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HABITAT USE AND SPECIES COMPOSITION OF BREEDING AVIFAUNA IN A DECIDUOUS FOREST ALTERED BY STRIP MINING

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ABSTRACT

The effects of habitat disturbances resulting from contour strip mining practices on breeding bird populations on a 25.9 ha plot in east Tennessee were studied. The habitat use and number of species were greater in disturbed and edge habitats as compared to the forested habitat. Several forest species were present in the disturbances indicating that these species could adjust to habitat alterations. However, disturbed area and edge species displayed a lesser ability to encroach on forested habitat.

Older contour strip mining procedures created narrow bands of disturbances surrounded by mature forest. The contour strip on the study area was characteristic of the mining methods of 20 years ago and contrasts strongly with the stripped areas of today. Recent strip mining methods produce broader, more expansive contour strip with less contact with the forest. The central areas are too far removed to be importantly influenced by a forest edge effect and as a consequence are expected to have lower bird populations.

INTRODUCTION

Breeding bird populations have been studied in habitats in various stages of succession (Kendeigh, 1946; Johnston and Odum, 1956; Shugart and James, 1973). However, only one study has been concerned with bird populations in habitats affected by strip mining (Karr, 1968). Karr dealt with a series of habitat types where time since mining, and, therefore, vegetation structure varied among study areas. His study areas were small portions of extensively mined areas, while the present study focuses on an area where mining was restricted to rather narrow bands in an extensive area of relatively undisturbed forest.

The primary objective of this study was to assess the impact of habitat disturbances resulting from narrow bands of strip mined land on breeding bird populations.

We studied breeding bird populations in 1972 and 1973 on a 25.9 ha area in a tract of deciduous forest 4.8 km west of Caryville, in the Cumberland Mountains of east Tennessee. A portion of the study area was mined for bituminous coal using contour strip mining practices.

METHODS

Sixteen breeding-bird counts were conducted in 1972 and 15 in 1973 from 23 May to 23 June as recommended by Hall (1964) and Robbins (1970). Census trips were made from sunrise to noon, and a few visits were made after sunset to determine the presence of nocturnal species. All portions of the plot were covered equally and at different times following a grid pattern.

A territory was estimated by outlining the approximate perimeter of singing male contacts assumed to be those of the same individual bird (Hall, 1964). Non-territorial species and woodpeckers required different criteria than those established for territorial species. Since the Brown-headed Cowbird (*Molothrus ater*) probably does not establish territories (but see Bent, 1958), the number of individuals was established by using the mean number of singing males encountered in an individual count. Each male was considered as a pair of birds. The detection of females was difficult in the forest habitat, and they were easily overlooked. All contacts of woodpeckers, including sight records, call notes, and drumming, were used to define separate territories.

A habitat description of the area was based on the flora occurring on twenty-five 0.04 ha circular plots selected from a table of random numbers using the techniques of James and Shugart (1970).

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RESULTS AND DISCUSSION

Study Area History. Logging operations were conducted in the general region in the 1920s and trees greater than 36 cm diameter breast height (dbh) were selectively removed. Part of the area had been subjected to contour strip mining in 1953. The area was planted in 1955 with meadow fescue (*Festuca elatior*) and Japanese clover (*Lespedeza striata*) as a reclamation procedure. (Botanical common and scientific names were taken from Gleason, 1952).

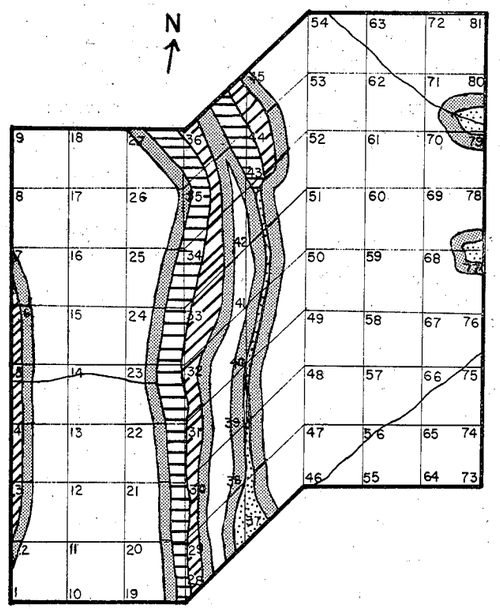

FIG. 1: *Habitat Divisions of the Study Plot: strip mine zone, horizontal lines; spoil zone, diagonal lines; openings zone, dotted region; Marginal area, shaded regions and Forest area, unshaded region. Stations of the grid pattern are indicated by numerals. Major streams are indicated by solid lines. Scales 1 cm = 64 m.*

