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Response of Tifway Bermudagrass and Tall Fescue Turfgrasses to Preemergence Herbicides[1]

B. Jack Johnson[2]
Department of Crop & Soil Sciences
University of Georgia
Georgia Station, Griffin, GA 30223-1797

Abstract

It is important that preemergence herbicides used for annual weed control in warm- and cool-season turf not injure the desired turfgrass species. A field experiment was conducted for two years to determine the tolerance of Tifway bermudagrass [*Cynodon transvaalensis* Burtt-Davy x *C. dactylon* (L.) Pers.] and K-31 tall fescue (*Festuca arundinacea* Schreb.) to preemergence herbicides. Herbicides were applied at recommended (1X) and twice the recommended (2X) rates. Prodiamine (Barricade) at ≤ 1.6 kg/ha (≤ 1.5 lb/A), butralin (EXP 30910A and EXP 31068A) at ≤ 11.2 kg/ha (≤ 10.1 lb/A), pendimethalin (Pre M and Weedgrass Control) at 3.4 kg/ha (3.0 lb/A), and dithiopyr EC (Dimension) at 0.8 kg/ha (0.75 lb/A) on February 24 did not reduce the quality or shoot density of Tifway bermudagrass. Tifway bermudagrass injured by oxadiazon (Ronstar) ≥ 4.5 kg/ha (≥ 4.0 lb/A) recovered by late April to early May, while turf treated with oxyfluorfen plus oryzalin (Rout) at 2.2 + 1.1 kg/ha (2.0 + 1.0 lb/A) recovered by late April and turf treated at 4.5 + 2.2 kg/ha (4.0 + 2.0 lb/A) generally did not recover by late June. Tifway bermudagrass treated with oryzalin (Surflan) alone at ≤ 6.7 kg/ha (≤ 6.0 lb/A) did not recover by late June. However, turf treated with benefin plus oryzalin (XL) at 1.7 + 1.7 kg/ha (1.5 + 1.5 lb/A) recovered by this date. None of the preemergence herbicides severely reduced quality or shoot density of tall fescue except oxyfluorfen plus oryzalin (Rout) applied at ≤ 4.5 + 2.2 kg/ha (≤ 4.0 + 2.0 lb/A), oryzalin (Surflan) at 6.7 kg/ha (6.0 lb/A), and benefin plus oryzalin (XL) at 3.4 + 3.4 kg/ha (3.0 + 3.0 lb/A).

Index words: *Cynodon dactylon* x *C. transvaalensis*, *Festuca arundinacea*, turf quality, shoot density

Herbicides used in this study: Prodiamine (Barricade), N^3,N^3-di-*n*-propyl-2,4-dinitro-6-(trifluoromethyl)-*m*-phenylenediamine; dithiopyr (Dimension), *S*,*S*-dimethyl 2-(difluoromethyl)-4-(2-methylpropyl)-6-(trifluoromethyl)-3,5-pyridinedicarbothioate; butralin (EXP 30910A in 1992 and EXP 31068A in 1993), 4-(1,1-dimethylethyl)-*N*-(1-methylpropyl)-2,6-dinitrobenzenamine; oxadiazon (Ronstar), 3-[2,4-dichlor-5-(1-methylethoxy)phenyl]-5-(1,1-dimethylethyl)-1,3,4-oxadiazol-2-(3*H*)-one; pendimethalin (Pre M and Weedgrass Control), *N*-(1-ethylpropyl)-3,4-dimethyl-2,6-dinitrobenzenamine; oxyfluorfen plus oryzalin (Rout), oxyfluorfen-2 chloro-1-(3-ethoxy-4-nitrophenoxy)-4-(trifluoromethyl) benzene, oryzalin-4-(dipropylamino)-3,5-dinitro-benzenesulfonamide; oryzalin (Surflan), include; benefin plus oryzalin (XL), benefin,-*N*-butyl-*N*-ethyl-2,6-dinitro-4-(trifluoromethyl)benzenamine, oryzalin, include.

Significance to the Nursery Industry

Preemergence herbicides are used to control weeds for high-quality turfgrass in home lawns, golf courses, athletic fields, parks, and other recreational areas. However, it is important that the herbicide used for weed control not injure the turfgrass. This research demonstrates that most preemergence herbicides applied at recommended rates are safe to Tifway bermudagrass and tall fescue turf.

