

II. Evidence for the Value of Corridors and Minimization of Isolation in Preservation of Biotic Diversity

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MacArthur and Wilson suggested in 1967 that fragmentation of forests into "habitat islands" should adversely affect the species richness of the fauna, but explicit investigation of the importance of size and isolation of forest tracts has been undertaken only recently (Galli *et al.*, 1975; Moore and Hooper, 1975; Forman *et al.*, 1976; Whitcomb *et al.*, 1976). Viewed in the context of island biogeography, studies by Bond (1957) and Linehan *et al.* (1967) have also demonstrated a clear relationship between tract size and avifaunal composition. In studies of forest tracts of different sizes in Maryland, surveys of Whitcomb *et al.* (in preparation) showed that the avifaunal assemblages of small isolated tracts in rural and suburban areas differed significantly from those of more extensive woodlands. Nevertheless, one of these small tracts (35 acres) — no larger than most others we had studied — was found to have an avifaunal composition that closely approximated that of much larger woodlands.

Examination of the biogeographic context of this tract revealed that it was an "island" actually connected to a 400-acre woodland by a disturbed corridor. It occurred to us that the relative avifaunal richness of the "island" could be explained by the proximity of this large woodland, the presence of the corridor and, perhaps most importantly, the proximity of an additional extensive forest system of more than 10,000 acres to which the 400-acre woodland was connected by other corridors. Together, these factors had combined to produce a forest *fragment* (a term that we apply to a tract with a tenuous or partial connection to a larger similar unit) minimally isolated from a "mainland" forest. Biogeographic theory suggests that the degree of isolation from a

"mainland" should be an important determinant of the relative ability of a forest fragment to support the avifauna typical of the larger forest. For this reason we chose the fragment and the surrounding forests for special study in 1975.

In all, five plots were chosen for complete censuses. The plots (Fig. 1) are located on the U S Beltsville Federal Masterplan Area, (CBPNA), 1976, Beltsville, Maryland. Two of the plots, Springfield East (predominantly pine forest) and Springfield West (predominantly mixed oak deciduous forest) together compose the 35-acre Springfield tract, described as the "island." This tract is surrounded on three sides by open fields. The fourth side is bounded by a lightly travelled blacktop road. A narrow, disturbed "corridor" of about 15 acres in size (Fig. 2), consisting of grazed woodland and early second growth intersected by a farm road, lies on the opposite side of the blacktop. This corridor connects the Springfield tract with a larger forest of about 400 acres traversed by a narrow stream (Beaver Dam Creek). It was, of course, necessary to census the corridor, despite its lack of homogeneity. The Beaver Dam West "mainland" plot, which lies in the west central portion of the large forest, was laid out within a patch of the tract most closely corresponding with the deciduous forest of the Springfield West plot. A census of a fifth plot lying within the 400-acre mainland tract but traversing the small stream, has been previously reported (Whitcomb *et al.* 1975). Census results for Springfield West and East, Beaver Dam West, and the corridor plot are given as Appendices I-IV.

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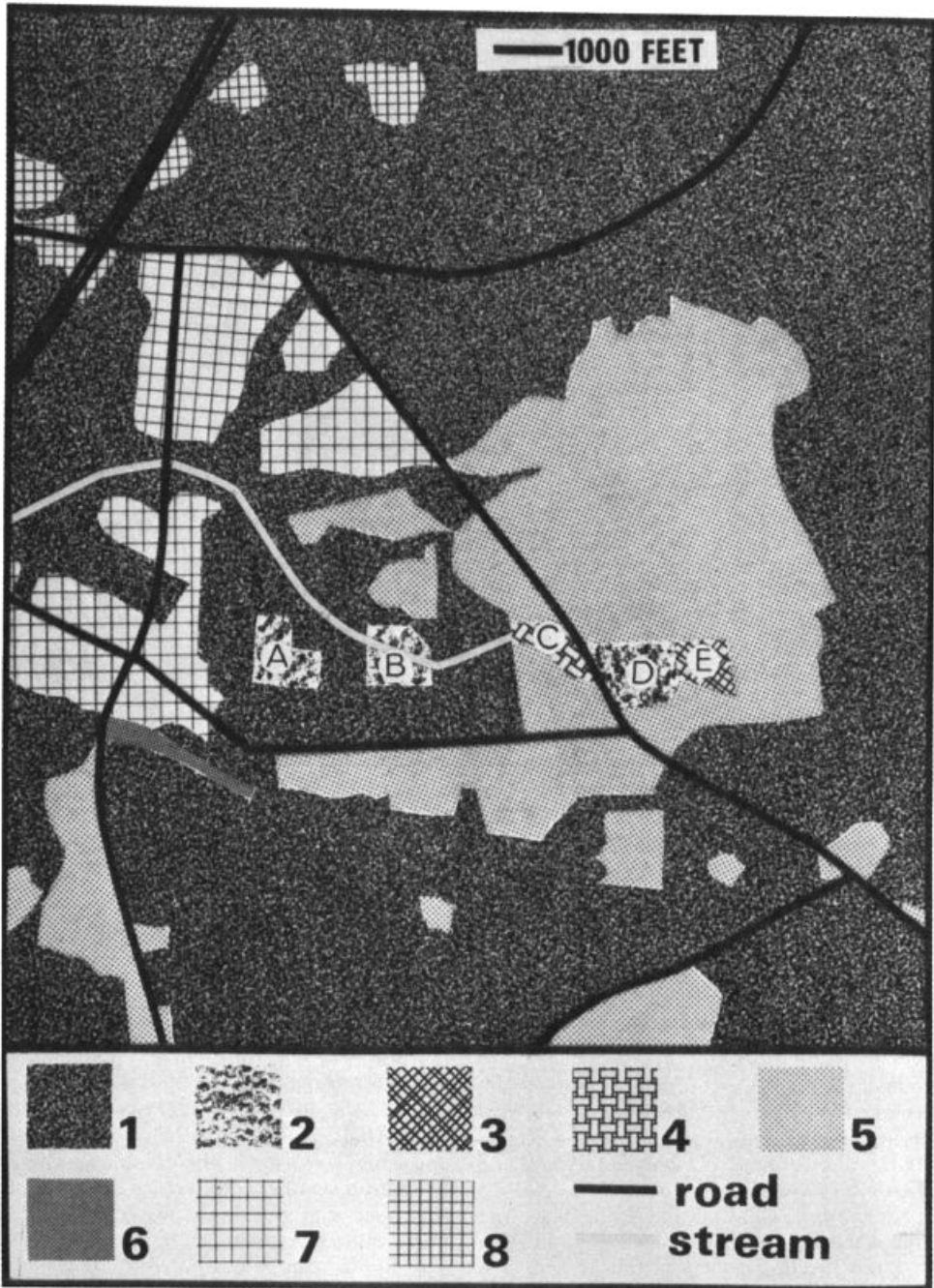


