

## MIST NETTING TRANS-GULF MIGRANTS AT COASTAL STOPOVER SITES: THE INFLUENCE OF SPATIAL AND TEMPORAL VARIABILITY ON CAPTURE DATA

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*Abstract.* We used constant effort mist netting during spring migration to sample populations of trans-Gulf migrants at two coastal study sites from 1987 to 1992. Approximately 2,500 individuals of 70 species were netted each season with approximately 5,000 net-hours of effort. Although captures per net hour and total species captured were fairly consistent each year, the seasonal patterns of capture, arrival condition, stopover duration, diversity of species, and number of individuals showed considerable variation from year to year. Differences in seasonal and annual weather patterns, the arrival condition of migrants, and habitat quality at stopover sites all influenced the probability of capturing birds with mist nets at our coastal stopover sites. Mist-net capture rates from coastal stopover sites, migratory activity indicated by radar echoes, and counts of migrants from censuses at mainland sites were correlated within a geographic radius of 100–150 km.

*Key Words:* capture variability, migration, mist netting, stopover, trans-Gulf migrants.

Over 80% of North American birds are migratory to some extent, and about half of those species cross the Gulf of Mexico during migration (Lowery 1946, Rappole and Warner 1976, Moore and Kerlinger 1987). The trans-Gulf flight is a dangerous, energetically expensive phase of the annual cycle. A typical migrant like an Ovenbird (scientific names in Table 1) deposits 40–50% of its body weight in fat each spring before departing on a 15–20 h non-stop flight en route from its tropical wintering grounds to the breeding grounds in North America. Crossing a large ecological barrier like the Gulf of Mexico is a risky endeavor for migrants, exposing them to the unpredictable forces of spring cold fronts and thunderstorms (Buskirk 1980). For migrants, this unpredictability often means that they have little control over their precise migratory trajectories (Gauthreaux 1971, Rappole et al. 1979, Moore and Kerlinger 1991). The inherently unpredictable nature of migration may make it a limiting factor for some populations. The variability in migratory patterns that emerge each year have important implications for the interpretation of mist netting data from migratory stopover sites along the northern Gulf coast.

The objectives of this paper are to examine how variability in seasonal patterns of capture, arrival condition, and stopover duration at stopover sites may confound estimates of larger scale population trends, and to compare mist net capture data with indices of activity derived simultaneously from mainland censuses and weather surveillance radar.

## METHODS

We worked at two study sites along the northern Gulf Coast from 1987 to 1992 (Fig. 1). Peveto Beach is a coastal woodland in southwestern Louisiana. East Ship and Horn islands are barrier islands in Mississippi Sound. The two stations are approximately 400 km apart. The vegetation and field methods have been described in detail elsewhere (Loria and Moore 1990, Moore and Kerlinger 1987, Moore et al. 1990, Kuenzi et al. 1991). Approximately 20, 12-m nets were run daily at each station from dawn to 1100 hours and from 1400 to 1800 hours. The field season ran from late March to early May each spring. Standard measurements were taken on all birds captured before they were banded and released. Levels of body fat were estimated according to the ordinal scale developed by Helms and Drury (1960). In 1992 we conducted 1-km strip transect censuses (Emlen 1977) in pine (N = 63) and deciduous forest (N = 63) habitats in coastal Mississippi (Simons et al. 2000). In that same year, we also analyzed the archived film record of the WSR-57 radar at Slidell, Louisiana from 23 March to 27 May (Gauthreaux 1971, 1992). To quantify the radar images we used a calibration curve that related the spatial extent of the migration echoes on the radar image (measured as the maximum radius in nautical miles) to the mean number of birds in the volume defined by the 1.75° conical radar beam (elevated 2.5°) sweeping 20° of azimuth at a range of 46.3 km (Gauthreaux 1994).

## RESULTS

Trans-Gulf migration occurs in spring from mid-March to late May, although the peak of activity is concentrated in April. Approximately 70 species

TABLE 1. MEAN ANNUAL CAPTURES AT EAST SHIP ISLAND, 1987-1991

Species	Captures/1,000 net-h	CV
Yellow-billed Cuckoo <i>Coccyzus americanus</i>	2.33	1.42
Eastern Wood Pewee <i>Contopus virens</i>	5.22	0.62
Yellow-bellied Flycatcher <i>Empidonax flaviventris</i>	1.05	1.16
Acadian Flycatcher <i>Empidonax virescens</i>	4.76	0.23
Least Flycatcher <i>Empidonax minimus</i>	0.57	0.93
Eastern Phoebe <i>Sayornis phoebe</i>	0.25	1.47
Great Crested Flycatcher <i>Myiarchus crinitus</i>	2.42	0.49
Eastern Kingbird <i>Tyrannus tyrannus</i>	1.26	0.76
White-eyed Vireo <i>Vireo griseus</i>	62.67	0.74
Yellow-throated Vireo <i>Vireo flavifrons</i>	10.48	0.35
Blue-headed Vireo <i>Vireo solitarius</i>	0.40	0.97
Warbling Vireo <i>Vireo gilvus</i>	0.07	2.24
Philadelphia Vireo <i>Vireo philadelphicus</i>	1.47	0.70
Red-eyed Vireo <i>Vireo olivaceus</i>	127.39	0.44
Black-whiskered Vireo <i>Vireo altiloquus</i>	0.12	1.38
Barn Swallow <i>Hirundo rustica</i>	0.13	2.24
Red-breasted Nuthatch <i>Sitta canadensis</i>	0.27	2.24
House Wren <i>Troglodytes aedon</i>	1.55	0.94
Ruby-crowned Kinglet <i>Regulus calendula</i>	1.44	1.40
Blue-gray Gnatcatcher <i>Polioptila caerulea</i>	0.69	1.43
Veery <i>Catharus fuscescens</i>	13.07	0.70
Gray-cheeked Thrush <i>Catharus minimus</i>	8.02	0.76
Swainson's Thrush <i>Catharus ustulatus</i>	12.24	0.93
Hermit Thrush <i>Catharus guttatus</i>	0.11	2.24
Wood Thrush <i>Hylocichla mustelina</i>	13.10	0.67
Cedar Waxwing <i>Bombycilla cedrorum</i>	0.07	2.24
Blue-winged Warbler <i>Vermivora pinus</i>	3.61	0.62
Golden-winged Warbler <i>Vermivora chrysoptera</i>	0.42	0.90
Tennessee Warbler <i>Vermivora peregrina</i>	9.31	0.55
Orange-crowned Warbler <i>Vermivora celata</i>	0.07	2.24
Northern Parula <i>Parula americana</i>	4.39	0.39
Yellow Warbler <i>Dendroica petechia</i>	15.03	0.59
Magnolia Warbler <i>Dendroica magnolia</i>	9.35	0.54
Cape May Warbler <i>Dendroica tigrina</i>	4.79	1.40
Black-throated Blue Warbler <i>Dendroica caerulescens</i>	1.16	0.68
Yellow-rumped Warbler <i>Dendroica coronata</i>	2.25	1.60
Black-throated Green Warbler <i>Dendroica virens</i>	2.95	0.79
Blackburnian Warbler <i>Dendroica fusca</i>	1.31	0.92
Yellow-throated Warbler <i>Dendroica dominica</i>	0.90	0.95
Prairie Warbler <i>Dendroica discolor</i>	2.00	1.17
Palm Warbler <i>Dendroica palmarum</i>	0.84	0.86
Bay-breasted Warbler <i>Dendroica castanea</i>	4.84	0.67
Blackpoll Warbler <i>Dendroica striata</i>	12.34	0.86
Cerulean Warbler <i>Dendroica cerulea</i>	0.98	0.36
Black-and-white Warbler <i>Mniotilta varia</i>	16.17	0.27
American Redstart <i>Setophaga ruticilla</i>	8.50	0.34
Prothonotary Warbler <i>Protonotaria citrea</i>	9.41	0.67
Worm-eating Warbler <i>Helmitheros vermivorus</i>	9.64	0.53
Swainson's Warbler <i>Limnothlypis swainsonii</i>	1.13	0.92
Ovenbird <i>Seiurus aurocapillus</i>	13.53	0.66
Northern Waterthrush <i>Seiurus noveboracensis</i>	6.75	0.56
Louisiana Waterthrush <i>Seiurus motacilla</i>	0.56	0.77
Kentucky Warbler <i>Oporornis formosus</i>	8.15	0.74
Connecticut Warbler <i>Oporornis agilis</i>	0.11	1.42
Common Yellowthroat <i>Geothlypis trichas</i>	14.29	0.66

TABLE 1. CONTINUED

Species	Captures/1,000 net-h	CV
Hooded Warbler <i>Wilsonia citrina</i>	27.97	0.65
Wilson's Warbler <i>Wilsonia pusilla</i>	0.05	2.24
Yellow-breasted Chat <i>Icteria virens</i>	3.45	0.72
Chestnut-sided Warbler <i>Dendroica pensylvanica</i>	2.41	0.67
Summer Tanager <i>Piranga rubra</i>	20.20	0.20
Scarlet Tanager <i>Piranga olivacea</i>	13.16	0.60
Dark-eyed Junco <i>Junco hyemalis</i>	0.05	2.24
Rose-breasted Grosbeak <i>Pheucticus ludovicianus</i>	18.47	0.68
Blue Grosbeak <i>Guiraca caerulea</i>	4.15	0.42
Indigo Bunting <i>Passerina cyanea</i>	43.85	0.54
Painted Bunting <i>Passerina ciris</i>	7.33	0.83
Dickcissel <i>Spiza americana</i>	0.38	1.56
Bobolink <i>Dolichonyx oryzivorus</i>	0.13	2.24
Orchard Oriole <i>Icterus spurius</i>	26.92	0.41
Northern Oriole <i>Icterus galbula</i>	4.49	0.49

were netted at each of our stations each year. Daily patterns of arrival at stopover sites varied considerably from year to year, as illustrated by five years of capture data from East Ship Island (Fig. 2). Numbers of individual birds captured/recaptured on East Ship Island each year were: 873/70 (1987), 2,327/385 (1988), 3,080/306 (1989), 2,585/437 (1990), and 2,151/240 (1991); and on Horn Island 2,022/419 (1992). The annual percent of birds recaptured one or more times ranged from 8.0–20.7% (mean =  $13.05 \pm 4.36\%$ ). Annual spring capture rates, first captures, and recaptures combined for all species, ranged from 0.35 to 0.70 birds per net hour.

The mean number of birds netted annually/1,000

net-h varied considerably within species (Table 1). Coefficients of variation (CV; Zar 1984) for annual mean rates from 1987 to 1991 on East Ship Island provide an index of annual within-station capture rate variability. For example, over all years, approximately 63 White-eyed Vireos were captured/1,000 net-h, but annual capture rates were highly variable (CV = 74%). In contrast, Black-and-white Warblers were caught less often (16/1,000 net-h), but annual capture rates were much less variable (CV = 27%).

Most of the birds captured at our study sites had low fat reserves. Overall, slightly over 50% were scored "0 fat," although there was some variation in the average condition of birds from year to year (Fig. 3).

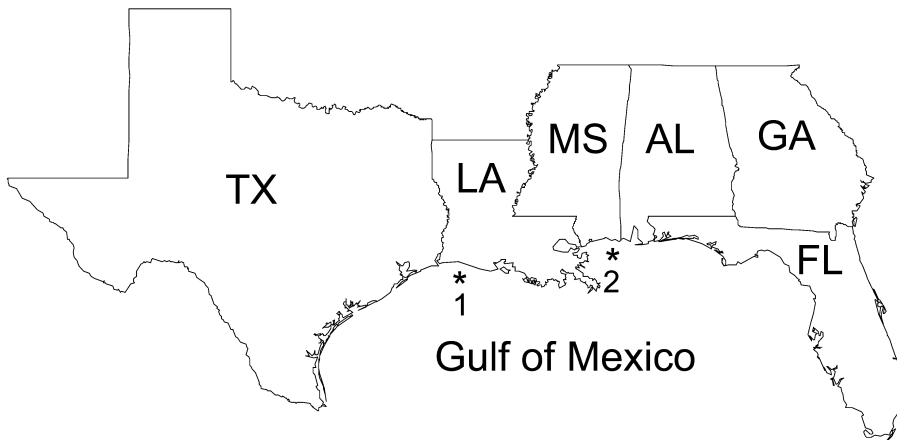


FIGURE 1. Study sites on the north shore of the Gulf of Mexico. Site 1 = Peveto Beach, Louisiana, Site 2 = Ship and Horn Islands, Mississippi.

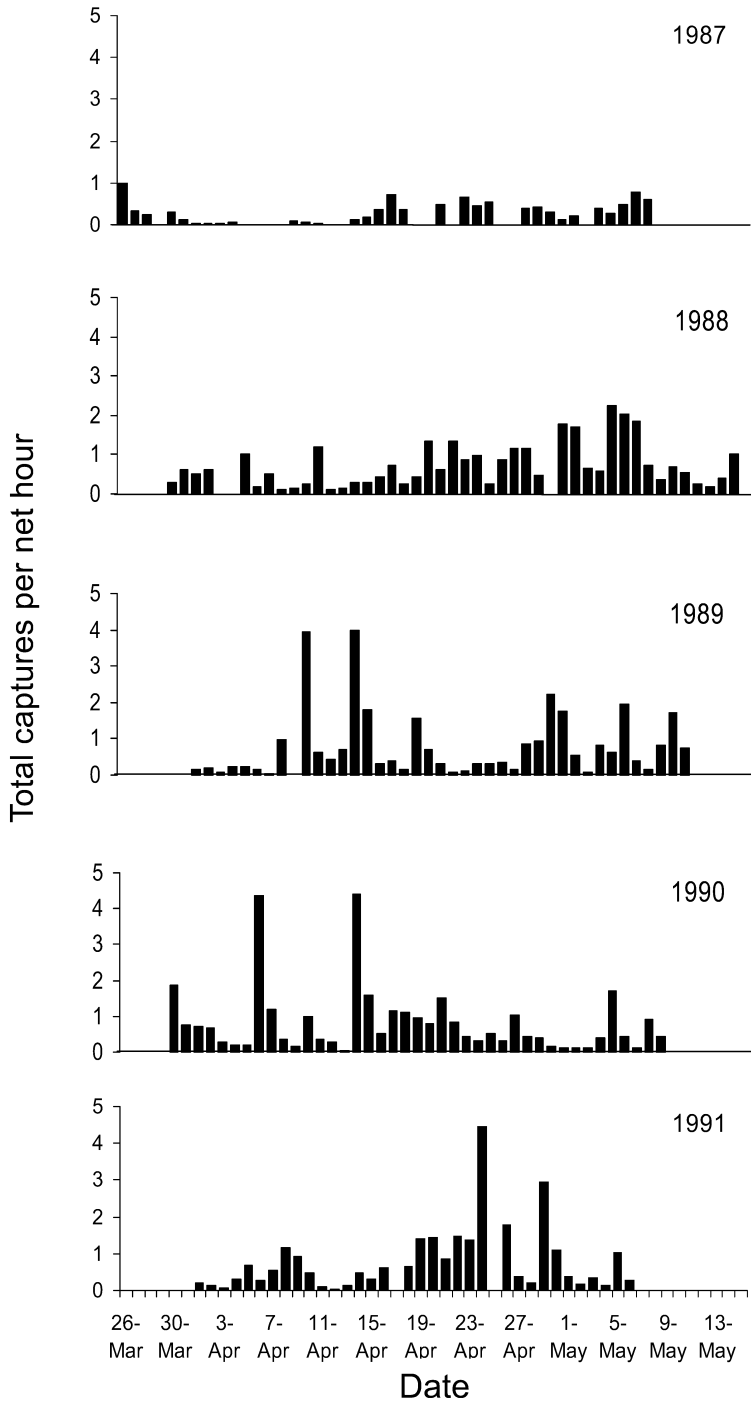


FIGURE 2. Capture rates of trans-Gulf migrants on East Ship Island, 1987–1991.

