Methods for Controlling Woody Invasion into CRP Fields in Tennessee

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Woody cover is an important component of northern bobwhite (*Colinus virginianus*) habitat; however, some species such as red maple (*Acer rubrum*) and sweetgum (*Liquidambar styraciflua*) grow aggressively and may become dominant on unmanaged areas. Six treatments with controls were implemented in a completely randomized design on a Conservation Reserve Program (CRP) old-field planted to tall fescue (*Lolium arundinarium*) with extensive invasion by sweetgum, red maple, and other woody saplings to determine the most effective method for reducing coverage of woody plants. Treatments included dormant-season burning in March 2004, applications of triclopyr, imazapyr, and glyphosate in July 2004, mowing in August 2004, and growing-season burning in September 2004. Resulting vegetation structure and composition were measured in July 2005. Percentage woody cover was reduced by all treatments (13-50%) except mowing (65.8%, SE=7.0) compared to control (80.4%, SE=7.6). Imazapyr (13.3%, SE=2.6), growing-season burn (14.2%, SE=3.1), and triclopyr (15.8%, SE=3.5) were most effective at reducing woody cover. Percentage cover of desirable legumes (*Chamaecrista* spp., *Desmodium* spp., *Lespedeza* spp.) was greatest in growing-season burn (54.2%, SE=6.7), imazapyr (28.3%, SE=5.9), and dormant-season burn (24.5%, SE=5.2) treatments. Imazapyr increased coverage of blackberry (*Rubus* spp.), while triclopyr increased coverage of warm- and cool-season grasses. Our results suggest growing-season fire in September was best at reducing woody plants and enhancing habitat for northern bobwhites. Growing-season fire resulted in the greatest coverage of desirable legumes, reduced litter depth, and increased percent bare ground. If burning is not possible, applications of imazapyr or tryclopyr may be suitable alternatives.

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Introduction

Managing woody cover for northern bobwhites (*Colinus virginianus*; hereafter bobwhite) can be difficult. In general, optimal cover for bobwhites consists of an annual weed community for feeding and brood rearing, a perennial grass component for nesting structure, and early successional shrubs to provide cover and mast (Stoddard 1931, Rosene 1969). These plant communities occur along a successional gradient that may be manipulated by management practices (Rosene 1969). While it is widely understood that burning is an effective management practice used to control the structure and composition of early successional vegetation, the effects of season, intensity, and frequency of fire are less clear.

In the southern US, desirable early successional "brushy" cover may include sumacs (*Rhus* spp.), plums (*Prunus* spp.), and blackberries. Unfortunately, "late successional species" (Lorimer 2001) commonly invade fields without proper management. Species such as sweetgum, winged elm (*Ulmus alata*), and red maple do not provide optimal structure for bobwhites and may shade out desirable plant communities. Undesirable woody plants can be controlled by using fire or disking, but these techniques may become less effective once plants advance past the seedling stage. Also, in some areas, use of fire is not a management option.

Advances in forest herbicides may provide managers with a means to control undesirable woody vegetation and improve bobwhite habitat (Miller and Miller 2004, Jones and Chamberlain 2004, Welch

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et al. 2004). Past research evaluated the use of herbicides and fire on wildlife habitat in power line rights-of-way (Arner et al. 1976, Bramble and Byrnes 1976). Several studies examined the effects of forest herbicides and fire used to manage encroaching hardwoods on wildlife habitat in pine stands in the South (Jones and Chamberlain 2004, Welch et al. 2004, Edwards et al. 2004). Research in Mississippi and Georgia tested the effects of forest herbicides for improving bobwhite habitat and controlling bermudagrass (*Cynodon dactylon*) on retired pasture sites (Hamrick et al. 2005, Bond et al. 2005). However, to our knowledge, no studies have examined the effectiveness of herbicide application on reducing undesirable woody plants in CRP fields and compared those treatments with different applications of prescribed fire. The objectives of this study were to determine the effects of late growing-season prescribed fire, dormant-season prescribed fire, mowing, and applications of three herbicides on encroaching hardwoods and resulting habitat for bobwhites in a CRP old-field.

Study Area

We conducted the study on a privately owned 7.3-hectare field in Benton County, Tennessee. The area was sown to tall fescue when it was enrolled into the CRP in 1985. Tall fescue coverage was reduced as undesirable woody species pioneered into the field from an adjacent hardwood stand. The field had been mowed annually since the early 1990s in an attempt to control the invading hardwoods. The portion of the field used in this study was evenly covered by invading hardwoods.