Introduction

It is often necessary to apply preemergence herbicides to control annual weeds in turfgrasses. Herbicides must control weeds without injuring turfgrasses used for home lawns, athletic fields, golf courses, industrial and recreational parks, and other turf areas. Goosegrass [*Eleusine indica* (L.) Gaertn.] and crabgrass (*Digitaria* spp.) are summer annual weeds which are controlled by various preemergence herbicides (1, 2, 3, 6, 7, 8, 9, 11, 12). Most of these herbicides caused some degree of injury to turfgrasses.

Researchers in Tennessee (2) reported that Tifgreen bermudagrass stand was reduced after three annual applications of oxadiazon (Ronstar) at the 1X rate [4.5 kg/ha (4.0 lb/A)]. Stand reduction was similar whether treated at 1X or 2X rate. In Georgia (5), oxadiazon (Ronstar) applied at 3.4 kg/ha (3.0 lb/A) in late February or early March for 4 consecutive years delayed green-up of Tifway, Tifgreen, and Tifdwarf bermudagrasses in late April, but the turfgrass fully recovered by mid-May. When butralin (EXP 30910–AEXP 31068A) was applied during the same period at 4.5 kg/ha (4.0 lb/A), Tifgreen and Tifdwarf bermudagrass did not recover by mid-May (5). When the rate was increased to 5.6 kg/ha (5.0 lb/A), the density of Tifgreen and Tifdwarf did not recover by mid-August. Butralin (EXP 30910A and EXP 31068A) applied 4.5 to 5.6 kg/ha (4.0 to 5.0 lb/A) (4,6) did not affect the quality of tall fescue. However, injury to tall fescue treated with oxadiazon (Ronstar) at 3.4 kg/ha (3.0 lb/A) varied from none (7) to slight injury (≤ 20%) in one year (4, 6).

Bhowmik and Bingham (1) reported that pendimethalin (Pre M and Weedgrass Control) at 0.8 kg/ha (0.75 lb/A) reduced root growth of Kentucky bluegrass (*Poa pratensis* L.) and common bermudagrass [*C. dactylon* (L.) Pers.], 6 weeks after treatment (WAT), but did not reduce root growth of tall fescue. They (1) reported that prodiamine (Barricade), applied at 0.3 kg/ha (0.25 lb/A) reduced root growth of Kentucky bluegrass and common bermudagrass at 6 WAT. However, root growth of tall fescue was not influenced by prodiamine (Barricade) until the rate was increased to 2.2 kg/ha (2.0 lb/A). The stand of mixed cool-season turfgrasses in Pennsylvania (11) was reduced by 20% at 3.5 WAT by prodiamine (Barricade) at 0.84 kg/ha (0.75 lb/A) when the 1.0 G formulation was used. Cooper et al. (3) reported that pendimethalin (Pre M and Weedgrass Control) at 3.4 kg/ha

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[2]Professor, Department of Crop and Soil Sciences.

Table 1. Tolerance of Tifway bermudagrass to preemergence herbicides, Griffin, GA 1992-93.

Herbicides[z]	Rate		Turf quality[y]					Shoot density[x]		
									1992	1993
	kg/ha	lb/A	Apr 14	Apr 20	May 5	May 25	Jun 24	May 25	Jun 24	Jun 21
			% untreated check					% untreated check		
Untreated	—	—	100	100	100	100	100	100	100	100
Oxyfluorfen	2.2+1.1	2.0+1.0	81	88	97	95	98	94	94	99
+ oryzalin[w]	4.5+2.2	4.0+2.0	77	78	79	87	97	88	87	99
Prodiamine	0.8	0.75	103	100	108	100	102	101	101	100
	1.6	1.5	90	97	90	92	96	93	91	98
Benefin	1.7+1.7	1.5+1.5	79	83	85	89	99	89	86	99
+ oryzalin[w]	3.4+3.4	3.0+3.0	74	76	73	80	92	78	81	95
Oryzalin	3.4	3.0	84	83	82	91	94	89	85	96
	6.7	6.0	76	82	75	82	94	83	82	97
Pendimethalin	3.4	3.0	89	94	93	95	97	96	93	99
	6.7	6.0	81	85	92	92	99	90	98	97
Dithiopyr (EC)	0.8	0.75	87	90	93	96	101	96	99	100
	1.6	1.5	77	85	81	91	100	89	96	98
Dithiopyr (G)	0.6	0.5	84	83	82	90	99	90	91	97
	1.1	1.0	77	82	79	87	99	84	96	99
Oxadiazon	4.5	4.0	84	89	95	97	101	100	99	100
	9.0	8.0	81	82	89	94	100	93	98	100
Butralin	5.6	5.0	98	103	100	96	98	98	95	99
	11.2	10.0	89	92	97	95	98	94	96	98
LSD @ 0.05			13	13	14	8	4	9	9	NS