Three basic divisions of the study area were established: Disturbed, Marginal and Forest areas. The Disturbed area (3.31 ha) encompassed all habitat altered by strip mining, logging, or natural forces. Three subdivisions of the Disturbed area were made (Figure 1). The strip mine zone (1.36 ha) consisted of a flattened portion 15 to 27 m wide which followed the contour of the mountain and divided the study plot into upper and lower parts, and a vertical high wall varying from 5 to 34 m high (Figure 2). The spoil zone (1.47 ha) consisted of two parts. A larger part (spoil I, 1.08 ha) was 15 to 37 m wide. It was created by the deposition of displaced soil and rocks excavated by strip mining and was extended by erosion. A smaller part (spoil II, 0.39 ha) was a narrow disturbance 11 to 15 m wide along a portion of the west border of the study plot. This spoil bank accompanied a small stripped area lying 9 to 17 m west of the study plot. A third subdivision was the openings zone (0.48 ha) which included an unimproved dirt road and small clearings near the east border of the study area. One clearing was created by logging and the other by natural forces.

The strip mine and spoil zones of the study plot were representative of areas affected by early strip mining practices in this region.

The Marginal area (3.44 ha) was defined as a 15 m "buffer zone" composed of vegetation similar to the Forest Area. The use of the 15 m border follows Rosene (1951).

In the Forest area (19.15 ha), no evidence of habitat disruption caused by strip mining or logging was noticeable.

The slope of the Forest and Marginal areas varied from 20 to 28° (Y = 24°). However, the slope of the spoil zones ranged from 41 to 50° (Y = 48°).

Botanical Description. The floristic composition and the height, density, and character of vegetation in a habitat often determine the nesting bird populations (Welty, 1962). A comparison of the common flora and vegetative structure in the three habitats of the study plot allows one to determine the impact of strip mining on the botanical features of these habitats (Table 1). The habitat alterations can then be assessed to give a better understanding of the use of various habitats resulting from these changes by the breeding bird populations.

The flora and vegetative structure in the Forest and Marginal areas were essentially identical, and these differed substantially from those of the Disturbed area.

Only shrubs (woody stems less than 8 cm dbh) were found on the strip mine zone; woody vegetation exceeding this diameter was absent from this habitat. The strip mine zone and spoil I were highest in mean percent ground cover and low in mean shrub density. A few live trees were present in spoil I; however, most trees were dead possibly due to the deposition of excess soil and rocks from strip mining.

HABITAT USE BY SPECIES

Breeding bird populations as determined by regular use of the study area included 35 species in 1972 (Yahner, 1972) and 37 in 1973 (Yahner, 1973) (Table 2).

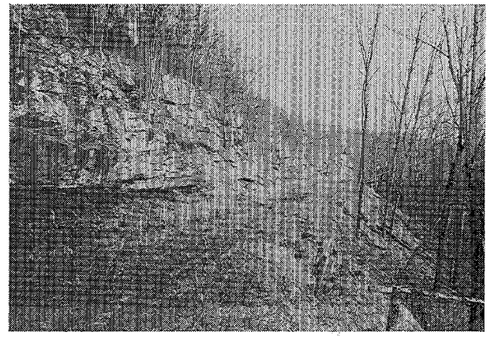

FIG. 2: *The Strip Mine Zone. The highwall is shown on the left and the spoil bank accompanying the strip mine cut is shown on the right. A pond can be located in the center of the picture by the presence of a patch of cattail (Typha latifolia). This picture was taken near Station No. 29 facing north in March 1973.*

Habitat utilization patterns for each species as indicated by the number of contacts of a species in each habitat are given in Table 3. Habitat preferences for a particular species may be inferred by examining the observed contacts (f) and expected contacts (F) for each habitat. The expected contacts were based on the proportional area of each habitat in the total study area. Two examples may illustrate the use of these values to indicate possible habitat preferences. The Indigo Bunting was seen more often in the Disturbed area than expected (50 vs. 10.5 contacts), while the Acadian Flycatcher exhibited a strong preference for the Forest area (72 vs. 54.0 contacts). We may thus conclude that the former species is a bird of disturbed habitat, and the latter species is a bird of undisturbed habitat in this study plot.