Methods

Study Design

We established treatment plots (0.10 ha) in a completely randomized design with four plots per treatment in March 2004 (28 plots total). Treatments included dormant-season burning in March 2004, applications of 5.60 kg/ha triclopyr (Garlon-4 at 5qts/acre), 0.84 kg/ha imazapyr (Arsenal AC at 24 oz/acre), and 4.48 kg/ha glyphosate (Gly-4 at 4qts/acre) in July 2004, mowing in August 2004, and late growing-season burning in September 2004. Treatment plots were rectangular (15.2 x 67 m) to facilitate herbicide applications. Average flame heights were >1 m and <1 m for March 2004 and September 2004 burns respectively. Herbicides were applied using an agricultural spray coupe with a 15.2-m spray boom using a total solution volume of 200 L/ha. All plots were mowed prior to the study in August 2003 and as a result, vegetation height was conducive to herbicide application in July 2004. Non-ionic surfactant was added to each herbicide application at 0.25% total spray volume to increase herbicide uptake. Control plots did not receive any treatment after mowing in August 2003.

Vegetation Sampling

We measured vegetative response in July of 2005. We measured vegetation characteristics by systematically placing a 1-m^2 subsample plot (Bonham 1989) at 3 locations within each treatment plot. We estimated percent cover of total vegetative canopy, litter, and bare ground, and percent cover of vegetative canopy classes including desirable legumes, other forbs, warm-season grasses, cool-season grasses, brambles, sedges, and woody species to the nearest 5%. Desirable legumes included members of *Desmodium*, *Lespedeza*, and *Chamaecrista*. Legumes considered undesirable (i.e, sericea lespedeza, *Lespedeza cuneata* were counted as forbs. Additionally, we counted the total number of woody stems within each subsample plot and measured litter depth at the plot center. We measured species composition along a 10-m line transect (Canfield 1941) placed along the cardinal azimuth passing through the center of each plot. We measured the distance (cm) along each line transect occupied by each plant species. We identified plants to species when possible. We measured maximum vegetation height at 0, 5, and 10 m along each line transect.

Statistical Procedures

We used a one-way analysis-of-variance (ANOVA) with subsampling error to test for differences in vegetation structure and percent composition among treatments (Montgomery 1997). If F-tests were significant ($\alpha = P < 0.05$), we used Tukey's Honest Significant Difference test to determine if pair-wise differences existed between treatments. All tests were performed using PROC GLM in the SAS system (Littell et al. 2002).

Results

Vegetation Structure

Percent cover was different among treatments for total vegetative cover ($F_{6,21}$ = 5.24, P = 0.002), litter ($F_{6,21}$ = 8.52, $P < 0.001$), bare ground ($F_{6,21}$ = 6.82, $P < 0.004$), forbs ($F_{6,21}$ = 3.14, $P < 0.008$), legumes ($F_{6,21}$ = 7.64, $P < 0.001$), woody species ($F_{6,21}$ = 22.10, $P < 0.001$), cool-season grasses ($F_{6,21}$ = 5.37, $P < 0.001$), warm-season grasses ($F_{6,21}$ = 4.59, P = 0.004), vegetation height ($F_{6,21}$ = 11.77, $P < 0.001$), litter depth ($F_{6,21}$ = 7.62, $P < 0.001$), and total woody stems ($F_{6,21}$ = 7.19, P = 0.003; Table 1). Percent woody cover and number of woody stems were reduced by all treatments except mowing compared to control. Imazapyr, growing-season burn, and triclopyr most effectively reduced percent woody cover. Percentage cover of desirable legumes was highest in growing-season burn, imazapyr, and dormant-season burn treatments. Percentage bare ground was greatest in late growing-season burn. Triclopyr had the greatest cover of cool- and warm-season grasses.

