INITIAL CERULEAN WARBLER RESPONSE TO EXPERIMENTAL SILVICULTURAL MANIPULATIONS, DESHA COUNTY, ARKANSAS

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Abstract—Cerulean warbler [*Dendroica cerulea* (Wilson) Aves, Parulidae] is a neotropical migratory bird that has become a focus of management attention. Since 1992, we have studied breeding birds on a 54-ha site owned by Anderson-Tully Company, in Desha County, AR. In 2002, we conducted an unreplicated experiment there to assess the species' response to silvicultural manipulation within its habitat. We applied one of two sulvicultural prescriptions to randomly selected halves of the plot. Establishment criteria were that each half-plot be the same size and have had a comparable history of warbler use. Treatments were (1) a standard Anderson-Tully Company prescription designed to establish regeneration, develop existing advance regeneration, and add growth to residual sawtimber trees; and (2) a prescription designed to add growth to residual sawtimber trees and favor development of trees similar to those used by the cerulean warbler. Our initial posttreatment survey identified three cerulean warbler territories on the subplot treated with the cerulean warbler prescription and none on the other portion.

INTRODUCTION

Successful management of forest lands requires the translation of identified objectives into silvicultural prescriptions that can be followed by timber markers and loggers. Difficulties in making specifications clear and implementable often have led some communities of interest to doubt the silviculturists' intent or sincerity (Hamel and others 2001). More particularly, clear management prescriptions designed to support habitat objectives for nongame wildlife, including songbirds, have been lacking. Development of dependable prescriptions capable of producing habitat for late-successional species is an especially daunting task.

Cerulean warbler [*Dendroica cerulea* (Wilson) Aves, Parulidae] is a neotropical migratory bird in need of management attention. To date, however, no silvicultural prescriptions to enhance or restore its habitat have been proffered (Hamel and others 2004). Populations have declined by as much as 50 percent since 1966, as measured by the Breeding Bird Survey (Hamel 2000a). Link and Sauer (2002) reported an annual reduction of 3 percent. In the Lower Mississippi Alluvial Valley, this songbird has become a target species for landscape management, conservation, and afforestation efforts (Mueller and others 1999). Its documented population declines led to a petition filed with the U.S. Fish and Wildlife Service to list it as threatened under provisions of the Endangered Species Act of 1973, as amended (Ruley 2000). The U.S. Fish and Wildlife Service ruled that the species not be listed (Williams 2002). Although quantitative assessments of cerulean warbler habitat are available (Hamel 2000b; Hamel 2005; Kahl and others 1985), no suitable silvicultural prescription has yet been articulated, and data on fitness consequences of different habitats for this species are scarce.

Male cerulean warblers routinely spend much of their time in large sawtimber trees singing, foraging, and attempting to attract females (Hamel 2005). Female cerulean warblers choose nest sites and tend to use trees smaller in stature and more shade-tolerant than those favored by the male (Hamel 2005). Jones and others (2001) have considered other features of vertical and horizontal habitat structure that also may be of great importance in habitat selection. This report is a beginning of one effort to articulate and evaluate a prescription suitable for both economically viable timber production and ecologically viable habitat production for this important songbird.

METHODS

Study Site

Since 1992, we have studied the breeding population of the cerulean warbler on a 54.5-ha site (hereafter study grid) in Desha County, AR (Hamel 1998, Woodson and others 1995). The site is part of a 130-ha compartment (hereafter treatment area) on more extensive property owned and managed by Anderson-Tully Company, for production of high-quality sawtimber (fig. 1). It is located in the Mississippi Alluvial Valley, in the batture land of the Mississippi River, on sandy loam soil

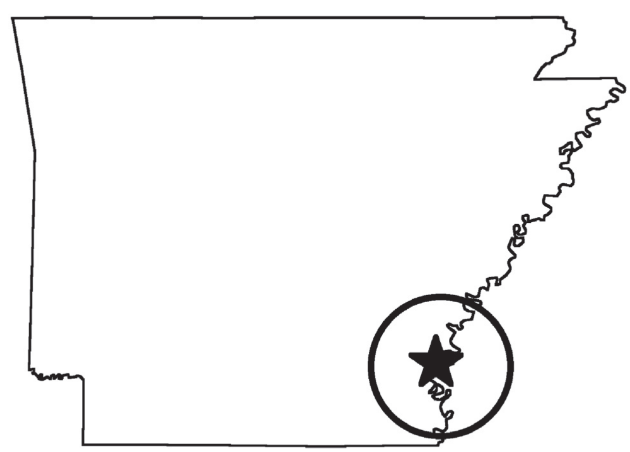

Figure 1—Locator map of cerulean warbler study site in Desha County, AR.

