Within-forest preferences of Wood Thrushes wintering in the rainforest of southern Veracruz.—Given current concern over the effects of tropical deforestation on wintering, nearctic, migrant species, we should ascertain how migrants distribute themselves within forests. Several tropical resident species have been shown to prefer treefall gaps in tropical forests (Willis and Oniki 1972, Stiles 1975, Gradwohl and Greenberg 1980, Schemske and Brokaw 1981, Levey 1988). Investigations of the within-forest distribution of wintering migrants which utilize tropical forest understory are scarce and rather inconclusive (e.g., Wunderle et al. 1987, Levey 1988). Here we present evidence for within-forest habitat (microhabitat) preference in the Wood Thrush (*Hylocichla mustelina*) on its wintering grounds in southern Veracruz, México.

Study area and methods.—The study was conducted during the boreal winters of 1983–1984, and 1984–1985 in the Sierra de Los Tuxtlas of southern Veracruz, México. Our main study site (8.75 ha, elev. 150 m) was located near the village of La Peninsula de Moreno (hence La Peninsula), in the Coxcoapan River valley, approximately 5.5 km ENE of the town of Coyame (Lago Catemaco). A second site (1.75 ha) on the slopes of the Volcán Santa Martha (approx. 15 km ESE of the La Peninsula site, elev. 470 m) was studied only during 9–19 March 1985. Both sites were located within primary rainforest (see Winker et al. 1990). Standard nylon mist nets (12 × 2.6 m) were placed 50 m apart on a 25-m grid system, and opened when weather permitted (both sites). Sampling various microhabitat types was not a focus of our main investigation (Rappole et al. 1989, Winker et al. 1990), and the areas sampled by individual nets occurred solely as a result of the location of a grid point. The 48 nets on the La Peninsula site were set in an 8 net by 6 net grid pattern, and were oriented perpendicular to the Coxcoapan River valley (approximately 50°). These nets were opened by block (either 12 or 16 nets) on a rotation basis to ensure relatively even sampling. Sampling periods included Oct. 1983–Jan. 1984, Nov. 1984–Mar. 1985. Nets were categorized subjectively as sampling "gap," "intact forest" or "mixed forest." Gaps are evident in forest through an increase in light levels, near-ground level vegetation (approx. 0–3 m), or, usually, both. Gaps on our site were present due to treefall, stream passage, or steep slopes. "Intact forest" was forest with a closed canopy and rather open understory. The "mixed" category was used when a net could not be confidently placed in either of the extreme categories due to the proximity of both microhabitat types. Sampling effort for each of the categories (mean net-h per net ± 1 SD) was: 16 "intact forest" nets (500.7 ± 28.3), 16 "gap" nets (477.6 ± 28.6), and 16 "mixed forest" nets (490.3 ± 25.1). Sampling efforts were different enough ($F = 2.86$, $P = 0.068$, one-way ANOVA) that analysis was performed upon capture rates, rather than individual captures.

Radio telemetry (2-g transmitters) was used to determine the home range size of 17 "sedentary" individuals using the La Peninsula site during the study period. Home range size was estimated using the modified minimum area method of Harvey and Barbour (1965). We did not sample all of the sedentary individuals occupying this site during these two winters in this manner. Further details on the telemetry aspect of this investigation can be found in Rappole et al. (1989) and Winker et al. (1990).

The La Peninsula site underwent very light selective logging in the mid-1970s. Vegetation occupying tree removal sites did not appear to be different in structure or composition from that occupying natural treefalls. All stumps on the La Peninsula site were located and mapped. The uneven distribution of stumps caused us to divide the site into two parts, one (3.5 ha) we called Part A (ca 1.1 stumps/ha), and the other (5.25 ha) Part B (ca 11.4 stumps/ha). The two parts were similar visually.

