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PREDICTING THE EFFECTS OF ECOSYSTEM MANAGEMENT HARVESTING TREATMENTS ON BREEDING BIRDS IN PINE HARDWOOD FORESTS

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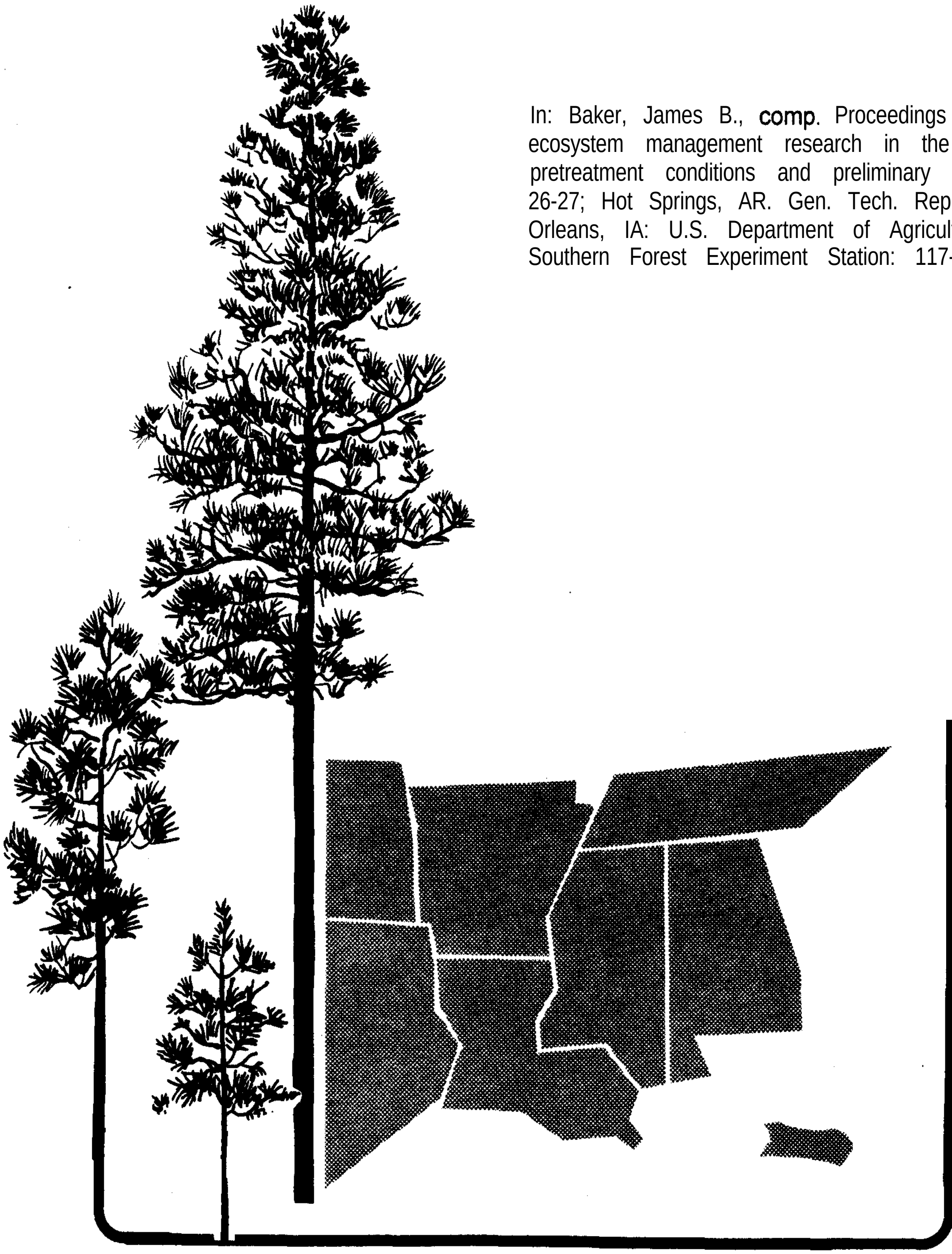