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with ridge and swale topography near the riverbank. The site is typical of riverfront hardwood tracts in the Lower Mississippi Valley. Prior to our study, a harvest treatment according to standard Anderson-Tully Company prescription was conducted on the tract in 1991. In that year, coauthor Mike Staten and his colleagues located cerulean warblers on the site while searching for suitable sites for a study of distribution, habitat use, and demography of that species in the Mississippi Alluvial Valley (Hamel 1998, Hamel and others 1998).

Pretreatment Monitoring

Avian sampling—From 1992 to 2001, we conducted annual spotmap surveys within the tract, sought nest locations, measured vegetation, and documented habitat use. We established a 50- by 50-m grid of points on the site using compass and tape. Initially, we marked intersections of the study grid (n = 230) with wooden stakes and annually installed individually labeled flags thereafter.

Vegetation sampling—We sampled vegetation at each intersection point of the study grid. At each point, we conducted a survey of forest trees, measured canopy cover using an ocular device (forest densiometer and/or forest densitometer), determined percent ground cover, and counted saplings < 7.5-cm diameter at breast height (d.b.h.) on 0.005-ha plots. Using a 30-basal area factor English (6.9-basal area factor metric) angle gauge (prism), we identified all trees within the variable-radius plot to species and measured height in meters, d.b.h. in centimeters, and crown class. We also noted the presence or absence of lianas reaching into the crown. Further vegetation sampling was done by identifying individual trees in which cerulean warblers were located and marking those trees with uniquely numbered aluminum tags placed at ground level on the north side of the tree. We measured those trees just as we had measured those in vegetation samples at the study grid intersections, as well as height of the bird in the tree and other associated metrics of its behavior. We identified > 1,000 trees in this way, principally from 1992 to 1994.

Preharvest timber cruise—The preharvest cruise in 2002 consisted of 144 circular plots systematically located 2 chains (40 m) apart, on transects 10 chains (201 m) apart. This represents an approximate 5 percent cruise of the 130-ha treatment area. Diameter and commercial height of trees ≥ 12 inches (30 cm) d.b.h. were tallied on 0.1-acre (0.04-ha) plots. Smaller trees, 6 to 12 inches (15 to 30 cm) d.b.h., were tallied on concentric 0.05-acre (0.02-ha) subplots. Regeneration stems 1 to 5 inches (2.5 to 12 cm) were tallied on concentric 0.01-acre (0.004-ha) subplots. We estimated available timber volume from these data using proprietary software and volume tables of Anderson-Tully Company.

Silvicultural Treatments

In 2002, the treatment area was scheduled for entry in the normal rotation of Company lands. We began an unreplicated experiment to assess the species' response to alternative silvicultural treatments. Harvesting was done by partial cutting during the nonbreeding period for cerulean warblers; it began in winter 2002 and was completed in winter 2004.

Subplot selection—We compiled composite spotmaps of cerulean warbler use of the study grid from 1992 to 1996. We also produced maps of the locations of uniquely marked cerulean warbler use and nest trees. We sought to divide the grid into two equal parts, reflecting equal cerulean warbler use and comparable vegetation. Use was heavier in the eastern part than in the western part of the grid but relatively equally distributed between the north and south (fig. 2). As a result,