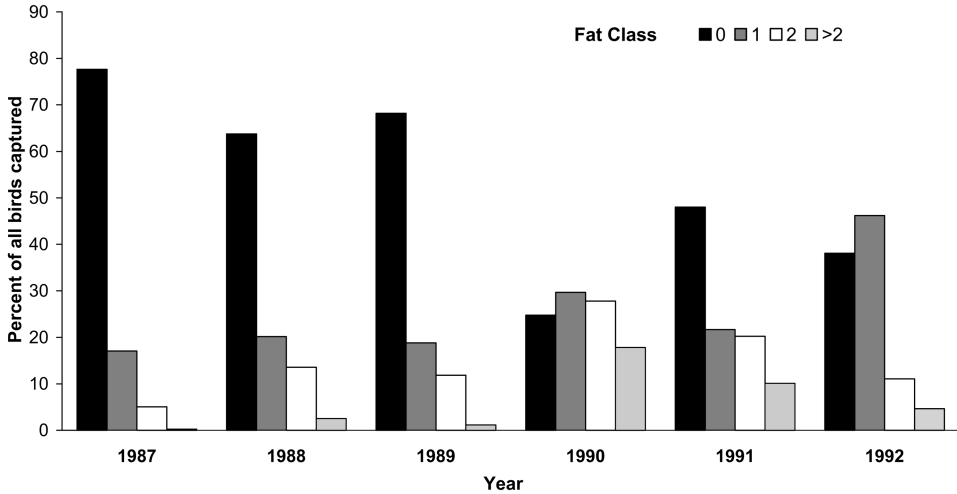


FIGURE 3. Distribution of arrival fat scores of trans-Gulf migrants netted at East Ship Island (1987–1991) and Horn Island (1992), Mississippi.

Birds with no fat reserves were more likely to remain at stopover sites and be recaptured than were birds with higher levels of body fat (Fig. 4). Examination of arrival weight and stopover length for six common species illustrates the pattern. In general, birds arrived at Peveto Beach in better condition (Table 2) and tended to depart sooner (Table 3) than birds at East Ship island. We previously found evidence of differences in habitat quality related to prey availability at the two stations (Moore and Simons 1992, Simons et al. 2000), which may explain why birds at Peveto Beach tended to gain weight more quickly than birds stopping over on East Ship Island (Table 4). Thus, the

capture probabilities for individual birds at these two stopover sites appeared to be a function both of the bird’s arrival condition and the availability of food at the stopover sites.

We compared mist netting data from Horn Island in Mississippi Sound with data collected simultaneously from a coastal weather radar site, and from field censuses on mainland habitats (Fig. 5), to evaluate the stopover habitat requirements of trans-Gulf migrants at broader geographic scales. Results provide some indication of the extent to which mist net data from a single station reflect conditions at a broader scale (Fig. 6). Over the course of the entire

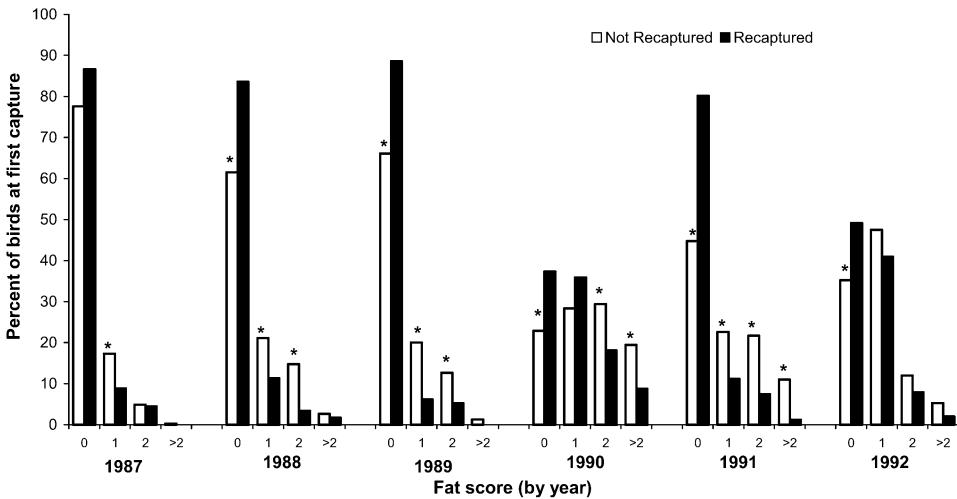


FIGURE 4. Fat score vs. recapture status of trans-Gulf migrants netted on East Ship Island (1987–1991) and Horn Island (1992), Mississippi. \* indicates difference between percents (t-test,  $P < 0.05$ ).

TABLE 2. AVERAGE ARRIVAL WEIGHT (GRAMS) OF TRANS-GULF MIGRANTS AT COASTAL STOPOVER SITES

Species	Site	1987			1988			1990			1991		
		Mean	SE	N	Mean	SE	N	Mean	SE	N	Mean	SE	N
Hooded Warbler	PEV	9.67 ± 0.86	(273)	*	9.57 ± 0.90	(288)		9.84 ± 0.85	(134)	**	9.62 ± 0.88	(58)	
	ESI	9.40 ± 0.90	(31)		9.80 ± 0.90	(32)		9.30 ± 1.10	(152)		9.70 ± 1.00	(94)	
Red-eyed Vireo	PEV	15.65 ± 0.16	(199)	**	15.79 ± 1.59	(574)	**	15.82 ± 1.53	(80)		16.26 ± 2.10	(25)	
	ESI	15.00 ± 1.70	(170)		15.5 ± 1.60	(883)		15.70 ± 1.70	(280)		16.40 ± 1.90	(370)	
Indigo Bunting	PEV	12.25	(1)		12.80 ± 1.38	(372)	**	12.88 ± 1.21	(49)		13.08 ± 1.43	(85)	
	ESI	12.70 ± 1.50	(50)		13.60 ± 1.80	(360)		12.80 ± 1.70	(101)		12.80 ± 1.40	(105)	
Black-and-white Warbler	PEV	9.53 ± 0.89	(33)		9.56 ± 0.90	(147)	**	9.62 ± 1.15	(31)	**	9.30 ± 0.75	(27)	
	ESI	9.30 ± 0.80	(29)		8.80 ± 1.00	(65)		8.60 ± 0.80	(62)		9.20 ± 0.90	(62)	
Summer Tanager	PEV	27.17 ± 2.38	(56)	*	27.63 ± 2.47	(154)	**	28.60 ± 3.50	(73)	*	27.77 ± 2.81	(37)	
	ESI	26.10 ± 2.30	(45)		26.30 ± 2.30	(93)		27.30 ± 3.30	(73)		28.80 ± 3.10	(43)	
White-eyed Vireo	PEV	11.15 ± 0.92	(41)	**	11.42 ± 1.12	(138)	**	11.27 ± 1.22	(81)	**	11.27 ± 1.05	(17)	
	ESI	10.60 ± 1.00	(73)		10.60 ± 0.90	(91)		10.60 ± 1.00	(536)		11.00 ± 1.20	(228)	

Notes: PEV = Peveto Beach, Louisiana, ESI = East Ship Island, Mississippi. Data are reported as mean ± one SE (N). Two sample t-test for differences between sites, one-tailed P values reported as \* (0.01 < P < 0.05), \*\* (P < 0.01).

TABLE 3. AVERAGE DAYS OF STOPOVER BY TRANS-GULF MIGRANTS AT COASTAL STOPOVER SITES (MOORE AND KERLINGER 1987)

Species	Site	1987			1988			1990			1991		
		Mean	SE	N	Mean	SE	N	Mean	SE	N	Mean	SE	N
Hooded Warbler	PEV	1.43 ± 0.74	(41)		3.15 ± 2.67	(106)		1.85 ± 1.66	(33)	*	2.61 ± 1.75	(23)	
	ESI	4.50 ± 4.95	(2)		1.00	(1)		2.97 ± 2.37	(30)		2.20 ± 1.48	(9)	
Red-eyed Vireo	PEV	2.00 ± 1.00	(4)		2.00 ± 1.80	(36)		2.92 ± 2.23	(12)		2.00	(1)	
	ESI	2.33 ± 1.53	(3)		1.97 ± 1.90	(29)		2.57 ± 1.90	(7)		1.80 ± 1.30	(5)	
Indigo Bunting	PEV	-			3.10 ± 4.36	(11)		-			2.00 ± 2.00	(2)	
	ESI	2.00 ± 1.00	(3)		3.52 ± 3.67	(31)		7.18 ± 9.81	(17)		2.20 ± 1.10	(5)	
Black-and-white Warbler	PEV	1.33 ± 0.58	(3)		2.50 ± 2.00	(19)	**	2.50 ± 2.12	(2)		2.00 ± 1.00	(3)	
	ESI	1.50 ± 0.71	(2)		1.50 ± 0.65	(14)		3.41 ± 2.69	(17)		2.60 ± 3.72	(10)	
Summer Tanager	PEV	1.75 ± 0.95	(4)		1.80 ± 0.87	(19)		2.22 ± 1.72	(9)		13.00	(1)	
	ESI	3.00 ± 2.83	(2)		1.75 ± 1.49	(8)		3.80 ± 4.09	(5)		3.67 ± 3.06	(3)	
White-eyed Vireo	PEV	1.83 ± 1.17	(6)		3.40 ± 3.45	(33)		2.18 ± 1.47	(11)	**	2.00 ± 1.73	(3)	
	ESI	2.67 ± 1.63	(6)		2.90 ± 2.71	(30)		5.11 ± 5.71	(75)		4.84 ± 5.62	(37)	

Notes: PEV = Peveto Beach, Louisiana, ESI = East Ship Island, Mississippi. Data are reported as mean ± one SE (N). Two sample t-test for differences between sites, one-tailed P values reported as \* (0.01 < P < 0.05), \*\* (P < 0.01).

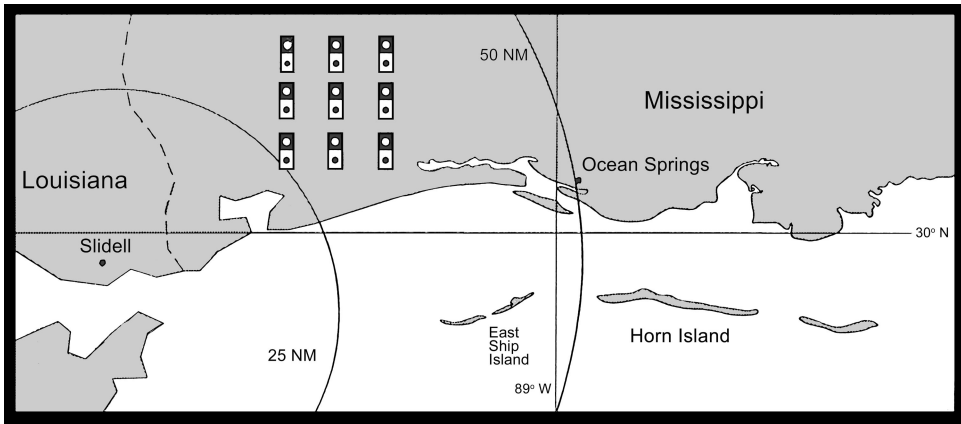


FIGURE 5. Study sites used for comparison of data on migratory bird activity collected using mist nets (Horn Island, Mississippi), field censuses (9 paired study sites in pine uplands and riparian habitats, coastal Mississippi; shown by paired squares with circles in them), and radar imagery (WSR-57 weather radar, Slidell, Louisiana).

season, mist-net capture rates, migratory activity indicated by radar echoes, and the number of migrants detected on field censuses were correlated within a geographic radius of 100 km. Peaks in coastal migratory bird activity evident in mist net and radar data around 30 March, 7 April, 20 April, and 1 May were generally followed by peaks in number of passage migrants detected by field censuses on the mainland

(Fig 6; Kendall's rank correlation analysis,  $W = 0.643$ ,  $\chi^2 = 32.793$ ,  $0.01 < P < 0.025$ ).

DISCUSSION

Data collected by netting birds at coastal stopover sites are useful for answering a variety of questions related to the ecology and habitat requirements of

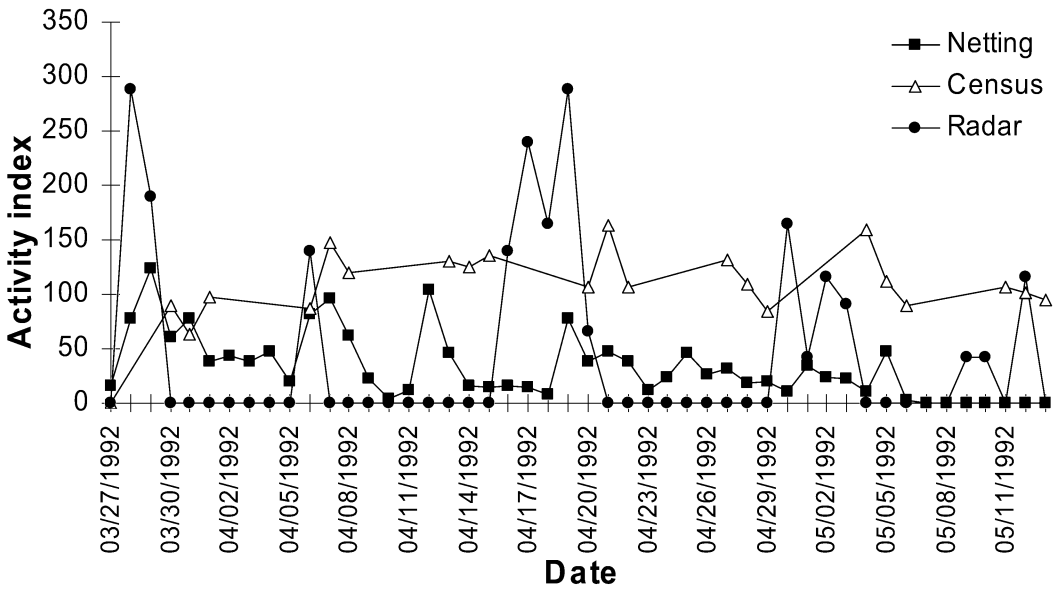


FIGURE 6. Comparison of migratory bird activity based on data from mist netting, field censuses, and WSR-57 radar imagery. Netting data (dark squares) are reported as number of birds captured/50 net-h. Census data (white triangles) are reported as total number of migrants counted in morning censuses. Radar data (dark circles) are reported as the mean number of flocks per 20° sector of the WSR-57 radar image (Gauthreaux 1994).

TABLE 4. AVERAGE MASS CHANGE (G/D, SEE KUENZLI ET AL., 1991) OF TRANS-GULF MIGRANTS AT COASTAL STOPOVER SITES

Species	Site	1987	1988	1990	1991
Hooded Warbler	PEV	0.16 ± 0.69 (41)	0.18 ± 0.39 (106)	0.003 ± 0.43 (33)	0.22 ± 0.25 (23)
	ESI	0.38 ± 1.59 (2)	-	-0.42 ± 1.78 (30)	-0.25 ± 0.95 (9)
Red-eyed Vireo	PEV	0.10 ± 0.56 (11)	-0.19 ± 0.78 (36) **	0.18 ± 0.40 (12) **	0.18 (1)
	ESI	-	-1.25 ± 0.73 (29)	-1.23 ± 1.13 (7)	-0.23 ± 0.91 (5)
Indigo Bunting	PEV	-	0.12 ± 0.47 (29)	-0.21 ± 0.10 (2)	-
	ESI	-0.17 ± 0.63 (3)	0.03 ± 0.95 (31)	0.48 ± 1.00 (17)	0.09 ± 0.65 (5)
Black-and-white Warbler	PEV	0.34 ± 0.26 (3)	0.15 ± 0.42 (33) *	0.19 ± 0.01 (2)	0.14 ± 0.60 (3)
	ESI	-0.50 ± 0.71 (2)	0.09 ± 1.24 (14)	0.21 ± 0.84 (17)	0.54 ± 0.71 (110)
Summer Tanager	PEV	0.60 ± 0.55 (4)	0.22 ± 2.27 (19) *	0.33 ± 1.00 (9) **	0.47 (1)
	ESI	1.25 ± 1.41 (2)	-1.64 ± 1.54 (8)	2.83 ± 1.47 (5)	0.72 ± 1.41 (3)
White-eyed Vireo	PEV	0.20 ± 0.65 (6)	0.33 ± 0.47 (33) *	0.16 ± 0.32 (11) **	0.27 ± 0.25 (3)
	ESI	-0.17 ± 0.70 (6)	0.08 ± 0.84 (30)	-0.43 ± 1.01 (75)	-0.07 ± 0.79 (37)

Notes: PEV = Peveto Beach, Louisiana, ESI = East Ship Island, Mississippi. Data are reported as mean ± one SE (N). Two sample t-test for differences between sites, one-tailed P values reported as \* (0.01 < P < 0.05), \*\* (P < 0.01).

migratory birds. However, population indices, such as mist-net captures from stopover sites along the Gulf Coast, may not provide data suitable for monitoring population levels if capture probabilities vary over time or space (Pollock et al. 2002).

