactant. During the first growing season, all sites received a banded treatment of 0.30 L/ha of Arsenal (BASF Corporation, Research Triangle Park, North Carolina) and 0.15 L/ha of Oust, E. I. du Pont de Nemours and Company, Wilmington, Delaware) for herbaceous weed control.

Methods

We quantified deer browse using biomass sampling, within each of the 10 stands described above, annually during summers of 2003–2005. Within each stand, we systematically located 10 1-m^2 sampling stations across the diagonal of the stand. Distance between stations depended on size of the stand; we placed stations in a manner to sample a diagonal that encompassed the entire stand. At each station, we removed all potential forage items up to a height of 1.5 m using small pruning shears (Hurst et al. 1979, Miller et al. 1999). Potential forage items included palatable green stems, new plant growth, or woody stems capable of being browsed and digested. We removed all herbaceous vegetation, vines, and forbs in entirety. We separated plants into genus and/or species (when possible), and placed them in paper bags. We immediately transported plants from the study site on the day of sampling, maintaining samples on ice during transport to Louisiana State University for processing. We froze plant samples until we were able to dry them. Once thawed, we oven dried samples at 70 C for 72 hours and weighed them to the nearest gram. During the initial sampling year (2003), we marked each plot sampled to prevent resampling in subsequent years.

We tested the null hypotheses that total plant biomass (all vegetation sampled), biomass of preferred forage plants, biomass of species groups (grasses, legumes, vines, woody) and biomass of important, individual species or genera of forage plants did not differ among years (2003, 2004, 2005) or treatments (PF, PFH). Woody plants and vines included all woody plants and vines considered moderate to high quality forage for deer (Miller and Miller 1999, Moreland 2005). Legumes included all leguminous plants on our sites, and grasses included plants in the genera *Andropogon* (bluestem), *Aristida* (threeawn), and *Dichanthelium* (panicgrass). Preferred forage plants included all plant species present on our sites reported as being moderate to highly preferred deer forage (Miller and Miller 1999, Moreland 2005; Table 1), with one exception. Miller and Miller (1999) categorized yaupon (*Ilex vomitoria*) as

Table 1. List of plant species considered quality forage plants for white-tailed deer based on information provided in Miller and Miller (1999).

Scientific name	Common name
Ambrosia artemisiifolia	Common ragweed
Callicarpa americana	American beautyberry
Campsis radicans	Trumpetcreeper
Centrosema virginianum	Spurred butterfly pea
Chamaecrista fasciculata	Partridge pea
Clitoria mariana	Butterfly pea
Desmodium spp.	Tickclover, beggarlice
Eupatorium spp.	Bonesets
Gelsemium sempervirens	Yellow jessamine
Lespedeza spp.	Lespedezas
Lonicera japonica	Japanese honeysuckle
Monarda punctata	Horsemint
Rhynchosia spp.	Snoutbean
Rubus spp.	Blackberry, dewberry
Smilax spp.	Greenbriar
Stylosanthes biflora	Pencilflower
Tephrosia spp.	Goat's rue, tephrosia
Toxicodendron spp.	Poison ivy/oak
Vaccinium spp.	Blueberry/sparkleberry
Vitis rotundifolia	Muscadine grape

an important forage plant for deer. While we do not discount their statement, we only observed one stem of yaupon browsed during our study, and this species has the propensity to completely dominate the understory of forest stands in our study area. Additionally, Moreland (2005) reported that yaupon was a low value forage plant, therefore we excluded yaupon from preferred forage plants. Finally, we selected six individual plant species/genera for analysis because of their importance to deer as forage in our area [French mulberry (*Callicarpa Americana*), common ragweed (*Ambrosia artemisiifolia*), greenbriars (*Smilax* ssp.), blueberry/huckleberry (*Vaccinium* spp.), and muscadine (*Vitis rotundifolia*); Moreland 2005]. We included yaupon in this analysis because of its aforementioned propensity to dominate understory plant communities and because a goal of chemical site preparation in combination with fire on our study area is to reduce prominence of this plant.

We used two-way analysis of variance (ANOVA) with year and treatment as main effects, year as a repeated measure, and a year by treatment interaction for all tests. We used mean biomass of each variable across plots, with stands as the experimental units ($N = 5$ per treatment) to quantify response variables. If significant year effects occurred, we used paired *t*-tests to determine where differences occurred, with bonferonni adjustments for multiple comparisons. All statistical tests were performed at an alpha level of 0.05. Results are presented as means ± standard errors and units reported, unless otherwise noted, are grams per meter-squared.