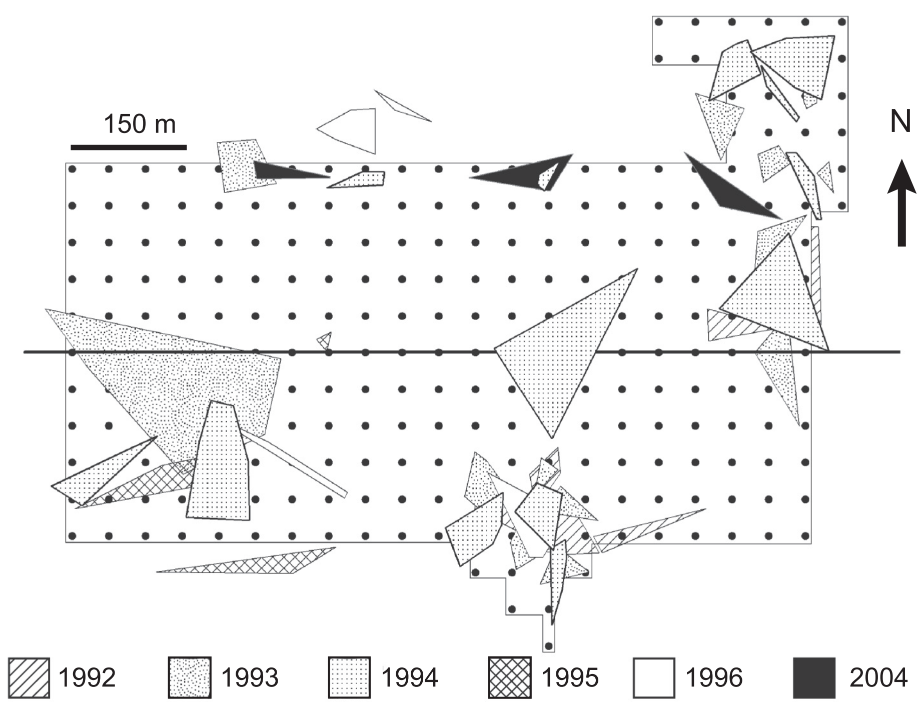

Figure 2—Distribution of cerulean warbler territories during pretreatment surveys 1992 to 1996, and posttreatment 2004, on cerulean warbler study grid, Desha County, AR. Horizontal line indicates boundary between the north and south subplots.

we subdivided the study grid into north and south subplots. By coin flip, the north subplot was selected to receive the cerulean warbler prescription.

Standard prescription—The Anderson-Tully Company standard prescription was applied to the southern half of the treatment area, including the southern half of the study grid. The partial-cutting prescription involved elements of improvement cutting, thinning, and regeneration cutting. It involved cutting in the overstory to reduce mortality, improve species composition and spacing, and increase growth of the residual stand. It further involved cutting in the midstory to remove poorly formed shade-tolerant species in order to release advance regeneration and encourage the establishment and growth of additional shade-intolerant regeneration of desirable species. The prescription was implemented by marking stems to be removed from the stand. Other stems, including all elm (*Ulmus americana* L.), sugarberry (*Celtis laevigata* L.), and boxelder (*Acer negundo* L.), were cut unless they were of superior form and quality.

Cerulean warbler prescription—Applied to the northern half of the treatment area, including the northern half of the study grid, the cerulean warbler prescription was based on the findings of Hamel (2005). It recognized the importance of tall sawtimber trees as song perch trees for the male and of large, often shade-tolerant trees for the nest. This partial-cutting prescription was a modification of the Company standard prescription, involving elements of improvement cutting, thinning, and regeneration cutting. It differed from the standard prescription in that fewer trees were removed from the shade-tolerant midstory. Researchers spent time in the stand with the foresters before timber marking in order to help them better recognize shade-tolerant midstory trees that were potential nest trees. Such trees were marked with an X and would be designated “leave trees” during the actual timber marking process.

Postharvest Monitoring

Harvest sampling—We recorded sawtimber volume removed by species and tons of pulpwood removed from the entire treatment area. Diameter class distributions of unharvested *A. negundo, C. laevigata,* and *U. americana* stems were used to calculate the difference in residual trees of these species between the two subplots. From the calculated differences, we made an estimate of the economic value of stems not harvested during application of the cerulean warbler prescription. Future measurements will evaluate the opportunity cost to the Company of implementing the cerulean warbler treatment, in terms of differences in the release of advance regeneration and establishment of additional desirable shade-intolerant regeneration compared to the Company standard treatment.

Vegetation sampling—In January 2005, we randomly selected and measured a sample of 26 intersection points in each subplot on the study grid. At each of the points we selected canopy trees for inclusion in the sample using a 30-BAF English (6.9-BAF metric) angle gauge. We identified each selected tree by species, measured its d.b.h. in cm, determined crown class, and noted the presence of vines in its canopy.

Cerulean warbler sampling—In 2004, we conducted a spotmap census of cerulean warbler and other warbler species present on the plot, as we had in the pretreatment surveys. We anticipate conducting annual or biennial spotmap censuses in the future.