Fig. 1 — Diagrammatic representation of the local biogeographic context of a forest "fragment." The fragment consists of a western portion (D) that is predominantly deciduous, and an eastern portion (E) that is predominantly coniferous. The fragment is connected to a larger tract of about 400 acres by a disturbed corridor (C; Fig. 2). Within the larger tract, a 15-acre plot (A) was laid out that corresponded as closely as possible to plot D. A second plot (B) of 21 acres was also censused (Whitcomb *et al.* 1975). The larger 400-acre tract is connected by several corridors to a surrounding forest system of

more than 10,000 acres. This largely upland forest (1) is entirely second growth, is situated on a mosaic of soil types, and varies greatly between patches in the proportion of Virginia and Loblolly Pine and several oak species. Textures 2, 3, and 4 are explained in Appendices I, II, and IV respectively. Open fields (5) consist largely of pasture, grassland, or abandoned fields. A shallow artificial lake (6), and other open areas which are farmed (7) or accommodate building complexes (8) comprise the remaining zones.

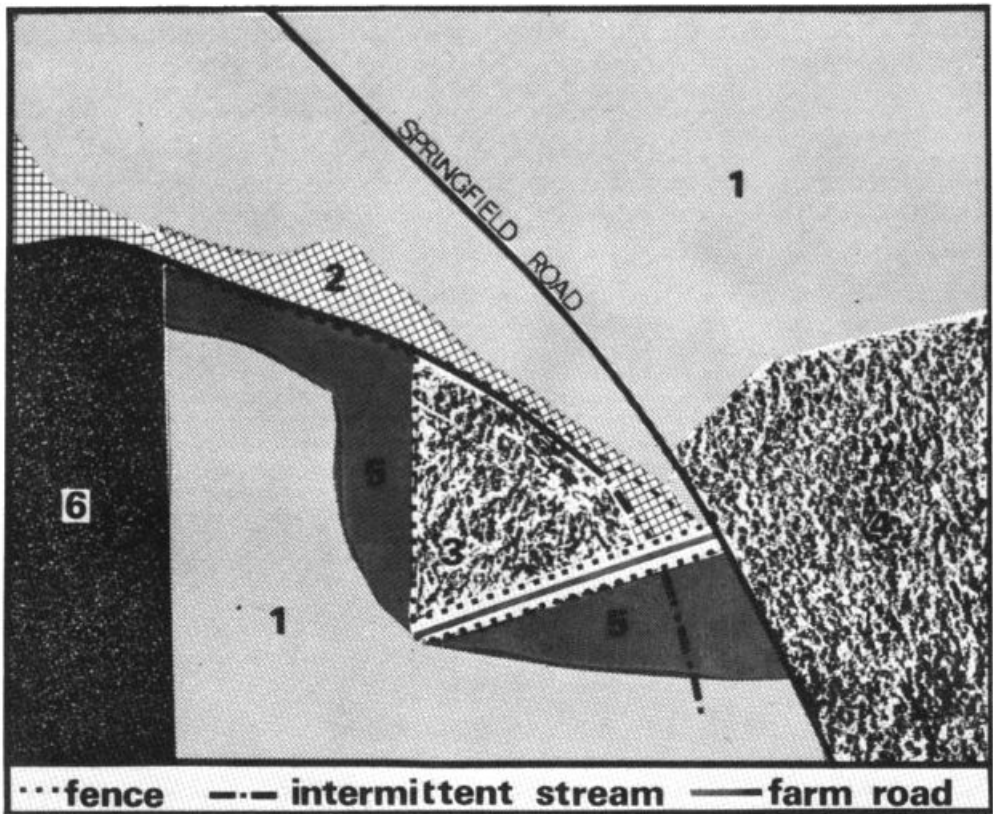


Fig. 2 — Diagrammatic representation of the corridor between two forest tracts. Zones are (1) open fields, (2) stream bed, (3) second growth deciduous wood lot,