Analysis of the arrival condition of birds at stopover sites suggests that birds with sufficient energy reserves continue migration, or move to alternate habitats more quickly than lean birds, or that they may simply over-fly some coastal stopover sites entirely. Confirmation of this phenomena is provided during a typical bird "fallout," which occurs when birds encounter late cold fronts or local thunderstorms. Under these conditions, it is common to capture birds with large fat reserves that, under favorable weather conditions, would have simply over-flown these coastal sites (Moore et al. 1990). In 1990, when fallout conditions occurred on East Ship Island in early and mid-April (Fig. 2), birds were fatter on average than in years when fallout events were less common (Fig. 3).

Weather is clearly a dominant factor influencing the total number of birds captured per net-hour at an individual station (Buskirk 1980, Moore and Kerlinger 1987). Weather conditions favorable for migration will reduce the proportion of a population stopping at a migratory stopover site. Favorable weather also increases the likelihood that birds visiting stopover sites will be in better condition. We have shown that recapture rates are lower for migrants in better energetic condition. The average energetic condition of birds (determined by their condition on departure from the wintering grounds, distances flown, or wind conditions encountered enroute) will all influence capture probabilities at stopover sites. It is usually not possible to distinguish whether differences in capture rates at stopover sites reflect differences in the average energetic condition of migrants or actual differences in population levels. For long-term trends to be unbiased it has to be assumed that variation in mean annual energetic condition occurs randomly among years.

Finally, variability of habitat quality at stopover sites will also influence the likelihood and duration of stopover, and therefore capture probabilities. Both the yearly succession of vegetation and the temporary abundance of prey within years influence capture probabilities at stopover sites, which is why recommendations for migration monitoring emphasize the need for maintaining uniform habitat (Hussell and Ralph 1998). Thus, differences in seasonal and annual weather patterns, the arrival condition of migrants, and habitat quality at stopover sites all influence the probability of capturing birds with mist nets at stopover sites along the northern Gulf coast.

Abundance estimates based on mist net based count indices can be adjusted by modeling date, weather, moon phase and year as covariables (Dunn and Hussell 1995, Dunn et al. 1997, Hussell et al. 1992, Pyle et al. 1993). These approaches may be most suitable for inland sites adjacent to breeding areas where the energetic condition of migrants, habitat conditions, and migratory pathways are less variable. At sites with high daily turnover rates, modeling covariates may provide unbiased indices of population size if the assumption that only newly arrived birds are included in analyses can be met (Dunn and Hussell 1995). When recapture rates are low (<10%) this assumptions may be valid. Higher recapture rates (up to 20%) at our study sites along the Gulf Coast may make it difficult to meet the assumptions of this approach. Modeling covariables may not be sufficient to control for the variability in capture probabilities inherent to populations migrating across large ecological barriers such as the Gulf of Mexico.

Not surprisingly, differences in the factors affecting mist-net capture probabilities appear to increase with the distance between study sites. Differences in the arrival condition of birds at Peveto Beach and East Ship Island (400 km apart) suggest that these sites are sampling populations following different migratory routes. In contrast, local WSR 57 radar, field census results, and mist net data were correlated on a scale of 50–100 km at our study sites in Mississippi. Williams et al. (2001) observed a similar local scale correspondence between observations of migrants in New Hampshire using portable marine radar, ceilometer, and ground census data.

Presumably, sampling at a fairly fine geographic

scale across the northern Gulf would be necessary to understand population level patterns of trans-Gulf migration. Nevertheless, establishing a network of sampling sites along the Gulf Coast would probably prove to be an inefficient approach to population monitoring, because while migration can be viewed as a broad-front phenomena on decadal or longer time scales, annual patterns of arrival tend to be quite localized. In any single year only a small percent of sites would be expected to collect data sufficient to assess population trends. Thus the sampling frame required to adequately track population trends would be very large and expensive.

Recent advances in the application of WSR-88D Doppler weather radar to bird migration hold the promise that it may one day be feasible to implement a sampling frame sufficient to monitor bird population trends through migration monitoring (Gauthreaux and Belser 1998, Gauthreaux and Russell 1998), although individual species can not be identified. On-going validation studies employing ground truthing of radar imagery with mist net and census based field data will determine the potential of this new technology.

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## LITERATURE CITED

- AKAIKE, H. 1973. Information theory and an extension of the maximum likelihood principle. Pp. 267–281 in B. N. Petran, and F. Csaki (editors). International Symposium on Information Theory. Akademiai Kiado, Budapest, Hungary.
- AMERICAN ORNITHOLOGISTS' UNION. 1983. Checklist of North American birds, 6th ed. American Ornithologists' Union, Washington, D.C.
- ANDERS, A. D., J. FAABORG, AND F. R. THOMPSON, III. 1998. Post-fledging dispersal, habitat use, and home-range size of juvenile Wood Thrushes. *Auk* 115:349–358.
- ANDERSON, D. R. 2001. The need to get the basics right in wildlife field studies. *Wildlife Society Bulletin* 29: 1294–1297.
- ANDERSON, D. R., E. G. COOCH, R. J. GUTIERREZ, C. J. KREBS, M. S. LINDBERG, K. H. POLLOCK, C. R. RIBIC, AND T. M. SHENK. 2003. Rigorous science: Suggestions on how to raise the bar. *Wildlife Society Bulletin* 31:296–305.
- ARNASON, A. N. 1972. Parameter estimates from experiments on two populations subject to migration and death. *Researches in Population Ecology* 13:97–113.
- ARNASON, A. N. 1973. The estimation of population size, migration rates and survival in a stratified population. *Researches in Population Ecology* 15:1–8.
- BAILLIE, S. R. 1990. Integrated population monitoring of breeding birds in Britain and Ireland. *Ibis* 132:151–166.
- BAILLIE, S. R., H. Q. P. CRICK, D. E. BALMER, L. P. BEAVEN, I. S. DOWNIE, S. N. FREEMAN, D. I. LEECH, J. H. MARCHANT, D. G. NOBLE, M. J. RAVEN, A. P. SIMPKIN, R. M. THEWLIS, AND C. V. WERNHAM. 2002. Breeding birds in the wider countryside: Their conservation status 2001. BTO Research Report No. 278. BTO, Thetford, U.K. <<http://www.bto.org/birdtrends/>> (29 September 2003).
- BAILLIE, S. R., R. E. GREEN, M. BODDY, AND S. T. BUCKLAND. 1986. An evaluation of the Constant Effort Sites Scheme. BTO Research Report No. 21, British Trust for Ornithology, Thetford, U.K.
- BAILLIE, S. R., AND J. H. MARCHANT. 1992. The use of breeding bird censuses to monitor common birds in Britain and Ireland: Current practices and future prospects. *Die Vogelwelt* 113:172–182.
- BAILLIE, S. R., AND N. McCULLOCH. 1993. Modelling the survival rates of passerines ringed during the breeding season from national ringing and recovery data. Pp. 123–140 in J.-D. Lebreton and P. M. North (editors). *Marked individuals in the study of bird populations*. Birkhäuser Verlag, Basel, Switzerland.
- BAILLIE, S. R., AND P. M. NORTH. 1999. Large-scale studies of marked birds. *Proceedings of the EURING97 Conference*. *Bird Study* 46 (supplement):1–308.
- BAILLIE, S. R., AND W. J. PEACH. 1992. Population limitation in migrants. *Ibis* 134 (supplement 1):120–132.
- BAIRLEIN, F. 1981. Ökosystemanalyse der Rastplätze von Zugvögeln: Beschreibung und Deutung der Verteilungsmuster von ziehenden Kleinvögeln in verschiedenen Biotopen der Stationen des "Mettnau-Reit-III mitz-Programmes." *Ökologie der Vögel* 3:7–137.
- BAIRLEIN, F. 1998. The European-African songbird migration network: New challenges for large-scale study of bird migration. *Biologia e Conservazione della Fauna* 102:13–27.
- BAIRLEIN, F., AND B. GIESSING. 1997. Spatio-temporal course, ecology and energetics of western Palearctic-African songbird migration. Summary Report 1994–96. Institut für Vogelforschung, Wilhelmshaven, Germany.
- BAIRLEIN, F., L. JENNI, A. KAISER, L. KARLSSON, A. VAN NOORDWIJK, W. PEACH, A. PILASTRO, AND F. SPINA. 1994. European-African Bird Migration Network. Manual of field methods. Institute für Vogelforschung, Wilhelmshaven, Germany.
- BAKER, M., N. NUR, AND G. R. GEUPEL. 1995. Correcting biased estimates of dispersal and survival due to limited study area: Theory and an application using Wrentits. *Condor* 97:663–674.
- BALLARD, G., G. R. GEUPEL, AND N. NUR. 2004 (*this volume*). The influence of mist-netting intensity on investigations of avian populations. *Studies in Avian Biology* 29:21–27.
- BALMER, D., AND L. MILNE. 2002. CES comes of age. *BTO News* 239:14–15.
- BARKER, R. J., AND J. R. SAUER. 1995. Statistical aspects of point count sampling. Pp. 125–130 in C. J. Ralph, J. R. Sauer, and S. Droege (editors). *Monitoring bird populations by point counts*. USDA Forest Service Gen. Tech. Rep. PSW-GTR-149. USDA Forest Service Pacific Southwest Research Station, Albany, CA.
- BART, J., AND S. EARNST. 2002. Double-sampling to estimate density and population trends in birds. *Auk* 119:36–45.
- BART, J., C. KEPLER, P. SYKES, AND C. BOCETTI. 1999. Evaluation of mist-net sampling as an index to productivity in Kirtland's Warblers. *Auk* 116:1147–1151.
- BASTIAN, A. 1992. Mobilität von Kleinvögeln in einem süddeutschen Rastgebiet während der Wegzugperiode. *Ökologie der Vögel* 14:121–163.
- BAUCHAU, V., AND A. J. VAN NOORDWIJK. 1995. Comparison of survival estimates obtained from three different methods of recapture in the same population of the Great Tit. *Journal of Applied Statistics* 22:1031–1037.
- BAUER, H.-G., AND P. BERTHOLD. 1997. *Die Brutvögel Mitteleuropas. Bestand und Gefährdung*. 2. Auflage. Aula-Verlag, Wiesbaden, Germany.
- BELL, B. D. 1969. Some thoughts on the apparent ecological expansion of the Reed Bunting. *British Birds* 62: 209–218.
- BELL, B. D., C. K. CATCHPOLE, AND K. J. CORBETT. 1968. Problems of censusing Reed Buntings, Sedge Warblers and Reed Warblers. *Bird Study* 15:16–21.
- BELL, H. L. 1982. A bird community of New Guinean low-

- land rainforest. 3. Vertical distribution of the avifauna. *Emu* 82:143–162.
- BERTHOLD, P. 1974. Die gegenwärtige Bestandsentwicklung der Dorngrasmücke (*Sylvia communis*) und anderer Singvogelarten im westlichen Europa bis 1973. *Vogelwelt* 95:170–183.
- BERTHOLD, P. 1996. Control of bird migration. Chapman and Hall, London, U.K.
- BERTHOLD, P. 2001. Bird migration. A general survey. Oxford University Press, Oxford, U.K.
- BERTHOLD, P. 2004 (*this volume*). The use of mist nets for monitoring landbird autumn population trends, and comparison with other methods. *Studies in Avian Biology* 29:112–115.
- BERTHOLD, P., W. FIEDLER, R. SCHLENKER, AND U. QUERNER. 1998. 25-year study of the population development of Central European songbirds: A general decline, most evident in long-distance migrants. *Naturwissenschaften* 85:350–353.
- BERTHOLD, P., G. FLIEGE, G. HEINE, U. QUERNER, AND R. SCHLENKER. 1991. Wegzug, Rastverhalten, Biometrie und Mauser von Kleinvögeln in Mitteleuropa. Eine kurze Darstellung nach Fangdaten aus dem Mettnau-Reit-Illmitz-Programm der Vogelwarte Radolfzell. *Vogelwarte* 36 (Sonderheft):1–224.
- BERTHOLD, P., G. FLIEGE, U. QUERNER, AND H. WINKLER. 1986. Die Bestandsentwicklung von Kleinvögeln in Mitteleuropa: Analyse von Fangzahlen. *Journal für Ornithologie* 127:397–437.
- BERTHOLD, P., AND W. FRIEDRICH. 1979. Die Federlänge: Ein neues nützliches Flügelmaß. *Vogelwarte* 30:11–21.
- BERTHOLD, P., E. GWINNER, AND H. KLEIN. 1970. Vergleichende Untersuchung der Jugendentwicklung eines ausgeprägten Zugvogels, *Sylvia borin*, und eines weniger ausgeprägten Zugvogels, *S. atricapilla*. *Vogelwarte* 25:297–331.
- BERTHOLD, P., A. KAISER, U. QUERNER, AND R. SCHLENKER. 1993. Analyse von Fangzahlen im Hinblick auf die Bestandsentwicklung von Kleinstvögeln nach 20-jährigem Betrieb der Station Mettnau, Süddeutschland. *Journal für Ornithologie* 134:283–299.
- BERTHOLD, P., AND U. QUERNER. 1978. Über Bestandsentwicklung und Fluktuationsrate von Kleinvogelpopulationen: Fünfjährige Untersuchungen in Mitteleuropa. *Ornis Fennica* 56:110–123.
- BERTHOLD, P., AND R. SCHLENKER. 1975. Das "Mettnau-Reit-Illmitz-Programm": ein langfristiges Vogelfangprogramm der Vogelwarte Radolfzell mit vielfältiger Fragestellung. *Vogelwarte* 28:97–123.
- BEZZEL, E., H.-W. HELB, AND K. WITT. 1992. Vogel des Jahres 1992: Das Rotkehlchen (*Erithacus rubecula*). Pp. 128–139 in *Ornithologen-Kalender 1992*. Aula-Verlag, Wiesbaden, Germany.
- BIBBY, C. J., N. D. BURGESS, AND D. A. HILL. 1992. Bird census techniques. Academic Press, London, U.K.
- BIERREGAARD, R. O., JR. 1990. Species composition and trophic organization of the understory bird community in a central Amazonian Terra Firme forest. Pp. 217–236 in A. H. Gentry (editor). *Four Neotropical forests*. Yale University Press, New Haven, CT.
- BLAKE, J. G. 1989. Birds of primary forest undergrowth in western San Blas, Panama. *Journal of Field Ornithology* 60:178–189.
- BLAKE, J. G., AND B. A. LOISELLE. 1992. Habitat use by Neotropical migrants at La Selva Biological Station and Braulio Carrillo National Park, Costa Rica. Pp. 257–272 in J. M. Hagan, III, and D. W. Johnston (editors). *Ecology and conservation of Neotropical migratory landbirds*. Smithsonian Institution Press, Washington D.C.
- BLAKE, J. G., AND B. A. LOISELLE. 2001. Bird assemblages in second growth and old-growth forests, Costa Rica: Perspectives from mist nets and point counts. *Auk* 118:304–326.
- BLUMS, P., J. D. NICHOLS, M. S. LINDBERG, J. E. HINES, AND A. MEDNIS. 2003. Estimating breeding dispersal movement rates of adult female European ducks with multi-state modeling. *Journal of Animal Ecology* 72:292–307.
- BODDY, M. 1992. Timing of Whitethroat arrival, breeding and moult at a coastal site in Lincolnshire. *Ring and Migration* 13:65–72.
- BÖHNING-GAESE, K. 1995. Dynamik von Zugvogelgemeinschaften in verschiedenen Gebieten und Zeiträumen. *Journal für Ornithologie* 136:149–158.
- BOHONAK, A. J. 2002. RMA software for reduced major axis regression v.1.12. San Diego State University, Department of Biology, San Diego, CA. <<http://www.bio.sdsu.edu/pub/andy/RMA.html>> (29September, 2003).
- BORGES, S. H., AND P. C. STOFFER. 1999. Bird communities in two types of anthropogenic successional vegetation in central Amazonia. *Condor* 101:529–536.
- BOULINIER, T., J. D. NICHOLS, J. R. SAUER, J. E. HINES, AND K. H. POLLOCK. 1998. Estimating species richness: The importance of heterogeneity in species detectability. *Ecology* 79:1018–1028.
- BRADLEY, M., R. JOHNSTONE, G. COURT, AND T. DUNCAN. 1997. Influence of weather on breeding success in Peregrine Falcons in the Arctic. *Auk* 114:786–791.
- BRENSING, D. 1977. Nahrungsökologische Untersuchungen an Zugvögeln in einem südwestdeutschen Durchzugsgebiet während des Wegzuges. *Vogelwarte* 29:44–56.
- BRENSING, D. 1989. Ökophysiologische Untersuchungen der Tagesperiodik von Singvögeln. Beschreibung und Deutung der tageszeitlichen Fangmuster der Fänge des "Mettnau-Reit-Illmitz-Programmes" und von Versuchsvögeln. *Ökologie der Vögel* 11:1–148.
- BREWER, A. D., A. W. DIAMOND, E. J. WOODSWORTH, B. T. COLLINS, AND E. H. DUNN. 2000. The Atlas of Canadian Bird Banding, 1921–1995. Volume 1: Doves, Cuckoos and Hummingbirds through Passerines. Canadian Wildlife Service Special Publication, Ottawa, Canada.
- BROKAW, N. V. L., AND R. A. LENT. 1999. Vertical structure. Pp. 373–399 in M. L. Hunter, Jr. (editor). *Maintaining biodiversity in forest ecosystems*. Cambridge University Press, Cambridge, U.K.
- BROWNIE, C., D. R. ANDERSON, K. P. BURNHAM, AND D. S. ROBSON. 1985. Statistical inference from band recovery

