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**IMPACT OF HURRICANE HUGO ON BIRD POPULATIONS
IN VIRGIN ISLANDS NATIONAL PARK**

**REPORT ON A RESEARCH PROJECT FUNDED
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ABSTRACT

Bird populations were surveyed in Virgin Islands National Park, St. John, U. S. Virgin Islands in 1987 (before Hurricane Hugo hit the Virgin Islands) and in 1990 (four months after the hurricane). Abundance was estimated using the fixed-radius point count method. The average number of individual permanent residents per survey point was significantly lower after the hurricane in both moist forest and dry evergreen woodland. Most of the resident species that showed substantial population declines feed primarily on fruit or nectar, which is consistent with the results of several other recent studies of the effect of hurricanes on forest bird communities. Two species of insectivorous winter residents (*Parula americana* and *Mniotilta varia*) also had significantly lower densities after the hurricane. Although many areas within the park were defoliated after the hurricane, most of the trees remained standing and they produced new leaves within a few weeks. Our results suggest, however, that even relatively mild storm damage can result in substantial population declines for some species of birds. Small populations of these species might be vulnerable to extirpation by hurricanes, especially if they are confined to relatively small preserves.

The Caribbean Basin is periodically subject to major disturbance by hurricanes. The structure and species composition of both marine and terrestrial communities in this region are probably strongly influenced by these storms (Connell, 1978; Boucher, 1990). This may be particularly true of habitats in the West Indies (Lugo, 1988), where hurricanes are relatively frequent and land masses are not large enough to substantially reduce the force of storms. Understanding the ecological impact of hurricanes in the West Indies is important for managing preserves like Virgin Islands National Park in order to maintain viable populations of native species. A high probability of disturbances that lead to catastrophic population declines results in a low probability for the survival of even relatively large populations (Shaffer, 1987). Many species are increasingly restricted to preserves, where the populations are relatively small. If hurricanes cause severe population declines, then these small populations are unlikely to persist. If, however, West Indian species are well adapted to hurricanes, and display either high survivorship or quick recovery of abundance in response to storms, then the prospects for maintaining viable populations in protected areas is much better.

The ecology of forest bird communities has been the subject of numerous studies in the West Indies and on the Caribbean coast of Central America, but very little is known about the impact of hurricanes on these communities. Only brief, anecdotal accounts of the impact of hurricanes on birds have been published. Sutton (1945) describes how small landbirds successfully survived a Florida

hurricane by taking shelter from the wind. Huntington and Barbour (1936) describe the great reduction in populations of many species of landbirds after a Cuban hurricane. Hill (1945) and Robertson and Kushlan (1974) briefly discuss similar population declines after hurricanes in Massachusetts and Florida, respectively.

During 1988 and 1989 three major hurricanes swept across the Caribbean, and the ecological impact of these storms on forest bird communities is being intensively studied at several sites on the Central American mainland and in the West Indies. Consequently we should soon have a much better understanding of the response of bird populations to major storms in the Caribbean Basin. In 1988 Hurricane Joan destroyed the rainforest canopy in a large area in southeastern Nicaragua. The impact of this storm on bird populations and forest structure is being monitored (Boucher, 1990). During the same year Hurricane Gilbert heavily damaged the forest at sites where bird populations had been intensively surveyed in Jamaica and on the Yucatan Peninsula. Quantitative data on bird densities and vegetation structure are available for these sites for periods before and after the hurricane, so the effects of the hurricane can be thoroughly assessed (Olmsted et al., 1989, Joseph Wunderle, personal communication). Similarly, in 1989 Hurricane Hugo damaged rainforest sites in Puerto Rico where Wunderle (1990) had been monitoring bird populations and sites in Virgin Islands National Park where we had censused birds. In both cases population densities could be quantitatively compared for periods before and after the hurricane.

Hurricane Hugo hit the U. S. Virgin Islands on 17 - 18 September 1989. The eye of the hurricane passed over St. Croix, about 64 km south of Virgin Islands National Park on St. John. The storm had sustained winds of 225 kph. Trees on ridgelines and on the south side of St. John were extensively defoliated and lost many branches, and many large trees were toppled by the wind (Gary Ray, personal communication). Within one month of the hurricane many of the defoliated trees produced new leaves, but the density of fruit and blossoms on woody species was low for several months (Gary Ray, personal communication). We surveyed birds in Virgin Islands National Park four months after the hurricane in order to assess the impact of the storm on bird populations. By that time the impact of any secondary effects of the storm (such as reduced food supply) on the abundance and distribution of birds would probably be evident.