(4) forest fragment (Springfield West plot), (5) grazed woodland, (6) mainland forest.

RESULTS

Avifaunal composition of "mainland" plot. The avifauna of the mainland forest closely resembled, in species composition and density, that recorded in previous censuses of large undisturbed second growth mixed oak forests in central Maryland and the District of Columbia (Audubon Society, D.C., 1948; Kolb *et al.*, 1948; Cole and Kolb, 1956). The carrying capacity (reflected in bird population density) and species richness of this 15-acre plot exceeded that of the previously censused plots, but was lower than that of the mature mesic Tulip-tree-oak upland forest reported in our companion paper. It is interesting to compare the avifauna of the Beaver Dam mainland with that of the Rock Creek Park plot in the District of Columbia when the latter plot was first censused in 1948 (Table 1). The disastrous subsequent decay of the Rock Creek avifauna, as documented by breeding bird censuses, has been summarized recently by Criswell (1975).

Comparison of deciduous portion of fragment with larger forest. Comparison of censuses (Appendices I and III) of the deciduous portion of the fragment with those of the mainland deciduous plot (Table 1) shows that the avifauna were similar in many respects. For example, there was little difference in populations of trunk foragers and canopy species in the two plots. There was, however, a significant difference in the number of edge species present in the two plots, as the fragment contained many more "edge territories." This finding can be attributed to the geometry of these territories, which was dependent on the exterior edge of the tract. Had the plot boundaries been drawn 100 ft. from the edge instead of 50 ft., most of these species would not appear in the census totals. A second difference between the two deciduous plots was the increased number of species and individuals inhabiting the shrub layer in the larger forest. Despite our best attempts to select comparable plots, the shrub layer in the mainland woods was more dense than that of the fragment (5581 shrub stems/acre compared to

Table 1. — Avifaunal compositions of the Springfield fragment compared with avifaunas of similar large forests in Central Maryland and the District of Columbia.

Species	Census		
	Rock Creek Park ^a	Beaver Dam Mainland	Springfield Fragment
Plot size (acres)	80	15	15
<i>Raptors</i>			
Broad-winged Hawk	+	0	0
Red-tailed Hawk	0	+	+
Cooper's Hawk	+	0	0
Turkey Vulture	0	+	+
Screech Owl	0	+	0
Barred Owl	2 ^b	0	0
<i>Trunk foragers</i>			
Downy Woodpecker	3	7	7
Hairy Woodpecker	+	+	+
Red-bellied Woodpecker	2	13	7
Com. Flicker	3	3	+
White-breasted Nuthatch	5	7	3
Black-and-white Warbler	5	10	7
<i>Flycatchers</i>			
Great Crested Flycatcher	6	7	7
E Wood Pewee	8	10	13
Acadian Flycatcher	25	0	0
Ruby-throated Hummingbird	3	0	0
Whip-poor-will	0	+	0
<i>Canopy specialists</i>			
Yellow-billed Cuckoo	2	7	7
Blue-gray Gnatcatcher	0	7	3
Yellow-throated Vireo	8	10	+
Red-eyed Vireo	53	40	40
Northern Parula	1	0	0
Pine Warbler	0	7	10
Scarlet Tanager	10	10	10
<i>Canopy generalists</i>			
Tufted Titmouse	4	13	10
Carolina Chickadee	4	10	10
Blue Jay	0	3	3
<i>Shrub layer specialists</i>			
Hooded Warbler	6	10	0
White-eyed Vireo	0	+	0
Kentucky Warbler	1	3	0
<i>Shrub layer generalists</i>			
Cardinal	1	vis.	17
Carolina Wren	0	10	7
<i>Ground foragers</i>			
Ovenbird	50	103	57
Wood Thrush	16	40	20
Rufous-sided Towhee	0	13	17
<i>Edge species^c</i>			
E Bluebird	1	0	0
Brown-headed Cowbird	1	7	7
Com. Crow	3	+	+
E Phoebe	1	+	0
Total density of territorial males/100 acres.	214	343	287 ^c
Total species	29	31	31 ^c

^a Audubon Society, District of Columbia (1948)

^b Territorial males/100 acres.

^c Edge species present on the fragment but not in the larger woods included Gray Catbird 10; Indigo Bunting 10, Com. Yellowthroat 7; Bobwhite +; Yellow-breasted Chat+.

