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Trends in Autumn Counts of Migratory Raptors in Northeastern North America, 1974–2004

Christopher J. Farmer,[1] *Ronald J. Bell,*[2]
Bruno Drolet,[3] *Laurie J. Goodrich,*[1]
Else Greenstone,[4] *David Grove,*[5]
David J. T. Hussell,[6] *David Mizrahi,*[7]
Frank J. Nicoletti,[8] *and Jason Sodergren*[9]

Abstract.—Hourly counts of migrating raptors have been collected for ≥10 years at >20 raptor migration watchsites in eastern North America. Using counts from seven watch sites with ≤30 years of counts, we calculated annual population indexes for 16 species of diurnal migrant raptors. The seven watchsites were at similar latitudes along an east-to-west transect from the Atlantic coastline of Connecticut to the western shoreline of Lake Superior. We also calculated population indexes for a shorter-term count at Observatoire d'oiseaux de

[1]*Acopian Center for Conservation Learning, Hawk Mountain Sanctuary, 410 Summer Valley Road, Orwigsburg, Pennsylvania 17961, USA;*
[2]*89 Peck Hill Road, Woodbridge, Connecticut 06525, USA;*
[3]*Populations Conservation Service, Canadian Wildlife Service, 1141 route de l'Eglise, CP10100, Québec G1V4H5, Canada;*
[4]*10 Moss Lane, Cranford, New Jersey 07016, USA;*
[5]*865 Alexander Spring Road, Carlisle, Pennsylvania 17015, USA;*
[6]*Ontario Ministry of Natural Resources, 2140 East Bank Drive, Peterborough, Ontario K9J 7B8, Canada;*
[7]*New Jersey Audubon Society, Cape May Bird Observatory Center for Research and Education, Cape May Court House, New Jersey 08210, USA;*
[8]*Hawk Ridge Bird Observatory, P.O. Box 3006, Duluth, Minnesota 55803, USA; and*
[9]*P.O. Box 1593, Homer, Alaska 99603, USA.*

Tadoussac, which receives migrants primarily from northeastern Québec and Newfoundland. We estimated geometric rates of change in the population indexes for the 16 species. Counts increased or remained stable for seven species and decreased for one species throughout the region from 1974 to 2004. Eight other species showed variable long-term trends across the region. Precision of long-term trend estimates from migration monitoring was generally good (n = 107), with 45 estimates rated with high (95% confidence interval [95% CI], ± 1.8% per year or less), 51 moderate (95% CI ± 1.8–3.5% per year), and 11 low (95% CI ± >3.5% per year) precision. Trends often were not linear, and several species that increased significantly during the 1980s—Osprey (*Pandion haliaetus*), Merlin (*Falco columbarius*), Peregrine Falcon (*F. peregrinus*)—did not do so in the 1990s. A few species showed geographic patterns in trends, which suggests either that different source populations were monitored in the eastern and western portions of the study area or that migration geography changed over the course of the study period.

Each autumn, large numbers of raptors migrate southward through North America (Zalles and Bildstein 2000). Migrating raptors are observed from many traditional watchsites operated by professionals and volunteer citizen-scientists (Bildstein 1998), who often use standardized techniques to count them (e.g., Barber et al. 2001, Holiday Beach Migration Observatory 2002, Kunkle 2002, Vekasy and Smith 2002). For most species, standardized migration monitoring offers the most feasible means of detecting temporal trends in breeding populations (Dunn and Hussell 2005, Farmer et al. 2007).

Trends typically are calculated for individual watchsites (e.g., Mueller et al. 1988, Bednarz et al. 1990, Kjellén and Roos 2000). Trends in the counts at a single watchsite may not be representative of an entire migrating population within a geographic region, however, and this has led to efforts to estimate regional trends based on data from several watchsites. Titus and Fuller (1990) used route regression to combine trends for six watchsites in eastern North America, weighting each watchsite by its total volume of migration. Whereas this weighting is intuitively appealing, it can produce biased regional trend estimates, because the volume of migrants at a site is unlikely to be correlated with the proportion of the breeding population sampled there (Dunn 2005). Hoffman and Smith (2003) compared trends from seven watchsites in western North America but did not attempt to generate quantitative regional trend estimates. Instead, they combined the trend information with information on the migration ecology of individual species to develop an overall qualitative assessment of regional population trends.