- data: A handbook, 2<sup>nd</sup> ed. U.S. Fish Wildlife Service, Resource Publication 156, Washington, D.C.
- BROWNIE, C., J. E. HINES, J. D. NICHOLS, K. H. POLLOCK, AND J. B. HESTBECK. 1993. Capture–recapture studies for multiple strata including non-Markovian transition probabilities. *Biometrics* 49:1173–1187.
- BROWNIE, C., AND D. S. ROBSON. 1983. Estimation of time-specific survival rates from tag–resighting samples: A generalization of the Jolly-Seber model. *Biometrics* 39: 437–453.
- BUCKLAND, S. T. 1982. A mark–recapture survival analysis. *Journal of Animal Ecology* 51:833–847.
- BUCKLAND, S. T., AND S. R. BAILLIE. 1987. Estimating survival rates from organized mist-netting programmes. *Acta Ornithologica* 23:89–100.
- BUCKLAND, S. T., AND A. C. HERWARD. 1982. Trap-shyness of Yellow Wagtails *Motacilla flava flavissima* at a pre-migratory roost. *Ring and Migration* 4:15–23.
- BURNHAM, K. P. 1981. Summarizing remarks: Environmental influences. *Studies in Avian Biology* 6:324–325.
- BURNHAM, K. P., AND D. R. ANDERSON. 1998. Model selection and inference: a practical information theoretic approach. Springer-Verlag, New York, NY.
- BURNHAM, K. P., D. R. ANDERSON, G. C. WHITE, C. BROWNIE, AND K. H. POLLOCK. 1987. Design and analysis methods for fish survival experiments based on release–recapture. American Fisheries Society Monograph No. 5, Bethesda, MD.
- BURNHAM, K. P., AND W. S. OVERTON. 1979. Robust estimation of population size when capture probabilities vary among animals. *Ecology* 60:579–604.
- BURTON, K. M., AND D. F. DESANTE. 2004 (*this volume*). The effects of mist-netting frequency on capture rates at Monitoring Avian Productivity and Survival (MAPS) stations. *Studies in Avian Biology* 29:7–11.
- BUSKIRK, W. H. 1980. Influence of meteorological patterns and trans-Gulf migration on the calendars of latitudinal migrants. Pp 485–491 in A. Keast and E. S. Morton (editors). *Migrant birds in the Neotropics*. Smithsonian Institution Press, Washington, D.C.
- BUTCHER, G. S. 1992. Needs assessment: Monitoring Neotropical migratory birds. Partners in Flight Monitoring Working Group, Virginia, September 4–5, 1992. Neotropical Migratory Bird Conservation Program, Cornell Lab of Ornithology, Ithaca, NY.
- BUTCHER, G. S., B. G. PETERJOHN, AND C. J. RALPH. 1993. Overview of national bird population monitoring programs and databases. Pp. 192–203 in D. M. Finch, and P. W. Stangel (editors). *Status and management of Neotropical migratory birds*. USDA Forest Service Gen. Tech. Rept. RM-229. USDA Forest Service Rocky Mountain Research Station, Ft. Collins, CO.
- CAROTHERS, A. D. 1973. The effects of unequal catchability on Jolly-Seber estimates. *Biometrics* 29:79–100.
- CAROTHERS, A. D. 1979. Quantifying unequal catchability and its effects on survival estimates in an actual population. *Journal of Animal Ecology* 48:863–869.
- CHAO, A. 2001. An overview of closed capture–recapture models. *Journal of Agricultural, Biological, and Environmental Statistics* 6:158–175.
- CHASE, M. K., N. NUR, AND G. R. GEUPEL. 1997. Survival, productivity, and abundance in a Wilson’s Warbler population. *Auk* 114:354–366.
- CILIMBURG, A. B., M. S. LINDBERG, J. J. TEWKSBURY, AND S. J. HEJL. 2002. Effects of dispersal on survival probability of adult Yellow Warblers (*Dendroica petechia*). *Auk* 119: 778–789.
- CLOBERT, J., R. JULLIARD, AND R. H. MCCLEERY. 1993. The components of local recruitment. Pp. 281–294 in J.-D. Lebreton and P. M. North (editors). *Marked individuals in the study of bird populations*. Advances in Life Sciences, Birkhauser Verlag, Berlin, Germany.
- CLOBERT, J., J.-D. LEBRETON, AND D. ALLAINE. 1987. A general approach to survival rate estimation by recaptures or resightings of marked birds. *Ardea* 75:133–142.
- CLOBERT, J., J.-D. LEBRETON, D. ALLAINE, AND J.-M. GAILLARD. 1994. The estimation of age-specific breeding probabilities from recaptures or resightings in vertebrate populations: II. Longitudinal models. *Biometrics* 50: 375–387.
- CLOBERT, J., J.-D. LEBRETON, AND G. MARZOLIN. 1990. The estimation of local immature survival rate and age-specific proportions of breeders in bird populations. Pp. 199–213 in J. Blondel, A. Gosler, J.-D. Lebreton, and R. McCleery (editors). *Population biology of passerine birds: An integrated approach*. Springer-Verlag, Berlin, Germany.
- COCHRAN, W. G. 1963. *Sampling techniques*, 3rd ed. John Wiley and Sons, Inc., New York, NY.
- COCHRAN, W. G. 1977. *Sampling techniques*. John Wiley and Sons, Inc., New York, NY.
- COHEN, J. 1988. *Statistical power analysis for the behavioral sciences*, 2nd ed. Lawrence Erlbaum Associates, Inc., Hillsdale, NJ.
- COKER, D. (EDITOR). 1993. *The B-RING user guide*. British Trust for Ornithology, Thetford, U.K.
- COLLISTER, D. M., AND R. G. FISHER. 1995. Trapping techniques for Loggerhead Shrikes. *Wildlife Society Bulletin* 23:88–91.
- COOCH, E., R. PRADEL, AND N. NUR. 1996. A practical guide to capture–recapture analysis using SURGE. Centre d’Ecologie Fonctionnelle et Evolutive: CNRS, Montpellier, France.
- CORMACK, R. M. 1964. Estimates of survival from sightings of marked animals. *Biometrika* 51:429–438.
- CRAMP, S., AND K. E. L. SIMMONS (EDITORS). 1977. *The Birds of the Western Palearctic*, Vol. 1. Oxford University Press, Oxford, U.K.
- CRICK, H. Q. P. 1992. A bird-habitat coding system for use in Britain and Ireland incorporating aspects of land-management and human activity. *Bird Study* 39:1–12.
- CROSBIE, S. F., AND B. F. MANLY. 1985. Parsimonious modeling of capture–mark–recapture studies. *Biometrics*. 41: 385–398.
- CUBITT, M. 2002. Integrated population monitoring reporter general overview, Version 2. British Trust for Ornithology, Thetford, U.K.
- DALE, B. C. 2004 (*this volume*). The effectiveness of infor-

- mal banding training at three western Canadian banding stations. *Studies in Avian Biology* 29:182–186.
- DAWSON, D. K. 1990. Migration banding data: A source of information on bird population trends? Pp. 37–40 in J. R. Sauer, and S. Droege (editors). *Survey designs and statistical methods for the estimation of avian population trends*. Biological Report 90(1). U.S. Fish and Wildlife Service, Washington, DC.
- DAWSON, D. K., J. R. SAUER, P. A. WOOD, M. BERLANGA, M. H. WILSON, AND C. S. ROBBINS. 1995. Estimating bird species richness from capture and count data. *Journal of Applied Statistics* 22:1063–1068.
- DESANTE, D. F. 1981. A field test of the variable circular-plot censusing technique in a California coastal scrub breeding bird community. *Studies in Avian Biology* 6: 177–185.
- DESANTE, D. F. 1991a. An avian biomonitoring program for the National Parks and other natural areas to detect large-scale, long-term changes in the productivity and survivorship of land birds. Pp. 285–296 in J. Edelbrock and S. Carpenter (editors). *Natural areas and Yosemite: Prospects for the future*. Yosemite Centennial Symposium Proceedings. U.S. National Park Service, Denver Service Center, Denver, CO.
- DESANTE, D. F. 1991b. The Monitoring Avian Productivity and Survivorship (MAPS) program: First annual report. The Institute for Bird Populations, Inverness, CA.
- DESANTE, D. F. 1992. Monitoring Avian Productivity and Survivorship (MAPS): A sharp, rather than blunt, tool for monitoring and assessing landbird populations. Pp. 511–521 in D. R. McCullough and R. H. Barrett (editors). *Wildlife 2001: Populations*. Elsevier Applied Science, London, U.K.
- DESANTE, D. F. 1995. Suggestions for future directions for studies of marked migratory landbirds from the perspective of a practitioner in population management and conservation. *Journal of Applied Statistics* 22:949–965
- DESANTE, D. F. 2000. Patterns of productivity and survivorship from the MAPS Program. Pp. 166–177 in R. Bonney, D. N. Pashley, R. J. Cooper, and L. Niles (editors). *Strategies for bird conservation: The Partners in Flight planning process*. USDA Forest Service Gen. Tech. Rep. RMRS-P-16. USDA Forest Service Rocky Mountain Research Station, Ogden, UT.
- DESANTE, D. F., AND K. M. BURTON. 1994. The Monitoring Avian Productivity and Survivorship (MAPS) program third annual report (1992). *Bird Populations* 2:62–89.
- DESANTE, D. F., K. M. BURTON, AND D. R. O'GRADY. 1996. The Monitoring Avian Productivity and Survivorship (MAPS) Program fourth and fifth annual report (1993 and 1994). *Bird Populations* 3:67–120.
- DESANTE, D. F., K. M. BURTON, J. F. SARACCO, AND B. L. WALKER. 1995. Productivity indices and survival rate estimates from MAPS, a continent-wide programme of constant-effort mist netting in North America. *Journal of Applied Statistics* 22:935–947.
- DESANTE, D. F., K. M. BURTON, P. VELEZ, AND D. FROELICH. 2002. MAPS Manual: 2002 Protocol. The Institute for Bird Populations, Point Reyes Station, CA.
- DESANTE, D. F., K. M. BURTON, AND O. E. WILLIAMS. 1993a. The Monitoring Avian Productivity and Survivorship (MAPS) program second annual report (1990–1991). *Bird Populations* 1:68–97.
- DESANTE, D. F., AND G. R. GEUPEL. 1987. Landbird productivity in central coastal California: The relationship to annual rainfall, and a reproductive failure in 1986. *Condor* 86:636–653.
- DESANTE, D. F., M. P. NOTT, AND D. R. O'GRADY. 2001. Identifying the proximate demographic cause(s) of population change by modeling spatial variation in productivity, survivorship, and population trends. *Ardea* 89(special issue):185–207.
- DESANTE, D. F., D. R. O'GRADY, K. M. BURTON, P. VELEZ, D. FROELICH, E. E. FEUSS, H. SMITH, AND E. D. RUHLEN. 1998. The Monitoring Avian Productivity and Survivorship (MAPS) Program Sixth and Seventh Annual Report (1995 and 1996). *Bird Populations* 4: 69–122.
- DESANTE, D. F., D. R. O'GRADY, AND P. PYLE. 1999. Measures of productivity and survival derived from standardized mist netting are consistent with observed population changes. *Bird Study* 46:178–188.
- DESANTE, D. F., J. F. SARACCO, D. R. O'GRADY, K. M. BURTON, AND B. L. WALKER. 2004 (*this volume*). Methodological considerations of the Monitoring Avian Productivity and Survivorship (MAPS) Program. *Studies in Avian Biology* 29:28–45.
- DESANTE, D. F., O. E. WILLIAMS, AND K. M. BURTON. 1993b. The Monitoring Avian Productivity and Survivorship (MAPS) Program: Overview and progress. Pp. 208–222 in D. M. Finch, and P. W. Stangel (editors). *Status and management of Neotropical migratory birds*. USDA Forest Service Gen. Tech. Rep. RM-229. USDA Forest Service Rocky Mountain Research Station, Ft. Collins, CO.
- DIXON, P. M. 1993. The bootstrap and the jackknife: Describing the precision of ecological indices. Pp. 290–318 in S. M. Scheiner and J. Gurevitch (editors). *Design and analysis of ecological experiments*. Chapman and Hall, New York, NY.
- DORSCH, H. 1998. Faktoren, die den Fang von Kleinvögeln mit Spannnetzen beeinflussen. *Vogelwelt* 119:91104.
- DRURY, W. H., AND J. A. KEITH. 1962. Radar studies of songbird migration in coastal New England. *Ibis* 104: 449–489.
- DU FEU, C. R., AND J. M. McMEEKING. 1991. Does constant effort netting measure juvenile abundance? *Ring and Migration* 12:118–123.
- DU FEU, C. R., AND J. M. McMEEKING. 2004 (*this volume*). The relationship of juveniles captured in constant effort netting with local abundance. *Studies in Avian Biology* 29:57–62.
- DUGGER, K. M., J. FAABORG, AND W. J. ARENDT. 2000. Rainfall correlates of bird populations and survival rates in a Puerto Rican dry forest. *Bird Populations* 5:11–27.
- DUNN, E. H. 2002. A cross-Canada comparison of mass change in birds during migration stopover. *Wilson Bulletin* 114:368–379.