Vegetation Composition

We recorded 47 plant species across all treatments in July 2005. Mean species richness did not differ among treatments ($F_{6,21}$ = 1.28, P = 0.328). We detected treatment effects for sweetgum ($F_{6,21}$ = 20.35, $P < 0.001$), winged elm (*Ulmus alata*) $F_{6,21}$ = 8.73, $P < 0.001$), blackberry ($F_{6,21}$ = 10.43, $P <$ 0.001), slenderleaf false foxglove (*Agalinis tenuifolia*, $F_{6,21}$ = 3.76, P = 0.0193), and sericea lespedeza ($F_{6,21}$ = 50.6, P = 0.006). Mean canopy coverage of sweetgum was greatest in control (8.17, SE = 0.55) and mowed (5.26, SE = 0.93) treatments, but was reduced by all other treatments. Imazapyr application increased canopy coverage of blackberry (4.5, SE = 1.01) compared to all other treatments.

Discussion

Woody cover is important to bobwhites (Cram et al. 2002). Taylor and Burger (2000) reported bobwhite broods in Mississippi selectively used habitats with greater canopy coverage of woody species (44.3%) than random sites (21.7%). Bobwhites in Illinois nested in old-fields with 20% woody cover (Roseberry and Klimstra 1984). Cram et al. (2002) observed a threshold-like increase in bobwhite abundance relative to woody cover <2 m; however, Guthery (1999) hypothesized an upper threshold to woody cover likely exists where too little herbaceous cover is present, resulting in a loss of usable space for bobwhites. Welch et al. (2004) defined severe woody invasion in pine uplands in Florida as areas with woody stem densities >5 stems/m^2. Our study area was severely invaded by undesirable woody species and as a result, provided suboptimal bobwhite habitat.

The Northern Bobwhite Conservation Initiative states adequate nesting and brood-rearing habitat often limit bobwhite populations in the South (Dimmick et al. 2002). Suitable bobwhite nesting habitat generally consists of 40-60% vegetative canopy cover of grasses suitable for nesting, 40-60 cm in height (Schroeder 1985). Additionally, bare ground is an important component of bobwhite nesting habitat (Rosene 1969). Triclopyr applications maintained greater warm-season grass coverage than all other treatments. Warm-season grasses, such as broomsedge, provide important nesting cover for bobwhites (Dimmick 1974). Warm-season grasses present on our study site included broomsedge (*Andropogon virginicus*), purpletop (*Tridens flavus*), beaked panicgrass (*Panicum anceps*), low panicgrass (*Dichanthelium* spp.), fall panicgrass (*Panicum dichotomiflorum*), and johnsongrass (*Sorghum halepense*).

Burger et al. (1990) described optimal bobwhite brood cover as fields with diverse annual weed communities produced by recent (<3 years) soil disturbance (i.e., disking or burning). Bobwhite broods

Table 1: Mean, standard error, and Tukeys HSD groupings[a] for vegetation structural characteristics measured in July 2005 for treatments and controls in a CRP old-field in Benton County, Tennessee.

		Control			Bushhog			Dormant-season burn			Late growing-season burn			Imazapyr			Glyphosate			Triclopyr		
	P	*X*	SE		*X*	SE		*X*	SE		*X*	SE		*X*	SE		*X*	SE		*X*	SE	
Cover	<0.001	97.5	(1.7)	a[a]	91.7	(2.1)	ab	90	(2.4)	ab	84.5	(3.4)	bc	81.7	(2)	bc	73.8	(2.7)	c	82.5	(3.6)	bc
Bare	<0.001	0	0	c	1.7	(1.3)	bc	5.8	(1.8)	b	14.5	(3.3)	a	1.7	(1.1)	bc	2.5	(1.3)	bc	1.7	(1.1)	bc
Litter	<0.001	3.3	(1.7)	cd	7.5	(1.9)	bc	4.6	(5.3)	cd	0.8	(0.8)	d	16.7	(2.5)	ab	23.7	(2.7)	a	15.8	(3.4)	ab
Forb	0.006	25.8	(5.6)	b	40	(6.7)	ab	39.2	(7.1)	ab	39.2	(7.1)	ab	62.5	(6.6)	a	55	(6.1)	a	51.2	(8.3)	ab
Legume[b]	<0.001	6.2	(2.9)	c	14.6	(3.8)	bc	24.5	(5.2)	b	54.2	(6.7)	a	28.3	(5.9)	b	15	(4.1)	bc	13.3	(4.1)	bc
Woody	<0.001	80.4	(7.6)	a	65.8	(7)	ab	50.4	(6.1)	bc	14.2	(3.1)	d	13.3	(2.6)	d	32.1	(6.4)	cd	15.8	(3.5)	d
Brambles	<0.001	15	(5.7)	a	15.4	(3.2)	a	19.1	(5.2)	a	19.2	(5.3)	a	28.8	(7.4)	a	13.8	(4)	a	0	0	b
CS grass[c]	<0.001	3.7	(2.5)	bc	7	(3)	bc	4.5	(1.6)	bc	0	0	c	4.5	(1.6)	bc	11.7	(3.1)	b	29.6	(7.2)	a
WS grass[d]	<0.001	5.8	(2.8)	b	7.1	(2.6)	b	4.1	(2)	b	10.8	(3.4)	b	1.3	(1.3)	b	5.4	(3.7)	b	29.6	(8.8)	a
Woody stems	<0.001	4.8	(0.6)	a	4.5	(0.5)	a	2.6	(0.4)	b	1.5	(0.4)	b	1.5	(0.3)	b	2.7	(0.5)	b	1.5	(0.3)	b
Litter (cm)	<0.001	1.5	(0.4)	b	1.8	(0.3)	ab	0.3	(0.2)	ab	0.1	(0.1)	c	1.8	(0.3)	ab	3.3	(0.8)	a	2.3	(0.2)	ab