Data Analysis

We tested the hypothesis that no differences existed in basal area and density of trees and saplings on the two subplots before and after harvest using an analysis of variance of year nested within subplot. We tested for interaction between year and subplot using analysis of variance with year and subplot as main effects. We used analysis of variance of year, tree species, subplot, and interaction between species and subplot to assess differences in composition between subplots. For grid points sampled in both 1993 and 2005, we calculated the change in basal area for each species on each plot and used analysis of variance to test for differences between plots. Harvest data were considered an inventory and examined in tabular form. Distribution of observed cerulean warbler occurrence on the plot from 1992 to 2001 was examined visually. Trees used by the birds were summarized graphically and in tabular form. Spotmap census from the first sample post-treatment was examined visually. Statistical tests were carried out in SAS (SAS Institute 1999-2000) with statistical significance accepted at $P = 0.05$.

RESULTS

Vegetation on Treatment Subplots

Analysis of variance of tree density and basal area revealed no interaction between year and subplot for either of the parameters. Sapling density did not differ between subplots in 1993 (north – 346 ± 40 saplings/ha, N = 137; south – 421 ± 38 saplings/ha, N = 123; $t_{258\ df} = -1.34$, $P = 0.18$) or 2005 ($t_{50\ df} = -0.68$, $P = 0.5$). Analysis of tree density as a function of subplot and year nested within subplot showed a significant result ($F_{3, 304} = 5.02$, $P = 0.002$, $R^2 = 0.05$) attributable to differences among years ($P = 0.0007$) but not subplots ($P = 0.5$). Tree density in the south subplot in 2005 (160 trees/ha) exceeded that in either subplot in 1993 (north – 96 trees/ha; south – 94/ha) but not that in the north in 2005 (138 trees/ha; fig. 3). Identical analysis of basal area also revealed a significant result ($F_{3, 304} = 8.11$, $P < 0.0001$, $R^2 = 0.07$) but here attributable to differences in subplots ($P < 0.0001$) but not to years nested within subplots ($P = 0.07$). The north subplot had significantly greater basal area than the south in 1993 (25.0 vs. 20.3 m^2/ha, $P = 0.01$) and 2005 (27.6 vs. 14.8 m^2/ha, $P = 0.001$).

Estimates of basal area of three species differed between the subplots. The north subplot had higher basal area than the south for sugarberry (7.9 vs. 4.4 m^2/ha, $F_{3, 304} = 7.51$, $P < 0.0001$, $R^2 = 0.07$) and bald cypress [*Taxodium distichum* (L.) Richard] (3.8 vs. 1.7 m^2/ha, $F_{3, 304} = 2.8$, $P = 0.04$, $R^2 = 0.03$). Basal area of *U. americana* on the south subplot declined significantly more from 1993 to 2005 than it did on the north, where it actually increased ($F_{1, 49} = 7.23$, $P = 0.01$, $R^2 = 0.13$; table 1).

Cerulean Warbler Use of Space and Vegetation 1992-2002

Cerulean warbler use of north and south parts of the study grid was nearly equal during the early, pretreatment period (fig. 2). From 1992 to 1996, an average of 4.4 (range 2 to 7.5) territories were present on the north subplot, and 4.1 territories (range 2 to 7) were present on the south. After 1996, the