- DUNN, E. H. 2003. Recommendations for fat scoring. *North American Bird Bander* 28:58–63.
- DUNN, E. H. In press. Counting migrants to monitor bird populations: State of the art. *In* C. J. Ralph and T. D. Rich (editors). *Bird conservation implementation and integration in the Americas: Proceedings of the third international Partners in Flight conference 2002*. USDA Forest Service Gen. Tech. Rep. USDA Forest Service Pacific Southwest Research Station, Albany, CA.
- DUNN, E. H., AND D. J. T. HUSSELL. 1995. Using migration counts to monitor landbird populations: Review and evaluation of current status. *Current Ornithology* 12: 43–88.
- DUNN, E. H., D. J. T. HUSSELL, AND R. J. ADAMS. 1997. Monitoring songbird population change with autumn mist netting. *Journal of Wildlife Management* 61: 389–396.
- DUNN, E. H., D. J. T. HUSSELL, AND R. J. ADAMS. 2004b (*this volume*). An investigation of productivity indices derived from banding of fall migrants. *Studies in Avian Biology* 29:92–96.
- DUNN, E. H., D. J. T. HUSSELL, C. FRANCIS, AND J. D. MCCracken. 2004a (*this volume*). A comparison of three count methods for monitoring songbird abundance during spring migration: Capture, census, and estimated totals. *Studies in Avian Biology* 29:116–122.
- DUNN, E. H., AND E. NOL. 1980. Age-related migratory behavior of warblers. *Journal of Field Ornithology* 51: 254–269.
- DUNN, E. H., AND C. J. RALPH. 2004 (*this volume*). The use of mist nets as a tool for bird population monitoring. *Studies in Avian Biology* 29:1–6.
- EMLEN, J. T. 1977. Estimating breeding season bird densities from transect counts. *Auk* 94:455–468.
- ERDMAN, T. C., AND D. F. BRINKER. 1997. Increasing mist net captures of migrant Northern Saw-whet Owls (*Aegolius acadicus*) with an audiolure. Pp. 533–544 *in* J. R. Duncan, D. H. Johnson, and T. H. Nicholls (editors). *Biology and conservation of owls of the Northern Hemisphere*. USDA Forest Service Gen. Tech. Rep. NC-190. USDA Forest Service North Central Research Station, St. Paul, MN.
- ERICKSON, M. M. 1938. Territory, annual cycle, and numbers in a population of Wrentits *Chamaea fasciata*. *University of California Publications in Zoology* 42:247–333.
- FAABORG, J. 1982. Avian population fluctuations during drought conditions in Puerto Rico. *Wilson Bulletin* 94: 20–30.
- FAABORG, J. 1985. Ecological constraints on West Indian bird distributions. Pp. 621–653 *in* P. A. Buckley, M. S. Foster, E. S. Morton, R. S. Ridgely, and F. G. Buckley (editors). *Neotropical ornithology*. Ornithological Monographs 36.
- FAABORG, J., AND W. J. ARENDT. 1989a. Longevity estimates of Puerto Rican birds. *North American Bird Bander* 14: 11–13.
- FAABORG, J., AND W. J. ARENDT. 1989b. Long-term declines in winter resident warblers in a Puerto Rican dry forest. *American Birds* 43:1226–1230.
- FAABORG, J., AND W. J. ARENDT. 1990. Long-term studies of Guanica Forest Birds. *Acta Científica* 4:69–90.
- FAABORG, J., AND W. J. ARENDT. 1992a. Rainfall correlates of bird population fluctuations in a Puerto Rican dry forest: A 15-year study. *Ornitología Caribena* 3:10–19.
- FAABORG, J., AND W. J. ARENDT. 1992b. Long-term declines of winter resident warblers in a Puerto Rican dry forest: Which species are in trouble? Pp. 57–63 *in* J. M. Hagan, III, and D. W. Johnston (editors). *Ecology and conservation of Neotropical migrant landbirds*. Smithsonian Institution Press, Washington, D.C.
- FAABORG, J., AND W. J. ARENDT. 1995. Survival rates of Puerto Rican birds: Are islands really that different? *Auk* 112:503–507.
- FAABORG, J., W. J. ARENDT, AND K. M. DUGGER. 2000. The Guanica, Puerto Rico, bird monitoring project. *Bird Populations* 5:102–111.
- FAABORG, J., W. J. ARENDT, AND K. M. DUGGER. 2004 (*this volume*). Bird population studies in Puerto Rico using mist nets: General patterns and comparisons with point counts. *Studies in Avian Biology* 29:144–150.
- FAABORG, J., W. J. ARENDT, AND M. S. KAISER. 1984. Rainfall correlates of bird population fluctuations in a Puerto Rican dry forest: A nine year study. *Wilson Bulletin* 96: 557–595.
- FAABORG, J., AND J. E. WINTERS. 1979. Winter resident returns and resident longevity and weights of Puerto Rican birds. *Bird-Banding* 50:216–223.
- FAANES, C. A., AND D. BYSTRAK. 1981. The role of observer bias in the North American Breeding Bird Survey. *Studies in Avian Biology* 6:353–359.
- FINCH, D. M., AND P. W. STANGEL (EDITORS). 1993. Status and management of Neotropical migrant birds. USDA Forest Service Gen. Tech. Rep. RM-GTR-229. USDA Forest Service Rocky Mountain Research Station, Ft. Collins, CO.
- FOWLER, J., AND L. COHEN. 1986. *Statistics for ornithologists*, 2nd ed. British Trust for Ornithology, Thetford, U.K.
- FRANCIS, C. M., AND D. J. T. HUSSELL. 1998. Changes in numbers of land birds counted in migration at Long Point Bird Observatory, 1961–1997. *Bird Populations* 4:37–66.
- FUJIWARA, M., AND H. CASWELL. 2002. A general approach to temporary emigration in mark-recapture analysis. *Ecology* 83:3266–3275.
- FULLER, R. J. 1987. Comparison and structure of bird communities in Britain. Ph.D. dissertation. University of London, London, U.K.
- FULLER, R. J. 1995. *Bird life of woodland and forest*. Cambridge University Press, Cambridge, U.K.
- FULLER, R. M., G. B. GROOM, A. R. JONES, AND A. G. THOMSON. 1993. Countryside Survey 1990. Mapping the land cover of Great Britain using Landsat imagery: A demonstrator project in remote sensing. Institute for Terrestrial Ecology, Abbots Ripton, Huntingdon, U.K.
- FULLER, R. J., AND J. H. MARCHANT. 1985. Species-specific problems of cluster analysis in British mapping censuses. Pp. 83–86 *in* K. Taylor, R. J. Fuller, and P. C. Lack (editors). *Bird census and atlas studies*. Proceedings

- VIII International Conference on Bird Census and Atlas Work. British Trust for Ornithology, Tring, U.K.
- FULLER, R. M., G. M. SMITH, J. M. SANDERSON, R. A. HILL, A. G. THOMSON, R. COX, N. J. BROWN, R. T. CLARKE, P. ROTHERY, AND F. F. GERARD. 2002. Land cover map 2000. Final Report. Centre for Ecology and Hydrology, Abbot's Ripton, Huntingdon, U.K.
- GANTNER, B., AND J. MADSEN. 2001. An examination of methods to estimate population size in wintering geese. *Bird Study* 48:90–101.
- GARDALI, T., G. BALLARD, N. NUR, AND G. R. GEUPEL. 2000. Demography of a declining population of Warbling Vireos in Coastal California. *Condor* 102:601–609.
- GATES, J. E., AND L. W. GYSEL. 1978. Avian nest dispersion and fledgling success in field-forest ecotones. *Ecology* 59:871–883.
- GAUTHREUX, S. A., JR. 1971. A radar and direct visual study of passerine spring migration in southern Louisiana. *Auk* 88:343–365.
- GAUTHREUX, S. A., JR. 1992. The use of weather radar to monitor long-term patterns of trans-Gulf migration in spring. Pp. 96–100 in J. M. Hagan, III, and D. W. Johnston (editors). *Ecology and conservation of Neotropical migrant landbirds*. Smithsonian Institution Press, Washington, D.C.
- GAUTHREUX, S. A., JR. 1994. Remote sensing of spatio-temporal patterns in bird migration. *Journal für Ornithologie* 135:504.
- GAUTHREUX, S. A., JR., AND C. G. BELSER. 1998. Displays of bird movements on the WSR-88D: Patterns and quantification. *Weather and Forecasting* 13:453–464.
- GAUTHREUX, S. A., JR., AND K. R. RUSSELL. 1998. Weather surveillance radar quantification of roosting Purple Martins in South Carolina. *Wildlife Society Bulletin* 26:5–16.
- GEISSLER, P. H., AND J. R. SAUER. 1990. Topics in route-regression analysis. Pp. 54–57 in J. R. Sauer, and S. Droege (editors). *Survey designs and statistical methods for the estimation of avian population trends*. U.S. Fish and Wildlife Service Biological Report, 90(1). U.S. Fish and Wildlife Service, Washington D.C.
- GENTRY, A. H. 1990. *Four Neotropical rainforests*. Yale University Press, New Haven, CT.
- GERRODETTE, T. 1987. A power analysis for detecting trends. *Ecology* 68:1364–1372.
- GEUPEL, G. R., AND G. BALLARD. 2002. Wrentit (*Chamaea fasciata*). In A. Poole and F. Gill (editors). *The Birds of North America*, No. 654. The Birds of North America, Inc., Philadelphia, PA.
- GEUPEL, G. R., AND D. F. DeSANTE. 1990. Incidence and determinants of double brooding in Wrentits. *Condor* 92:67–75.
- GIBBONS, D. W., J. B. REID, AND R. A. CHAPMAN. 1993. *The new atlas of breeding birds in Britain and Ireland: 1988–91*. T. and A. D. Poyser, London, U.K.
- GONZALEZ-ALONSO, H., M. K. McNICHOLL, P. B. HAMEL, M. ACOSTA, E. GODINEZ, J. HERNANDEZ, D. RODRIGUEZ, J. A. JACKSON, C. M. GREGO, R. D. McRAE, AND J. SIROIS. 1992. A cooperative bird-banding project in Peninsula de Zapata, Cuba, 1988–1989. Pp. 131–142 in J. M. Hagan, III, and D. W. Johnston (editors). *Ecology and conservation of Neotropical migratory landbirds*. Smithsonian Institution Press, Washington D.C.
- GORDON, M. 1972. Reed Buntings on an Oxfordshire farm. *Bird Study* 19:81–90.
- GRAM, W. K., AND J. FAABORG. 1997. Distribution of Neotropical migrant birds wintering in the El Cielo Biosphere Reserve, Tamaulipas Mexico. *Condor* 99:658–670.
- GREEN, R. E. 1999. Diagnosing the causes of bird population declines using comparative methods: The value of data from ringing. *Ring and Migration* 19 (supplement):S47–S56.
- GREENBERG, R. 1992. Forest migrants in non-forest habitats on the Yucatan Peninsula. Pp. 273–286 in J. M. Hagan, III, and D. W. Johnston (editors). *Ecology and conservation of Neotropical migratory landbirds*. Smithsonian Institution Press, Washington D.C.
- GREENWOOD, J. J. D., S. R. BAILLIE, H. Q. P. CRICK, J. H. MARCHANT, AND W. J. PEACH. 1993. Integrated population monitoring: Detecting the effects of diverse changes. Pp. 267–342 in R. W. Furness and J. J. D. Greenwood (editors). *Birds as monitors of environmental change*. Chapman and Hall, London, U.K.
- GREENWOOD, P. J. 1980. Mating systems, philopatry and dispersal in birds and mammals. *Animal Behaviour* 28:1140–1160.
- GROSCH, K. 1995. *Die Nahrungszusammensetzung rastender Kleinvögel auf der Halbinsel Mettnau*. M.S. thesis. University of Bayreuth, Bayreuth, Germany.
- HAGAN, J. M., III, AND D. W. JOHNSTON (EDITORS). 1992. *Ecology and conservation of Neotropical migratory landbirds*. Smithsonian Institution Press, Washington, D.C.
- HAGAN, J. M., III, T. L. LLOYD-EVANS, J. L. ATWOOD, AND D. S. WOOD. 1992. Long-term changes in migratory landbirds in the northeastern United States: Evidence from migration capture data. Pp. 115–130 in J. M. Hagan, III, and D. W. Johnston (editors). *Ecology and conservation of Neotropical migrant landbirds*. Smithsonian Institution Press, Washington, D.C.
- HALL, G. A. 1981. Fall migration patterns of wood warblers in the southern Appalachians. *Journal of Field Ornithology* 52:43–49.
- HANOWSKI, J. M., J. G. BLAKE, G. J. NIEMI, AND P. T. COLLINS. 1993. Effects of extremely low frequency electromagnetic fields on breeding and migrating birds. *American Midland Naturalist* 129:96–115.
- HARRISON, N. M., M. J. WHITEHOUSE, P. A. PRINCE, AND N. HUIN. 2000. What problems do local habitat change represent for the Constant Effort Site ringing scheme? *Ring and Migration* 20:1–8.
- HEIMERDINGER, M. A., AND R. C. LEBERMAN. 1966. The comparative efficiency of 30 and 36 mm mesh in mist nets. *Bird-Banding* 37:280–286.
- HELMS, C. W., AND W. H. DRURY. 1960. Winter and migratory weight and fat: Field studies on some North American buntings. *Bird-Banding* 31:1–40.
- HERZOG, S. K., M. KESSLER, AND T. M. CAHILL. 2002.

- Estimating species richness of tropical bird communities from rapid assessment data. *Auk* 119:49–769.
- HESTBECK, J. B., J. D. NICHOLS, AND K. A. MALECKI. 1991. Estimate of movement and site fidelity using mark–resight data of wintering Canada Geese. *Ecology* 72: 523–533.
- HILDÉN, O., AND J. SHARROCK. 1982. Recent changes in the status of European birds. *Lintumies* 17:150–160.
- HILTON, B., JR., AND M. W. MILLER. 2003. Annual survival and recruitment in a Ruby-throated Hummingbird population, excluding the effect of transient individuals. *Condor* 105:54–62.
- HINES, J. E. 1994. MSSURVIV user's manual. USGS Patuxent Wildlife Research Center, Laurel, MD.
- HINES, J. E., T. BOULINIER, J. D. NICHOLS, J. R. SAUER, AND K. H. POLLOCK. 1999. COMDYN: Software to study the dynamics of animal communities using a capture–recapture approach. *Bird Study* 46 (supplement):S209–S217.
- HINES, J. E., W. L. KENDALL, AND J. D. NICHOLS. In press. On the use of the robust design with transient capture–recapture models. *Auk*.
- HOSMER, D. W., AND S. LEMESHOW. 2000. Applied logistic regression, 2nd ed. John Wiley, New York, NY.
- HOWELL, S. N. G., AND S. WEBB. 1995. A guide to the birds of Mexico and northern Central America. Oxford University Press, Oxford, U.K.
- HULL, B., P. BLOOM, AND THE NORTH AMERICAN BANDING COUNCIL. 2001. The North American banders' manual for raptor banding techniques. North American Banding Council Publications Committee, Point Reyes Station, CA. Available through <<http://www.nabanding.net/nabanding/pubs.html>> (29 September, 2003).
- HUMPLE, D., AND G. R. GEUPEL. 2002. Autumn populations of birds in riparian habitat of California's Central Valley. *Western Birds* 33:35–50.
- HUSSELL, D. J. T. 1981. The use of migration counts for monitoring bird population levels. *Studies in Avian Biology* 6:92–102.
- HUSSELL, D. J. T. 1982. Migrations of the Yellow-bellied Flycatcher in southern Ontario. *Journal of Field Ornithology* 53:223–234.
- HUSSELL, D. J. T. 1991. Fall migrations of Alder and Willow flycatchers in southern Ontario. *Journal of Field Ornithology* 62:260–270.
- HUSSELL, D. J. T. 2004 (*this volume*). Determining productivity indices from age composition of migrants captured for banding: Problems and possible solutions. *Studies in Avian Biology* 29:82–91.
- HUSSELL, D. J. T., M. H. MATHER, AND P. H. SINCLAIR. 1992. Trends in numbers of tropical- and temperate-wintering migrant landbirds in migration at Long Point, Ontario, 1961–88. Pp. 101–114 in J. M. Hagan, III, and D. W. Johnston (editors). *Ecology and conservation of Neotropical migrant landbirds*. Smithsonian Institution Press, Washington, D.C.
- HUSSELL, D. J. T., AND C. J. RALPH. 1998. Recommended methods for monitoring bird populations by counting and capture of migrants. <<http://www.fs.fed.us/psw/topics/wildlife/birdmon/pif/migmon.html>> (29 September, 2003).
- HUTTO, R. L., S. M. PLETSCHE, AND P. HENDRICKS. 1986. A fixed-radius point count method for non-breeding and breeding season use. *Auk* 103:593–602.
- JENNI, L., M. LEUENBERGER, AND F. RAMPAZZI. 1996. Capture efficiency of mist nets with comments on their role in the assessment of passerine habitat use. *Journal of Field Ornithology* 67:263–274.
- JENNI, L., AND R. WINKLER. 1994. *Moult and ageing of European passerines*. Academic Press, London, U.K.
- JOHNSON, M. D., AND G. R. GEUPEL. 1996. The importance of productivity to the dynamics of a Swainson's Thrush population. *Condor* 98:133–141.
- JOHNSON, N. K. 1972. Origin and differentiation of the avifauna of the Channel Islands, California. *Condor* 74: 295–315.
- JOLLY, G. M. 1965. Explicit estimates from capture–recapture data with both death and immigration: Stochastic model. *Biometrika* 52:225–247.
- KAISER, A. 1992. Fat deposition and theoretical flight range of small autumn migrants in southern Germany. *Bird Study* 39:96–110.
- KAISER, A. 1993a. A new multi-category classification of subcutaneous fat deposits of songbirds. *Journal of Field Ornithology* 64:246–255.
- KAISER, A. 1993b. Rast- und Durchzugsstrategien mitteleuropäischer Singvogel. Analysen von Fang- und Wiederfangdaten von Fanganlagen zur Beschreibung der Okophysiologie und Verhaltens rastender Populationen. Ph.D dissertation. University of Konstanz, Konstanz, Germany.
- KAISER, A. 1995. Estimating turnover, movements and capture parameters of resting passerines in standardized capture–recapture studies. *Journal of Applied Statistics* 22:1039–1047.
- KAISER, A. 1996. Zugdisposition mitteleuropäischer Kleinvögel: Mauser, Körpermasse, Fettdeposition und Verweildauer. *Journal für Ornithologie* 137:141–180.
- KAISER, A., AND H.-G. BAUER. 1994. Zur Bestimmung der Populationsgröße von Brutvögeln mit der Fang-Wiederfang-Methode und gängigen Kartierungsmethoden. *Vogelwarte* 37:206–231.
- KAISER, A., AND P. BERTHOLD. 1995. Population trends of resting migratory passerines at the Mettnau Peninsula, Germany: First annual report of the MRI-program (1992 and 1993). *Bird Populations* 2:127–135.
- KAISER, A., AND P. BERTHOLD. 2004 (*this volume*). A European example of standardized mist netting in population studies of birds. *Studies in Avian Biology* 29:75–81.
- KANYAMBWA, S., A. SCHIERER, R. PRADEL, AND J.-D. LEBRETON. 1990. Changes in adult annual survival rates in a western European population of the White Stork *Ciconia ciconia*. *Ibis* 132:27–35.
- KARR, J. R. 1976. Seasonality, resource availability, and community diversity in tropical bird communities. *American Naturalist* 110:973–994.
- KARR, J. R. 1979. On the use of mist nets in the study of bird communities. *Inland Bird Banding* 51:1–10.