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Predicting the Effects of Ecosystem Management Harvesting Treatments on Breeding Bids in Pine-Hardwood Forests'

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ABSTRACT

Habitat relationships of birds are well known compared to those of other taxa. However, a major obstacle to developing rigorous management plans for birds is the collation and transfer of information from widely scattered technical and academic publications to a form that can be applied directly to the management of species. Recognizing this dilemma, Hamel (1992) produced a comprehensive summary of bird-habitat relationships for 23 forest types in the Southeastern United States. The explicit purpose of Hamel's summary was to aid land managers in projecting the impacts of silvicultuml practices and management activities on bii populations. Ecosystem Management Research offered a unique opportunity to develop and teat predictions derived from Hamel's bird-habitat matrices. Given its probable widespread use by wildlife biologists and land managers, Hamel's compilation oeeds its strengths and weaknesses identified for the future development of accwate predictive models of wildlife habitat in the Southeastern United States. Predictions of immediate changes in abundances of species and guilds occupying late-rotation pine-hardwood stands were developed in this paper for four harvesting treatments. Clearcutting and shelterwood harvesting were predicted to be more detrimental to the overall breeding bird community in late-rotation stands than were group or single-tree selection, although at least several species were predicted to increase in each silvicultural treatment. Bark, aerial, and canopy insectivores were predicted to exhibit more substantial declines in populations than carnivores, shrub insectivores, and ground foragers. In addition, species that place their nests in shrubs were predicted to undergo fewer declines than species that place nests in the canopy, tree cavities, and oo the ground.

INTRODUCTION

The negative environmental consequences associated with human populatioo growth and economic expansion have focused much attention on the long-term sustainability of natural resources as well as prompting detailed examination of the ways in which those resources am managed. For wildlife biologists involved in those issues, the goal is often to develop predictive algorithms that relate land-use practices or management techniques to the density and viability of wildlife populations oo local (e.g., Venter and others 1986) and regional (e.g., Joyce and others 1990) scales. Those efforts, however, are often hindered because of lack of detailed information on the habitat associations, nesting and food requirements, aod life-history traits of most species (DeGraaf 1991, Martin 1992).

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Ecology and habitat relationships of North American birds are well known relative to those of other taxa, such as mammals, amphibians, and reptiles (Capen 1981, DeGraaf 1978, Evans 1978, Evans and Kirkman 1981, Ruggiero and others 1991). Nevertheless, one major obstacle to developing rigorous management plans for birds is the collation and transfer of information from technical academic publications to a form that can be applied directly to the management of those species. Recognizing this dilemma, several authors have synthesized large volumes of literature on regional habitat relationships of birds in attempts to provide comprehensive, yet condensed, summaries to land managers (e.g., Hamel and others 1982, Verner and Boss 1980). These summaries have the explicit purpose of guiding land managers in evaluating the projected impact of different management practices on terrestrial land birds. However, not only are these bird-habitat matrices incomplete due to a scant primary literature and lack of geographic specificity, but the nonquantitative format might allow land managers to construct only generalized predictions. For example, extreme types of habitat manipulations (e.g., clearcutting) may have predictable outcomes on bird populations, but consequences of more subtle management prescriptions (e.g., thinning of hardwoods) may be impossible to estimate from bird-habitat matrices or even from existing primary literature. The potential widespread use of bird-habitat matrices by wildlife and land managers requires that the accuracy and precision of projections from those summaries be tested before actually being put into field use.

In 1992, Paul Hamel produced the most comprehensive regional summary of bird-habitat relationships ever published in the United States, a revision of a document completed 10 years earlier (Hamel and others 1982). Hamel's (1992) summary of information for 23 forest types in the Southeastern United States provided state-of-the-art guidelines for land managers in that 13-state region. The guide had two primary uses, one of which was "to aid the manager both in prescribing treatments aimed at improving avian habitats and in assessing and ameliorating the impacts of other management activities on bird communities' (Hamel 1992, p. 3). Hamel also stressed that guidelines provided in the manual could be improved through further testing and supplementation of information.