Rather than sample each net site, points for vegetation analysis were selected to ascertain the structure of forest used by thrushes whose home ranges were restricted to Part A or Part B. From radio tracking results no individuals appeared to use any of our qualitative microhabitat categories exclusively. Although our vegetation analysis considers the macrohabitat structure of different areas of forest rather than the structure of the specific microhabitat types sampled by individual nets, we think it is important to quantify the overall structure of forest used by Wood Thrushes rather than selectively quantify the extremes they encounter. The Santa Martha site was located in virgin forest at a higher altitude, and is included here for an "outside," macrohabitat comparison.

Vegetation analysis was conducted using a modified point-quarter method (Cottam and Curtis 1956, Phillips 1959). Plant taxonomy was ignored, and types were separated largely by size. Trees were defined as woody stems >7 cm diameter at breast height (dbh). "Saplings" were woody stems 2–7 cm dbh, and "shrubs" were plants both woody and non-woody from seedling size to 2 cm dbh. "Saplings" were mostly understory palms, primarily *Astrocaryum* species. "Shrubs" were primarily young "sapling" species and plants whose adult sizes fell between that of saplings and common herbaceous species. Canopy and ground cover were estimated as outlined by James and Shugart (1970). Because lianas (woody vines) and true vines are an important element of the tropical forest (Gradwohl and Greenberg 1980), they were counted when present on any tree or sapling measured, and each was categorized on the basis of diameter (by increments of 0.5 cm). Younger aerial roots of hemiepiphytes (e.g., strangler figs) close to tree trunks were probably measured occasionally, although when distinguishable (usually due to their stage of growth) they were excluded. Fifty points were sampled at Santa Martha and from both parts of the La Peninsula site (150 total); sample points were selected at random from the 25-m grid points. See Winker (1989) for more details of methods and descriptions of study sites. Overall netting effort was as follows: La Peninsula: 48 nets, 23,498 net-h; Santa Martha: 16 nets, 832 net-h.

Results. — We captured 117 Wood Thrushes on the La Peninsula site during the winter periods considered; because of statistical assumptions of independence, recaptures are not included in this analysis. Capture rates were normal in distribution (Kolmogorov-Smirnov test). To satisfy the assumptions of the statistical test, analysis was performed upon log-transformed capture rates ($\log_{10}[1 +$ capture rate of net x]). Capture rates of Wood Thrushes were higher in nets sampling "gap" sites (8.52/1000 net-h, SD = 6.74) than in "intact forest" (3.14/1000 net-h, SD = 2.52) and "mixed forest" nets (3.55/1000 net-h, SD = 3.25; $F =$ 6.5, $P = 0.003$, one-way ANOVA). This suggests within-forest, or microhabitat preference.

Home range sizes on the La Peninsula were as follows: Part A (N = 6) $\bar{x} = 0.64$ (± 0.31) ha; Part B (N = 11) $\bar{x} = 0.30$ (± 0.11) ha; overall (N = 17) $\bar{x} = 0.42$ (± 0.26) ha. Home ranges were significantly larger within Part A of the La Peninsula site than in Part B ($t =$ 4.48, df = 14, $P < 0.001$; t-test for independent samples, unequal variance).

Forest structure among the three sites differed in several respects (Table 1). Part B had significantly smaller trees on average ($\bar{x} = 0.23$ m dbh) than Part A ($\bar{x} = 0.32$ m dbh) and Santa Martha ($\bar{x} = 0.32$ m dbh; $\chi^2 = 13.12$, $P = 0.001$, Kruskal-Wallis). This analysis is presented with the caveat that such a comparison suffers from Hurlbert's (1984) pseudo-replication. Lack of replication, as well as several differences between these plots (e.g., topography, altitude) result in an inability to ascribe any of the similarities or differences found to a single causative factor. Nevertheless, it appears that on Parts A and B, differences in ground cover (apparently negatively correlated with canopy cover) correspond with the differences found in home range size on the two parts (Table 1).