[z]Herbicides were applied February 24, 1992 and 1993.

[y]Turf quality ratings were based on percent of untreated check, where 1 = turf brown or dead and 10 = dark green with a uniform, dense stand, and are averages from two years.

[x]Turf density ratings were based on percent of untreated check, where 1 = no turf and 10 = uniform cover, and data on May 25 are averages from two years.

[w]Herbicides were applied in one application as a single product.

(3.0 lb/A) resulted in a short-term suppression in root growth of Kentucky bluegrasses immediately following application, but there was no cultivar by herbicide interaction.

Dithiopyr (Dimension) which is labeled for use in certain turfgrasses, did not injure either tall fescue or bermudagrass (8, 9). It is difficult to determine the amount of injury that is caused by dithiopyr (Dimension) or other herbicides (7), when weeds are present in untreated and treated plots where herbicides did not control weeds effectively. When weed competition is eliminated, turfgrass tolerance from herbicide treatments can be determined more accurately. Information on tolerance of warm- and cool-season turfgrasses to several preemergence herbicides is limited, experiments were conducted to determine the tolerance of Tifway bermudagrass and tall fescue to eight preemergence herbicides applied at two rates to determine initial injury, and length of quality reduction.

Materials and Methods

Eight preemergence herbicides were applied to Tifway bermudagrass and tall fescue at two rates (1X and 2X) on February 24, 1992 and 1993. The herbicides and rates of application are given in Table 1. Oryfluorfen plus oryzalin (Rout) and benefin plus oryzalin (XL) were each applied as a single product. An untreated check was included. The herbicide in each Experiment was applied to separate plots each year. The soil type at the Tifway bermudagrass site was an Appling sandy clay loam (clayey kaolinitic, thermic Typic Hapludults) with 1.7% organic matter, 55% sand, 22% silt, and 23% clay. The soil type at the tall fescue site was a Cecil sandy clay loam (clayey kaolinitic, thermic Typic Hapludults) with 2.1% organic matter, 55% sand, 18% silt, and 27% clay.

Tifway bermudagrass was mowed with a reel mower three times per week during the growing season at 2 to 3 cm (0.8 to 1.2 in) height. Tall fescue was mowed with a rotary mower twice per week at a height of 7 cm (2.8 in). Clippings from Tifway bermudagrass and tall fescue were returned following each mowing. Tifway bermudagrass was fertilized with 50 N-22P-42K kg/ha (45N-20P-38K lb/A) in mid-April, and again early September. An additional 50 kg N/ha (45 lb/A) was applied in late May and early July. Tall fescue was fertilized with 50N-22P-42K kg/ha (45N-20P-38K lb/A) in early September and again in mid-February. An additional 50 kg N/ha (45 lb/A) was applied in November and late

Table 2. Influence of preemergence herbicides on quality and density of tall fescue at Griffin, GA. 1992-93.