The USDA Forest Service's Ecosystem Management Research in the Ouachita and Ozark National Forests offers a unique opportunity to assess the predictability of Hamel's bird-habitat matrices, as well as to improve upon the information contained therein. In this paper, Hamel's bird-habitat matrices were used to project changes in relative population densities of species and in representation of foraging and nesting guilds that will occur within the first few (1 to 3) years following different Ecosystem Management harvesting regimes. (Examination of predicted trends with observed outcomes will be completed after several years of posttreatment data are gathered.) Given the immediate widespread use of Hamel's landmark guide by USDA Forest Service personnel, as well as other government and private land managers, identification of strengths and weaknesses of this compilation is both timely and critical for development of accurate predictive models of wildlife habitat in the Southeastern United States.

METHODS

Study Sites

Birds were surveyed on 20 of the Ecosystem Management Research stands in the Ozark and Ouachita National Forests of Arkansas and Oklahoma (Thill and others, this volume). Each 14 to 16 ha site corresponded to an individual USDA Forest Service compartment and stand and was separated from other sites by more than 5 km. Stands were comprised of mixed pine-hardwoods that were more than 70 years old. Dominant midstory and overstory tree species included *Carya* spp. *Pinus cchinata* Mill., *Quercus alba* L., Q. *marilandica* Muenchh., *Q. rubra* L., *Q. stellata* Wangenh., and Q. *velutina* Lam. Canopies were largely closed and had attained heights of 15-25 m. All sites were positioned on southeast-, south-, or southwest-facing slopes. Additional details of site and vegetative characteristics can be found in Baker (this volume) and Thill and others (this volume).

Pretreatment Data: Breeding Bird Communities of Late-Rotation Pine-Hardwood Stands

Bird abundance was quantified in five or six (depending on size and shape of the site) 40-m mdius (0.5 ha) circular plots spaced at greater than 130 m intervals over each site. Between 28 April and 2 June in 1992 and 1993, three visits were made to each site during which time all birds seen or heard within bird survey plots were recorded. Bird counts lasted 10 minutes and were conducted between 06:00 and 12:O0. Birds seen outside of survey plots were noted but were not included in this paper (see D.R. Petit and others [this volume] for additional details).

Fifty-five species were recorded on the 20 sites in 1992 and 1993. Most species were rare, with 82 percent of all individuals being represented by just 10 species (D.R. Petit and others, this volume). All species were assigned to a nesting and foraging/trophic guild based upon Hamel (1992) and Ehrlich and others (1988).

Ecosystem Management Harvesting Treatments

Four harvesting treatments are to be applied to each of four sites (four additional stands will act as control sites where no harvesting will be performed). On all sites (except controls), understory hardwoods will be controlled (herbicide or mechanical methods) when necessary to ensure regeneration of an appropriate pine and hardwood mixture. Treatment descriptions below are taken from the Ecosystem Management study plan (summarized in Baker [this volume]) and represent general harvesting goals.

(1) ***Clearcut*** -- All pine and hardwoods will be harvested or removed, except for hardwoods in greenbelt buffer strips along drainages. Altogether, approximately 10 percent of hardwoods will be retained for den-trees and mast production.

(2) Pine/hardwood shelterwood -- Twenty to forty overstory pines and hardwoods (4 to 5 m^2 basal area [BA]) per hectare (ha) are to be retained throughout the stand (i.e., approximately 70 to 80 percent of merchantable trees harvested).

(3) Pine/hardwood group selection -- All merchantable pines and hardwoods will be harvested within 0.04 to 0.40 ha group openings. Cutting will be oo a 10-year rotation. No hardwoods outside openings will be harvested, but pines in those areas will be thinned to approximately 7 m^2 BA/ha (i.e., approximately 10 to 20 percent of the merchantable pines removed).

(4) Pine/hardwood single-tree selection -- Approximately 40 to 50 percent of overstory pines (5 to 7 m^2 BA/ha retained) and hardwoods (2 to 4 m^2 BA/ha retained) will be harvested in the initial thinning. Subsequent, less intensive thinning on a 10-year cycle will be used to create an uneven-aged forest structure.