On the Santa Martha site only one Wood Thrush was captured, and at most only one individual was seen on any given day (the marked individual following capture). This capture rate was lower than the capture rate on either Part A or Part B of the La Peninsula site (χ^2

TABLE 1

VEGETATIVE STRUCTURE OF THE LA PENINSULA AND SANTA MARTHA SITES. PART A AND PART B ARE SUB-PARTS OF THE LA PENINSULA SITE

	Part A	Part B	Santa Martha	ANOVA[a]
Trees/ha	528 (319, 1036)[b]	616 (327, 1570)	373 (217, 783)	(A, B)(SM)
Basal area (m²/ha)	42.9 (11.1, 95.4)	24.7 (7.3, 52.2)	29.3 (3.3, 81.10)	(A, SM)(B)
Ground cover (%)	39.6 (23.2, 56.0)	70.0 (57.6, 82.4)	39.4 (26.5, 52.3)	(A, SM)(B)
Canopy cover (%)	84.7 (75.5, 93.9)	61.7 (49.3, 74.1)	84.1 (71.1, 97.1)	(A, SM)(B)
"Saplings"/ha	2783 (1543, 6443)	2609 (1425, 6235)	2296 (897, 14,349)	(A, B, SM)
Seedlings/ha	13,146 (6012, 48,374)	23,729 (10,525, 95,472)	18,159 (5535, 509,744)	(A)(B, SM)
Canopy height (m)	18.3 (11.3, 25.3)	13.4 (6.8, 20.0)	22.2 (13.1, 31.3)	(A)(B)(SM)
Mean diam. lianas/stem (cm)	3.6 (1.0, 6.2)	2.4 (0.6, 4.2)	1.5 (0, 3.2)	(A, B)(SM)

[a] Results of one-way ANOVA performed upon raw measurement data. Groups within parentheses do not differ significantly. A = Part A, B = Part B, SM = Santa Martha, parenthetical groups differ significantly ($P < 0.05$).

[b] Because some mean values represent estimates calculated with a formula involving distance squared, parenthetical values represent a range calculated from the mean $\pm$ 1 SD.

= 23.0, $P < 0.00005$, Kruskal-Wallis) suggesting that this area was marginal for the species—possibly due to altitudinal differences (150 m vs 470 m). Given several structural similarities between the Santa Martha site and the La Peninsula site (particularly ground and canopy cover, Table 1), vegetative characters alone do not appear to be predictors of thrush distribution in Los Tuxtlas.

Discussion.—Broad descriptions of "habitat preference" provide only a very coarse-grained assessment of a bird's needs. Although many migrants are known to prefer various forest types on their wintering ranges (Rappole et al. 1983), little is known of settlement and movement patterns within these forests. At La Peninsula, capture rates suggest that within this lowland rainforest Wood Thrushes preferred areas with gaps. Sedentary birds bearing radio transmitters had smaller home ranges in an area with heavier ground cover than elsewhere on the study site. Capture rate differences between our qualitative microhabitat types may simply reflect that nonterritorial birds frequent such areas. The Wood Thrush is primarily a ground-level forager, though, and the heavier ground cover found in Part B (which implies higher ground-level production) suggests that such areas would be preferred foraging locales for sedentaries as well. Territory size is often inversely correlated with food density (Featherstone 1966, Watson 1967, Cody and Cody 1972, Gill and Wolf 1975). Smaller average home range size in Part B of the La Peninsula site is consistent with the hypothesis that heavier ground cover within forest has a positive value to sedentary Wood Thrushes.

Denser understory within the forest can be caused by any factor creating canopy breaks. On our site these included treefalls, stream passage, and steep slopes, but river passage and soil type might be additional contributing factors elsewhere. The apparently even distribution of territorial birds in the forest (Rappole and Warner 1980:360–61, Winker 1989), together with observations of individuals whose home ranges included no gaps, shows that this type of microhabitat is not required.