We estimated population trends for the period 1974–2004 at seven watchsites in northeastern North America and characterized regional trends in much the same manner as Hoffman and Smith (2003). Together, these watchsites count an average of ~275,000 migratory raptors annually. We also estimated trends for the decades, 1980–1990 and 1990–2000 (and 1994–2004 at an eighth watchsite, Observatoire d'oiseaux de Tadoussac), to reveal temporal patterns in population change that might be obscured in long-term trend estimates.

Methods

Data Collection

We analyzed counts of visible migrating raptors at Observatoire d'oiseaux de Tadoussac, Québec; Lighthouse Point Hawk Watch, Connecticut; Cape May Bird Observatory, New Jersey; Montclair Hawk Lookout, New Jersey; Hawk Mountain Sanctuary, Pennsylvania; Audubon's Hawk Watch at Waggoner's Gap, Pennsylvania; Holiday Beach Migration Observatory, Ontario; and Hawk Ridge Bird Observatory, Minnesota (Table 1, Fig. 1). Table 1 provides descriptions of daily and seasonal coverage at each site. Binoculars (7–10× magnification) were used at all watchsites to detect and identify migrating raptors. Telescopes were used occasionally to identify, but not to detect, raptors. Depending on weather and the volume of migration, observations at the watchsites often were extended beyond or terminated before the end of the standard daily sampling window.

For the purposes of this chapter, we divided the watchsites into three subregional groups: Atlantic Coast (Lighthouse Point and Cape May), Inland (Tadoussac, Montclair, Hawk Mountain, and Waggoner's Gap), and Great Lakes (Holiday Beach and Hawk Ridge) based on the migration geography of Goodrich and Smith (Chapter 2).

Migration Count Index

We identified a seasonal passage window for each species at each site, defined as the period during which 95% of migrants were observed to pass by the site (all years combined). We also identified a daily passage window as the hours of the day during which 95% of individuals were counted at each watchsite. Daily passage windows were compared and combined into a single daily passage window for each site if no major differences were found among species. Raptors counted outside of the daily and seasonal passage windows were excluded from analysis. For days when coverage was incomplete (i.e., less than the standard daily window), passage rates (birds h^{-1}) for the portion of the day covered were extrapolated to fill in the missing hours, and these days were weighted in analyses according to the proportion of the day actually covered.

We derived an annual index, representing the estimated mean daily count, for each species at each watchsite, based on estimates of the "geometric mean" daily count that were calculated following Farmer et al. (2007) and Farmer and Hussell (Chapter 4). The analytical approach was

Table 1. Watchsites included in this analysis (arranged by subregion) with details of the data sets.

Subregion	Location	Latitude	Longitude	Count season	Mean (range) days season^{-1}	Mean (SD) hours day^{-1}	Standard daily window (n hours)
Great Lakes	Hawk Ridge Bird Observatory, Minnesota[a]	46°45′N	92°02′W	15 Aug.–30 Nov.	87 (63–115)	6.1 (0.9)	0600–1500 (10)
	Holiday Beach Migration Observatory, Ontario[b]	42°02′N	83°03′W	1 Sep.–30 Nov.	79 (27–91)	7.4 (2.1)	0600–1500 (10)
Inland	Audubon's Hawk Watch at Waggoner's Gap, Pennsylvania[c]	40°17′N	77°17′W	1 Aug.–31 Dec.	104 (20–149)	6.0 (2.2)	0700–1600 (10)
	Hawk Mountain Sanctuary, Pennsylvania[d]	40°38′N	75°59′W	15 Aug.–15 Dec.	109 (65–132)	8.0 (2.7)	0700–1600 (10)
	Montclair Hawk Lookout, New Jersey[e]	40°51′N	74°13′W	1 Sep.–30 Nov.	81 (72–94)	7.0 (3.4)	0800–1600 (9)
	Observatoire d'oiseaux de Tadoussac, Québec[f]	48°09′N	69°40′W	8 Aug. –30 Nov.	83 (49–97)	4.4 (2.5)	0700–1400 (8)
Atlantic Coast	Cape May Bird Observatory, New Jersey[g]	38°56′N	74°57′W	1 Sep.–30 Nov.	86 (70–91)	8.9 (2.2)	0600–1500 (10)
	Lighthouse Point Hawk Watch, Connecticut[h]	41°15′N	72°54′W	1 Sep.–30 Nov.	79 (36–100)	6.0 (2.2)	0600–1300 (8)