Hamel's Bird-Habitat Matrices and Development of Predictions

Hamel (1992) included in his summarization information oo forest types, seral stages, and vertical vegetative layers used by species during the breeding season. In addition, specific requirements for nesting and foraging and minimum tract sizes for each species were provided, when known. Bird-habitat matrices primarily consisted of qualitative assessments of whether a given resource category (e.g., seral stage or vegetative layer) was used by each species. With the exception of seral stages and minimum tract sizes, oeither the extent of use of those resources (e.g., weighted use of vegetative layers) oor estimates of optimal conditions (e.g., percent canopy cover) were given. Predictions developed in this paper were based upon data from the mixed pine-hardwood forest type. See Hamel (1992) for additional information.

Use of qualitative measures to predict general changes from pretreatment bird populatioo densities is difficult because of the subjectiveness involved in estimating the magnitude of treatment effects on those populations. The projected relative changes in seral stage, tree density, vegetative structure, and other environmental features (e.g., leaf litter, fragmentation) associated with each of the four harvesting treatments (table 1) were estimated through examination of Ecosystem Management harvesting goals (Baker, this volume) and Phase I summaries of pretreatment and posttreatment stand conditions (Baker 1992).[3] Those changes were compared to key habitat and condition requirements indicated for each bird species by Hamel (1992), and predictions were generated on whether harvesting treatments would result in changes in relative population densities. Magnitudes of predicted changes in bird populations were estimated by assigning a score to each environmental feature within each treatment that would reflect the degree of change in the stand environment from the pretreatment (control) conditions (table 1). Subtle differences in initial harvesting volumes between group selection and single-tree selection made differentiation between effects of the two treatments oo bird populations particularly difficult. Hence, projections were based oo differences in spatial configurations of habitat alterations in addition to residual pine and hardwood basal area.

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[3] Baker, James B. 1992. New Perspectives research on the Ouachita/Ozark National Forests: Phase I -- an unreplicated pilot test. 10 p. Monticello, AR: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, Forestry Sciences Laboratory, Establishment/Progress Report FS-SO-4 106-8 1.

T&Y 1.—Changes in environmental features associated with different harvesting treatments. Environmental variables were taken from Hamel (1992). Projected estimates represent the relative changes in extent and/or condition compared w pretreatment (control) characteristics. Posttreatment conditions reflect stand characteristics expected during the initial 1 w 3 year postharvesting period

Environmental variable	Harvesting treatment			
	Clearcut	Shelterwood	Group selection	Single tree
Seral stage				
Grass/forb	I3	I3	II	I1
Shrub/seedling	I3	I3	I1	II
Sapling/poletimber	D3	D2	D1	D1
Sawtimber	D3	M	D1	D1
Vegetative layer				
Bare soil	I1	11	I1	I1
Leaf litter	M	D2	D1	D1
Herbs	I2	I2	I1	I1
Shrubs	I2	I2	11	I1
Midstory	D3	M	D1	D1
Overstory	D3	D2	D1	D1
Kay requirements				
Closed canopy	D3	D3	D2	D2
Open canopy	I1	I3	I2	I3
Grassy openings	I2	I2	13	I2
Big trees	D3	D2	D1	D1
Snags/cavity trees	D3	D2	D1	D1
Forest continuity	D2	D2	M	D1

. Letters represent decrease (D) or increase (I) in resource. Numbers represent extant of change: I = alight, 2 = moderate, 3 = major.