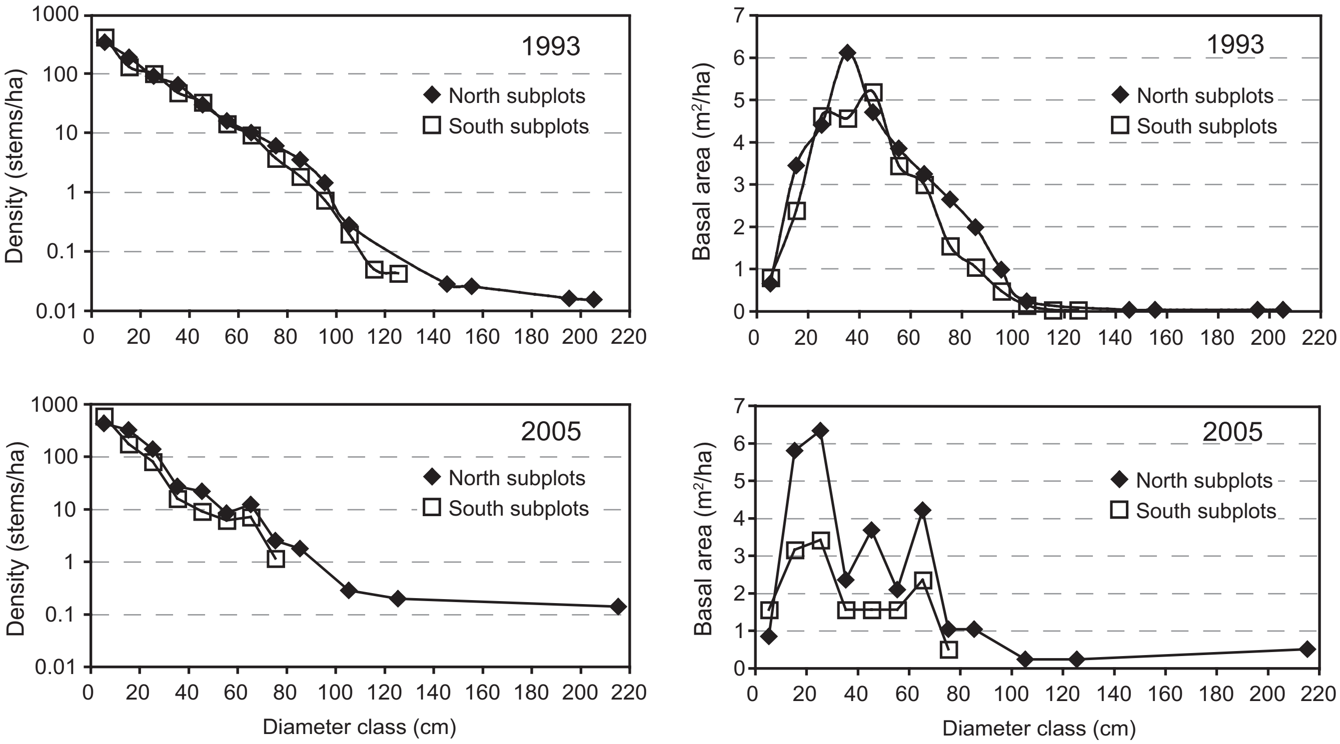

Figure 3—Diameter class distribution of basal area and stem density on north and south subplots of cerulean warbler study grid, Desha County, AR, in 1993 (pretreatment) and 2005 (posttreatment).

Table 1—Comparison of vegetation samples in the pretreatment and posttreatment subplots, Cerulean Warbler Experimental Study Grid, Desha County, AR

	North		South	
	Sample			
	Size[a]	Plots (no,)[b]	Size[a]	Plots (no.)[b]
Species[c]	137	26	123	26
Acer negundo	2.6 ± 0.4	2.1 ± 0.74	2.2 ± 0.43	1.59 ± 0.69
A. rubrum L.	0.05 ± 0.05	0 ± 0	0 ± 0	0 ± 0
Carya illinoiensis (Wang.) K. Koch	0.6 ± 0.2	1.6 ± 0.79	0.39 ± 0.14	1.06 ± 0.5
Celtis laevigata[d]	7.3 ± 0.64	10.1 ± 1.9	4.2 ± 0.48	5 ± 1.6
Cornus drummondii C.A. Meyer	0 ± 0	0.53 ± 0.37	0 ± 0	0 ± 0
Diospyros virginiana L.	0 ± 0	0 ± 0	0 ± 0	0.26 ± 0.26
Fraxinus pennsylvanica	4.4 ± 0.73	4.2 ± 1.62	4.1 ± 0.71	2.1 ± 0.92
Liquidambar styraciflua L.	0.4 ± 0.2	0 ± 0	1.01 ± 0.27	1.3 ± 0.66
Platanus occidentalis	2.1 ± 0.33	0.79 ± 0.44	2.97 ± 0.46	1.85 ± 0.61
Populus deltoides	0.25 ± 0.17	0.26 ± 0.26	0.28 ± 0.15	0.26 ± 0.26
Quercus nuttallii Palmer	0.1 ± 0.07	0 ± 0	0 ± 0	0 ± 0
Dead trees	0.9 ± 0.2	0 ± 0	0.95 ± 0.24	0 ± 0
Taxodium distichum[d]	3.5 ± 0.74	5.3 ± 1.9	1.8 ± 0.49	1.06 ± 0.5
Ulmus americana[d, e]	2.2 ± 0.31	2.9 ± 0.87	2.3 ± 0.35	0.26 ± 0.26
Total basal area/ha[f]	32 ± 1.17	27.8 ± 2.92	26.8 ± 1.16	14.8 ± 2.08
Total tree density/ha	89 ± 5.3	138 ± 13	90 ± 6	160 ± 44
Sapling density/ha	346 ± 40	444 ± 99	420 ± 38	541 ± 102

Numbers represent basal area/ha ± S.E.