[a] Counts made by staff aided by volunteers. Only counts from the main lookout are included. Migrants recorded if they moved south or southeast across an imaginary southeast–northwest line from the main overlook.

[b] Counts made by a primary volunteer aided by other volunteers. Migrants recorded if they moved west across an imaginary north–south line.

[c] Counts made by a primary volunteer aided by other volunteers. Migrants recorded if they moved south or southwest past the lookout.

[d] Counts made by a rotating group of staff and trained volunteers. Migrants recorded if they moved south or southwest across an imaginary southeast–northwest line.

[e] Counts made by a primary intern or volunteer counter aided by other volunteers. Migrants recorded if they moved southwest past the lookout.

[f] Counts made by pairs of trained staff from two sites ~1 km apart on an east–west axis (only one site used in 1993). The two sites maintained radio contact and attempted to avoid overlap in their counts. Migrants recorded if they moved south past one of the sites.

[g] Counts made by one or two trained staff. Migrants recorded if they moved south past an observation platform.

[h] Counts made by a primary volunteer aided by other volunteers. Migrants recorded if they moved west across New Haven Harbor.

Fig. 1. Watchsites used in our analyses: (1) Observatoire d'oiseaux de Tadoussac, Québec; (2) Lighthouse Point Hawk Watch, Connecticut; (3) Cape May Bird Observatory, New Jersey; (4) Montclair Hawk Lookout, New Jersey; (5) Hawk Mountain Sanctuary, Pennsylvania; (6) Audubon's Hawk Watch at Waggoner's Gap, Pennsylvania; (7) Holiday Beach Migration Observatory, Ontario; and (8) Hawk Ridge Bird Observatory, Minnesota.

similar to that used previously in analyses for both diurnal and nocturnal migrants (Hussell 1981, 1985; Hussell et al. 1992; Dunn et al. 1997; Francis and Hussell 1998).

We do not report indexes or trends for species-watchsite combinations with <0.5 individuals counted per standardized count day (~20 individuals per year). Such counts necessarily contain a large number of days when the count is zero, producing skewed residuals that violate the assumptions of regression analysis.

Trend Analysis

We estimated trends (geometric mean rate of change over predetermined time interval; sensu Link and Sauer 1997) in annual indexes for each species-site combination for the periods 1974–2004, 1980–1990, and 1990–2000. We first estimated population trajectories (patterns of change over time) by fitting a polynomial regression model to the time series of index values. To reduce correlation among the polynomial terms, we centered each regression at the midpoint in the time series. Using the three-step process described by Farmer et al. (2007) and Farmer and Hussell (Chapter 4), we then identified a best-fitting polynomial trajectory model.