The observed contacts/ha (f/ha) for each species are given in Table 3. These values also allow one to evaluate habitat use by individual species per standard area size. More importantly, the use of this conversion factor (contacts/ha) will allow future workers to compare data on individual species and total bird populations nesting in other heterogeneous habitats. This can be accomplished simply by converting these numbers to a percentage which effectively treats the data on a relative basis. An example may illustrate this point. The Yellow-billed Cuckoo was observed 0.3, 2.0, and 1.9 times per hectare in each of the three areas (Table 3). Therefore, our data indicates a 7.2%, 47.6%, and 45.2% relative usage of the Disturbed, Marginal, and Forest areas, respectively. Likewise, all other species may be individually considered as well as the total nesting populations. From Table 3, the total observed contacts per hectare (Σf/ha) are 129.7, 166.9, and 105.8 for the three areas. Therefore, the relative use of the Disturbed, Marginal, and Forest areas by all species is 32.2%, 41.5%, and 26.3%, respectively. Perhaps future studies of bird populations in areas with different flora and vegetative characteristics may be

conveniently compared using this standardized conversion factor. These data may shed some light on the patterns of habitat use by particular species and the "quality" of certain habitats to the total breeding avifauna.

A differential utilization of the three habitat types by the total breeding bird populations was determined by use of a chi-square test. The total observed contacts (Σf) were compared to the total expected contacts (ΣF) (Table 3). A greater number of total observed contacts than expected was found in the Disturbed and Marginal areas as compared to that of the Forest area ($\chi^2 = 94.7$, df $= 2$, $P < 0.001$).

More species were observed in the Disturbed area (35) and in the Marginal area (37) than in the Forest area (31) (Table 3). Karr (1968) also reported a decrease in the number of species present in the climax forest compared to some successional habitats in Illinois. He suggested that this was due to a mixing of edge and forest faunas in the disturbed habitats.

The significance of the relatively small areas involved in the Disturbed and Marginal areas to the species composition was difficult to discern in the present study. However, eight species were found in these areas but not in the Forest area, while only four species were not observed in the Disturbed area (Table 3). This suggests that forest species were more likely to encroach on the edge, while specialized edge species were less likely to be found in the forest habitat. Terborgh and Weske (1969) stated that birds characteristic of mature habitats, such as the Forest area, have a greater tendency to invade other habitats than the reverse. Their conclusions were based on the avifauna of tropical forests, and the extent of application to the avifauna of temperate forests may be questionable. However, studies of birds in temperate areas (Brooks 1940, 1947; Walcheck, 1970) indicated a wide tolerance by forest species to habitats which were altered abruptly, and these findings offer support to the conclusions made in the present study.

MacArthur (1964) suggested that within a homogeneous habitat (such as the Forest areas) the number of layers in the vegetative structure was sufficient to account for the number of species present. However, in a heterogeneous habitat (such as the Disturbed area) species used more than just the vegetative profile in the choice of suitable habitat. Several characteristics of the Disturbed and Marginal areas may account for the higher number of observations and number of species in these habitats as compared to the Forest area.

Some species were attracted to the stripped habitat in the Disturbed area due to the presence of flowing water and the high wall which provided nesting sites for the Eastern Phoebe and the Rough-winged Swallow.

TABLE 1: [1]BOTANICAL DESCRIPTION OF HABITATS[2]