[a] In 1993.

[b] In 2005.

[c] Unless otherwise indicated, values in the columns do not differ at $P = 0.05$.

[d] North subplot has significantly higher basal area than South; years don't differ.

[e] Decline in basal area per plot from1993 to 2005 was significantly greater in South subplot than in North subplot.

[f] North subplot has significantly higher basal area than South subplot in 1993 and 2005; 1993 basal area is significantly higher than 2005 as well.

birds virtually had disappeared from the plot, presumably as a result of a 1994 ice storm that severely damaged the forest canopy. The birds' use of tree species in relation to availability, summarized over the entire plot, indicated that use of the most abundant species, *C.laevigata* and *A, negundo*, was less than expected; that use of moderately abundant species, *U, americana* and green ash (*Fraxinus pennsylvanica* Marshall) was in proportion to their availability; and use of the less numerous sycamore (*Platanus occidentalis* L.) and cottonwood (*Populus deltoides* Marshall) exceeded that predicted by the number of available stems (fig. 4).

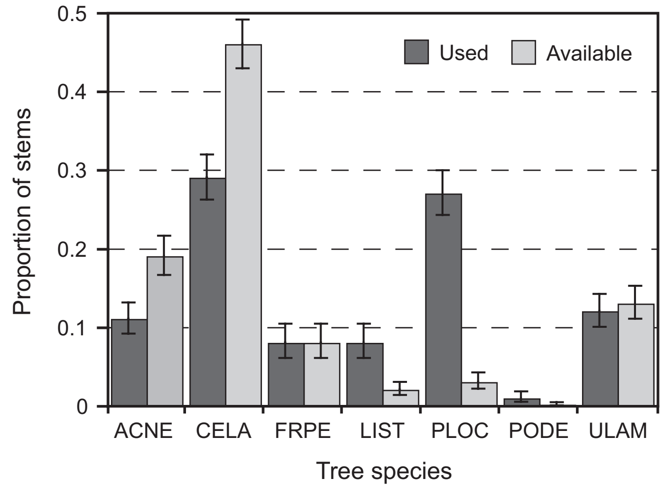

Figure 4—Availability and use by cerulean warblers of trees on cerulean warbler study grid, Desha County, AR, 1992 to 2001. Error bars indicate 95 percent confidence limits. Tree species codes are ACNE = *Acer negundo*, CELA = *Celtis laevigata*, FRPE = *Fraxinus pennsylvanica*, LIST = *Liquidambar styraciflua*, PLOC = *Platanus occidentalis*, PODE = *Populus deltoides*, and ULAM = *Ulmus americana*.

Harvest Removals, Value of Unharvested Stems, and Opportunity Costs

Standing crop estimate of available sawtimber by subplot and combined sawtimber removals from the entire treatment area reflect differences apparent in vegetation sampling (table 2). Comparison of diameter class distribution of predominant pulpwood species (table 3) and pulpwood removals indicates an estimated value of unharvested pulpwood and sawlogs resulting from the cerulean warbler prescription (relative to the Company standard) to be approximately $100 per acre ($250/ha) on the 160-acre (65-ha) north subplot. Opportunity costs of lost advance regeneration cannot yet be estimated.

Cerulean Warbler Use Posttreatment

Initial posttreatment survey of cerulean warbler response located the birds using portions of the study grid treated with the cerulean warbler prescription (fig. 2). Importantly, some 2004 use occurred in parts of the plot that had not been part of territories identified during pretreatment surveys, possibly indicating a specific response to the treatment.