We derived trend estimates and their significance ($\alpha = 0.05$) by reparameterizing the year terms of the trend regression as described by Francis and Hussell (1998) and Farmer et al. (2007). Trends with *P*-values between 0.05 and 0.10 may be considered marginally significant, and we have highlighted trends matching this criterion in the tables. We also have highlighted trends with *P*-values between 0.10 and 0.50 to distinguish them from trends with *P*-values >0.50. The reparameterization transformed year terms so that the first-order year term estimated the rate of change between the two sets of years (Chapter 4). We constructed 95% confidence intervals (CIs) around the estimated trend for the longest available time series for each species-watchsite combination. Confidence intervals may be interpreted in two ways: (1) that any trend values *not* within the confidence interval can be considered rejected at the 95% probability level, or (2) that the true value of the trend lies within the CI with a 95% probability (Hoenig and Heisey 2001). We consider precision of trend estimates to be high if the limits of the 95% CI are ≤1.8% per year from the estimate, moderate if 1.8–3.5% from the estimate, and low if >3.5% from the estimate. Moderate precision in this context indicates that a departure from the trend estimate >3.5% per year would be detected. By extension, moderate precision corresponds to the ability to detect a rate of change that would produce a 50% change in the population over a period of 20 years (see Chapter 4).

Results and Discussion

The eight watchsites together counted an annual average of 275,658 total hawks of 16 species from 1974 to 2004 (1994–2005 at Tadoussac). Three species, Broad-winged Hawk (see Table 2 for scientific names of raptors) ($\bar{x}$ = 102,922, SD = 42,248), Sharp-shinned Hawk ($\bar{x}$ = 72,239, SD = 17,881), and Red-tailed Hawk ($\bar{x}$ = 23,059, SD = 8,441), made up over 75% of these annual total counts (Table 2).

Although there was variation in the magnitude of 95% CIs around trend estimates (Tables 3–5), 96 of 107 (90%) long-term trend estimates were of high or moderate precision. Confidence intervals in the seven long-term data sets generally were narrower for Ospreys, *Buteos*, and small *Accipiters* than for falcons, vultures, and Northern Goshawks (Table 3). Among *Buteos*, the Broad-winged Hawk, which is a flocking migrant with a relatively narrow seasonal migration window, had broader confidence intervals than other species. Precision of trend estimates increases as a function of the length of time series available for estimation (Lewis and Gould 2000), and confidence intervals were therefore relatively broad for all of the 10-year time series (all species at Tadoussac [11 of 12 low precision] and Black Vultures at Hawk Mountain and Waggoner's Gap). Confidence intervals in all three periods were wider at Atlantic Coast watchsites than at those in the Great Lakes and Inland subregions (Tables 3–5), presumably because there is higher interannual variation in counts at coastal watchsites.

Trends (annual percentage of change) are shown in Tables 3–5 for the time periods 1974–2004, 1980–1990, and 1990–2000, respectively. Although these give an overall picture of population status, linear trends for arbitrarily chosen time periods can mask underlying nonlinear change. Therefore, we also show the annual indexes and fitted trajectories for each species and site (Figs. 2–17).

Summarizing trends across all watchsites, regardless of region, indicates considerable agreement among sites for certain species (Table 6). Seven species increased from 1974 to 2004 and had generally positive trends in both decadal periods. These included Black Vulture, Turkey Vulture, Osprey, Bald Eagle, Golden Eagle, Merlin, and Peregrine Falcon. No species showed sustained regional declines over the same intervals. All other species showed mixed results, either by time period or among sites. Broad-winged Hawks and American Kestrels, however, exhibited a gradient of trends across the region over the long term (1974–2004), with significant decreases in the Atlantic Coast and Inland subregions and increases in the Great Lakes.

From 1980 to 1990, there was a gradient in trends for Sharp-shinned Hawks across the region, with nonsignificant positive trends in the Great Lakes subregion and negative trends that increased in magnitude and

Table 2. Average annual total count (CV in parentheses) of 16 raptor species within 95% daily passage windows and average total count of all species at eight watchsites in eastern North America from 1974 to 2004.[a] Watchsites are arranged from Great Lakes (left) to Atlantic coast (right) subregions.