1943 shrub stems/acre for the layer 2-10 ft. high; for the ericaceous layer 0-2 ft. high the values were 53,088/27,987). Species that inhabit these layers — Hooded Warbler, Kentucky Warbler, and Carolina Wren — appeared to favor the mainland plot. Similarly, Wood Thrush, although a ground forager, places its nests in the shrub and understory layers, and was more abundant in the mainland plot. Thus, the major avifaunal differences between the two plots can be explained by the most evident structural differences between them.

Comparison of coniferous portion of fragment with larger forest. Comparison of the eastern section of the fragment with the mainland was attempted by a point survey method. Three habitat patches that closely resembled the pine forest of the Springfield East plot were selected in the surrounding major forest system. A point in the center of each patch was surveyed by recording the number of territories that could be perceived in a 60 minute sample period, subdivided into three 20 minute intervals on three different days in June. The average number of territories per point could then be computed for the three points (Table 2). Comparison of the census from the Springfield East plot (Appendix II) with that of the surrounding larger forest revealed close similarity. Species absent from the fragment, but recorded in point surveys of the larger forest, included Mourning Dove, Hairy Woodpecker, Acadian Flycatcher, and Am. Robin. The only deletion which is suggestive of a possible size effect is Acadian Flycatcher; on the other hand, we were surprised to find this species in the upland pine forests where we conducted our point surveys, and do not consider it to be common in local pine forests of any size. Certain species present on the fragment reflect the existence and structure of the surrounding edge, including White-eyed Vireo, Yellow-breasted Chat, and Prairie Warbler. Other species held territory on the fragment outside the plot boundaries, and thus were recorded as visitors to Springfield East. These included E. Wood Pewee, Yellow-billed Cuckoo, Brown Thrasher and Black-and-white Warbler. In all, including species recorded as visitors, the fragment plot and similar habitat in larger woods had 24 species in common; furthermore, species most abundant in surrounding larger pine woods were also commonest in the fragment. Thus there is little evidence that the status of the Springfield East plot as part of a forest fragment resulted in avifaunal depletion.

Corridor. The corridor census was a major surprise. This miserably disturbed and patchy habitat furnished breeding territory for several

Table 2. — Avifaunal comparison of coniferous portion of fragment with similar habitat in larger forest.

Bird species	Fragment	
	Large forest	(Springfield East)
Red-tailed Hawk	0	+ ^b
Bobwhite	0	+
Mourning Dove	0.33 ^a	0
Yellow-billed Cuckoo	0.33	visitor
Red-bellied Woodpecker	0.33	1.0
Hairy Woodpecker	0.67	0
Great Crested Flycatcher	0.67	0.5
Acadian Flycatcher	0.67	0
E. Wood Pewee	0.33	visitor
Blue Jay	+	0.5
Com. Crow	+	+
Carolina Chickadee	1.33	1.0
Tufted Titmouse	1.33	1.0
Carolina Wren	1.00	2.0
Gray Catbird	0.33	2.5
Brown Thrasher	0.67	visitor
Am. Robin	0.67	0
Wood Thrush	1.33	2.5
Red-eyed Vireo	1.33	3.5
White-eyed Vireo	0	3.0
Black-and-white Warbler	0.67	visitor
Yellow-breasted Chat	0	1.0
Pine Warbler	1.33	1.0
Prairie Warbler	0	2.5
Ovenbird	1.67	2.0
Com. Yellowthroat	0.33	3.0
Com. Grackle	+	0.5
Brown-headed Cowbird	0.33	1.0
Scarlet Tanager	1.0	0.5
Cardinal	1.33	1.5
Am. Goldfinch	0.33	visitor
Rufous-sided Towhee	1.67	4.0
Indigo Bunting	0.33	2.0
Field Sparrow	0	+

^a Mean number of territorial males recorded per point in a point survey consisting of three 20 min. samples on three days during breeding season.

^b Census data from Appendix II.

forest-interior species. Other species which were closely associated with the corridor also utilized portions of both the Springfield and Beaver Dam woods in the course of the nesting season. These species included Com. Flicker, Hairy Woodpecker, Blue-gray Gnatcatcher, and Yellow-throated Vireo. Our observations of seasonal shifts in the foraging grounds of species such as Blue-gray Gnatcatcher recall similar observations of Root (1967) in California. Yellow-throated

Vireo also appeared to forage over wide areas; such species may have large area requirements, at least in part to accommodate their foraging behaviors.

Status of Ovenbird. The most abundant species in Beaver Dam West was the Ovenbird, with a density of 103 males per 100 acres (15.5 in 15 acres, all delineated by simultaneous registrations). Some interior territories were close to the 1/2-acre minimum given by Hann (1937); territories closer to the moist stream alluvium along the floodplain were larger. Similar observations were common in other parts of the large local forest (Whitcomb *et al.*, 1975). Ovenbirds were less populous in the fragment, with a density of 57 per 100 acres in the deciduous portion. In this tract also, birds were most densely packed in habitat distant from the edge. The territories, ranging in size from 1/2 to 2 acres, were concentrated near the center of the fragment. In contrast, apparently suitable habitat along the periphery was unused. Similarly, the single Ovenbird territory in the corridor was located at the center of the plot. Stenger (1958) has shown that the size of Ovenbird territories is inversely proportional to the invertebrate food resources on the forest floor, but we can see no reason why such levels should be highest in the geometrical centers of tracts. It seems more likely that psychological factors of habitat selection restrict the utilization of the marginal areas of forest fragments and islands by Ovenbirds.