The algorithm used to project bird population changes was simply the sum of the key individual environmental components identified for each species (e.g., I3 = +3, D2 = -2). Based upon the distribution of these scores, arbitrary cutpoints were designated which corresponded to each level of predicted change (e.g., moderate increase). These methods represent a relatively parsimonious approach that can be updated as knowledge of species and environmental changes associated with harvesting treatments increased. Predictions were developed only for those species recorded within fixed-radius plots. Species detected on the sites, but outside of bird survey plots were excluded because those species were extremely rare, such that statistical tests aimed at testing the predictions may not be powerful. Bird species not recorded in late-rotation stands during pretreatment surveys, but known to occur in other seral stages or habitats in the region, also were not included because of the lack of information about local population levels of those species. For instance, one could predict that a certain early-successional species, which was not detected during pretreatment surveys, should be present on clearcut stands. However, if that prediction was not supported by data collected during posttreatment bird surveys, it would be difficult to conclude that clearcutting had no effect on populations of that species because factors other than habitat manipulation (e.g., geographic distribution, local abundance) could account for the lack of response.

RESULTS

Based upon information provided by Hamel (1992), harvesting treatments were predicted to have different effects on the bird species breeding in late-rotation, mixed pine-hardwood forests. Clearcut (CC) and sheltenvood (SH) probably will have the most dramatic effects on the pretreatment bird communities (table 2; see the companion paper in this volum [D.R. Petit and others] for scientific names). A total of 52 (88 percent) and 50 (85 percent) of the 59 species detected within fixed-radius plots in 1992 and 1993 were expected to exhibit appreciable decreases in population density within 1 to 3 years after clearcutting and shelterwood cuts, respectively. In contrast, only 38 (64 percent) and 36 (61 percent) of the bird species were predicted to decline after the group (GR) and single-tree (ST) treatments, respectively. Moreover, the declines under the latter hvo harvesting treatments were projected to be much less severe than the former treatments. Overall, population declines associated with harvesting treatments were predicted to be highest in CC, followed by SH, GR, and ST.

Table 2.— *Predicted population responses by bird species breeding in late-rotation pine-hardwood stands to harvesting treatments in the Ouachita and Ozark National Forests*

SPECIES	GUILD		TREATMENT			
	N	F	CC	SH	GR	ST
COOPER'S HAWK	C	CA	--	--	0/-	0/-
RED-SHOULDERED HAWK	C	CA	-	0/-	0/-	0/+
BROAD-WINGED HAWK	C	CA	-	0/-	0/-	0/+
RED-TAILED HAWK	C	CA	0/-	0/-	0/+	0/+
WILD TURKEY	G	G	--	-	0/-	0/-
NORTHERN BOBWHITE	G	G	+t	+tt	tt	+ı
MOURNING DOVE	C	GR	0/-	0/+	t	t
BLACK-BILLED CUCKOO	C	C	--	--	0/-	0/-
YELLOW-BILLED CUCKOO	C	C	--	--	0/-	0/-
BARRED OWL	H	CA	--	--	0/-	0/-
GREAT-HORNED OWL	C	CA	-	0/-	0/+	0/+
CHUCK-WILL'S WIDOW	G	A	--	--	0/-	0/-
RUBY-THROATED HUMMINGBIRD	C	N	--	-	0/+	0/+
BELTED KINGFISHER	0	P	--	-	0/-	0/-
RED-HEADED WOODPECKER	H	B	-	0/-	0/+	0/+
RED-BELLIED WOODPECKER	H	B	--	--	-	0/-
DOWNY WOODPECKER	H	B	--	--	0/-	0/-
HAIRY WOODPECKER	H	B	--	--	--	-
NORTHERN FLICKER	H	B	--	-	0/+	0/+
PILEATED WOODPECKER	H	B	--	--	--	-