Although it appears that gaps are used more frequently by Wood Thrushes than areas of relatively open understory, this increased use is not immediately apparent. The selective logging done on our site in the mid-1970s artificially raised the number of treefalls on Part B, and enabled us to know the relative age of most of our gap understory microhabitats (ca 10 yr). No thrushes were seen frequenting recent treefall sites (2–3 yr old) in the forest, other than occasional edge use (pers. obs.). Webb et al. (1977) found that the Wood Thrush showed declines following 100% logging (clearcutting) on its breeding grounds in the Adirondacks. During the 10 years after clearcutting, the species increased until populations were at or above pre-logged levels. Our data suggesting heavier use of gaps, most nearly 10 yr old, combined with observations showing little use of areas recently disturbed (2–3 yr old) imply that increased use of gaps by Wood Thrushes occurs only after years have passed, and is probably related to development of understory vegetation. Study of the effects of selective logging on other species would be necessary before advocating such a management practice for tropical forests (for example, see Crawford et al. 1981). Selective logging in Los Tuxtlas has usually been a precursor to total forest eradication (pers. obs.). If the La Peninsula site had not been located within a recently protected area (Reserva Biosfera de la Sierra Santa Martha), it is questionable whether any forest would have remained for a 10 yr period following logging.

LITERATURE CITED

CODY, M. L. AND C. B. J. CODY. 1972. Territory size, clutch size, and food populations of wrens. Condor 74:473–477.

COTTAM, G. AND J. T. CURTIS. 1956. Use of distance measures in phytosociological sampling. Ecology 37:451–460.

CRAWFORD, H. S., R. G. HOOPER, AND R. W. TITTERINGTON. 1981. Song bird population response to silvicultural practices in central Appalachian U.S.A. hardwoods. J. Wildl. Manage. 45:680–692.

FEATHERSTONE, J. D. 1966. Effects of food supply on the utilised territory of the Ovenbird (*Seiurus aurocapillus*). M.S. thesis, Univ. Toronto, Toronto, Canada.

GILL, F. B. AND L. L. WOLF. 1975. Economics of feeding territoriality in the Golden-winged Sunbird. Ecology 56:333–345.

GRADWOHL, J. AND R. GREENBERG. 1980. The formation of antwren flocks on Barro Colorado Island, Panama. Auk 97:385–396.

HARVEY, M. J. AND R. W. BARBOUR. 1965. Home range of *Microtus ochrogaster* as determined by a modified minimum area method. J. Mammal. 46:398–402.

HURLBERT, S. H. 1984. Pseudoreplication and the design of ecological field experiments. Ecol. Monogr. 54:187–211.

JAMES, F. C. AND H. H. SHUGART. 1970. A quantitative method of habitat description. Aud. Field Notes 24:727–736.

LEVEY, D. J. 1988. Tropical wet forest treefall gaps and distributions of understory birds and plants. Ecology 69:1076–1089.

PHILLIPS, E. A. 1959. Methods of vegetation study. Holt, Rhinehart and Winston, New York, New York.

RAPPOLE, J. H., E. S. MORTON, T. E. LOVEJOY, III, AND J. L. RUOS. 1983. Nearctic avian migrants in the neotropics. U.S. Fish and Wildl. Serv., Washington, D.C.

———, M. A. RAMOS, AND K. WINKER. 1989. Wintering Wood Thrush movements and mortality in southern Veracruz. Auk 106:402–410.

——— AND D. W. WARNER. 1980. Ecological aspects of migrant bird behavior in Veracruz, México. Pp. 353–393 *in* Migrant birds in the neotropics (A. Keast and E. S. Morton, eds.). Smithson. Inst. Pr., Washington, D.C.

SCHEMSKE, D. W. AND N. BROKAW. 1981. Treefalls and the distribution of understory birds in a tropical forest. Ecology 62:938–945.

STILES, F. G. 1975. Ecology, flowering phenology, and hummingbird pollination of some Costa Rican *Heliconia* species. Ecology 56:285–301.

WATSON, A. 1967. Territory and population in the Red Grouse. Nature 215:1274–1275.

WEBB, W. L., D. F. BEHREND, AND B. SAISORN. 1977. Effects of logging on songbird populations in a northern hardwood forest. Wildl. Monogr. 55:1–35.

WILLIS, E. O. AND Y. ONIKI. 1972. Ecology and nesting behavior of the Chestnut-backed Antbird (*Myrmeciza exsul*). Condor 74:87–98.