In April 1975, a fire swept through some 45 acres of the predominantly deciduous forests of the Patuxent Wildlife Research Center that were located near our plots. Even after this severe burning of the forest floor and shrub layer, a number of Ovenbirds, possibly birds holding territory in previous years, attempted colonization of the burned-over tract. This is in agreement with previous studies by Emlen (1970), in which immediate attempted utilization of recently burned-over areas was also noted. Nevertheless, some birds that would otherwise have utilized the Patuxent forest may have colonized the Springfield fragment instead. Fortunately, results of a 1974 point survey (Whitcomb *et al.*, in preparation) on the fragment are available. The results confirm that in 1974, at least two Ovenbirds and a Pine Warbler held territory on the fragment. Acadian Flycatcher and Hooded Warbler were also recorded in the 1974 survey but were not present in our 1975 census.

Careful examination of existing literature indicates that the Ovenbird, which is among the species least likely to colonize small tracts in the Maryland Piedmont, has been recorded in certain

circumstances on small tracts in other regions. For example, Jones *et al.* (1966) reported a density of 40 territorial males per 100 acres on a 24-acre tract in Delaware. Examination of the USGS North Wilmington Quadrangle Map, however, reveals that this 24-acre tract is in close proximity to a woodland of about 650 acres, and we predict that the larger woodland would be found to contain a large population of Ovenbirds.

DISCUSSION

In the course of two seasons, the upland forest fragment of 35 acres upon which we have focused our attention was utilized as breeding habitat by most of the bird species which characterize the avifaunal communities of extensive upland eastern forests. However, intensive survey and census work in the Maryland Piedmont and Coastal Plain (Whitcomb *et al.*, in preparation) have shown that most of the local forests thought of or designated as "preserves" have in fact failed to preserve some species that are able to colonize the minute Springfield plot. What property of this tract accounts for the high species richness of its avifauna? The soils of the area are not exceptionally fertile. The vegetational structure of the tract is typical of the local mixed forest. No effort or expense has been directed toward management or preservation of the tract and the fences that partially surround it are down in several places. The reduced shrub and understory layers suggest that disturbance such as fire or grazing may at some time in the past have impacted the lower vegetational layers. Thus, we are unaware of any property of the plot which could impart a preserve function to it, other than its biogeographical position with minimal isolation from a forest mainland. The value of bigness in the design of faunal preserves has been stressed by several workers (Terborgh, 1974; Diamond, 1975, 1976; Wilson and Wills, 1975; Whitcomb *et al.* 1976), whose diverse studies of oceanic and habitat islands have brought acute awareness of the problem of maintenance of biotic diversity on a globe with a constantly shrinking supply of natural habitat. Among the suggestions of such workers has been the maintenance of corridors between tracts and minimization of isolation. Our censuses appear to offer explicit evidence of the wisdom of these recommendations.

SUMMARY

Censuses of four plots and supplemental observations in forests surrounding the plots suggest that most of the forest interior bird species characteristic of the region are able to breed in

forest fragments as small as 35 acres. However, this is apparently only possible if the fragment is "subsidized" by a nearby major forest system. The results emphasize the requirement for preserves of large size and confirm the importance of minimal isolation and corridors connecting fragmented forest tracts for preservation of maximum biotic diversity.

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Appendix I

UPLAND PREDOMINANTLY DECIDUOUS MIXED FOREST FRAGMENT. — **Location:** Maryland; Prince George's Co., Beltsville; 39°01'N, 76°49'18"W, Laurel Quadrangle, USGS. **Continuity:** New (Censused in 1975). **Size:** 6.1 ha = 15 acres (rectangular, 2x3 ha grid). **Description of Plot:** Dominant canopy species are White Oak (*Quercus alba*), Black Oak (*Q. velutina*), and Black Gum (*Nyssa sylvatica*); the canopy is about 60% closed. Scrub and Loblolly Pine (*Pinus virginiana* and *P. taeda*), remnants of an earlier successional stage, comprise about 6% of the mature trees. The understory is composed mainly of saplings of the canopy species and of Red Maple (*Acer rubrum*) and American Holly (*Ilex opaca*). The ericaceous shrub layer, including *Gaylussacia* and *Vaccinium* spp., occupies 30% of the vertical space from 0 to 5 ft. Ground cover, estimated at 65%, includes Partridge-berry (*Mitchella repens*), Common Greenbrier (*Smilax rotundifolia*), Summer-sweet (*Clethra alnifolia*), and club mosses (*Lycopodium* spp.); large patches of Cinnamon Fern (*Osmunda cinnamomea*) cover about 30% of the forest floor. The humus layer is about 4 in. deep. **Local Biogeography:** This plot comprises the W half of a 35-acre forest "fragment" which is linked to a 400-acre "mainland" woodland by a narrow, disturbed corridor. Both