METHODS

During the winters of 1987 and 1990 we surveyed bird populations in moist forest and dry evergreen woodland in Virgin Islands National Park, St. John, U.S. Virgin Islands. Moist forest, which is restricted to high slopes, ravines and coastal basins, is taller and structurally more complex than dry woodland; see Woodbury and Weaver (1987) for a detailed description of the two habitat types. Moist forest covers 18% of St. John while dry evergreen woodland covers 67% (Askins et al., 1989). Other less widespread habitats (coastal scrub, gardens, and transitional areas between moist

and dry forest) were surveyed in 1987, but not in 1990, so they are not considered in this report.

We used the fixed-radius point count method (Hutto et al. 1986) to estimate the abundance of birds. We recorded all birds detected within 25 m of the survey point during a ten-minute observation period. Observations were made between 0630 and 0930. Recorded "spishing" noises were played for 60 s during the second and sixth minutes of the observation period to attract birds closer to facilitate identification. Surveys were conducted between 31 October and 3 December 1987, and between 10 and 16 January 1990. We completed surveys at 55 points in moist forest and 35 points in dry woodland in 1987, and at 40 points in moist forest and 22 points in dry woodland in 1990. All survey points were located along trails, and adjacent survey points were separated by at least 200 m (as determined by pacing). All trails surveyed in 1990 had also been surveyed in 1987. In 1990 each survey point was marked with a numbered aluminum tag attached to a tree with an aluminum nail approximately 1.5 m above the ground on the side of the tree away from the trail. The position of each point was marked on a USGS topographical map and nearby landmarks were described in detail. During June, 1990, these marked survey points were located within one or two minutes after pacing to the approximate location, so population surveys can easily be repeated at these points in the future.

We also completed vegetation surveys at all bird survey points. Percent cover was estimated for the herb layer (all plants < 0.5 m), shrub layer (all plants 0.5 - 4 m) and tree canopy (all plants > 4 m).

To evaluate percent cover, we sighted into each of these strata with a piece of PCV tubing (2.7 cm diameter, 5.5 cm long). The proportion of the field of view covered by leaves was categorized as follows: 0 (0%), 1 (1 - 25%), 2 (25 - 50%), 3 (50 - 75%), and 4 (75 - 100%). Cover estimates were made at 2 m intervals along four, 11-m transects radiating in the four cardinal directions from the bird survey point. At sites with a dense thorn scrub understory, the readings were taken along two parallel, 22-m transects on opposite sides of the trail. The sum of the 25 readings for each vegetation stratum yielded the overall percent cover. We also determined the elevation of each survey point, and in 1987 we determined average canopy height, litter cover, number of columnar cacti, number of palms, and aspect for each vegetation plot (Askins et al., in press).

The frequency of occurrence of birds at survey points was compared for 1987 and 1990 using analysis of variance (SPSS, 1986). Multiple range testing (Newman-Keuls Test; Zar, 1974) was used to determine whether the frequency of particular species differed for the two years. The following species were not included in the analyses of the abundance of particular species because they were detected too infrequently (i.e., at less than five survey points in both years) to provide an adequate sample size : Red-tailed Hawk, American Kestrel, Barn Swallow, Yellow-throated Vireo, Blue-winged Warbler, Magnolia Warbler, Cape May Warbler, and Blackpoll Warbler (see Appendix for scientific names). Data on these species were included in the analyses of the total number of permanent residents or winter residents, however.

RESULTS

The average number of individual birds per survey point was significantly lower in 1990 than in 1987. This was true both in moist forest ($F = 12.0$, $P = 0.001$) and dry evergreen woodland ($F = 18.2$, $P < 0.001$). Both permanent and winter residents were significantly less frequent in 1990 at survey points in moist forest ($p = 0.01$ in both cases; Figure 1). The pattern is similar in dry woodland (Figure 1), but the difference between the years is only significant for permanent residents ($p < 0.001$), not for winter residents (which occur at relatively low frequencies in this habitat; Askins et al., 1989).