Species [3]	F	M	Disturbed Area: st	Spoil Zone: sI	Spoil Zone: sII	Openings Zone: ur	Openings Zone: id
Sugar Maple (*Acer saccharum*)	X	X		X	X	X	X
Black Gum (*Nyssa sylvatica*)	X	X			X		X
Chestnut Oak (*Quercus prinus*)	X	X			X		X
Red Oak (*Quercus borealis*)	X	X			X		X
Shagbark Hickory (*Carya ovata*)	X	X		X		X	
Basswood (*Tilia heterophylla*)	X	X					X
Flowering Dogwood (*Cornus florida*)	X	X			X	X	X
Sassafras (*Sassafras albidum*)	X	X			X		X
Black Locust (*Robinia pseudoacacia*)			X	X	X		
Wild Cherry (*Prunus serotina*)			X	X	X		
Dead Trees				X [4]			
White Snakeroot (*Eupatorium rugosum*)	X	X		X	X		X
Black Snakeroot (*Cimicifuga racemosa*)	X	X			X		X
Blue Cohosh (*Caulophyllum thalictroides*)	X	X			X		X
Solomon's Seal (*Polygonatum biflorum*)	X	X			X		X
False Solomon's Seal (*Smilacina racemosa*)	X	X			X		X
Trillium (*Trillium spp.*)	X	X					X
Meadow Fescue (*Festuca elatior*)			X	X			
Mexican Bamboo (*Polygonum cuspidatum*)			X	X		X	
Pokeweed (*Phytolacca americana*)			X	X			
White Sweet Clover (*Melilotus alba*)			X				
Cattail (*Typha latifolia*)			X				
Common Blackberry (*Rubus allegheniensis*)				X	X	X	X
Wild Hydrangea (*Hydrangea aborescens*)			X	X		X	
Ragweed (*Ambrosia trifida*)				X	X	X	
Daisy Fleabane (*Erigeron philadelphicus*)						X	
Ox-eye Daisey (*Chrysanthemum leucanthemum*)						X	
Touch-me-not (Impatients biflora)						X	
Mean shrub density (shrubs/.01 ha)	95.1	97.0	0.4	3.4	110.1	2.3	102.5
Range shrub density (shrubs/.01 ha)	88.7–102.1	90.2–110.6	0.0–0.9	2.2–6.7	82.2–130.6	1.0–5.1	95.6–117.2
Mean canopy cover (%)	81	78	4	5	71	26	62
Range canopy cover (%)	73–94	72–88	0–6	1–12	55–82	3–40	51–77
Mean ground cover (%)	51	53	95	98	75	65	68
Range ground cover (%)	22–68	25–70	92–99	97–99	70–88	60–74	59–81
Maximum canopy height (m)	28	16	5	20	12	12	20

[1] The habitat description is based on the analysis of the flora occuring on twenty-five 0.04 ha circular plots chosen at random (James and Shugart, 1970).

[2] Habitats abbreviated as follows: Forest area, F; Marginal area, M; strip mine zone, st; spoil I, sI; spoil II, sII; unimproved dirt road, ur; and isolated disturbances, id.

[3] Species abundant in a habitat is indicated by an X.

[4] Dead tree density was 188 trees per hectare: 82%, 0 to 12 m; 16%, 13 to 24 m, and 2%, 25 to 37 m, respectively, from the east edge of the strip mine zone.

TABLE 2: TOTAL NUMBER OF TERRITORIES IN STUDY AREA [1]

Species	1972	1973
Yellow-billed Cuckoo (*Coccyzus americanus*)	4	3
Common Flicker (*Colaptes auratus*)	1	1
Pileated Woodpecker (*Dryocupus pileatus*)	1+	1+
Red-bellied Woodpecker (*Centurus carolinus*)	1	1
Hairy Woodpecker (*Dendrocopos villosus*)	0	1
Downy Woodpecker (*Dendrocopos pubescens*)	1+	1
Eastern Phoebe (*Sayornis phoebe*)	5	3
Acadian Flycatcher (*Epidonax virescens*)	3+	5
Eastern Wood Pewee (*Contopus virens*)	2	2
Rough-winged Swallow (*Stelgidopteryx ruficollis*)	1	0
Blue Jay (*Cyanocitta cristata*)	1	1
Carolina Chickadee (*Parus carolinensis*)	2	2
Tufted Titmouse (*Parus bicolor*)	2	4
White-breasted Nuthatch (*Sitta carolinensis*)	1	1
Carolina Wren (*Thryothorus ludovicianus*)	4+	4+
Wood Thrush (*Hylocichla mustelina*)	9+	10
Eastern Bluebird (*Sialia sialis*)	1	1
Blue-gray Gnatcatcher (*Polioptila caerulea*)	1+	2
White-eyed Vireo (*Vireo griseus*)	3	1
Yellow-throated Vireo (*Vireo flavifrons*)	5	5+
Solitary Vireo (*Vireo solitarius*)	0	1
Red-Eyed Vireo (*Vireo olivaceus*)	21	28
Black-and-White Warbler (*Mniotilta varia*)	5	6
Worm-eating Warbler (*Helmitheros vermivorus*)	3+	4+
Golden-winged Warbler (*Vermivora chrysoptera*)	1	2
Cerulean Warbler (*Dendroica cerulea*)	17+	22
Ovenbird (*Seiurus aurocapillus*)	3	5
Kentucky Warbler (*Oporornis formosus*)	11	9+
Yellow-breasted Chat (*Icteria virens*)	1+	2
Hooded Warbler (*Wilsonia citrina*)	19	18
American Redstart (*Setophaga ruticilla*)	28	38
Brown-headed Cowbird (*Molothrus ater*) [2]	3	3
Scarlet Tanager (*Piranga olivacea*)	11+	10
Cardinal (*Cardinalis cardinalis*)	7	7
Indigo Bunting (*Passerina cyanea*)	6	6
American Goldfinch (*Spinus tristis*)	1	0
Rufous-sided Towhee (*Pipilo erythrophthalmus*)	3+	4+
Field Sparrow (*Spizella pusilla*)	0	1
Song Sparrow (*Melospiza melodia*)	0	1
Total territories	193.5	218.5
Total territories/ha	7.5	8.4