tracts, fragment and mainland, are located within a semi-continuous forest system of over 10,000 acres. The 35-acre fragment is structurally divided into vegetationally distinct halves, each of which was censused. A 15-acre plot on the predominantly deciduous half was compared with a similar tract of the same size within the nearby 400-acre woodland. **Edge:** The plot was drawn to exclude at least 50 ft. of wooded area around all sides. The tract is bounded on the N, S and E by cultivated fields, and on the W by a two-lane blacktop road. Beyond the road lies a narrow corridor of grazed woodland and early second growth which connects the fragment to the 400-acre tract. **Topography:** Flat, with an elevation of about 140 ft. **Coverage:** May 21, 24, 28; June 4, 7, 10, 15, 19, 29; July 1. Visits between 0500 and 1900 totaled 20 hours. **Census:** Ovenbird, 8.5 (139, 57); Red-eyed Vireo, 6 (98, 40); Wood Thrush, 3 (49, 20); Cardinal, 2.5; Rufous-sided Towhee, 2.5; E. Wood Pewee, 2.0; Carolina Chickadee, 1.5; Tufted Titmouse, 1.5; Gray Catbird, 1.5; Pine Warbler, 1.5; Scarlet Tanager, 1.5; Indigo Bunting, 1.5; Yellow-billed Cuckoo, 1; Red-bellied Woodpecker, 1; Downy Woodpecker, 1; Great Crested Flycatcher, 1; Carolina Wren, 1; Black-and-white Warbler, 1; Com. Yellowthroat, 1; Brown-headed Cowbird, 1; Blue Jay, 0.5; White-breasted Nuthatch, 0.5; Blue-gray Gnatcatcher, 0.5; Turkey Vulture, +; Red-tailed Hawk, +; Bobwhite, +; Com. Flicker, +; Hairy Woodpecker, +; Com. Crow, +; Yellow-throated Vireo, +; Yellow-breasted Chat, +. **Total:** 31 species; 43 territorial males (705/km², 287/100 acres).



Fig. 3. Upland predominantly deciduous mixed forest fragment. Note absence of vegetation in terrestrial and shrub layer.

Appendix II

UPLAND PREDOMINANTLY CONIFEROUS MIXED FOREST FRAGMENT.

— **Location:** Maryland; Prince George's Co., Beltsville; 39°01'N, 76°49'8"W, Laurel Quadrangle, USGS. **Continuity:** New (Censused in 1975). **Size:** 6.1 ha = 15 acres (rectangular, 2x3 ha grid). **Description of Plot:** Dominant canopy trees are Loblolly Pine (*Pinus taeda*), Red Maple (*Acer rubrum*), and Black Gum (*Nyssa sylvatica*). The understory is composed of seedlings of these species along with sapling oaks and Am. Holly (*Ilex opaca*). A thick growth of Com. Greenbrier (*Smilax rotundifolia*), Japanese Honeysuckle (*Lonicera japonica*), and *Viburnum* spp. fills about 60% of the space from 0 to 3 ft. in height. The ground cover of 50% consists of Virginia Creeper (*Parthenocissus quinquefolia*), Summer-sweet (*Clethra alnifolia*), and various ferns and mosses. The forest floor is covered with a 3-in. layer of pine needles. The edges of the plot adjacent to a dirt road form a distinct vegetational belt about 40 ft. wide. Few canopy trees in this section are more than 30 ft. tall and include Sweet Gum (*Liquidambar styraciflua*), Scrub Pine (*Pinus virginiana*), Am. Beech (*Fagus grandifolia*), and Choke Cherry (*Prunus serotina*). A thick understory, composed mainly of Red Maple and Black Gum seedlings occupies 80% of the vertical space below the canopy. Dense growths of Common Greenbrier and Japanese Honey-

suckle cover the ground. **Local Biogeography:** This plot forms the E half of a 35-acre forest fragment which is linked to a 400-acre woodland by a disturbed narrow corridor. Both tracts, "fragment" and "mainland," lie within an intermittent forest system that encompasses more than 10,000 acres. The 35-acre fragment was structurally divided into halves; this plot is the eastern, predominantly coniferous half. It was probably kept in cultivation longer than the deciduous half and thus is in an earlier stage of succession. **Edge:** The plot is bordered on the W by the other half of the 35-acre fragment, on the E and S by cultivated fields, and on the N by an overgrown weedy field. A narrow dirt road runs diagonally through the southern quarter of the plot. **Topography:** Flat. Elevation of about 140 feet. **Coverage:** May 21, 24, 28; June 4, 7, 10, 15, 29, totaling 18 hours between 0500 and 1800. **Census:** Rufous-sided Towhee, 4 (66, 27); Red-eyed Vireo, 3.5 (57, 23); White-eyed Vireo, 3 (49, 20); Com. Yellowthroat, 3; Gray Catbird, 2.5; Wood Thrush, 2.5; Prairie Warbler, 2.5; Carolina Wren, 2; Ovenbird, 2; Indigo Bunting, 2; Cardinal, 1.5; Red-bellied Woodpecker, 1; Carolina Chickadee, 1; Tufted Titmouse, 1; Pine Warbler, 1; Yellow-breasted Chat, 1; Brown-headed Cowbird, 1; Great Crested Flycatcher, 0.5; Blue Jay, 0.5; Com. Grackle, 0.5; Scarlet Tanager 0.5; Red-tailed Hawk, +; Bobwhite, +; Com. Crow, +; Field Sparrow, +. **Total:** 25 species; 36.5 territorial males (598/km², 243/100 acres). **Visitors:** Yellow-billed Cuckoo, E. Phoebe, E. Wood Pewee, Brown Thrasher Blue-gray Gnatcatcher, Am. Goldfinch.