The most abundant permanent resident in moist forest, the Pearly-eyed Thrasher, was equally abundant in 1987 and 1990 (Newman-Keuls Test: $p > 0.05$; Figure 2). Most of the difference between the two years in overall abundance of permanent-residents was due to significantly lower densities for three species: Scaly-naped Pigeon, Antillean Crested Hummingbird, and Bananaquit ($P < 0.001$ in all cases; Figure 2). Other species of permanent residents occurred at relatively low densities during both years (Figure 2), and only Gray Kingbird (which was not detected in moist forest after the hurricane) was significantly less frequent in 1990 than in 1987 ($P < 0.05$).

The overall change in the abundance of winter residents in moist forest was largely due to significantly lower frequencies of Black-and-white Warbler and Northern Parula in 1990 than in 1987 ($P < 0.001$; Figure 3). In contrast, Northern Waterthrushes were

significantly more abundant in 1990. Other species of winter residents did not show significant changes between the two years and there were no consistent overall trends for these species (Figure 3).

Most of the permanent residents that are common in the dry woodland had lower densities in 1990 than in 1987 (Figure 4). This was true not only for the two nectar-feeding species that showed lower frequencies in moist forest in 1990 (Bananaquit and Antillean Crested Hummingbird; $P < 0.001$ in both cases), but also for Pearly-eyed Thrasher; $P < 0.001$), Caribbean Elaenia ($P < 0.001$), Common Ground-Dove ($P < 0.05$) and Smooth-billed Ani ($P < 0.05$). Another nectar-feeding species, the Green-throated Carib, was less abundant in 1990 than in 1987, but this difference was not significant. Two seed-eating species, Black-faced Grassquit and Lesser Antillean Bullfinch, had significantly higher densities in 1990 ($P < 0.05$).

Winter residents were infrequent in dry woodland during both years (Figure 5). Although most species of winter residents had lower frequencies in dry woodland in 1990 than in 1987, none of these differences were significant (Student's *t*-test; $P > 0.05$).

The average percent cover for each of the three vegetation strata was surprisingly similar for the two years (Table 1). In dry woodland there was no significant difference in average percent cover for any of the three strata (Student's *t*-test; $P > 0.05$). In moist forest the average percent cover for the tree and herb layers were almost identical for the two years ($P > 0.05$). The variance in percent cover for trees was greater for 1990 than for 1987 ($F = 1.88$, $P = 0.032$), however, probably reflecting the obvious openings in the

forest canopy created when the hurricane toppled trees, snapped trunks, and broke large branches. Percent cover for the shrub layer was significantly lower in the moist forest in 1990 than in 1987 ($t = 9.0$, $DF = 86$, $P < 0.001$). Gary Ray (personal communication) reports relatively little change in the shrub layer before and after the hurricane, so the difference we found may be a result of differences in the survey points sampled during the two years. When the comparison is made only for survey points along trails that were surveyed during both 1987 and 1990, the difference in shrub cover for the two years is smaller, but it is still significant.

DISCUSSION

Many species of birds had lower densities after Hurricane Hugo than in 1987, two years before the storm. Among the permanent residents, nectar-feeding species (Bananaquit, Antillean Crested Hummingbird and Green-throated Carib; Faaborg, 1985) declined in both moist forest and dry woodland. Two species that primarily feed on fruit (Scaly-naped Pigeon in moist forest and Caribbean Elaenia in dry woodland; Wetmore, 1927; Crowell, 1968,) also declined. This is consistent with the results of several recent studies, which have shown that species that depend on nectar and fruit suffer the greatest declines following hurricanes, presumably because these food sources are scarce for a long period following a storm (Boucher, 1990; Olmsted et al., 1989; Wunderle, 1990; Joseph Wunderle, personal communication). The omnivorous Pearly-eyed Thrasher (Wetmore, 1927) declined markedly in dry woodland, but not in

moist forest, suggesting that moist forest became a preferred habitat after the storm. (Before the storm the frequency of this species was similar in the two habitats; Figures 2 and 4.) In contrast, two species of seed-eaters (Black-faced Grassquit and Lesser Antillean Bullfinch; Wetmore, 1927) had greater densities in dry woodland after the storm, suggesting that these species were buffered from the effects of the storm, perhaps because their food supply persisted. Another seed-eater, the Common Ground-Dove (Bent, 1932), was less abundant in dry woodland after the storm, however. Lesser Antillean Bullfinch first colonized St. John in 1971 and its population has been expanding on the island (Raffaele and Roby, 1977; Norton, 1979), so the greater frequency of this species in 1990 than in 1987 is not surprising.