Herbicides[z]	Rate		Turf quality[y]			Shoot density[x]			
							1992		1993
	kg/ha	lb/A	Mar 9	Apr 12	May 5	May 5	May 25	Jun 24	Jun 28
			% untreated check						
Untreated	—	—	100	100	100	100	100	100	100
Oxyfluorfen	2.2+1.1	2.0+1.0	74	86	96	96	98	93	102
+ oryzalin[w]	4.5+2.2	4.0+2.0	68	78	90	92	85	95	102
Prodiamine	0.8	0.75	99	99	99	100	101	102	98
	1.6	1.5	97	95	106	98	99	94	98
Benefin	1.7+1.7	1.5+1.5	100	97	101	101	95	98	102
+ oryzalin[w]	3.4+3.4	3.0+3.0	100	94	96	93	74	94	100
Oryzalin	3.4	3.0	101	95	99	99	98	99	101
	6.7	6.0	92	85	91	88	70	85	91
Pendimethalin	3.4	3.0	97	98	100	97	100	101	98
	6.7	6.0	97	98	96	100	93	98	104
Dithiopyr (EC)	0.8	0.75	105	98	101	103	100	99	101
	1.6	1.5	101	94	100	99	98	101	99
Dithiopyr (G)	0.6	0.5	97	95	97	98	96	100	100
	1.1	1.0	100	94	92	95	93	98	99
Oxadiazon	4.5	4.0	100	98	99	102	97	99	99
	9.0	8.0	92	92	104	99	98	98	96
Butralin	5.6	5.0	100	97	100	100	99	102	99
	11.2	10.0	101	97	99	101	99	93	96
LSD @ 0.05			6	6	9	7	7	12	6

[z]Herbicides were applied February 24, 1992 and 1993.

[y]Turf quality ratings were based on percent of untreated check where 1 = turf brown or dead and 10 = dark green with a uniform, dense stand, and ratings are averages from two years.

[x]Turf density ratings were based on percent of untreated check where 1 = no turf and 10 = uniform cover. Ratings made on May 5 are averages from two years.

[w]Herbicides were applied in one application as a single product.

May. The turfgrasses were irrigated as needed to maintain optimum growth.

Visual ratings for turf quality and shoot density were made for Tifway bermudagrass and tall fescue. Turf quality ratings were based on 1 to 10 where 1 = turf brown or dead and 10 = dark green with a uniform, dense turf. Shoot density ratings were based on 1 to 10 where 1 = no turf and 10 = uniform turf cover. The quality and shoot density ratings were transformed to percentage of the untreated check. Ratings for Tifway bermudagrass were initiated in mid-April and continued at weekly to biweekly intervals until late June. Ratings for tall fescue were initiated in early March and continued until late June. The delay in the first rating for Tifway bermudagrass occurred since the turf did not initiate spring growth until late March or early April.

Herbicide treatments were arranged in a randomized complete block design with four replications. Plot size was 2.4 × 3.0 M (5 × 10 ft). Analysis of variance (ANOVA) using the Statistical Analysis System (General Linear Model Procedure) was carried out within and across years (10), and the means were separated by LSD at the 0.05 level. When herbicide by year interaction occurred, the means are presented separately.

Results and Discussion

Tifway Bermudagrass Experiment. Prodiamine (Barricade) and butralin (EXP 30910A and EXP 31068A) at 1X and 2X were the only herbicides that did not reduce the quality and shoot density of Tifway bermudagrass (Table 1). The tolerance of Tifway bermudagrass to prodiamine (Barricade) indicates that it can be safely applied during the spring and summer. A single application of butralin on Tifway bermudagrass did not reduce turf quality, but repeated annual applications were injurious (5). In the earlier study, the green-up of Tifway bermudagrass was delayed in April and shoot density was lower in May when the herbicide was applied to the same plots for two or more years. Prodiamine (Barricade) and butralin (EXP 30910A and EXP 31068A) can be safely used for weed control without injury to Tifway bermudagrass.

Pendimethalin (Pre M and Weedgrass Control) at 3.4 kg/ha (3.0 lb/A) and dithiopyr EC (Dimension) at 0.8 kg/ha (0.75 lb/A) did not affect the quality or shoot density of Tifway bermudagrass (Table 1). However, when the rate for pendimethalin (Pre M and Weedgrass Control) was increased to 6.7 kg/ha (6.0 lb/A), the turf did not recover until May 5.