Fig. 4. Upland predominantly coniferous mixed forest fragment.

Appendix III

LARGE UPLAND MIXED FOREST.

— **Location:** Maryland; Prince George's Co., Beltsville; 39°01'N, 76°50'25"W, Laurel Quadrangle, USGS. **Continuity:** New (Censused in 1975). **Size:** 6.1 ha = 15 acres (L-shaped, 3x3 ha grid with northeastern 3 ha deleted). **Description of Plot:** Dominant canopy species are White Oak (*Quercus alba*), Black Oak (*Q. velutina*), and Black Gum (*Nyssa sylvatica*). Remnants of an earlier successional stage are Scrub and Loblolly Pine (*Pinus virginiana* and *P. taeda*), which account for only about 4% of the mature trees. Saplings of the canopy species are prominent in the understory along with Mountain Laurel (*Kalmia latifolia*), Red Maple (*Acer rubrum*), and Sassafras (*Sassafras albidum*). An abundance of ericaceous plants, including *Gaylussacia*, *Lyonia*, and *Vaccinium* spp. composes a dense shrub layer. Ground cover is sparse, but includes such species as Partridgeberry (*Mitchella repens*), Moccasin-flower (*Cypripedium acaule*), Summer-sweet (*Clethra alnifolia*), and *Lycopodium* spp. Patches of Cinnamon Fern (*Osmunda cinnamomea*) occur in moist depressions throughout the plot. The forest floor is covered with oak leaves and a substantial layer of humus. The canopy layer, estimated to be about 90% closed, ranges from 40 to 80 ft.; the understory layer, 15 to 30 ft., occupies only about 30% of the vertical space. Ground cover is estimated at 20%. **Local Biogeography:** The plot is located in the west central portion of a 400-acre woodland tract which sur-



Fig. 5. Large upland mixed forest. Note comparatively high density of terrestrial and shrub-layer vegetation.

rounds the headwaters of Beaver Dam Creek. This tract is connected by corridors of forest to other large acreages of forest to the W, N, and S; the total semi-continuously wooded area of which this tract is a part exceeds 10,000 acres. On the E, the 400-acre woodland is connected by a narrow, disturbed corridor to a 35-acre forest fragment. Similar 15-acre plots on the large and small tracts were censused and compared. **Edge:** The plot is bordered on E and W by similar upland forest, on the N by a narrow belt of such forest beyond which lies riparian woodland, and on the S by a powerline right-of-way. The plot was drawn to exclude 50 ft. of wooded area on the south. **Topography:** Essentially flat; the plot lies above the floodplain woodland of Beaver Dam Creek at an elevation of about 140 ft. **Coverage:** May 20, 23, 27, 29, 31; June 2, 9, 21, 22, 25, 30; July 1, 3, between 0500 and 2000, totaling 26 hours. **Census:** Ovenbird, 15.5 (254, 103); Wood Thrush, 6 (98, 40); Red-eyed Vireo, 6; Red-bellied Woodpecker, 2; Tufted Titmouse, 2; Rufous-sided Towhee, 2; E. Wood Pewee, 1.5; Carolina Chickadee, 1.5; Carolina Wren, 1.5; Yellow-throated Vireo, 1.5; Black-and-white Warbler, 1.5; Hooded Warbler, 1.5; Scarlet Tanager, 1.5; Yellow-billed Cuckoo, 1; Great Crested Flycatcher, 1; White-breasted Nuthatch, 1; Blue-gray Gnatcatcher, 1; Pine Warbler, 1; Brown-headed Cowbird, 1; Com. Flicker, 0.5; Blue Jay, 0.5; Kentucky Warbler, 0.5; Turkey Vulture, +; Red-tailed Hawk, +; Screech Owl, +; Hairy Woodpecker, +; Downy Woodpecker, +; E. Phoebe, +; Com. Crow, +; White-eyed Vireo, +; Whip-poor-will, +. **Total:** 31 species; 51.5 territorial males (844/km², 343/100 acres).