[1] Individual territories with one half or more of the total contacts within the study area are designated as full territories. Those with more than one half of the contacts outside the study area are designated as partial territories and are indicated by a (+) (Martin, 1960; Hall, 1964). A partial territory is given a value of 0.5 in the total territories calculation. Two or more partial territories equal in size to one half of a representative territory for that species is considered a full territory.

[2] Number of males.

Though the percent ground cover in this habitat was high (Table 1), it probably had little influence on the bird populations. Karr and Roth (1971) found that the addition of a grass layer to a barren habitat had little effect on bird species diversity.

Spoil I was the most heterogeneous habitat in the study plot. The vegetation at the upper border of the spoil bank near the stripped habitat was similar to this habitat, but shrub density increased rapidly near the lower edge adjacent to the Marginal area. The addition of a shrub layer to a grass layer apparently increased the number of species and the use of this habitat. These findings were consistent with those of Karr and Roth (1971). A few large living trees and many dead trees were present on this spoil bank (Table 1). The use of these trees as singing posts and for the location of nesting cavities can attract species to a area (Lack, 1933).

The Marginal area functioned as a "buffer" habitat separating the Forest and Disturbed areas. Forest species were well represented in this habitat, and few edge species used the forest habitat beyond this 15 m border (Table 3). The high use of this area by a large number of species is likely due to the high shrub density in adjacent disturbed habitats. These species could feed in the dense undergrowth and nest in the larger trees found in the Marginal area. The extensive edge effect produced by the junction of the Disturbed and Marginal areas created an ideal habitat for edge species and opportunistic forest species tolerant of habitat disturbances.

TABLE 3: TOTAL CONTACTS OF SPECIES IN THE DISTURBED MARGINAL, AND FOREST AREAS.