- KARR, J. R. 1981a. Surveying birds with mist nets. *Studies in Avian Biology* 6:62–67.
- KARR, J. R. 1981b. Surveying birds in the tropics. *Studies in Avian Biology* 6:548–553.
- KARR, J. R. 1990. The avifauna of Barro Colorado Island and the Pipeline Road, Panama. Pp. 183–198 in A. H. Gentry (editor). *Four Neotropical forests*. Yale University Press, New Haven, CT.
- KARR, J. R., J. D. NICHOLS, M. K. KLIMKIEWICZ, AND J. D. BRAUN. 1990a. Survival rates of birds of tropical and temperate forests: Will the dogma survive? *American Naturalist* 136:277–291.
- KARR, J. R., S. K. ROBINSON, J. G. BLAKE, AND R. O. BIERREGAARD, JR. 1990b. The birds of four Neotropical forests. Pp. 237–272 in A. H. Gentry (editor). *Four Neotropical forests*. Yale University Press, New Haven, CT.
- KARR, J. R., D. W. SCHEMSKE, AND N. V. L. BROKAW. 1982. Temporal variation in the understory bird community of a tropical forest. Pp. 441–453 in E. G. Leigh, A. S. Rand, and D. M. Windsor (editors). *The ecology of a tropical forest: Seasonal rhythms and longer-term changes*. Smithsonian Institution Press, Washington, D.C.
- KASPAK, M. 1981. *Die Mauser der Singvögel Europas: ein Feldführer*. Dachverband Deutscher Avifaunisten, Lengede, Germany.
- KEAST, A., AND E. S. MORTON (EDITORS). 1980. *Migrant birds in the Neotropics: Ecology, behavior, distribution, and conservation*. Smithsonian Institution Press, Washington, D.C.
- KENDALL, W. L., AND R. BJORKLAND. 2001. Using open robust design models to estimate temporary emigration from capture–recapture data. *Biometrics* 57:1113–1122.
- KENDALL, W. L., AND J. D. NICHOLS. 2002. Estimating state-transition probabilities for unobservable states using capture–recapture–resighting data. *Ecology* 83:3276–3284.
- KENDALL, W. L., J. D. NICHOLS, AND J. E. HINES. 1997. Estimating temporary emigration and breeding proportions using capture–recapture data with Pollock’s robust design. *Ecology* 78:563–578.
- KENDALL, W. L., K. H. POLLOCK, AND C. BROWNIE. 1995. A likelihood-based approach to capture–recapture estimation of demographic parameters under the robust design. *Biometrics* 51:293–308.
- KENDALL, W. L., J. R. SAUER, J. D. NICHOLS, R. PRADEL, AND J. E. HINES. 2004 (*this volume*). On the use of capture–recapture models in mist-net studies. *Studies in Avian Biology* 29:173–181.
- KRICHER, J. C., AND W. E. DAVIS. 1992. Patterns of avian species richness in disturbed and undisturbed habitats in Belize. Pp. 24–246 in J. M. Hagan, III, and D. W. Johnston (editors). *Ecology and conservation of Neotropical migratory landbirds*. Smithsonian Institution Press, Washington D.C.
- KUENZLI, A. J., F. R. MOORE, AND T. R. SIMONS. 1991. Stopover of Neotropical landbird migrants on East Ship Island following trans-Gulf migration. *Condor* 93: 869–883.
- LACK, D. 1966. *Population studies of birds*. Oxford University Press, Oxford, U.K.
- LANCIA, R. A., J. D. NICHOLS, AND K. H. POLLOCK. 1994. Estimating the number of animals in wildlife populations. Pp. 215–253 in T. A. Bookhout (editor). *Research and management techniques for wildlife and habitats*. The Wildlife Society, Bethesda, MD.
- LATTA, S. C., AND J. FAABORG. 2001. Winter site fidelity of Prairie Warblers in the Dominican Republic. *Condor* 103:455–468.
- LATTA, S. T., AND J. FAABORG. 2002. Demographic and population responses of Cape May Warblers wintering in multiple habitats. *Ecology* 83:2502–2515.
- LEBRETON, J.-D., K. P. BURNHAM, J. CLOBERT, AND D. D. ANDERSON. 1992. Modeling survival and testing biological hypotheses using marked animals: A unified approach with case studies. *Ecological Monographs* 62:67–118.
- LEBRETON, J.-D., J. E. HINES, R. PRADEL, J. D. NICHOLS, AND J. A. SPENDELOW. 2003. The simultaneous estimation by capture–recapture of accession to reproduction and dispersal-fidelity in a multisite system. *Oikos* 101: 253–264.
- LEFEBVRE, G., B. POULIN, AND R. MCNEIL. 1992. Abundance, feeding behavior, and body condition of nearctic warblers wintering in Venezuelan mangroves. *Auk* 104:400–412.
- LEFEBVRE, G., B. POULIN, AND R. MCNEIL. 1994. Temporal dynamics of mangrove bird communities in Venezuela with special reference to migrant warblers. *Auk* 111: 405–415.
- LEVEY, D. J. 1988. Tropical wet forest treefall gaps and distributions of understory birds and plants. *Ecology* 69: 1076–1089.
- LINK, W. A., R. J. BARKER, J. R. SAUER, AND S. DROEGE. 1994. Within-site variability in surveys of wildlife populations. *Ecology* 75:1097–1108.
- LINK, W. A., AND J. D. NICHOLS. 1994. On the importance of sampling variance to investigations of temporal variation in animal population size. *Oikos* 69:539–544.
- LINK, W. A., AND J. R. SAUER. 1994. Estimating equation estimates of trends. *Bird Populations* 2:23–32.
- LITTELL, R. C., G. A. MILLIKEN, W. W. STROUP, AND R. D. WOLFINGER. 1996. SAS system for mixed models. SAS Institute Inc., Cary, NC.
- LOERY, G., K. H. POLLOCK, J. D. NICHOLS, AND J. E. HINES. 1987. Age-specificity of avian survival rates: An analysis of capture–recapture data for a Black-capped Chickadee population, 1958–1983. *Ecology* 68:1038–1044.
- LOISELLE, B. A., AND J. G. BLAKE. 1991. Temporal variation in birds and fruits along an elevational gradient in Costa Rica. *Ecology* 72:180–193.
- LOPEZ DE CASENAVE, J., J. P. PELOTTO, S. M. CAZIANI, M. MERMOS, AND J. PROTOMASTRO. 1998. Responses of avian assemblages to a natural edge in a Chaco semiarid forest in Argentina. *Auk* 115:425–435.
- LORIA, D. E., AND F. R. MOORE. 1990. Energy demands of migration on Red-eyed Vireos, *Vireo olivaceus*. *Behavioral Ecology* 1:24–35.
- LOWERY, G. H. 1946. Evidence of trans-Gulf migration. *Auk* 63:175–211.
- LYNCH, J. F. 1989. *Distribution of over wintering nearctic*

- migrants in the Yucatan Peninsula, I: General patterns of occurrence. *Condor* 91:515–544.
- LYNCH, J. F. 1992. Distribution of over wintering nearctic migrants in the Yucatan Peninsula, II: Use of native and human-modified vegetation. Pp. 178–196 in J. M. Hagan, III, and D. W. Johnston (editors). *Ecology and conservation of Neotropical migratory landbirds*. Smithsonian Institution Press, Washington D.C.
- MACHADO, R. B., AND G. A. B. DA FONSECA. 2000. The avifauna of Rio Doce Valley, southeastern Brazil, a highly fragmented area. *Biotropica* 32:914–924.
- MACKENZIE, D. I., AND W. L. KENDALL. 2002. How should detection probability be incorporated into estimates of relative abundance? *Ecology* 83:2387–2393.
- MÄDLÖW, W. 1994. Die Habitatwahl auf dem Wegzug rastender Kleinvögel in einer norddeutschen Uferzone. *Acta Ornithoecologica* 3:57–72.
- MAGURRAN, A. E. 1988. *Ecological diversity and its measurement*. Princeton University Press, Princeton, NJ.
- MALIZIA, L. R. 2001. Seasonal fluctuations of birds, fruits, and flowers in a subtropical forest of Argentina. *Condor* 103:45–61.
- MALLORY, E. P., AND N. V. L. BROKAW. 1993. *Birds of Rio Bravo Conservation and Management Area, Belize*. Manomet Observatory for Conservation Sciences, Manomet, MA.
- MALLORY, E. P., N. V. L. BROKAW, AND S. C. HESS. 2004 (*this volume*). Coping with capture rate bias: Canopy height and several extrinsic factors. *Studies in Avian Biology* 29:151–160.
- MALLORY, E. P., A. C. VALLELY, AND N. V. L. BROKAW. 1998. *Rapid Bird Assessment of the Rio Bravo Conservation and Management Area, Belize*. A project of Wings of the Americas. The Nature Conservancy, Arlington, VA.
- MANLEY, P. 1993. U.S. Forest Service goals and programs for monitoring Neotropical migratory birds. Pp. 252–257 in D. M. Finch and P. W. Stangel (editors). *Status and management of Neotropical migratory birds*. USDA Forest Service Gen. Tech. Rep. RM-229. USDA Forest Service Rocky Mountain Research Station, Ft. Collins, CO.
- MARCHANT, J. H. 1992. Recent trends in breeding populations of some common trans-Saharan migrant birds in northern Europe. *Ibis* 134 (supplement 1):113–119.
- MARCHANT, J. H., R. HUDSON, S. P. CARTER, AND P. WHITTINGTON. 1990. *Population trends in British Breeding Birds*. Maund and Irvine, Ltd., and British Trust for Ornithology, Tring, U.K.
- MARTIN, T. E., AND G. R. GEUPEL. 1993. Nest-monitoring plots: Methods for locating nests and monitoring success. *Journal of Field Ornithology* 64:507–519.
- MARTIN, T. E., AND KARR, J. R. 1986. Temporal dynamics of Neotropical birds with special reference to frugivores in second-growth woodlands. *Wilson Bulletin* 98:38–60.
- MASON, D. 1996. Responses of Venezuelan understory birds to selective logging, enrichment strips, and vine cutting. *Biotropica* 28:296–309.
- MAWSON, P. 2000. Sex bias or sampling bias? What you see isn't necessarily what you get. *Eclectus* 8:12–14.
- MILLER, M. W., A. ARADIS, AND G. LANDUCCI. 2003. Effects of fat reserves on annual apparent survival of blackbirds *Turdus merula*. *Journal of Animal Ecology* 73:127–132.
- MILLS, E. D., AND D. T. ROGERS. 1992. Ratios of Neotropical migrant and Neotropical resident birds in winter in a citrus plantation in central Belize. *Journal of Field Ornithology* 63:109–240.
- MOORE, F. R., AND P. KERLINGER. 1987. Stopover and fat deposition by North American wood-warblers (Parulinae) following spring migration over the Gulf of Mexico. *Oecologia* 74:47–54.
- MOORE, F. R., AND P. KERLINGER. 1991. Nocturnality, long distance migration, and ecological barriers. *Acta XX Congressus Internationalis Ornithologici*:1122–1129.
- MOORE, F. R., P. KERLINGER, AND T. R. SIMONS. 1990. Stopover on a Gulf coast barrier island by spring trans-Gulf migrants. *Wilson Bulletin*. 102:487–500.
- MOORE, F. R., AND T. R. SIMONS. 1992. Habitat suitability and the stopover ecology of Neotropical passerine migrants. Pp. 345–355 in J. M. Hagan, III, and D. W. Johnston (editors). *Ecology and conservation of Neotropical migrant landbirds*. Smithsonian Institution Press, Washington, D.C.
- MURPHY, M. T., K. L. CORNELL, AND K. L. MURPHY. 1998. Winter bird communities on San Salvador, Bahamas. *Journal of Field Ornithology* 69:402–414.
- MURRAY, B. G., JR. 1966. Migration of age and sex classes of passerines on the Atlantic coast in autumn. *Auk* 83: 352–360.
- NAYLOR, A., AND R. GREEN. 1976. Timing of fledging and passage of juvenile Reed Warblers. *Wicken Fen Group Report* 8:15–18.
- NEMAC, A. F. L. 1991. *Power analysis handbook for the design and analysis of forestry trials*. W. A. Bergerud (editor). *Biometrics information handbook*, 2. British Columbia Ministry of Forests, Victoria, BC.
- NETER, J., AND W. WASSERMAN. 1974. *Applied linear statistical models*. Richard D. Irwin, Inc., Homewood, IL.
- NETER, J., W. WASSERMAN, AND M. H. KUTNER. 1990. *Applied linear statistical models: Regression, analysis of variance, and experimental designs*, 3rd ed. Richard D. Irwin, Inc., Homewood, IL.
- NICE, M. M. 1937. *Studies in the life history of the Song Sparrow*. Volume I. *Transactions of the Linnean Society of New York* 4:1–247.
- NICHOLS, J. D. 1992. Capture–recapture models: Using marked animals to study population dynamics. *BioScience* 42:94–102.
- NICHOLS, J. D. 1994. Capture–recapture methods for bird population studies. *Proceedings of the Italian Ornithological Congress* 6:31–51.
- NICHOLS, J. D. 1996. Sources of variation in migratory movements of animal populations: Statistical inference and a selective review of empirical results for birds. Pp. 147–197 in O. E. Rhodes, R. K. Chesser, and M. H. Smith (editors). *Spatial and temporal aspects of population processes*. University of Chicago Press, Chicago, IL.
- NICHOLS, J. D., T. BOULINIER, J. E. HINES, K. H. POLLOCK, AND J. R. SAUER. 1998a. Estimating rates of local extinc-