	Great Lakes		Inland				Atlantic Coast	
Species	Hawk Ridge	Holiday Beach	Waggoner's Gap	Hawk Mountain	Montclair	Tadoussac	Cape May	Lighthouse Point
Black Vulture (*Coragyps atratus*)	na[b]	na	38 (112)	20(99)	10 (280)	na	76 (127)	4 (489)
Turkey Vulture (*Cathartes aura*)	893 (60)	11,558 (67)	384 (127)	109 (116)	534 (77)	8 (97)	1,423 (106)	166 (89)
Osprey (*Pandion haliaetus*)	269 (52)	92 (40)	289 (52)	500 (31)	521 (27)	575 (19)	2,346 (60)	1,250 (65)
Bald Eagle (*Haliaeetus leucocephalus*)	1,351 (111)	37 (64)	65 (85)	77 (76)	35 (98)	101 (49)	87 (95)	21 (109)
Northern Harrier (*Circus cyaneus*)	448 (57)	663 (61)	230 (44)	268 (29)	144 (37)	273 (34)	1,657 (45)	433 (44)
Sharp-Shinned Hawk (*Accipiter striatus*)	13,329 (34)	12,494 (27)	4,850 (44)	6,079 (34)	3,345 (35)	4,766 (30)	27,224 (50)	6,790 (29)
Cooper's Hawk (*A. cooperii*)	100 (87)	514 (51)	425 (70)	520 (50)	120 (104)	na	2,497 (53)	635 (84)
Northern Goshawk (*A. gentilis*)	687 (130)	30 (65)	71 (68)	78 (50)	5 (59)	231 (32)	34 (63)	12 (82)
Red-shouldered Hawk (*Buteo lineatus*)	7 (133)	752 (53)	241 (43)	268 (28)	165 (40)	na	444 (44)	74 (132)
Broad-winged Hawk (*B. platypterus*)	37,414 (87)	36,723 (70)	4,257 (69)	8,653 (59)	14,330 (72)	1,284 (57)	2,344 (119)	2,126 (115)
Red-tailed Hawk (*B. jamaicensis*)	6,199 (58)	5,700 (43)	3,250 (38)	3,730 (21)	994 (32)	4,819 (48)	1,943 (60)	340 (81)

Table 2. Continued.

Species	Great Lakes		Inland				Atlantic Coast	
	Hawk Ridge	Holiday Beach	Waggoner's Gap	Hawk Mountain	Montclair	Tadoussac	Cape May	Lighthouse Point
Rough-legged Hawk (*B. lagopus*)	326 (71)	107 (71)	11 (63)	11 (51)	2 (77)	423 (63)	4 (75)	2 (118)
Golden Eagle (*Aquila chrysaetos*)	59 (105)	46 (74)	114 (56)	72 (51)	2 (55)	47 (44)	12 (60)	2 (124)
American Kestrel (*Falco sparverius*)	1,316 (63)	2,948 (42)	212 (54)	533 (25)	775 (36)	1,386 (38)	9,106 (45)	2,309 (47)
Merlin (*F. columbarius*)	121 (82)	46 (68)	29 (106)	75 (69)	45 (78)	175 (40)	1,463 (40)	245 (96)
Peregrine Falcon (*F. peregrinus*)	37 (77)	30 (70)	29 (74)	28 (65)	19 (76)	65 (44)	632 (65)	32 (65)
TOTAL HAWKS	66,236	72,102	14,684	21,192	21,132	14,375	51,297	14,651

[a] Cape May, 1976–2004; Tadoussac, 1994–2005.
[b] na = species does not occur regularly.

Table 3. Population trends (average percentage of change per year ±95% confidence interval) for 16 raptor species at seven watchsites in eastern North America from 1974 to 2004.[a] Watchsites are arranged from Great Lakes to Atlantic coast subregions.