WINKER, K. 1989. The Wood Thrush (*Catharus mustelinus*) on its wintering grounds in southern Veracruz, México. M.S. thesis, Univ. Minnesota, Minneapolis, Minnesota.

———, J. H. RAPPOLE, AND M. A. RAMOS. 1990. Population dynamics of the Wood Thrush (*Hylocichla mustelina*) in southern Veracruz, México. Condor 92:444–460.

WUNDERLE, J. M., A. DIAZ, I. VELAZQUEZ AND R. SCHARRÓN. 1987. Forest openings and the distribution of understory birds in a Puerto Rican rainforest. Wilson Bull. 99:23–37.

KEVIN WINKER, *Bell Museum of Natural History, 10 Church Street SE, Univ. Minnesota, Minneapolis, Minnesota 55455*; JOHN H. RAPPOLE, *Conservation and Research Center, National Zoological Park, Front Royal, Virginia 22630*; AND MARIO A. RAMOS, *World Wildlife Fund, U.S. 1250 24th Street NW, Washington, D.C. 20037.* Received 23 Sept. 1989, accepted 7 April 1990.

Boat census of Bald Eagles during the breeding season.—Subadults, birds in predefinitive plumage, and non-breeding adult Bald Eagles (*Haliaeetus leucocephalus*) are poorly censused by breeding season aerial surveys (Whitfield et al. 1974). This study tests whether a boat survey provides a reliable estimate of the number of individuals in a summer (May–August) population of Bald Eagles on a moderately large lake. Boats have been used to locate nests (Hodges 1982, Gerrard et al. 1983), but should also be suitable for counting eagles since these birds spend much time at the aquatic-terrestrial interface (Leighton et al. 1979, Gerrard et al. 1980, Gerrard and Bortolotti 1988). A second objective was to test whether eagle numbers fluctuated in response to the availability of dead fish. Preliminary studies showed occasional congregations of immatures and non-breeding adults on small lakes adjacent to Besnard Lake; we censused such lakes to achieve a third objective—to find out whether changes in the population on Besnard Lake resulted from movements to and from these nearby lakes.

Study area and methods.—Besnard Lake (55°25′N, 106°00′W) lies along the southern boundary of the Canadian Shield region in north-central Saskatchewan. The lake has an irregular outline with rocky shores and numerous islands. The shoreline length is 400 km (as measured using 1:15,000 scale maps) with a surface area of 197 km², of which 177 km² is open water and the remainder is occupied by 255 islands (Chen 1974). It is surrounded by low, forested hills, not exceeding 100 m in height. White spruce (*Picea glauca*) and trembling aspen (*Populus tremuloides*) predominate near the lake shore. The study area also includes six small lakes of 0.4 to 3.7 km² water area near Besnard Lake. The character of the shores and forests surrounding these lakes was similar to Besnard Lake, except that one of the small lakes had extensive shallow, reedy areas. Eagles breeding on these lakes were not significantly affected by DDT, and the population has been stable from 1973 to 1989 (Gerrard et al. 1983, Gerrard 1985).

Bald Eagle surveys.—Twenty-three boat censuses of Besnard Lake were conducted; nine in 1976, eight in 1977, two in 1978 and four in 1984. At least one census was conducted per month from May to August each year, except for 1978 when the July and August censuses were omitted. The design of the boat census was based on an earlier raptor census by Craighead and Craighead (1969). The shoreline was divided into 50 sections of 8 km each. To reduce the total time of the census, each census consisted of a survey of half of the shoreline of the lake; a pilot census in 1975 showed that surveying fewer than half the sections reduced the accuracy of the overall census. Alternate sections (i.e., 25 sections total) around the lake were censused by one or more observers traveling 100 m from shore in a motorized canoe or other boat at a speed of 8–16 km/h. If an eagle was flushed, it tended to fly into the next section (i.e., one that was not on the present census) thus reducing the likelihood of counting any eagles twice. Censuses were conducted during daylight hours when winds were less than 32 km/h and visibility was good. No censusing was done in moderate or heavy rain. A complete census of 25 sections took three to eight days ($\bar{x} = 4.8$), depending on the weather.