DISCUSSION

Initial results of this experiment suggest that a specific silvicultural prescription for cerulean warbler may be possible in bottomland hardwood forests. Modest differences between the subplots occurred where *C. laevigata* was most abundant. Within the treatment area, this species is plentiful and, in fact, it occurs in far higher abundance than is used by the birds. Differences between subplots in abundance of *T. distichum* reflect differences in extent of ridge and swale topography; because these differences occurred for a tree species for which no cerulean warbler use was registered, they are not relevant to our experiment. Difference between the subplots in abundance of *U. americana* after the harvest treatment, however, are relevant, and they reflect the specific intent of the two prescriptions. In the Company standard prescription, the commercially less valuable *U. americana* was removed.

Table 2—Sawtimber available and removals from the subplots of the Cerulean Warbler treatment area

	Preharvest cruise		
	North	South	Total removals
Species	160 (65)[a]	160 (65)[a]	320 (130)[a]
	board feet (m^3)		
Carya illinoiensis	108,642 (256.4)	93,983 (221.8)	27,539 (65)
Celtis laevigata	102,647 (242.2)	74,016 (174.7)	101,753 (240.1)
Fraxinus pennsylvanica	294,460 (694.8)	166,725 (393.4)	185,290 (437.2)
Liquidambar styraciflua	3,605 (8.5)	42,279 (99.8)	14,611 (34.5)
Platanus occidentalis	118,895 (280.6)	277,895 (655.8)	175,519 (414.2)
Populus deltoides	35,673 (84.2)	63,101 (148.9)	45,187 (106.6)
Quercus lyrata Walter	3,087 (7.3)	0 (0)	1,431 (3.4)
Q. nuttallii	7,076 (16.7)	9,665 (22.8)	5,344 (12.6)
Taxodium distichum	216,670 (511.3)	189,362 (446.8)	71,855 (169.6)
Ulmus americana	45,385 (107.1)	39,320 (92.8)	21,060 (49.7)
Other species	13,000 (30.7)	10,000 (23.6)	21,544 (50.8)
Total	949,140 ± 189,828 (2,240 ± 448)	966,346 ± 193,269.2 (2,280 ± 456)	671,133 ± 134,226.6 (1,584 ± 317)

[a] Area, acres (ha).

Table 3—Pulpwood removals and costs to company of applying the cerulean warbler prescription

Diameter at breast height	Pulpwood		Sawlogs	
inches (cm)	*tons per acre (mt/ha)*		*board feet per acre (m^3/ha)*	
10 (25)	5.88	(1.082)		
14 (35)	4.03	(0.741)		
18 (45)	0.30	(0.056)	316	(0.745)
22 (55)	0.26	(0.048)	298	(0.704)
26 (65)	0.21	(0.039)	175	(0.413)
Total	10.68	(1.966)	789	(1.862)
Cost per acre (/ha)	53.42	(131.95)	51.29	(126.69)
Total cost, treatment area (dollars)	8,547.40		8,206.64	

Values in the table reflect the difference between estimated standing crop of *Acer negundo, Celtis laevigata,* and *Ulmus americana* in 2005 on the North and South subplots. Cost estimate reflects market values in January 2005.

In the cerulean warbler prescription, *U. americana* stems in favorable codominant and intermediate positions were left as potential nest trees. Our experimental manipulation thus created a contrast between effects of treatments that emphasize the desired difference between treatments. The experiment thus offers a test of a prediction made by Robbins and others (1992) that *U. americana* is important to cerulean warbler.

The cerulean warbler prescription appears to have fostered use by the bird in the direction of the desired future condition; this is encouraging, although it has been observed in an unreplicated study. We are cautious, also, because the species' presence does not equate with successful reproduction. Until further work is completed, we cannot distinguish the current result from one in which the birds occur in the north simply as a result of historical presence in small numbers in the northern part of the study grid but not in the southern part.

Finally, we offer a word about the difficulty of developing common terminology, measurement, and data analysis among the professions represented in the investigators of this work. Standard methods in practical forestry take measures in English units, easily produce summaries that reflect commercially important volumetric parameters, and may be developed in software that does not admit exchange of datasets with other analytical tools. Standard methods in avian behavioral ecology take measures in metric units, cannot easily produce estimates of commercial parameters but are easily communicated among analytical tools. These differences made it very difficult for us to develop a common framework for expressing preharvest conditions, as well as to create a common vocabulary for communicating instructions to the timber markers who applied the prescriptions. We hope our experience will benefit others who undertake the development of silvicultural prescriptions for songbirds and other species of special concern.