	Great Lakes		Inland			Atlantic Coast	
Species	Hawk Ridge	Holiday Beach	Waggoner's Gap	Hawk Mountain	Montclair	Cape May	Lighthouse Point
Black Vulture	na[b]	na	na	na	na	6.9 ± 2.1*	na
Turkey Vulture	4.0 ± 1.9*[c]	10.3 ± 2.1*	10.0 ± 2.7*	12.5 ± 1.8*	10.5 ± 2.7*	1.5 ± 3.8§	8.8 ± 1.3*
Osprey	4.3 ± 1.3*	0.8 ± 1.6§	2.0 ± 1.7‡	1.5 ± 0.9*	2.4 ± 1.7*	2.4 ± 2.1‡	5.1 ± 2.2*
Bald Eagle	10.4 ± 1.2*	7.8 ± 2.5*	6.7 ± 2.5‡	4.7 ± 0.6*	7.7 ± 2.4*	8.4 ± 1.7*	15.7 ± 7.0*
Northern Harrier	0.6 ± 1.8	–2.6 ± 2.5†	–0.4 ± 1.3	–2.0 ± 0.9*	0.6 ± 1.9	–0.7 ± 2.6§	0.7 ± 1.5§
Sharp-Shinned Hawk	0.7 ± 1.2§	–0.5 ± 1.1	–0.6 ± 1.5§	–1.1 ± 0.9*	1.4 ± 1.7†	–4.5 ± 2.6*	1.8 ± 1.3‡
Cooper's Hawk	4.0 ± 1.9*	2.6 ± 1.2*	5.1 ± 1.0*	4.1 ± 0.8*	10.2 ± 1.4*	4.6 ± 2.3*	7.5 ± 2.2*
Northern Goshawk	1.7 ± 2.7§	4.4 ± 3.2*	0.1 ± 2.2	–2.7 ± 1.7*	na	–0.6 ± 1.9	na
Red-shouldered Hawk	na	–1.3 ± 2.2§	0.2 ± 1.3	–0.6 ± 0.8§	1.3 ± 1.1‡	–0.3 ± 1.4	3.3 ± 1.5*
Broad-winged Hawk	1.1 ± 2.9§	–5.2 ± 3.8*	–1.5 ± 2.7§	–3.1 ± 1.0*	–1.8 ± 3.0§	–1.4 ± 2.5	–0.4 ± 1.8§
Red-tailed Hawk	0.9 ± 1.2§	–2.4 ± 2.7†	–0.2 ± 2.0	–1.9 ± 0.9*	–1.7 ± 2.3§	–1.8 ± 2.8	3.1 ± 1.3*
Rough-legged Hawk	–1.2 ± 1.7§	–6.6 ± 3.6*	na	na	na	na	na
Golden Eagle	5.7 ± 1.3*	1.5 ± 2.8§	3.1 ± 1.1*	2.1 ± 1.3*	na	na	na
American Kestrel	3.2 ± 1.3*	–0.4 ± 1.6	–0.3 ± 2.9	–1.6 ± 0.9*	–3.3 ± 1.3*	–4.5 ± 1.5*	–3.1 ± 1.5*
Merlin	12.0 ± 1.8*	11.9 ± 2.4*	11.0 ± 2.3*	5.1 ± 0.7*	7.2 ± 2.6*	1.8 ± 2.0†	7.8 ± 2.7*
Peregrine Falcon	7.8 ± 2.0*	4.7 ± 1.9*	2.3 ± 2.0‡	4.3 ± 1.1*	na	6.0 ± 2.0*	7.8 ± 2.0*

[a] Cape May, 1976–2004.
[b] na = no trend could be calculated for the species because average annual counts were <20 birds per year.
[c] $^{\S}P \leq 0.50$, $^{\dagger}P \leq 0.10$, $^{\ddagger}P \leq 0.05$, $^{*}P \leq 0.01$.

Table 4. Population trends (average percentage of change per year ±95% confidence interval) for 16 raptor species at seven watchsites in eastern North America from 1980 to 1990. Watchsites are arranged from Great Lakes to Atlantic coast subregions.