When the rate for dithiopyr EC (Dimension) was increased to 1.6 kg/ha (1.5 lb/A), the turf did not recover until June 24. The response from dithiopyr G (Dimension) at 0.6 kg/ha (0.5 lb/A) was similar to 1.6 kg/ha (1.5 lb/A) dithiopyr EC (Dimension). Therefore, the G formulation had a higher activity related to damage of Tifway bermudagrass turf than the EC formulation. The higher activity from the G formulation was also observed on higher crabgrass and goosegrass control in an earlier study (7). The use of either pendimethalin (Pre M and Weedgrass Control) or dithiopyr EC (Dimension) was safe on Tifway bermudagrass provided the herbicides were applied at the 1X rates. When rate exceeded this level, the turf was slower to green-up in the spring and required a longer recovery period. It appears that the 0.6 kg/ha (0.5 lb/A) rate for dithiopyr G (Dimension) is higher than the normal rate should be. Therefore, the 0.6 kg/ha (0.5 lb/A) rate should probably be a 2X rate when the herbicide is used for weed control in Tifway bermudagrass.

Oryzalin (Surflan) applied alone or with benefin (XL) delayed green-up of Tifway bermudagrass in April, which resulted in a lower than normal quality rating (Table 1). The recovery of turf treated with 1X rate of either herbicide was faster through May than when treated at the 2X rate. The recovery in shoot density from oryzalin (Surflan) and benefin plus oryzalin (XL) treatments was faster during 1993 than during 1992 (Table 1).

Oxyfluorfen plus oryzalin (Rout), oryzalin (Surflan), and benefin plus oryzalin (XL) delayed green-up of Tifway bermudagrass in mid-April (Table 1). Turf treated with oxyfluorfen plus oryzalin (Rout) at 1X rate (2.2 + 1.1 kg/ha (2.0 + 1.0 lb/A)) recovered by late April without affecting shoot density. The quality of turf treated at the 2X rate level recovered by late June, however, shoot density did not fully recover by this date. When oryzalin (Surflan) was applied alone or with benefin (XL) or oxyfluorfen (Rout) to Tifway bermudagrass, a delay in turf green-up can be expected. Turf recovered faster when turf was treated at 1X than at 2X rate levels.

Oxadiazon (Ronstar) delayed spring green-up by reducing quality of Tifway bermudagrass in April, but the turf fully recovered by early May (Table 1). These results agree with an earlier study (5). The quality ratings in April in the present study was similar regardless of rate of application, indicating that the delay in early green-up was temporary and the turf recovered within a short time even when treated with a 2X rate.

Tall Fescue Experiment. Preemergence herbicides applied in late February injured Tifway bermudagrass more than tall fescue (Tables 1, 2). The combination of oxyfluorfen plus oryzalin (Rout) was the only herbicide treatment applied at the 1X rate at 2.2 + 1.1 kg/ha (2.0 + 1.0 lb/A) that injured tall fescue and reduced turf quality. The injury was observed during March and April from the combination treatment, but the turfgrass fully recovered by early May with no influence on shoot density. When the rate was increased to 4.5 + 2.2 kg/ha (4.0 + 2.0 lb/A), the turf did not fully recover until late June.

Oryzalin (Surflan) at 6.7 kg/ha (6.0 lb/A), and oxadiazon (Ronstar) at 9.0 kg/ha (8.0 lb/A) were the only herbicides applied at 2X rates that reduced tall fescue quality during March and April (Table 2). By early May, the quality of turf in treated plots was equal to turf in untreated plots. The 2X rate of oxadiazon (Ronstar) did not affect shoot density, while 2X rate of oryzalin (Surflan) reduced the density in late May 1992 and in late June both years.

Benefin plus oryzalin (XL) did not affect the quality of tall fescue when applied at any rate (Table 2). However, turf density was lower when treated at 2X rate when rating was made May 25, 1992, compared with untreated turf. No other difference was observed in shoot density ratings from the 2X rate. Prodiamine (Barricade), pendimethalin (Pre M and Weedgrass Control), dithiopyr (Dimension) EC and G formulation, and butralin (EXP 30910A and EXP 31068A) did not reduce quality or shoot density of tall fescue regardless of rate of application.