- tion, colonization and turnover in animal communities. *Ecological Applications* 8:1213–1225.
- NICHOLS, J. D., T. BOULINIER, J. E. HINES, K. H. POLLOCK, AND J. R. SAUER. 1998b. Inference methods for spatial variation in species richness and community composition when not all species are detected. *Conservation Biology* 12:1390–1398.
- NICHOLS, J. D., C. BROWNIE, J. E. HINES, K. H. POLLOCK, AND J. B. HESTBECK. 1993. The estimation of exchanges among populations or subpopulations. Pp. 265–279 in J.-D. Lebreton and P. N. North (editors). *Marked individuals in the study of bird populations*. *Advances in Life Sciences*. Birkhauser Verlag, Berlin, Germany.
- NICHOLS, J. D., AND M. J. CONROY. 1996. Estimation of species richness. Pp. 226–234 in D. E. Wilson, J. D. Nichols, R. Rudran, F. R. Cole, and M. S. Foster (editors). *Measuring and monitoring biodiversity: Standard methods for mammals*. Smithsonian University Press, Washington, D. C.
- NICHOLS, J. D., AND J. E. HINES. 2002. Approaches for the direct estimation of lambda, and demographic contributions to lambda, using capture–recapture data. *Journal of Applied Statistics* 29:539–568.
- NICHOLS, J. D., J. E. HINES, J.-D. LEBRETON, AND R. PRADEL. 2000. Estimation of contributions to population growth: A reverse-time capture–recapture approach. *Ecology* 81: 3362–3376.
- NICHOLS, J. D., AND W. L. KENDALL. 1995. The use of multistate capture–recapture models to address questions in evolutionary ecology. *Journal of Applied Statistics* 22: 835–846.
- NICHOLS, J. D., T. S. SILLETT, J. E. HINES, AND R. T. HOLMES. In press. Approaches for the direct estimation of rate of increase in population size using capture–recapture data. In C. J. Ralph and T. D. Rich (editors). *Bird Conservation Implementation and Integration in the Americas*. Proceedings of the Third International Partners in Flight Conference 2002. USDA Forest Service Gen. Tech. Rep. USDA Forest Service Pacific Southwest Research Station, Albany, CA.
- NORTH AMERICAN BANDING COUNCIL. 2001a. The North American banders' study guide. North American Banding Council Publications Committee, Point Reyes Station, CA. Available through <<http://www.nabanding.net/nabanding/pubs.html>> (29 September, 2003).
- NORTH AMERICAN BANDING COUNCIL. 2001b. The North American bander's manual for banding passerines and near passerines (excluding hummingbirds and owls). North American Banding Council Publications Committee. Point Reyes Station, CA. Available through <<http://www.nabanding.net/nabanding/pubs.html>> (29 September, 2003).
- NORTH AMERICAN BANDING COUNCIL. 2001c. The instructor's guide to training passerine bird banders in North America. North American Banding Council Publications Committee. Point Reyes Station, CA. Available through <<http://www.nabanding.net/nabanding/pubs.html>> (29 September, 2003).
- NOTT, P. M., AND D. F. DESANTE. 2002. Demographic monitoring and the identification of transients in mark–recapture models. Pp. 727–736 in J. M. Scott, P. J. Heglund, M. L. Morrison, J. B. Hauffer, M. G. Rafael, W. A. Wall, and F. B. Samson (editors). *Predicting species occurrences: Issues of accuracy and scale*. Island Press, Covello, CA.
- NOTT, P. M., D. F. DESANTE, R. B. SIEGEL, AND P. PYLE. 2002. Influences of the El Niño/Southern Oscillation and the North Atlantic Oscillation on avian productivity in forests of the Pacific Northwest of North America. *Global Ecology and Biogeography* 11:333–342.
- NUR, N., AND G. R. GEUPEL. 1993a. Validating the use of constant effort mist-netting to monitor avian populations. Report of the Point Reyes Bird Observatory to Office of Migratory Bird Management, U.S. Fish and Wildlife Service, Laurel, MD. (Available from PRBO, Stinson Beach, CA 94970.)
- NUR, N., AND G. R. GEUPEL. 1993b. Evaluating mist-netting, nest-searching and other methods of monitoring demographic processes in landbird populations. Pp. 237–244 in D. M. Finch, and P. W. Stangel (editors). *Status and management of Neotropical migratory birds*. USDA Forest Service Gen. Tech. Rep. RM-229. USDA Forest Service Rocky Mountain Research Station, Ft. Collins, CO.
- NUR, N., G. R. GEUPEL, AND G. BALLARD. 1995. Validating the use of constant effort mist-netting to monitor avian populations. II: Studies of Song Sparrows, Wrentits and other species. Report by Point Reyes Bird Observatory to U.S. Fish and Wildlife Service, Office of Migratory Bird Management. (Available from PRBO, 4990 Shoreline Highway, Stinson Beach, CA 94970).
- NUR, N., G. R. GEUPEL, AND G. BALLARD. 2000. The use of constant-effort mist-netting to monitor demographic processes in passerines: Annual variation in survival, productivity, and floaters. Pp. 185–194 in R. Bonney, D. N. Pashley, R. J. Cooper, and L. Niles (editors). *Strategies for bird conservation: The Partners in Flight planning process*. USDA Forest Service Proceedings RMRS-P-16. USDA Forest Service Rocky Mountain Research Station, Ogden, UT.
- NUR, N., G. R. GEUPEL, AND G. BALLARD. 2004 (*this volume*). Estimates of adult survival, capture probability and recapture probability: Evaluating and validating constant effort mist netting. *Studies in Avian Biology* 29:63–70.
- NUR, N., S. L. JONES, AND G. R. GEUPEL. 1999. A statistical guide to data analysis of avian monitoring programs. U.S. Fish and Wildlife Service Biol. Tech. Publ. BTP-R6001-1999. Department of the Interior, Washington, D.C.
- O'CONNOR, R. J., AND R. J. FULLER. 1984. A re-evaluation of the aims and methods of the Common Birds Census. BTO Research Report No. 15. British Trust for Ornithology, Thetford, U.K.
- O'CONNOR, R. J., AND J. H. MARCHANT. 1981. A field validation of some Common Birds Census techniques. BTO Research Report No. 4. British Trust for Ornithology, Thetford, U.K.
- OTIS, D. L., K. P. BURNHAM, G. C. WHITE, AND D. R. ANDERSON. 1978. Statistical inference from capture data

- on closed animal populations. *Wildlife Monographs*, no 62.
- PAGEN, R. W., F. R. THOMPSON, III, AND D. E. BURHANS. 2002. A comparison of point-count and mist-net detections of songbirds by habitat and time-of-season. *Journal of Field Ornithology* 73:53–59.
- PARDECK, K., AND R. B. WAIDE. 1992. Mesh size as a factor in avian community studies using mist nets. *Journal of Field Ornithology* 63:250–255.
- PEACH, W. J. 1993. Combining mark–recapture data sets for small passerines. Pp. 107–122 in J.-D. Lebreton, and P. M. North (editors). *Marked individuals in the study of bird populations*. Birkhäuser Verlag, Basel, Switzerland.
- PEACH, W. J., AND S. R. BAILLIE. 1990. Population changes on constant effort sites, 1988–1989. *BTO News* 167: 6–7.
- PEACH, W. J., AND S. R. BAILLIE. 1993. Population changes on Constant Effort Sites 1991–92. *BTO News* 186: 10–12.
- PEACH, W. J., AND S. R. BAILLIE. 1994. Implementation of the Mountford indexing method for the Common Birds Census. Pp. 653–662 in W. Hagemeyer and T. Verstrael (editors). *Bird numbers 1992: Distribution, monitoring and ecological aspects*. Proceedings of 12th International Conference of the International Bird Census Committee and European Ornithological Atlas Committee. SOVON, Beek-Ubbergen, The Netherlands.
- PEACH, W. J., AND S. R. BAILLIE. 2004 (*this volume*). Estimating adult survival rates from between-year recaptures in the British Trust for Ornithology Constant Effort Sites scheme. *Studies in Avian Biology* 29:71–74.
- PEACH, W. J., S. R. BAILLIE, AND D. E. BALMER. 1998. Long-term changes in the abundance of passerines in Britain and Ireland as measured by constant effort mist-netting. *Bird Study* 45:257–275.
- PEACH, W. J., S. R. BAILLIE, AND S. P. BUCKLAND. 2004 (*this volume*). Current practices in the British Trust for Ornithology Constant Effort Sites scheme and comparisons of temporal changes in mist-net captures with changes in spot-mapping counts at the extensive scale. *Studies in Avian Biology* 29:46–56.
- PEACH, W. J., S. R. BAILLIE, AND L. UNDERHILL. 1991. Survival of British Sedge Warblers *Acrocephalus schoenobaenus* in relation to west African rainfall. *Ibis* 133:300–305.
- PEACH, W. J., S. T. BUCKLAND, AND S. R. BAILLIE. 1990. Estimating survival rates using mark–recapture data from multiple ringing sites. *The Ring* 13:87–102.
- PEACH, W. J., S. T. BUCKLAND, AND S. R. BAILLIE. 1996. The use of constant effort mist-netting to measure between-year changes in the abundance and productivity of common passerines. *Bird Study* 43:142–156.
- PEACH, W. J., H. Q. P. CRICK, AND J. H. MARCHANT. 1995. The demography of the decline in the British Willow Warbler population. *Journal of Applied Statistics* 22: 905–922.
- PEACH, W. J., C. R. DU FEU, AND J. M. McMEEKING. 1995. Site tenacity and survival rates of wrens and treecreepers in a Nottinghamshire wood. *Ibis* 137:497–507.
- PEACH, W. J., G. M. SIRIWARDENA, AND R. D. GREGORY. 1999. Long-term changes in over-winter survival rates explain the decline of reed buntings in Britain. *Journal of Applied Ecology* 36:798–811.
- PEARSON, D. L. 1971. Vertical stratification in birds in a tropical dry forest. *Condor* 73:46–55.
- PERRINS, C. 1979. *British tits*. New Naturalist, Collins, London, U.K.
- PETERJOHN, B. G., AND J. R. SAUER. 1993. North American Breeding Bird Survey annual summary 1990–1991. *Bird Populations* 1:1–15.
- PETIT, D. R., L. J. PETIT, AND K. G. SMITH. 1992. Habitat associations of migratory birds overwintering in Belize, Central America. Pp. 247–256 in J. M. Hagan, III, and D. W. Johnston (editors). *Ecology and conservation of Neotropical migrant landbirds*. Smithsonian Institution Press, Washington, D.C.
- PLEDGER, S. 2000. Unified maximum likelihood estimates for closed capture–recapture models using mixtures. *Biometrics* 56:434–442.
- POLLOCK, K. H. 1982. A capture–recapture design robust to unequal probability of capture. *Journal of Wildlife Management* 46:757–760.
- POLLOCK, K. H., J. D. NICHOLS, C. BROWNIE, AND J. E. HINES. 1990. Statistical inference for capture–recapture experiments. *Wildlife Monographs* no. 107.
- POLLOCK, K. H., J. D. NICHOLS, T. R. SIMONS, G. L. FARNSWORTH, L. L. BAILEY, AND J. R. SAUER. 2002. The design of large scale wildlife monitoring studies. *Environmetrics* 13:1–15.
- POULIN, B., G. LEFEBVRE, AND R. MCNEIL. 1993. Variations in bird abundance in tropical arid and semi-arid habitats. *Ibis* 135:432–441.
- POULSEN, B. O. 1996. Relationships between frequency of mixed-species flocks, weather and insect activity in a montane cloud forest in Ecuador. *Ibis* 138:466–470.
- PRADEL, R. 1993. Flexibility in survival analysis from recapture data: Handling trap-dependence. Pp. 29–37 in J.-D. Lebreton, and P. M. North (editors). *Marked individuals in the study of bird populations*. Birkhäuser Verlag, Basel, Switzerland.
- PRADEL, R. 1996. Utilization of capture–mark–recapture for the study of recruitment and population growth rate. *Biometrics* 52:703–709.
- PRADEL, R., J. CLOBERT, AND J.-D. LEBRETON. 1990. Recent developments for the analysis of capture–recapture multiple data sets. *The Ring* 13:193–204.
- PRADEL, R., J. E. HINES, J.-D. LEBRETON, J. D. NICHOLS, AND A. VIALLEFONT. 1997. Capture–recapture survival models taking account of transients. *Biometrics* 53:60–72.
- PRADEL, R., AND J.-D. LEBRETON. 1999. Comparison of different approaches to the study of local recruitment of breeders. *Bird Study* 46(supplement):74–81.
- PRADEL, R., C. M. A. WINTREBERT, AND O. GIMINEZ. 2003. A proposal for a goodness-of-fit test to the Arnason-Schwarz multisite capture–recapture model. *Biometrics* 59:43–53.
- PRATT, A. M., AND W. J. PEACH. 1991. Site tenacity and an-

- nual survival of a Willow Warbler *Phylloscopus trochilus* population in southern England. *Ring and Migration* 12:128–134.
- PYLE, P. 1997. Identification guide to North American birds, Part 1, Columbidae to Ploceidae. Slate Creek Press, Bolinas, CA.
- PYLE, P., N. NUR, AND D. F. DESANTE. 1994. Trends in nocturnal migrant landbird populations at southeast Farallon Island, California, 1968–1992. *Studies in Avian Biology* 15:58–74.
- PYLE, P., N. NUR, R. P. HENDERSON, AND D. F. DESANTE. 1993. The effects of weather and lunar cycle on nocturnal migration of landbirds at Southeast Farallon Island, California. *Condor* 95:343–361.
- PYLE, P., S. N. G. HOWELL, R. P. YUNICK, AND D. F. DESANTE. 1987. Identification guide to North American passerines. Slate Creek Press, Bolinas, CA.
- RALPH, C. J. 1971. An age differential of migrants in coastal California. *Condor* 73:243–246.
- RALPH, C. J. 1976. Standardization of mist net captures for quantification of avian migration. *Bird-Banding* 47:44–47.
- RALPH, C. J. 1978. The disorientation and possible fate of young passerine coastal migrants. *Bird-Banding* 49:237–247.
- RALPH, C. J. 1981. Age ratios and their possible use in determining autumn routes of passerine migrants. *Wilson Bulletin* 93:164–188.
- RALPH, C. J., E. H. DUNN, W. J. PEACH, AND C. M. HANDEL. 2004a (*this volume*). Recommendations for the use of mist nets for inventory and monitoring of bird populations. *Studies in Avian Biology* 29:187–196.
- RALPH, C. J., G. R. GEUPEL, P. PYLE, T. E. MARTIN, AND D. F. DESANTE. 1993. Handbook of field methods for monitoring landbirds. USDA Forest Service Gen. Tech. Rep. PSW-144. USDA Forest Service, Pacific Southwest Research Station, Albany, CA. <<http://www.fs.fed.us/psw/publications/gtrs.shtml>> (29 September, 2003).
- RALPH, C. J., AND K. HOLLINGER. 2003. The status of the Willow and Pacific-slope flycatchers in northwestern California and southern Oregon. *Studies in Avian Biology* 26:104–117.
- RALPH, C. J., K. HOLLINGER, AND S. L. MILLER. 2004b (*this volume*). Monitoring productivity with multiple mist-net stations. *Studies in Avian Biology* 29:12–20.
- RALPH, C. J., J. R. SAUER, AND S. DROEGE (EDITORS). 1995. Monitoring bird populations by point counts. USDA Forest Service Gen. Tech. Rep. PSW-GTR-149. USDA Forest Service Pacific Southwest Research Station, Albany, CA.
- RAMSEY, F. L., V. WILDMAN, AND J. ENGBRING. 1987. Covariate adjustments to effective area in variable-area wildlife surveys. *Biometrics* 43:1–11.
- RAPPOLE, J. H., W. J. MCSHEA, AND J. VEGA RIVERA. 1993. Evaluation of two survey methods in upland avian breeding communities. *Journal of Field Ornithology* 64:55–70.
- RAPPOLE, J. H., AND M. A. RAMOS. 1995. Determination of habitat requirements for migratory birds. Pp 235–241 in M. H. Wilson, and S. A. Sader (editors). Conservation of Neotropical migratory birds in Mexico. Maine Agricultural and Forest Experiment Station, Orono, ME.
- RAPPOLE, J. H., M. A. RAMOS, R. J. OEHLenschLAGER, D. W. WARNER, AND C. P. BARKAN. 1979. Timing of migration and route selection in North American songbirds. Pp. 199–214 in D. L. Drawe (editor). Proceedings First Welder Wildlife Foundation Symposium. Welder Wildlife Foundation, Sinton, TX.
- RAPPOLE, J. H., AND D. W. WARNER. 1976. Relationships between behavior, physiology and weather in avian transients at a migration stopover site. *Oecologia* 26:193–212.
- RAPPOLE, J. H., K. WINKER, AND G. V. N. POWELL. 1998. Migratory bird habitat use in Southern Mexico: Mist nets versus point counts. *Journal of Field Ornithology* 69:635–643.
- REMSEN, J. V., JR. 1994. Use and misuse of bird lists in community ecology and conservation. *Auk* 111:225–227.
- REMSEN, J. V., JR., AND D. A. GOOD. 1996. Misuse of data from mist net captures to assess relative abundance in bird populations. *Auk* 113:381–398.
- REMSEN, J. V., JR., AND T. A. PARKER, III. 1983. Contribution of river-created habitats to bird species richness in Amazonia. *Biotropica* 15:223–231.
- REXSTAD, E., AND K. P. BURNHAM. 1991. User's guide to interactive program CAPTURE. Department of Biology and Wildlife, University of Alaska, Fairbanks, AK.
- REYNOLDS, R. T., J. M. SCOTT, AND R. A. NUSSBAUM. 1980. A variable circular-plot method for estimating bird numbers. *Condor* 82:309–313.
- RICHARDSON, W. J. 1978. Timing and amount of bird migration in relation to weather: A review. *Oikos* 30:224–272.
- RIMMER, C. C., S. D. FACCIO, T. L. LLOYD-EVANS, AND J. M. HAGAN, III. 2004 (*this volume*). A comparison of constant-effort mist netting results at a coastal and inland New England site during migration. *Studies in Avian Biology* 29:123–134.
- ROBBINS, C. S., B. A. DOWELL, D. K. DAWSON, J. A. COLÓN, R. ESTRADA, A. SUTTON, R. SUTTON, AND D. WEYER. 1992. Comparison of Neotropical migrant landbird populations wintering in tropical forest, isolated forest fragments, and agricultural habitats. Pp. 207–220 in J. M. Hagan, III, and D. W. Johnston (editors). Ecology and conservation of Neotropical migrant landbirds. Smithsonian Institution Press, Washington, D.C.
- ROBBINS, C. S., J. R. SAUER, R. S. GREENBERG, AND S. DROEGE. 1989. Population declines in North American birds that migrate to the Neotropics. *Proceedings of the National Academy of Sciences (USA)* 86:7658–7662.
- ROBINSON, S. K., AND J. TERBORGH. 1990. Bird communities of the Cocha Cashu Biological Station in Amazonian Peru. Pp. 199–216 in A. H. Gentry (editor). Four Neotropical forests. Yale University Press, New Haven, CT.
- ROSENSTOCK, S. S., D. R. ANDERSON, K. G. KIESEN, T. LEUKERING, AND M. F. CARTER. 2002. Landbird counting techniques: Current practices and an alternative. *Auk* 119:46–53.