SPECIES	GUILD		TREATMENT			
	N	F	CC	SH	GR	ST
EASTERN WOOD-PEWEE	C	A	--	--	0/-	0/-
ACADIAN FLYCATCHER	C	A	--	--	-	0/-
GREAT CRESTED FLYCATCHER	H	A	--	--	-	-
BLUE JAY	C	O	-	-	0/+	0/+
AMERICAN CROW	C	O	--	-	0/-	0/-
CAROLINA CHICKADEE	H	C	--	--	0/-	0/-
TUFTED TITMOUSE	H	C	--	--	0/-	0/-
WHITE-BREASTED NUTHATCH	H	B	--	--	-	-
BROWN-HEADED NUTHATCH	H	B	--	--	0/-	0/-
CAROLINA WREN	H	G	-	0/-	0/+	0/+
BLUE-GRAY GNATCATCHER	C	C	--	--	0/-	0/-
WOOD THRUSH	S	G	--	--	-	0/-
GRAY CATBIRD	S	S	-	0/-	0/+	0/+
CEDAR WAXWING	C	C	-	0/-	0/+	0/+
WHITE-EYED VIREO	S	S	0/-	0/+	+	+
YELLOW-THROATED VIREO	C	C	--	--	0/-	0/-
RED-EYED VIREO	C	C	--	--	-	0/-
NORTHERN PARULA	C	C	--	--	-	0/-
YELLOW-THROATED WARBLER	C	C	--	--	-	-
PINE WARBLER	C	C	--	--	-	0/-

SPECIES	GUILD		TREATMENT			
	N	F	CC	St-I	GR	ii
PRAIRIE WARBLER	s	s	tt	tt	+	+
BLACK-AND-WHITE WARBLER	G	B	--	--	--	-
AMERICAN REDSTART	C	C	--	--	0/-	0/-
WORM-EATING WARBLER	G	S	--	--	-	0/-
SWAINSON'S WARBLER	S	G	--		0/-	0/
OVENBIRD	G	G	--	-	0/-	0/
LOUISIANA WATERTHRUSH	G	G	-	-	0/-	0/
KENTUCKY WARBLER	G	G	-	0/-	0/-	0/
HOODED WARBLER	S	S	--	-	0/-	0/
YELLOW-BREASTED CHAT	S	S	tt	tt	tt	t
SUMMER TANAGER	C	C	--	--	-	0/
SCARLET TANAGER	C	C	--	--	-	-
NORTHERN CARDINAL	S	S	-	0/-	0/+	0/+
RUFOUS-SIDED TOWHEE	S	G	-	0/-	0/+	0/+
CHIPPING SPARROW	S	G	0/+	t	t	++
COMMON GRACKLE	C	G	-	0/-	0/+	0/i
BROWN-HEADED COWBIRD	O	G	0/+	+	++	++
AMERICAN GOLDFINCH	S	S	0/+	+	+	+
INDIGO BUNTING	S	S	0/+	+	++	++

Note: **Nesting (N) guilds:** C = canopy, S = shrub, G = ground. H = hole (cavity) in tree, 0 = other.
Foraging (F) guilds: CA = carnivore, C = canopy insectivore, S = shrub insectivore, B = bark insectivore, A = aerial insectivore, G = ground, P = piscivore, N = nectarivore, 0 = omnivore.
Harvesting treatments: CC = clearcut, SH = shelterwood, GR = group selection, ST = single-tree selection.
Predicted population responses: '+ +' = major increase, '+' = moderate increase, '0/+' = slight increase, '- -' = major decrease, '-' = moderate decrease, '0/-' = slight decrease.

Harvesting treatments were not predicted to affect all nesting and foraging guilds equally. Bark, aerial, and canopy insectivores probably will exhibit more declines than carnivores, shrub insectivores, and ground foragers (fig. 1). At least 90 percent of the bark, air, and canopy foragers were predicted to decline under CC and SH treatments compared with 10 to 60 percent of those species after single-tree and group selection cuts. Fewer than 10 percent of the species which are shrub insectivores, ground foragers, and carnivores were expected to show marked declines after ST and GR cuts. In contrast, clearcutting was predicted to result in declines for approximately 80 percent of carnivores and ground foragers. Shelterwood cuts were predicted to be intermediate in their impact on carnivores and ground foragers. Only 25 percent and 40 percent of shrub insectivores were predicted to exhibit declines after SH and CC, respectively.

Ecosystem Management harvesting treatments probably will have relatively small initial negative effects on birds that place their nests in shrubs compared to those species that build nests in tree canopies, on the ground, or in cavities (fig. 2). The GR and ST harvests may reduce populations of 10 to 40 percent of the species in each of the latter three nesting guilds, whereas CC and SH methods may result in declines in 75 to 100 percent of the species comprising those guilds.