Tolerance of Tifway bermudagrass and tall fescue to preemergence herbicides indicate that in most instances, Tifway bermudagrass was injured more than tall fescue. Prodiamine (Barricade), and butralin (EXP 30910A and EXP 31068A), applied at any rate and pendimethalin (Pre M and Weedgrass Control) and dithiopyr EC (Dimension) applied at 1X rate did not significantly reduce quality and shoot density at any time during the growing season. Oxadiazon (Ronstar) applied at any rate and oxyfluorfen plus oryzalin (Rout) applied at 1X rate delayed spring green-up, but the turf was fully recovered by late April. Tifway bermudagrass treated with oryzalin (Surflan) alone or with benefin (XL) did not fully recover by late June, but quality and density were generally within an acceptable range by this ($\geq$ 90% quality and density ratings) date. Tall fescue tolerated all preemergence herbicides when applied at 1X rates. Oxyfluorfen plus oryzalin (Rout) was the only herbicide applied at 1X rate that injured the turfgrass immediately following treatment, but fully recovered by early May. Benefin plus oryzalin (XL), oryzalin (Surflan), and oxadiazon (Ronstar) applied at 2X rates reduced quality and shoot density at various intervals during the 2-year period. However, the quality and density ratings were, in most instances, within the acceptable level.

(*Ed. note*: This paper reports the results of research only and does not imply registration of a pesticide under amended FIFRA. Before using any of the products mentioned in this research paper, be certain of their registration by appropriate state and/or federal authorities.

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Importance of Red Oak Mother Tree to Nursery Productivity[1]

Daniel K. Struve[2] and Steven E. McKeand[3]
Department of Horticulture
The Ohio State University
Columbus, OH 43210-1097

Abstract

Acorns from 19 red oak (*Quercus rubra* L.) trees were collected in fall 1988. Whips were produced in 1989 and field planted in 1990. Mother tree identity was maintained throughout the study. Growth during the whip production phase was rapid; the average height growth for the 19 families was 122 cm (approximately 4 ft). The best family averaged 167 cm (5.5 ft), the worst 73 cm (2.5 ft) with average individual whip values of $11.20 and $2.80, respectively. When transplanted to nursery fields, the whips had high survival and rapid growth rates. Average individual tree value at the end of three growing seasons ranged from $38.60 to $11.20 for families 6 and 12, respectively. All the traits measured in this study: height, caliper, % acceptable and individual tree value, have relatively high heritability estimates, indicating that traits are under genetic control and thus subject to manipulation by nursery mangers and breeders. The family that produced the highest value whips, did not produce the highest value finish stock. Average finish stock value for a family was determined more by the percentage of the acceptable trees (a measure of quality), than by plant height or caliper (measures of growth).

Index words: heritability, tree improvement, nursery productivity, plant quality, *Quercus rubra.*

Significance to the Nursery Industry

High quality red oak whips can be produced rapidly under Ohio Production System conditions. OPS-produced whips transplanted to nursery fields have high survival and rapid growth rates. During production, growth and quality are strongly influenced by red oak mother tree. All the traits measured in this study, height, caliper, percent acceptable and family individual tree value, have relatively high heritability estimates, indicating that traits are under genetic control and thus subject to manipulation by nursery managers. Nursery productivity (defined in this study as gross dollars/year) can be significantly increased by raising whips and finish stock from selected mother trees. It is also expected that net nursery productivity would also be increased by raising nursery stock from genetically superior mother trees. The best family for whip production was not the best family for finish stock production. Finish stock value was determined more by percentage of acceptable trees (a quality indicator), than by growth (plant height or caliper). The greatest gains are made by combining the best cultural practices, which may included novel production systems, with genetically superior seed sources. However, raising nursery stock from genetically superior seed sources will increase nursery productivity in any production system.

Introduction

Most tree species are propagated by seed. With woody landscape plants, seed source, or provenance, has a dramatic effect on plant growth (10, 11) and thus on nursery productivity. Selecting and growing the best seed sources can boost nursery productivity because it costs no more to produce seedlings from genetically superior seed sources than it does genetically inferior sources.

There is great variability in economically important traits among red oak provenances (4, 5, 6). If the variability is under genetic control then the variability can be manipulated by the nursery manager. Narrow sense heritability estimates are used to estimate the degree of genetic control for a given trait when using seed (sexual) propagation. Heritability estimates range from 0, no genetic control, to 1, complete genetic control. One study found narrow sense heritability estimates for juvenile red oak height growth to be high, 0.64 (9).

The effects of mother tree on whip production have been described (8). The purpose of this study was to document

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172-93 of the Ohio Agriculture Research and Development Center, The Ohio State University, Columbus, OH.

[2]Associate Professor.

[3]Associate Professor, Department of Forestry, North Carolina State University, Raleigh, NC 27695-8002.