Appendix IV

DISTURBED WOODED CORRIDOR. — **Location:** Maryland; Prince George's Co., Beltsville; 39°01'N, 76°49'32"W, Laurel Quadrangle, USGS. **Continuity:** New (Censused 1975). **Size:** 6.1 ha = 15 acres (irregular). **Description of Plot:** The plot (Fig. 2) is divided into five zones, two of which consist of woodland which had been heavily grazed prior to the breeding season. Trees in this grazed area are widely spaced, leaving nearly half of the canopy open; dominant species are White Oak (*Quercus alba*), Bitternut Hickory (*Carya cordiformis*), and in wetter areas near an intermittent stream, Red Maple (*Acer rubrum*). Other oak species and Black Gum (*Nyssa sylvatica*) are less common. In these grazed, open woods, there is virtually no shrub layer, although a few Am. Holly (*Ilex opaca*) have escaped the animals. Instead the ground vegetation is well developed with such plants as Virginia Creeper (*Parthenocissus quinquefolia*), Pokeweed (*Phytolacca americana*), goldenrod (*Solidago* spp.), elder (*Sambucus* spp.), *Polygonum cespitosum* var. *longisetum*, and Richweed (*Pilea pumila*). Several grasses are prominent, including panic-grasses (*Panicum* spp.), *Muhlenbergia* spp., *Agrostis*, and *Leersia virginica*. A third zone has been protected from grazing by fences, and adjoins a powerline right-of-way which also serves as a lightly-used farm road. This zone has a well-defined shrub-understory layer whose foliage is about 6-30 ft. above a forest floor covered mostly with oak leaves. Herbaceous plants on the ground include Lady Fern

(*Athyrium filix-femina*), Solomon's Seal (*Polygonatum biflorum*), Richweed, and *Rubus* spp. The shrub and understory plants include Choke Cherry (*Prunus serotina*), *Viburnum* spp., Sassafras (*Sassafras albidum*), Black Gum, Flowering Dogwood (*Cornus florida*), Virginia Creeper, Japanese Honeysuckle (*Lonicera japonica*), Com. Greenbrier (*Smilax rotundifolia*), and Red Maple. The narrow fourth zone consists of channels that carry an intermittent stream flow. A fence follows the general course of the stream bed. The dominant herbaceous plant in this zone is the grass *Cinna arundinacea*, and only Red Maple and willows (*Salix* spp.) have been able to colonize the overstory. Most of the trees in this zone are young with a maximum height of 30-40 ft. *Leersia virginica*, Richweed, Com. Greenbrier, and *Impatiens biflora* have also colonized the swampy area near the streambed and among the channels. The east edge of the plot is overgrown, in some places forming dense thickets, with such plants as Choke Cherry, Tulip-tree (*Liriodendron tulipifera*), *Solidago* spp., *Panicum* and *Impatiens* spp., Muscadine Grape (*Vitis rotundifolia*), elder, Japanese Honeysuckle, and *Rubus* spp. Of particular importance on this edge is the fence, which is buried in many places under a profuse growth of Com. Greenbrier. **Local Biogeography:** The plot serves to connect a 400-acre woodland tract traversed by a narrow stream with a 35-acre forest fragment surrounded by fields. All three tracts are situated within an intermittent

woodland system of over 10,000 acres. The corridor was censused, in spite of its disturbed state and patchy habitat, to investigate its value as a connecting link between the smaller and larger tracts, the forest fragment and the forest "mainland." **Edge:** The corridor (Fig. 2) is bounded on the N and S by open fields, on the W by the 400-acre woodland, and on the E by a two-lane lightly traveled blacktop road beyond which lies the 35-acre forest fragment. **Topography:** Traversed by an intermittent stream at an elevation of about 120 ft. **Coverage:** May 27, 28; June 6, 17, 18, 25, 26, 28, between 0500 and 1200, totaling 12 observer hours. **Census:** Com. Yellowthroat, 3 (49, 20); Indigo Bunting, 3; Cardinal, 1.5; Rufous-sided Towhee, 1.5; Am. Woodcock, 1; Yellow-billed Cuckoo, 1; Red-bellied Woodpecker, 1; Downy Woodpecker, 1; E. Wood Pewee, 1; Blue Jay, 1; Carolina Chickadee, 1; Tufted Titmouse, 1; Carolina Wren, 1; Gray Catbird, 1; White-eyed Vireo, 1; Yellow-throated Vireo, 1; Red-eyed Vireo, 1; Ovenbird, 1; Field Sparrow, 1; Great Crested Flycatcher, 0.5; White-breasted Nuthatch, 0.5; Brown Thrasher, 0.5; Blue-gray Gnatcatcher, 0.5; Bobwhite, +; Com. Flicker, +; Hairy Woodpecker, +; E. Bluebird, +; Brown-headed Cowbird, +. **Total:** 28 species, 26 territorial males (426/km², 173/100 acres). **Visitors:** Red-shouldered Hawk, Am. Robin, Blue Grosbeak, Am. Goldfinch. **Remarks:** This census is remarkable in having fewer territorial males than species!



Fig. 6. Disturbed wooded corridor. Wood Reedgrass dominates the bed of the intermittent stream, and young trees form a narrow outer belt of wooded vegetation on each side.