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LITERATURE CITED

Hamel, P.B. 1998. Landscape and habitat distribution of the cerulean warbler *Dendroica cerulea* in extensively fragmented Mississippi alluvial valley, USA. In: Adams, N.J.; Slotow, R.H., eds. Proceedings of the 22d international ornithological congress. Ostrich. 69(3&4): 286.

Hamel, P.B. 2000a. Cerulean warbler status assessment. St. Paul, MN: U.S. Department of the Interior, Fish and Wildlife Service. 141 p. Available online at: <http://www.fws.gov/midwest/endangered/birds/cerw/cerw-sa.pdf> [Date accessed: August 9, 2005].

Hamel, P.B. 2000b. Cerulean warbler *Dendroica cerulea*. In: Poole, A.; Gill, F., eds. The birds of North America series, No. 511. Philadelphia, PA: The Birds of North America, Inc. 20 p.

Hamel, P.B. 2005. Suggestions for a silvicultural prescription for Cerulean Warblers in the lower Mississippi Alluvial Valley. In: Ralph, C.J.; Rich, T.D., eds. Bird conservation implementation and integration in the Americas: proceedings of the third international partners in flight conference. Gen. Tech. Rep. PSW-191. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station: 567-575.

Hamel, P.B.; Cooper, R.J.; Smith, W.P. 1998. The uncertain future for cerulean warblers in the Mississippi Alluvial Valley. In: Proceedings of the Delta conference. Madison, MS: U.S. Department of Agriculture, Natural Resources Conservation Service: 95-108.

Hamel, P.B.; Dawson, D.K.; Keyser, P.D. 2004. Overview: how we can learn more about the cerulean warbler (*Dendroica cerulea*). Auk. 121(1): 7-14.

Hamel, P.B.; Meadows, J.S.; Gardiner, E.S.; Stanturf, J.A. 2001. Chainsaws, canebrakes, and cotton fields: sober thoughts on silviculture for songbirds in bottomland forests. In: Hamel, P.B.; Foti, T.L., tech. eds. Bottomland hardwoods of the Mississippi Alluvial Valley: characteristics and management of natural function, structure, and composition. Gen. Tech. Rep. SRS-42. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station: 99-105.

Jones, J.; DeBruyn, R.D.; Barg, J.J.; Robertson, R.J. 2001. Assessing the effects of natural disturbance on a Neotropical migrant songbird. Ecology. 82: 2628-2635.

Kahl, R.B.; Baskett, T.S.; Ellis, J.A.; Burroughs, J.N. 1985. Characteristics of summer habitats of selected nongame birds in Missouri. Research Bulletin 1056. Columbia, MO: University of Missouri-Columbia Agricultural Experiment Station. 155 p.

Link, W.A.; Sauer, J.R. 2002. A hierarchical analysis of population change with application to Cerulean Warblers. Ecology. 83: 2832-2840.

Mueller, A.J.; Twedt, D.J.; Loesch, C.R. 1999. Development of management objectives for breeding birds in the Mississippi Alluvial Valley. In: Bonney, R.; Pashley, D.N.; Cooper, R.J.; Niles, L., eds. Strategies for bird conservation: the partners in flight planning process. Cornell Laboratory of Ornithology. <http://www.birds.cornell.edu/pifcapemay/mueller.htm> [Date accessed: August 9, 2005].

Robbins, C.S.; Fitzpatrick, J.; Hamel, P.B. 1992. A warbler in trouble: *Dendroica cerulea*. In: Hagan, J.M., III; Johnston, D.W., eds. Ecology and conservation of Neotropical migrant landbirds. Washington, D.C.: Smithsonian Institution Press: 549-562.

Ruley, D.A. 2000. Petition under the Endangered Species Act to list the cerulean warbler, *Dendroica cerulea*, as a threatened species. Asheville, NC: Southern Environmental Law Center. 50 p.

SAS Institute. 1999-2000. The SAS system for Windows, proprietary release 8.1. Cary, NC: SAS Institute. [Not paged].

Williams, B. 2002. Cerulean warbler: to list or not to list! The Chattooga Quarterly, Winter 2002. <http://www.chattoogariver.org/Articles/2002W/cerulean.htm> [Date accessed: February 24, 2005].

Woodson, C.A.; Cooper, R.J.; Hamel, P.B. 1995. Cerulean warbler life history research in bottomland hardwood forests. The Habitat. 12(1): 5, 6, 12.