Table 2. Results of repeated measures analysis of variance (ANOVA) for year (three levels) and treatment (prepared with a combination of prescribed fire and imazapyr + triclopyr application or prescribed fire only) on mean biomass (g/m2) for selected plant species or species groups that differed by year, treatment, or both in forest stands site in Washington Parish, Louisiana, 2003–2005. All tests significant at $P < 0.05$.

	Repeated measures ANOVA results		
Plant species or species group	Effect[a]	F-value	*P*-value
Total forage	Year	17.5	<0.001
	Treatment	6.1	0.02
	Year*Treatment	0.4	0.67
Preferred forage	Year	3.9	0.04
	Treatment	1.3	0.26
	Year*Treatment	1.6	0.24
Grasses	Year	23.28	<0.001
	Treatment	7.7	0.01
	Year*Treatment	2.52	0.11
Vines	Year	3.84	0.04
	Treatment	3.61	0.07
	Year*Treatment	0.71	0.51
Woody	Year	0.05	0.95
	Treatment	12.23	0.002
	Year*Treatment	0.35	0.71
Vitis spp.	Year	5.55	0.01
	Treatment	4.78	0.04
	Year*Treatment	3.47	0.051
Yaupon	Year	0.58	0.57
	Treatment	16.24	<0.001
	Year*Treatment	0.86	0.44

a. Degrees of freedom (numerator, denominator) are 2, 20 for year; 1, 20 for treatment; and 2, 20 for year*treatment

Results

Mean total biomass of plants sampled across years was 2143 kg/ha (SD = 682) and 2820 kg/ha (SD = 574) on stands site prepared with herbicides and fire, and fire only, respectively. For PF sites, total biomass (summed across replicates) was 3260 kg/ha during year 1, 3030 kg/ha during year 2, and 2180 kg/ha during year 3. For PFH sites, total biomass was 2760 kg/ha during year 1, 2260 kg/ha during year 2, and 1410 kg/ha during year 3.

There was not a significant (*P*.0.05) year by treatment effect for any comparisons (Table 2). Total forage biomass significantly differed between treatments and among years (Tables 2, 3), with more total biomass in PF (252.3 ± 13.3) than in PFH (206.3 ±10.8). Additionally, more total biomass occurred in year 1 (281.8 ±16.1; $t_{20} = 5.63$, $P < 0.0001$) and year 2 (252.8 ± 13.6; $t_{20} = 4.36$, $P = 0.0001$) than in year 3 (153.4 ± 11.7; Table 3). Biomass of preferred forage plants did not differ between treatments, but did differ among years (Table 2, Table 3). More preferred forage plants occurred in year 1 (91.5 ± 9.2; $t_{20} = 2.72$, $P = 0.04$) than in year 3 (61.3 ± 5.9; Table 3). Grasses significantly differed between treatments and among years (Table 2, Table 3), with less grasses in PF (32.9 ± 4.1 than in PFH (54.9 ± 6.2). Additionally, biomass of grasses was greater in year 1 (68.7 ± 8.8; $t_{20} = 6.42$, $P < 0.001$) and year 2 (56.7 ± 5.3; $t_{20} = 5.20$, $P < 0.001$) than in year 3 (6.4 ± 1.1; Table 3). Biomass of legumes did not differ among years ($F_{2, 20} = 0.53$, $P = 0.60$) nor between treatments ($F_{1,20} = 1.55$, $P = 0.23$). Biomass of vines did not differ between treatments, but did differ among years (Tables 2, 3). Vine biomass was greater in year 1 (65.5 ± 7.0; $t_2 = 2.72$, $P = 0.04$) than in year 3 (38.2 ± 5.0; Table 3). Biomass of woody species differed between treatments but not among years (Tables 2, 3), with greater biomass in PF (101.8 ± 11.3) than in PFH (48.9 ± 6.6).