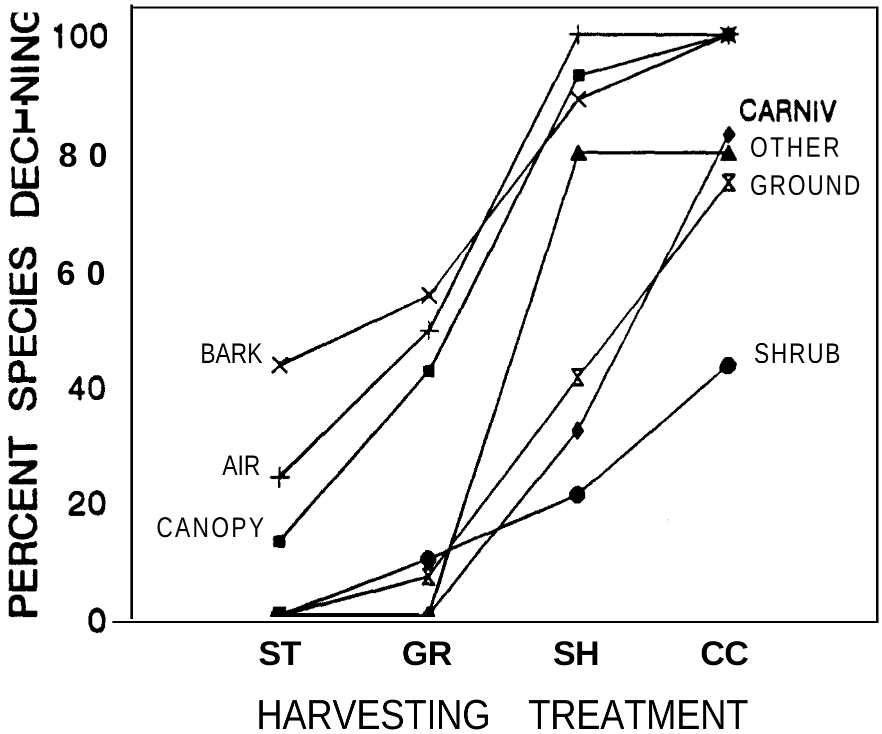

Figure 1.– *Effects of Ecosystem Management harvesting treatments on avian foraging guilds. Symbols represent the percentage of species in each guild predicted to exhibit substantial declines in population density. Harvesting treatments: ST = single-tree selection; GR = gmup selection; SH = shelterwood; CC = clearcut. See text for descriptions of treatments. Foraging guilds: Canopy = canopy (> 3 m) insectivore; Shrub = shrub (< 3 m) insectivore; Ground = ground insectivore; Bark = bark insectivore; Air = aerial insectivore; Carniv = camiwre: Other = nectarivore, granivore, piscivore, omnivore.*