Most species of migrants had similar densities in 1987 and 1990, but two species that are largely restricted to the canopy and subcanopy (Northern Parula and Black-and-white Warbler) had lower frequencies in 1990. Northern Parulas feed primarily on leaf insects in the canopy (Lack and Lack, 1972), so several weeks of defoliation of trees following the hurricane could have a severe impact on their food supply. Black-and-white Warblers feed primarily on bark insects (Lack and Lack, 1972), so it is not obvious that their food supply would be severely affected by the storm. Black-and-white Warblers (but not Northern Parulas) also declined significantly at two sites in Jamaica after Hurricane Gilbert (Joseph Wunderle, personal communication). Both of these species arrive in the Virgin Islands from their northern breeding areas in September and October, so many individuals would have arrived in the

wintering area when much of the moist forest (their preferred winter habitat; Askins et al., 1989) was still defoliated following the storm in mid-September. They may either have suffered high mortality or moved on to other wintering areas.

The Northern Waterthrush was significantly more abundant in moist forest after the hurricane. In the Virgin Islands this species is most abundant in mangrove swamps (Robertson, 1962). Mangrove swamps were heavily damaged by Hurricane Hugo; a large proportion of the trees were blown down in many of the black mangrove (*Avicennia germinans*) swamps, and red mangroves (*Rhizophora mangle*) suffered high mortality after the storm (personal observation). Perhaps waterthrushes were forced to move into moist forest because of the extensive damage to these swamps.

These conclusions must be judged with caution because we are comparing a single winter before the storm with the winter following the storm. Bird populations vary from year to year in the absence of hurricanes, and the differences we detected between 1987 and 1990 may have been due to rainfall patterns in the years preceding the surveys or other stochastic environmental factors. Also, the detectability of species during surveys might change if the storm greatly modified vegetation structure, but our data on percent cover in the different vegetation strata indicate that this probably was not an important factor. Detectability might also vary seasonally with frequency of singing, but this is unlikely to be a factor in the present study because all surveys were completed during the winter, when most species are not breeding (Raffaele, 1989). Differences in shrub density for points surveyed in 1987 and 1990 could explain some of

the differences in abundance of birds in moist forest, but this would not explain similar differences in dry woodland, where percent cover was similar for points surveyed in the two years.

The decline of species that primarily feed on fruit or nectar in both moist forest and dry woodland in the Virgin Islands is consistent with the pattern described at several other sites after a major hurricane. Fruit and nectar specialists declined in the months following a hurricane in the lowland rainforests of Nicaragua (Boucher, 1990), tropical dry forest in the Yucatan (Olmsted et al. 1989), montane habitats in Jamaica (Joseph Wunderle, personal communication), and rainforest in Puerto Rico (Wunderle, 1990). The pattern is surprisingly consistent given the diversity of habitats surveyed in these different studies and the great variation in the amount of damage to the vegetation caused by the storm, from a leveling of the forest in Nicaragua to defoliation of trees and scattered blowdowns on St. John. This suggests that the populations of nectar and fruit specialists are likely to undergo catastrophic declines following major storms, making these species particularly vulnerable to extinction if they are restricted to small, isolated preserves in regions subject to frequent hurricanes. This was dramatically illustrated by the effect of Hurricane Hugo on the endangered Puerto Rican Parrot, a frugivorous species that is found only in the Luquillo rainforest of Caribbean National Forest in northeastern Puerto Rico. Before Hurricane Hugo hit the Luquillo forest, only 45 Puerto Rican Parrots remained in the wild, and only about half of these have been seen since the storm (Boucher, 1990). Although none of the bird species in Virgin Islands National Park are