For individual species, French mulberry, ragweed, greenbriars, and blueberry/huckleberry did not differ among years or between treatments ($P > 0.17$; Table 3). Biomass of muscadine differed between treatments and among years (Table 2, Table 3), with greater biomass in PF (16.8 ± 4.1) than PFH (4.6 ± 1.6). Additionally,

Table 3. Mean biomass (g/m²) with associated standard errors (SE) of selected plant species or species groups in forest stands site prepared with a combination of prescribed fire and imazapyr + triclopyr application (PFH) or prescribed fire only (PF) in Washington Parish, Louisiana, 2003–2005.

Plant species or species group	Mean biomass (SD)					
	2003		2004		2005	
	PF	PFH	PF	PFH	PF	PFH
Total forage	297.1 (21.1)	266.7 (24.5)	287.4 (23.5)	218.2 (12.3)	172.5 (20.5)	134.2 (10.9)
Preferred forage[a]	106.6 (14.1)	76.5 (11.6)	77.6 (7.9)	86.6 (10.6)	66.4 (10.2)	56.3 (5.9)
Grasses	59.7 (9.3)	77.6 (14.9)	33.9 (5.7)	79.5 (7.7)	5.1 (1.2)	7.7 (1.7)
Legumes	2.3 (1.3)	3.9 (1.1)	3.5 (1.7)	5.5 (1.5)	4.0 (1.9)	5.3 (1.4)
Vines	80.0 (11.3)	50.9 (7.9)	63.4 (7.3)	51.6 (6.8)	41.3 (8.5)	35.2 (5.4)
Woody	98.3 (20.9)	47.3 (14.2)	13.4 (20.6)	43.9(11.4)	93.7 (17.5)	55.2 (8.3)
French mulberry	11.9 (7.7)	9.2 (4.2)	8.0 (4.7)	12.9 (7.0)	20.00 (6.4)	9.4 (3.5)
Ragweed	1.5 (0.9)	0.5 (0.3)	0.2 (0.2)	1.4 (0.7)	0.06 (0.03)	0.4 (0.2)
Smilax spp.	3.8 (1.5)	0.2 (0.1)	3.7 (3.5)	0.4 (0.2)	0.3 (0.2)	1.8 (0.6)
Vaccinium spp.	9.3 (3.6)	7.2 (3.8)	2.7 (1.1)	13.7 (6.3)	2.0 (1.8)	5.6 (2.0)
Vitis spp.	40.4 (11.4)	7.2 (4.2)	3.6 (1.9)	2.0 (1.4)	6.4 (2.2)	4.4 (1.7)
Yaupon	41.6 (16.3)	9.1 (7.4)	72.7 (17.9)	6.6 (2.9)	54.9 (16.0)	17.2 (6.4)

a. Indicates species considered to be moderate to high quality deer browse by Miller and Miller (1999) and Moreland (2005).

muscadine biomass was greater in year 1 (23.8 ± 6.3; t_{20} = 3.06, P = 0.02) than year 2 (2.8 ± 1.2 and year 3 (5.4 ± 1.4; t_{20} = 2.68, P = 0.04; Table 3. Biomass of yaupon differed between treatments but not among years (Tables 2, 3), with greater biomass in PF (56.4 ± 9.7) than PFH (10.9 ± 3.4).

Discussion

All sites received a banded herbaceous weed control treatment. Because the banded treatment only applied herbicide in the rows containing pine trees, native vegetation between the rows was not affected (e.g., Blake et al. 1987, Duda 2003, Edwards 2004). Also, because all sites received the banded treatment, we assumed effects on plant communities were similar among sites. Other research has documented quick recovery of vegetation following banded herbaceous control, often after the first year (MacKinnon and Freedman 1993, Duda 2003, Keyser et al. 2003, Edwards 2004). Therefore, effects of the herbaceous control on our results would be most pronounced during the first growing season and negligible for subsequent years.

We documented that site preparation using a combination of herbicides and fire reduced biomass of woody species, increased biomass of grasses, and did not significantly affect biomass of legumes or vines. Notably, biomass of preferred deer forage plants did not differ between site preparation treatments. This observation is consistent with previous studies examining effects of chemical site preparation on deer forage plants (Blake et al. 1987; Defazio et al. 1987; Parker et al. 1993, 1994), indicating that effects of site preparation techniques on abundance of preferred forage plants for deer are relatively short-lived. However, we noted differences in biomass of preferred forage plants during the first growing season, irrespective of site preparation technique. We attribute this observation to successional changes in plant communities, as biomass of select vines (e.g., muscadine) declined after the first growing season.