Species	Contacts of Species (f, F, f/ha) [1]		
	Disturbed	Marginal	Forest
Yellow-billed Cuckoo [3]	1, 5.6, 0.3	7, 5.9, 2.0	36, 32.5, 1.9
Common Flicker [3]	5, 1.7, 1.5	5, 1.7, 1.5	3, 9.6, 0.2
Pileated Woodpecker [3]	4, 4.7, 1.2	4, 4.9, 1.2	29, 27.4, 1.5
Red-bellied Woodpecker [2]	2, 3.2, 0.6	5, 3.3, 1.5	18, 18.5, 0.9
Hairy Woodpecker [3]	1, 0.8, 0.3	3, 0.8, 0.9	2, 4.4, 0.1
Downy Woodpecker [3]	6, 5.2, 1.8	8, 5.4, 2.3	27, 30.3, 1.4
Eastern Phoebe [2]	44, 6.5,13.3	2, 6.8, 0.6	5, 37.7, 0.3
Acadian Flycatcher	0, 9.3, 0.0	1, 9.7, 0.3	72, 54.0, 3.8
Eastern Wood Pewee [3]	17, 4.6, 5.1	15, 4.8, 4.4	4, 26.6, 0.2
Rough-winged Swallow [2]	10, 1.3, 3.0	0, 1.3, 0.0	0, 7.4, 0.0
Blue Jay [3]	5, 4.7, 1.5	8, 4.9, 2.3	24, 27.4, 0.7
Carolina Chickadee	4, 7.2, 1.5	10, 7.4, 2.9	41, 41.4, 2.1
Tufted Titmouse	5,11.1, 1.5	14,11.6, 4.1	68, 64.3, 3.6
White-breasted Nuthatch	0, 1.7, 0.0	2, 1.7, 0.6	11, 9.6, 0.6
Carolina Wren [3]	21, 9.2, 6.3	19, 9.6, 5.5	32, 53.2, 1.7
Wood Thrush	4,17.5, 1.2	26,18.2, 7.6	107,101.3, 5.6
Eastern Bluebird [3]	8, 1.3, 2.4	2, 1.3, 0.6	0, 7.4, 0.0
Blue-gray Gnatcatcher	0, 2.7, 0.0	4, 2.8, 1.2	17, 15.5, 0.9
White-eyed Vireo [4]	10, 1.9, 3.0	5, 2.0, 1.5	0, 11.1, 0.0
Yellow-throated Vireo [3]	1, 7.7, 0.3	12, 8.0, 3.5	47, 44.4, 2.5
Solitary Vireo	0, 0.6, 0.0	1, 0.7, 0.3	4, 3.7, 0.2
Red-eyed Vireo	22,41.0, 6.7	55,42.6,16.0	244,237.3,12.7
Black-and-White Warbler	4, 8.6, 1.5	17, 8.9, 4.9	45, 49.5, 2.4
Worm-eating Warbler [3]	1, 8.2, 0.3	7, 8.5, 2.0	56, 47.3, 2.9
Golden-winged Warbler	11, 1.9, 3.3	4, 2.0, 1.2	0, 11.1, 0.0
Cerulean Warbler	20,37.2, 6.0	69,38.7,20.1	202,215.2,10.6
Overbird [3]	2, 7.5, 0.6	4, 7.8, 1.2	53, 43.6, 2.8
Kentucky Warbler	14,22.0, 4.2	32,25.5, 9.3	126,142.0, 7.6
Yellow-breasted Chat [4]	16, 2.8, 4.8	6, 2.9, 1.7	0, 16.3, 0.0
Hooded Warbler	18,33.6, 5.4	51,34.9,14.8	194,194.5,10.1
American Redstart	46,59.0,13.9	81,61.4,25.6	335,341.6,17.5
Brown-headed Cowbird	6, 8.2, 1.8	6, 8.5, 1.7	52, 47.3, 2.7
Scarlet Tanager	12,18.4, 3.6	24,19.1, 7.0	108,106.5, 5.6
Cardinal	12, 9.9, 3.6	21,10.2, 6.1	44, 56.9, 2.3
Indigo Bunting	54,10.5,16.3	25,10.9, 7.3	3, 60.6, 0.2
American Goldfinch	6, 0.9, 1.8	1, 0.9, 0.3	0, 5.2, 0.0
Rufous-sided Towhee	21, 4.5, 6.3	10, 4.6, 2.9	4, 25.9, 0.2
Field Sparrow	8, 1.0, 2.4	0, 1.1, 0.0	0, 5.9, 0.0
Song Sparrow [2]	8, 1.0, 2.4	0, 1.1, 0.0	0, 5.9, 0.0
Total Observed Contacts (Σf) [5]	431	566	2013
Total Expected Contacts (F)	386.0	401.1	2232.9
Total Observed Contacts/ha (Σf/ha)	129.7	166.9	105.8
Total Species	35	37	31
Size of Area (ha)	3.31	3.44	19.15

[1] Observed contacts (f), expected contacts (F), observed contacts/ha (f/ha).
[2] Majority (>75%) of observed contacts (f) in the Disturbed area recorded in the strip mine zone.
[3] Majority (>75%) of observed contacts (f) in the Disturbed area recorded in the spoil zone.
[4] Majority (>75%) of observed contacts (f) in the Disturbed area recorded in the openings zone.
[5] Chi-square test. The total observed contacts (Σf) is compared to the total expected contacts (Σf) for each of the three areas. $X^2 = 94.7$ (df = 2) is significant at $P = <0.001$.

It is important to note that this study was based on a relatively small, narrow strip mine area which was closely surrounded by a lightly disturbed forest and had accumulated plant growth for 20 years. In the region of this study plot, strip mining methods of the late 1960s and early 1970s often resulted in more extensive stripped areas. Such recently created, larger stripped areas have much lower bird populations since their central parts are remote from the forest which surrounds them. The slope of the spoil banks in these areas often exceeded 55° (Yahner et al., in press).

Recent legislation (Tennessee Code Annotated, Chapter 15, Sections 58-1540 through 58-1564; effective 23 March 1972; amended by House Bill 1630, approved 20 March 1974), known as "The Tennessee Surface Mining Law" (Bureau of National Affairs, Inc., 1974), forbids the granting of permits for mining of an area characterized by a slope below the coal seam greater than 28°. The operator of present strip mining procedures must now prepare and submit a reclamation plan for the area affected by his operation. The reclamation of the affected area includes a regrading of the area to restore the approximate topography, eliminating the unsightly high walls and spoil banks, and filling water-collecting depressions. The area must also be revegetated in accordance with Section 58-1548 of this act.

It is hoped this legislation will minimize the habitat disturbances, pollution of streams, and effect on the flora and fauna of these exploited areas as strip mining continues in the future.

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