- ROTH, R. R., AND R. K. JOHNSON. 1993. Long-term dynamics of a Wood Thrush population breeding in a forest fragment. *Auk* 110:37–48
- RUSSELL, S. M., R. O. RUSSELL, AND THE NORTH AMERICAN BANDING COUNCIL. 2001. The North American banders' manual for banding hummingbirds. North American Banding Council Publications Committee, Point Reyes Station, CA. Available through <<http://www.nabanding.net/nabanding/pubs.html>> (29 September, 2003).
- SAS INSTITUTE. 1985. SAS user's guide: Statistics, Version 5. SAS Institute Inc., Cary, NC.
- SAS INSTITUTE. 1988. SAS user's guide: Statistics, 5th ed. SAS Institute Inc., Cary, NC.
- SAS INSTITUTE. 1993. SAS companion for the OS/2 environment, Version 6, 2nd ed. SAS Institute Inc., Cary, NC.
- SAS INSTITUTE. 1996. SAS/STAT users guide (release 6.03). SAS Institute Inc.
- SAS INSTITUTE. 1999. SAS statistical software (Release 8.0). SAS Institute Inc., Cary, NC.
- SAUER, J. R., J. E. HINES, I. THOMAS, J. FALLON, AND G. GOUGH. 2000. The North American Breeding Bird Survey, results and analysis 1966–1999. Version 98.1. USGS Patuxent Wildlife Research Center, Laurel, MD.
- SAUER, J. R., AND W. A. LINK. 2004 (*this volume*). Some consequences of using counts of birds banded as indices to populations. *Studies in Avian Biology* 29:168–172.
- SCHAUB, M., R. PRADEL, L. JENNI, AND J.-D. LEBRETON. 2001. Migrating birds stop over longer than usually thought: An improved capture–recapture analysis. *Ecology* 82: 852–859.
- SCHWARZ, C. J. 1993. Estimating migration rates using tag recovery data. Pp. 255–264 in J.-D. Lebreton and P. M. North (editors). *Marked individuals in the study of bird populations*. Advances in Life Sciences, Birkhauser Verlag, Berlin, Germany.
- SCHWARZ, C. J., AND A. N. ARNASON. 1996. A general methodology for the analysis of capture–recapture experiments in open populations. *Biometrics* 52:860–873
- SCHWARZ, C. J., J. F. SCHWEIGERT, AND A. N. ARNASON. 1993. Estimating migration rates using tag-recovery data. *Biometrics* 49:177–193
- SCHWARZ, C. J., AND G. A. F. SEBER. 1999. Estimating animal abundance: Review III. *Statistical Science* 14:427–456.
- SCHWARZ, C. J., AND W. T. STOBO. 1997. Estimating temporary migration using the robust design. *Biometrics* 53: 178–194.
- SEBER, G. A. F. 1965. A note on the multiple-recapture census. *Biometrika* 52:249–259.
- SEBER, G. A. F. 1982. *The estimation of animal abundance and related parameters*. Macmillan, New York, NY.
- SEÑAR, J. C., M. J. CONROY, AND A. BORRAS. 2002. Asymmetric exchange between populations differing in habitat quality: A metapopulation study on the Citril Finch. *Journal of Applied Statistics* 29:425–441.
- SEÑAR, J. C., J. DOMÈNECH, AND M. J. CONROY. 1999. *Funnel traps capture a higher proportion of juvenile Great tits Parus major than automatic traps. Ringing and Migration* 19:257–259.
- SHEALER, D. A., AND S. W. KRESS. 1994. Post-breeding movements and prey selection of Roseate Terns at Stratton Island, Maine. *Journal of Field Ornithology*. 65: 349–362.
- SILKEY, M., N. NUR, AND G. R. GEUPEL. 1999. The use of mist-net capture rates to monitor annual variation in abundance: A validation study. *Condor* 101:288–298.
- SIMONS, T. R., F. R. MOORE, AND S. A. GAUTHREUX. 2004 (*this volume*). Mist netting trans-Gulf migrants at coastal stopover sites: The influence of spatial and temporal variability on capture data. *Studies in Avian Biology* 29:135–143.
- SIMONS, T. R., S. A. PEARSON, AND F. R. MOORE. 2000. Application of spatial models to the stopover ecology of trans-Gulf migrants. *Studies in Avian Biology* 20:4–14.
- SIRIWARDENA, G. M., S. R. BAILLIE, S. T. BUCKLAND, R. M. FEWSTER, J. H. MARCHANT, AND J. D. WILSON. 1998. Trends in the abundance of farmland birds: A quantitative comparison of smoothed Common Birds Census indices. *Journal of Applied Ecology* 35:24–43.
- SKALSKI, J. R., AND D. S. ROBSON. 1992. *Techniques for wildlife investigation: Design and analysis of capture data*. Academic Press, Inc., New York, NY
- SNEDECOR, G. W., AND W. G. COCHRAN. 1967. *Statistical methods*, 6th ed. Iowa State University Press, Ames, IA.
- SOGGE, M. K., J. C. OWEN, E. H. PAXTON, S. M. LANGRIDGE, AND T. J. KORONKIEWICZ. 2001. A targeted mist net capture technique for the Willow Flycatcher. *Western Birds* 32: 167–172.
- SPENDELOW, J. A., J. D. NICHOLS, J. E. HINES, J.-D. LEBRETON, AND R. PRADEL. 2002. Modeling post-fledging survival and age-specific breeding probabilities in species with delayed maturity: A case study of Roseate Terns at Falkner Island, Connecticut. *Journal of Applied Statistics* 29:385–405
- SPENDELOW, J. A., J. D. NICHOLS, I. C. T. NISBET, H. HAYS, G. D. CORMONS, J. BURGER, C. SAFINA, J. E. HINES, AND M. GOCHFELD. 1995. Estimating annual survival and movement rates within a metapopulation of Roseate Terns. *Ecology* 76:2415–2428.
- STAMM, D. D., D. E. DAVIS, AND C. S. ROBBINS. 1960. A method of studying wild bird populations by mist-netting and banding. *Bird-Banding* 31:115–130.
- STANLEY, T. R., AND K. P. BURNHAM. 1998. Estimator selection for closed-population capture–recapture. *Journal of Agricultural, Biological, and Environmental Statistics* 3: 31–150.
- STATA CORP. 1997. *Stata statistical software: Release 5.0*. Stata Corporation, College Station, TX.
- STEIDL, R. J., AND L. THOMAS. 2001. Power analysis and experimental design. Pp. 14–26 in Scheiner, S. and J. Gurevitch (editors). *Design and analysis of ecological experiments*, 2nd ed. Oxford University Press, Oxford, United Kingdom.
- STILES, F. G. 1983. Chapter 10. Birds. Introduction. Pp. 502–530 in D. H. Janzen (editor). *Costa Rican natural history*. University of Chicago Press, Chicago, IL
- STILES, F. G., AND A. F. SKUTCH. 1989. *A guide to the Birds of Costa Rica*. Cornell University Press, Ithaca, NY.

- STOFFER, P. C., AND R. O. BIERREGAARD. 1995. Use of Amazonian forest fragments by understory insectivorous birds. *Ecology* 76:2429–2445.
- STREIF, M. 1991. Analyse der Biotoppräferenzen auf dem Wegzug in Süddeutschland rastender Kleinvögel. *Ornithologische Jahreshefte für Baden-Württemberg* 7: 1–132.
- STUTCHBURY, B., AND S. ZACK. 1992. Delayed breeding in avian social systems: The role of territory quality and floater tactics. *Behaviour* 123:194–219.
- SVENSSON, L. 1992. Identification guide to European passerines. Lars Svensson, Stockholm, Sweden.
- SWINEBROAD, J. 1964. Net-shyness and wood thrush populations. *Bird-Banding* 35:196–202.
- SYSTAT. 1998. SYSTAT 8.0 statistics. SPSS Inc., Chicago, IL.
- TEMPLE, S. A., AND J. A. WIENS. 1989. Bird populations and environmental changes: Can birds be bio-indicators? *American Birds* 43:260–270.
- TERBORGH, J. 1983. Five New World primates: A study in comparative ecology. Princeton University Press, Princeton, NJ.
- TERBORGH, J. 1985. The role of ecotones in the distribution of Andean birds. *Ecology* 66:1237–1246.
- TERBORGH, J. 1989. Where have all the birds gone? Essays on the biology and conservation of birds that migrate to the American tropics. Princeton University Press, Princeton, NJ.
- TERBORGH, J., AND J. FAABORG. 1973. Turnover and ecological release in the avifauna of Mona Island, Puerto Rico. *Auk* 90:759–779.
- THIBODEAU, M. D. 1999. Analysis of mist net tier capture frequencies in a coastal California riparian habitat. *North American Bird Bander* 24:3–5.
- THIOLLAY, J.-M. 1994. Structure, density, and rarity in an Amazonia rainforest bird community. *Journal of Tropical Ecology* 10:449–481.
- THOMAS, L. 1997. Evaluation of statistical methods for estimating long-term population change from extensive wildlife surveys. Ph.D. dissertation. University of British Columbia, Vancouver, BC.
- THOMAS, L., G. R. GEUPEL, N. NUR, AND G. BALLARD. 2004 (*this volume*). Optimizing the allocation of count days in a migration monitoring program. *Studies in Avian Biology* 29:97–111.
- THOMAS, L., AND K. MARTIN. 1996. The importance of analysis method for Breeding Bird Survey population trend estimates. *Conservation Biology* 10:479–490.
- THOMPSON, W. L. 2002. Towards reliable bird surveys: Accounting for individuals present but not detected. *Auk* 119:18–25.
- THOMSON, D. L., S. R. BAILLIE, AND W. J. PEACH. 1997. The demography and age-specific annual survival of song thrushes during periods of population stability and decline. *Journal of Animal Ecology* 66:414–424.
- THOMSON, D. L., S. R. BAILLIE, AND W. J. PEACH. 1999. A method for studying post-fledging survival rates using data from ringing recoveries. *Bird Study* 46 (supplement):104–111.
- TUCKER, G. M. AND M. F. HEATH. 1994. Birds in Europe: Their conservation status. BirdLife International (BirdLife Conservation Series 3), Cambridge, U.K.
- VANSTEENWEGAN, C., G. HÉMERY, AND E. PASQUET. 1990. Une réflexion sur le programme français du suivi temporel du niveau d'abondance des populations d'oiseaux terrestres communs (S.T.O.C.). *Alauda* 58:36–44.
- VEGA RIVERA, J. H., J. H. RAPPOLE, W. J. MCSHEA AND C. A. HAAS. 1998. Wood thrush postfledging movements and habitat use in northern Virginia. *Condor* 100:69–78.
- VERNER, J. 1985. Assessment of counting techniques. *Current Ornithology* 2:247–302.
- WAIDE, R. B. 1980. Resource partitioning between migrant and resident birds: The use of irregular resources. Pp. 337–352 in A. Keast and E. S. Morton (editors). *Migrant birds in the Neotropics: Ecology, behavior, distribution, and conservation*, Smithsonian Institution Press, Washington, D.C.
- WAIDE, R. B. 1991. The effect of Hurricane Hugo on bird populations in the Luquillo Experimental Forest Puerto Rico. *Biotropica* 23(4 Part A):475–480.
- WALLACE, G. E., H. G. ALONZO, M. K. MCNICHOLL, D. R. BATISTA, R. O. PRIETO, A. L. SOSA, B. S. ORIA, AND E. A. H. WALLACE. 1996. Winter surveys of forest-dwelling Neotropical migrant and resident birds in three regions of Cuba. *Condor* 98:745–768.
- WANG, Y., AND D. M. FINCH. 2002. Consistency of mist netting and point counts in assessing landbird species richness and relative abundance during migration. *Condor* 104:59–72.
- WASSENAAR, L., AND K. A. HOBSON. 2001. A stable-isotope approach to delineate geographical catchment areas of avian migration monitoring stations in North America. *Environmental Science and Technology* 35:1845–1850.
- WHITACRE, D. F., J. MADRID M., C. MARROQUIN, M. SCHULTZE, L. JONES, J. SUTTER, AND A. J. BAKER. 1993. Migrant songbirds, habitat change, and conservation prospects in northern Peten, Guatemala: Some initial results. Pp. 339–345 in D. M. Finch, and P. W. Stangel (editors). *Status and management of migratory birds*. USDA Forest Service Gen. Tech. Rept. RM-229. USDA Forest Service Rocky Mountain Forest and Range Experimental Station, Ft. Collins, CO.
- WHITAKER, A. H. 1972. An improved mist net rig for use in forests. *Bird-Banding* 43:1–8.
- WILSON, R. R., AND R. S. ALLAN. 1996. Mist netting from a boat in forested wetlands. *Journal of Field Ornithology* 67:82–85.
- WHITE, G. C., D. R. ANDERSON, K. P. BURNHAM, AND D. L. OTIS. 1982. Capture–recapture and removal methods for sampling closed populations. LA-8787-NERP, Los Alamos National Laboratory, Los Alamos, NM.
- WHITE, G. C., AND K. P. BURNHAM. 1999. Program MARK: Survival estimation from populations of marked animals. *Bird Study* 46 (supplement):120–139.
- WHITMAN, A. A. 2004 (*this volume*). Use of mist nets for study of Neotropical bird communities. *Studies in Avian Biology* 29:161–167.
- WHITMAN, A. A., J. H. HAGAN, III, AND N. V. L. BROKAW.

1995. A comparison of two bird survey techniques in a sub-tropical forest. Manomet Observatory for Conservation Sciences, Manomet, MA.
- WHITMAN, A. A., J. M. HAGAN, III, AND N. V. L. BROKAW. 1997. A comparison of two bird survey techniques used in a subtropical forest. *Condor* 99:955–965.
- WILKINSON, L. 1990. SYSTAT: The system for statistics. SYSTAT, Inc., Evanston, IL.
- WILL, T. 1991. Birds of a severely hurricane-damaged Atlantic coast rain forest in Nicaragua. *Biotropica*. 23(4 Part A):497–507.
- WILLIAMS, B. K., J. D. NICHOLS, AND M. J. CONROY. 2002. Analysis and management of animal populations. Academic Press, New York, NY.
- WILLIAMS, T. C., J. M. WILLIAMS, P. G. WILLIAMS, AND P. STOKSTAD. 2001. Bird migration through a mountain pass studied with high resolution radar, ceilometers, and census. *Auk* 118:389–403.
- WILSON, M. S., AND S. A. SADER (EDITORS). 1995. Conservation of Neotropical migratory birds in Mexico. Maine Agricultural and Forest Experimental Station, Miscellaneous Publication 727. Orono, ME.
- WINSTANLEY, D., R. SPENCER, AND K. WILLIAMSON. 1974. Where have all the Whitethroats gone? *Bird Study* 21: 1–14.
- WOODFORD, J., AND D. J. T. HUSSELL. 1961. The use of a Heligoland trap and mist-nets at Long Point, Ontario. *Bird-Banding* 32:115–125.
- WOODWORTH, B. L., J. FAABORG, AND W. J. ARENDT. 1999. Survival and longevity of the Puerto Rican Vireo. *Wilson Bulletin* 111:376–380.
- WUNDERLE, J. M., JR. 1995. Responses of bird populations in a Puerto Rico forest to hurricane Hugo: The first 18 months. *Condor* 97:879–896.
- YOUNG, B. E., D. DEROISER, AND G. V. N. POWELL. 1998. Diversity and conservation of understory birds in the Tilaran Mountains, Costa Rica. *Auk* 115:998–1016.
- ZAR, J. H. 1984. Biostatistical analysis. Prentice-Hall, Englewood Cliffs, NJ.
- ZINK, G. 1973–1985. Der Zug europäischer Singvögel. Ein Atlas der Wiederfunde beringter Vögel. Vol. 1–4. Vogelzug Verlag, Möggingen, Germany.