[a] Means with the same lower case letter(s) within the same row are not statistically different

[b] Desirable legumes

[c] Cool-season grasses

[d] Warm-season grasses

feed heavily on invertebrates (Stoddard 1931); therefore, bobwhite brood habitat quality is directly related to invertebrate availability (Hurst 1972, Jackson et al. 1987, DeVos and Mueller 1993). Although invertebrate availability may be highly variable, greater invertebrate abundance and diversity may be associated with diverse plant communities (Shelton and Edwards 1983), particularly the forb component (Harper et al. 2001). Grass monocultures, regardless of type, support relatively few invertebrates (Fettinger et al. 2002). Availability of invertebrates to chicks is determined largely by vegetation density at ground level, which determines foraging efficiency of chicks (Hurst 1972).

All treatments increased percent forb cover compared to control. No treatment effects were observed in our study for plant species richness, but all treatments met species richness requirements for bobwhite brood-rearing habitat (Schroeder 1985). Increase in desirable legumes by burning and imazapyr treatments likely enhanced brood-rearing habitat (Jones and Chamberlain 2004). Arner et al. (1976) found desirable legume response after burning in power line rights-of-ways was inconsistent and depended on soil fertility and past land use. Bobwhite broods in Mississippi and Florida used areas with mean bare ground cover >20% (Taylor and Burger 2000, DeVos and Mueller 1993). Late growing-season burning produced the greatest percentage cover of bare ground in our study; however no treatment produced enough bare ground to be considered optimal brood-rearing habitat (Schroeder 1985). Although dormant-season burning did not provide the greatest decrease in percentage of undesirable woody cover (the primary objective of this study), the reduced coverage of sweetgum relieved competition on desirable forbs and legumes which likely provided better bobwhite brooding habitat (Jones and Chamberlain 2004).

Growing-season fires have been used to control undesirable hardwoods in pine stands in the South. Rosene (1969) stated growing-season fire would destroy nests, eggs, and broods of birds and should be used only when necessary to control invading hardwoods. Fields with severe woody invasion similar to the one used in our study do not provide suitable nesting or brood-rearing habitat for bobwhites because of a lack of nesting structure, annual plant communities, and adequate bare ground. We recommend growing-season fire in September if bobwhite nesting and brood rearing is limited by undesirable woody encroachment.

While we recommend September burning to manage CRP fields invaded by undesirable woody species; we recognize burning is not always possible. In that case, applications of imazapyr or tryclopyr may provide a suitable management alternative for woody control. Imazapyr may provide greater brood-rearing habitat benefits than triclopyr because it has less adverse effects on legumes and blackberry. Although triclopyr applications resulted in greater coverage of warm-season grasses and controlled sericea lespedeza, cool-season grasses were increased. Bobwhite habitat benefits are reduced when cool-season grasses such as tall fescue (Barnes et al. 1995) and orchardgrass (*Dactylis glomerata*) are present. We recommend managers address invasive plants such as sericea lespedeza, tall fescue, and undesirable woody species aggressively, as the density of these plants will only increase over time. Once invasive plants are controlled, we recommend prescribed fire and disking to set back succession in old-fields and maintain desirable plant communities for bobwhites.

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