Previous research has shown that chemical site preparation often promotes increased herbaceous vegetation during the first growing season after treatment, and also may contribute to greater abundance of selected vines and forbs even in instances where total forage for deer is reduced (Parker et al. 1993, Welch et al. 1999, Gassett et al. 2000). This appears to be the case in our study as there was more total biomass on fire only sites, but much of this difference in biomass was due to a high proportion of woody biomass (i.e., yaupon) on fire only sites. In contrast, plant communities on sites prepared with imazapyr and triclopyr in our study were initially dominated by *Andropogon* spp., *Solidago* spp., and a variety of forbs and vines.

Although yaupon is often reported as an important forage plant for deer (Miller and Miller 1999), we considered presence of this species on our sites as potentially negative for several reasons. First, as mentioned previously, we did not observe deer foraging on yaupon on our sites, suggesting that in the presence of other forage species, yaupon may not be a preferred forage plant in our study area (Moreland 2005). Second, yaupon has the propensity to outcompete and eventually dominate understory plant communities, significantly reducing understory species richness and diversity. Indeed,yaupon comprised a substantial portion of total plant biomass within stands site prepared with fire only. Also, as yaupon matures, any browse material is beyond the reach of deer and this, combined with shading of the understory, has a negative impact on other desireable understory plant species. Yaupon is also undesirable silviculturally due to competition with young planted pines and increased fire danger in pine stands (www.fs.fed.us/databse/feis/plants/shrub/ilevom/all.html). However, control of yaupon also compromised availability of muscadine grape (a valuable forage species), which had greater biomass on sites prepared with fire only. Although this compromise was most prominent in the first growing season (see Table 3), it is important to note when assessing quality of sites for deer.

From a structural standpoint, it is important to note that biomass of woody species was greater on sites prepared with fire only and that biomass of grass species was greater in the first two growing seasons, and on sites chemically site prepared. This indicates that succession was delayed by at least one, and maybe two years on chemically treated sites due to the temporary suppression of the woody component on these sites, consistent with other studies (e.g., Miller and Witt 1990, Miller and Miller 2004). Therefore, in our study, chemically treated sties may provide an extra year, or perhaps two, of herbaceous vegetation with the possible tradeoff of earlier canopy closure of pines (McComb and Hurst 1987, Duda 2003, Edwards 2004).

Management Implications

The management of public and private forests continues to evolve throughout the southeastern United States. Specifically, management of industrial forests continues to intensify, as the demand for wood fiber increases and landowners focus on managing for greater yields on reduced acreages (Miller and Wigley 2004). Within this framework, many industrial landowners garner considerable income through leasing of managed forests for sport hunting directed towards deer. Our findings suggest that site preparation using a combination of imazapyr and triclopyr with prescribed fire in eastern Louisiana does not reduce total deer browse but does impact composition of the plant community. This suggests that judicious use of chemical site preparation may not negatively affect forage abundance for deer on a broad scale, and may actually result in improvements to plant communities relative to browse for deer. However, it is important to interpret our results with caution as our study was not replicated across multiple landscapes and herbicide effects on plant communities vary greatly across sites (Miller and Miller 2004).

Although deer are a socially and economically important species, a host of other wildlife species will be affected by site preparation techniques. For instance, northern bobwhite (*Colinus virginianus*) populations, and associated early successional bird species, typically benefit from timber harvest that creates abundant early successional habitats (Dickson et al. 1995, Burger 2001). However, forested sites that quickly become dominated with excessive woody vegetation, such as yaupon, are not conducive to use by these bird communities, and result in shortened periods of usefulness for these species. In our study, stands site prepared with fire and herbicides were dominated by herbaceous vegetation, legumes, and various forbs during the first growing season following site preparation, whereas stands prepared with fire were dominated by woody and vine species. Therefore, our findings suggest that the chemical site preparation combination used in our study (imazapyr + triclopyr with prescribed fire) may improve habitat quality for early successional bird communities, based on vegetation response we observed and previous research on northern bobwhite (Burger et al. 1994, O'Connell 1993, Thompson 2002), However, this improved habitat condition could come at the cost of a shorter time stands spend in early successional condition due to a decrease in time to canopy closure (Duda 2003, Miller and Miller 2004).

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