	Great Lakes		Inland			Atlantic Coast	
Species	Hawk Ridge	Holiday Beach	Waggoner's Gap	Hawk Mountain	Montclair	Cape May	Lighthouse Point
Black Vulture	na[a]	na	na	na	na	11.5 ± 5.2*	na
Turkey Vulture	4.0 ± 1.9*[b]	12.4 ± 3.1*	20.1 ± 6.7*	26.2 ± 4.5*	7.0 ± 5.4‡	1.5 ± 3.8§	10.1 ± 2.0*
Osprey	4.1 ± 2.7*	3.1 ± 2.0*	0.9 ± 4.4	2.9 ± 2.0*	0.3 ± 2.2	5.4 ± 3.6*	14.1 ± 4.9*
Bald Eagle	8.4 ± 2.9*	2.6 ± 4.1§	5.4 ± 3.0*	4.5 ± 1.2*	14.1 ± 4.3*	9.6 ± 3.3*	26.6 ± 13.5*
Northern Harrier	0.6 ± 1.8	7.2 ± 4.2*	–2.7 ± 5.0§	–1.4 ± 0.7*	–3.4 ± 4.3†	–0.7 ± 2.6§	2.5 ± 2.2‡
Sharp-Shinned Hawk	4.0 ± 2.8*	–0.7 ± 2.7§	–0.6 ± 1.5§	–0.6 ± 1.6	–3.4 ± 3.5‡	–10.0 ± 5.4*	–1.0 ± 2.9§
Cooper's Hawk	11.0 ± 2.6*	5.2 ± 1.8*	5.1 ± 1.0*	4.1 ± 0.8*	10.2 ± 1.4*	8.2 ± 4.8*	22.8 ± 5.1*
Northern Goshawk	1.7 ± 2.7	2.1 ± 3.1§	0.1 ± 2.2	–4.7 ± 0.2*	na	1.6 ± 3.3§	na
Red-shouldered Hawk	na	4.7 ± 4.2*	0.4 ± 1.7	–0.6 ± 0.8§	1.3 ± 1.1‡	–0.3 ± 1.4	9.2 ± 3.6*
Broad-winged Hawk	1.1 ± 2.9	1.7 ± 3.9§	–9.1 ± 5.7*	–3.1 ± 1.0*	–1.3 ± 4.6§	–1.4 ± 2.5	–0.8 ± 2.6§
Red-tailed Hawk	–1.4 ± 2.5§	0.7 ± 8.2§	–4.9 ± 4.4‡	–1.9 ± 0.9*	–3.9 ± 4.4†	1.4 ± 5.7	3.1 ± 1.3*
Rough-legged Hawk	–1.2 ± 1.7§	1.5 ± 4.5	na	na	na	na	na
Golden Eagle	5.7 ± 1.3*	7.4 ± 3.5*	2.4 ± 1.5*	2.1 ± 1.3*	na	na	na
American Kestrel	7.0 ± 1.8*	1.0 ± 2.3§	–1.1 ± 4.9	–0.6 ± 1.4	–3.3 ± 1.3*	–4.5 ± 1.5*	0.5 ± 3.4
Merlin	17.6 ± 2.8*	10.6 ± 4.3*	11.0 ± 2.3*	7.9 ± 2.0*	10.5 ± 5.1*	1.6 ± 4.4§	15.5 ± 5.4*
Peregrine Falcon	7.8 ± 2.0*	9.8 ± 9.8*	4.8 ± 4.1‡	8.8 ± 2.9*	na	10.2 ± 3.9*	12.9 ± 3.9*

[a] na = no trend could be calculated for the species because average annual counts were <20 birds per year.

[b] §$P \le 0.50$, †$P \le 0.10$, ‡$P \le 0.05$, *$P \le 0.01$.

Table 5. Population trends (average percentage of change per year ±95% confidence interval) for 16 raptor species at eight watchsites in eastern North America from 1990 to 2000.[a] Watchsites are arranged from Great Lakes to Atlantic coast subregions.