as critically endangered as the Puerto Rican Parrot, two species that were classified as frugivorous by Faaborg (1985), the Bridled Quail Dove and White-crowned Pigeon, have relatively small populations in the U.S. Virgin Islands. The latter is considered a threatened species in the territory (Wiley, 1985). We do not have adequate data to compare the abundance of these two species before and after the hurricane because Bridled Quail Doves were infrequent during both years (Figure 2) and White-crowned Pigeons are primarily summer residents (Raffaele, 1989). However, Askins (unpublished data) completed additional surveys in Virgin Islands National Park during May and June, 1990, when both of these species are present, and when they are nesting (Raffaele, 1989) and presumably calling frequently. Both species were infrequent and apparently highly localized. If these species depend primarily on fruit and have small populations, they may be especially vulnerable to the impact of hurricanes. The White-crowned Pigeon is definitely a fruit specialist (Wiley and Wiley, 1979), but the feeding behavior of the Bridled Quail Dove is not well known (David Nellis, personal communication).

Our results indicate that even relatively mild storm damage may substantially reduce populations of some species of birds, especially those that depend primarily on fruit and nectar. Consequently, these species might be especially prone to disappear from isolated preserves that are periodically subjected to hurricanes. To determine how vulnerable they are, it will be important to monitor their populations during the next few years to determine how quickly they recover.

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Table 1. Average percent cover for three vegetation strata in plots centered at bird survey points in moist forest and dry evergreen woodland in Virgin Islands National Park, St. John, U.S. Virgin Islands. Vegetation surveys were completed in 1987 (before the hurricane) and 1990 (after the hurricane).

Habitat	Tree Cover		Shrub Cover		Herb Cover	
	1987	1990	1987	1990	1987	1990
Moist forest	68.2	69.4	40.5	17.9	26.6	25.5
Dry woodland	34.4	37.9	32.9	35.2	31.5	29.3

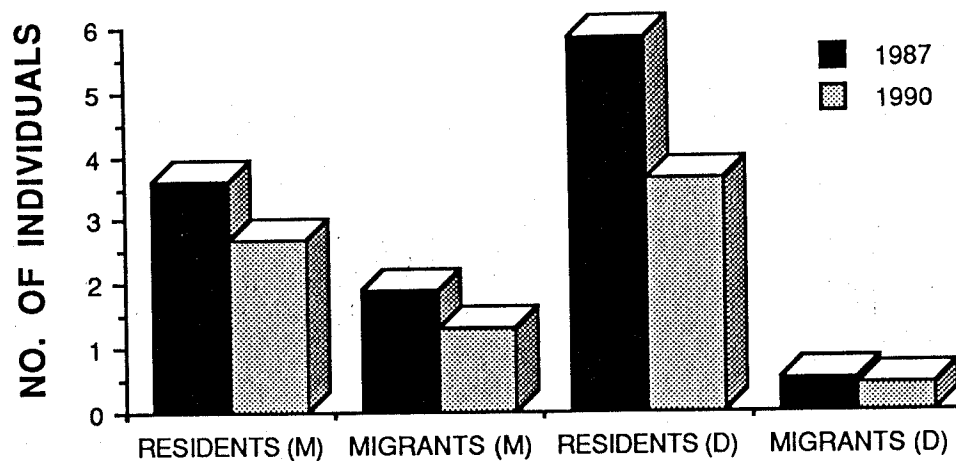


Figure 1. Comparison of the average number of individuals per survey point in moist forests (M) and dry evergreen woodland (D) for 1987 (before Hurricane Hugo) and 1990 (four months after Hurricane Hugo). Averages for permanent residents (residents) and winter residents (migrants) are shown separately.