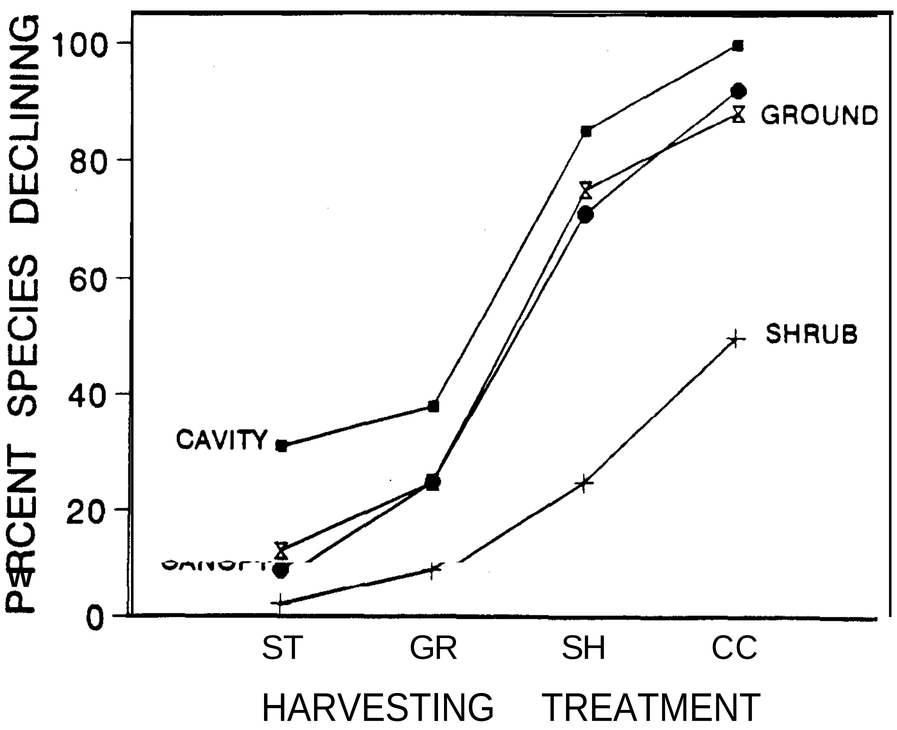

Figure 2.– Effects of Ecosystem Management harvesting treatments on avian nesting guilds. Symbols represent the percentage of species in each guild predicted to exhibit substantial declines in population density. Harvesting treatments: ST = pine/hardwood single-me selection; GR = pine/hardwood group selection; SH = pine/hardwood shelterwood; CC = clearcut. See tat for descriptions of treatments. Nesting guilds: Canopy = open-cup, canopy; Shntb = open-cup, shrubs; Cavity = me cavity; Ground.

DISCUSSION AND CONCLUSIONS

Projected posttreatment habitat characteristics in this study (table 1) were based upon conditions *expected within 3 years* of harvest because of uncertainty about long-term continuation of bird surveys on these sites. Clearly, however, turnover in species composition through time occurs after habitat alteration, so that bird community characteristics in any given period are likely to be different from those during other periods (Johnston and Odum 1956). Thus, predictions of changes in relative bird densities made in this paper are applicable only during a relatively brief postharvest period. Monitoring bird populations on these sites over several decades or longer would provide critical information on the long-term impacts of Ecosystem Management harvesting treatments. In fact, following timber harvesting, ecosystem structure and function may take a century or more to return to a state similar to preharvest conditions (e.g., Duffy and Meier 1992). Nevertheless, knowledge of the immediate effects of forest management on wildlife populations is imperative for development of effective wildlife management plans.

If population projections presented in this paper are accurate, wildlife biologists can expect that foraging and nesting guilds will be differentially affected by the Ecosystem Management timber harvesting treatments. Predicted decreases in these guilds are closely related to key ecological requirements that are altered by the various harvesting regimes. Knowledge of those requirements may allow forest managers to modify harvesting schemes to optimize the tradeoff between retention of ecological features critical for maintenance of forest bird assemblages and production of timber.

Projected changes in bird population and guild densities generally were consistent with changes documented in previous empirical studies of avian responses to different types of habitat alteration (e.g., Crawford and others 1981, Conner and others 1979, Medin 1985, Webb and others 1977), as well as with general impressions of the direction and magnitude of changes based upon our knowledge of bird-habitat relationships. This may not seem surprising given the fact that Hamel's (1992) bird-habitat matrix was built upon those previous studies, as well as expert opinion. However, although a logical basis exists for concurrence between the predictions and the data upon which the matrix was constructed, one main purpose of this exercise was to assess the efficacy of the matrix to produce reasonable predictions of population change without application of sophisticated mathematical manipulations. Given the qualitative format of Hamel's (1992) guide, we were encouraged by the apparently accurate projections of bird population densities. In fact, predictions developed in this paper appear to provide support for this type of approach in wildlife management. Predictions derived from Hamel's (1992) work, whether needing substantial refinement or not, may be the best that land managers have to work with until predictions are tested and additional research is conducted to evaluate the effects of traditional and nontraditional silvicultural treatments on bird populations.

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