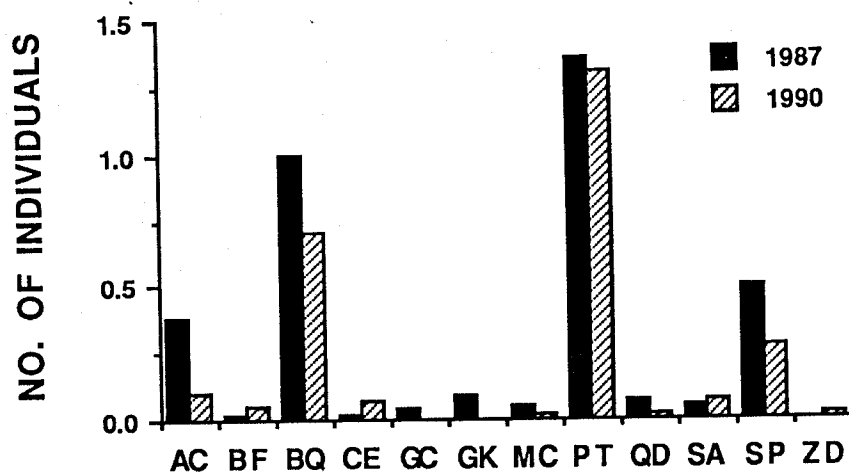


Figure 2. Comparison of the average number of individuals per survey point in moist forest during 1987 and 1990 for the following species of permanent residents: Antillean Crested Hummingbird (AC), Black-faced Grassquit (BF), Bananaquit (BQ), Caribbean Elaenia (CE), Green-throated Carib (GC), Gray Kingbird (GK), Mangrove Cuckoo (MC), Pearly-eyed Thrasher (PT), Bridled Quail Dove (QD), Smooth-billed Ani (SA), Scaly-naped Pigeon (SP), and Zenaida Dove (ZD).

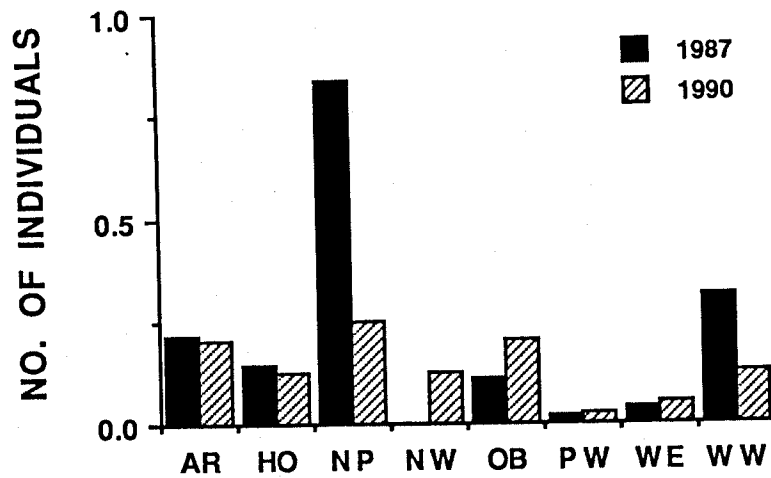


Figure 3. Comparison of the average number of individuals per survey point in moist forest during 1987 and 1990 for the following species of winter residents: American Redstart (AR), Hooded Warbler (HO), Northern Parula (NP), Northern Waterthrush (NW), Ovenbird (OB), Prairie Warbler (PW), Worm-eating Warbler (WE), and Black-and-white Warbler (WW).

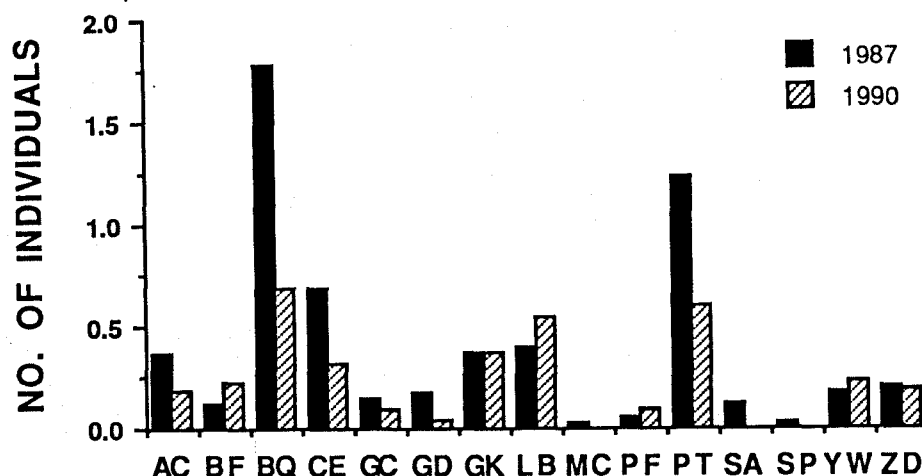


Figure 4. Comparison of the average number of individuals per survey point in dry evergreen woodland during 1987 and 1990 for the following species of permanent residents: Antillean Crested Hummingbird (AC), Black-faced Grassquit (BF), Bananaquit (BQ), Caribbean Elaenia (CE), Green-throated Carib (GC), Common Ground-Dove (GD), Gray Kingbird (GK), Lesser Antillean Bullfinch (LB), Mangrove Cuckoo (MC), Puerto Rican Flycatcher (PF), Pearly-eyed Thrasher (PT), Smooth-billed Ani (SA), Scaly-naped Pigeon (SP), Yellow Warbler (YW), and Zenaida Dove (ZD).

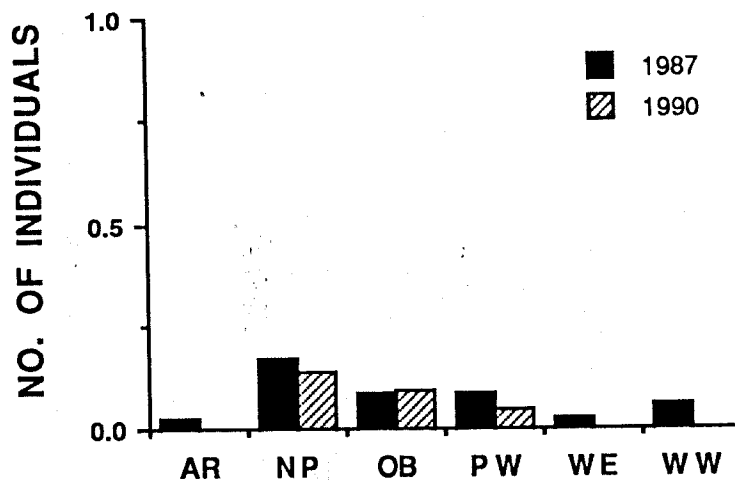


Figure 5. Comparison of the average number of individuals per survey point in dry evergreen woodland during 1987 and 1990 for the following species of winter residents: American Redstart (AR), Northern Parula (NP), Ovenbird (OB), Prairie Warbler (PW), Worm-eating Warbler (WE), and Black-and-white Warbler (WW).

Appendix. Scientific names of bird species.

- Red-tailed Hawk (*Buteo jamaicensis*)
American Kestrel (*Falco sparverius*)
White-crowned Pigeon (*Columba leucocephala*)
Scaly-naped Pigeon (*Columba squamosa*)
Zenaida Dove (*Zenaida aurita*)
Common Ground-Dove (*Columbina passerina*)
Bridled Quail-Dove (*Geotrygon mystacea*)
Puerto Rican Parrot (*Amazona vittata*)
Mangrove Cuckoo (*Coccyzus minor*)
Smooth-billed Ani (*Crotophaga ani*)
Green-throated Carib (*Eulampis holosericeus*)
Antillean Crested Hummingbird (*Orthorhyncus cristatus*)
Gray Kingbird (*Tyrannus dominicensis*)
Puerto Rican Flycatcher (*Myiarchus antillarum*)
Caribbean Elaenia (*Elaenia martinica*)
Pearly-eyed Thrasher (*Margarops fuscatus*)
Yellow-throated Vireo (*Vireo flavifrons*)
Blue-winged Warbler (*Vermivora pinus*)
Northern Parula (*Parula americana*)
Yellow Warbler (*Dendroica petechia*)
Magnolia Warbler (*D. magnolia*)
Cape May Warbler (*D. tigrina*)
Prairie Warbler (*D. discolor*)
Blackpoll Warbler (*D. striata*)
Black-and-white Warbler (*Mniotilta varia*)

American Redstart (*Setophaga ruticilla*)

Worm-eating Warbler (*Helminthos vermivorus*)

Ovenbird (*Seiurus aurocapillus*)

Northern Waterthrush (*S. noveboracensis*)

Hooded Warbler (*Wilsonia citrina*)

Bananaquit (*Coereba flaveola*)

Lesser Antillean Bullfinch (*Loxigilla noctis*)

Black-faced Grassquit (*Tiaris bicolor*)