	Great Lakes		Inland				Atlantic Coast	
Species	Hawk Ridge	Holiday Beach	Waggoner's Gap	Hawk Mountain	Montclair	Tadoussac	Cape May	Lighthouse Point
Black Vulture	na[b]	na	10.3 ± 3.2‡	3.7 ± 5.4§	na	na	9.8 ± 3.7*	na
Turkey Vulture	4.0 ± 1.9*[c]	7.1 ± 3.4*	29.8 ± 4.6*	5.3 ± 4.5‡	8.5 ± 3.4*	na	1.5 ± 3.8	6.9 ± 1.8*
Osprey	3.6 ± 2.9§	2.0 ± 2.0‡	–0.9 ± 3.2	–2.7 ± 2.2*	–1.2 ± 2.1§	–1.4 ± 5.6	–0.7 ± 3.3	–9.0 ± 4.6*
Bald Eagle	16.1 ± 2.5*	3.8 ± 4.3†	4.4 ± 2.0*	5.7 ± 1.1‡	9.2 ± 4.2*	4.7 ± 2.5*	10.8 ± 3.2*	8.8 ± 6.5*
Northern Harrier	0.6 ± 1.8	–8.2 ± 4.0*	–0.8 ± 3.7	–3.5 ± 1.5*	0.7 ± 3.9	1.3 ± 7.1	–0.7 ± 2.6§	–1.9 ± 2.2†
Sharp-Shinned Hawk	2.3 ± 2.7†	–1.8 ± 1.8†	–0.6 ± 1.5§	–3.5 ± 1.5*	0.2 ± 3.6	0.9 ± 6.0	3.0 ± 5.3§	–3.3 ± 2.8‡
Cooper's Hawk	8.1 ± 2.6*	–1.2 ± 2.0§	5.1 ± 1.0*	4.1 ± 0.8*	10.2 ± 1.4*	na	3.3 ± 4.7§	–4.0 ± 4.5†
Northern Goshawk	1.7 ± 2.7§	0.2 ± 2.9	0.1 ± 2.2	–2.4 ± 3.2§	na	–2.8 ± 4.8§	–2.7 ± 3.1†	na
Red-shouldered Hawk	na	–5.0 ± 5.5*	1.0 ± 1.6§	–0.6 ± 0.8§	1.3 ± 1.1‡	na	–0.3 ± 1.4	–2.1 ± 2.7
Broad-winged Hawk	1.1 ± 2.9§	–2.2 ± 4.3§	4.3 ± 4.2‡	–3.1 ± 1.0*	–6.4 ± 4.8*	–1.7 ± 10.5	–1.4 ± 2.5§	–2.3 ± 2.8†
Red-tailed Hawk	6.1 ± 2.4*	–3.4 ± 3.9†	4.5 ± 3.4‡	–1.9 ± 0.9*	–2.8 ± 4.6§	–0.4 ± 7.5	0.3 ± 5.5	3.1 ± 1.3*
Rough-legged Hawk	–1.2 ± 1.2§	–7.8 ± 4.1*	na	na	na	–1.2 ± 12.2	na	na
Golden Eagle	5.7 ± 1.3*	1.1 ± 3.1§	3.0 ± 1.4*	2.1 ± 1.3*	na	–3.8 ± 7.5§	na	na
American Kestrel	5.3 ± 1.8*	–2.6 ± 2.6†	2.3 ± 3.5†	–0.2 ± 1.6	–3.3 ± 1.3*	–1.8 ± 8.0	–4.5 ± 1.5*	–7.1 ± 3.2*
Merlin	3.7 ± 2.8*	3.0 ± 4.2§	11.0 ± 2.3*	3.6 ± 1.9*	4.0 ± 4.6†	–0.8 ± 6.5	0.2 ± 4.3	–3.7 ± 4.8
Peregrine Falcon	7.8 ± 2.0*	4.6 ± 1.8*	2.1 ± 2.9§	1.5 ± 3.1§	na	7.2 ± 3.6*	3.4 ± 4.6†	–0.5 ± 3.2

[a] Tadoussac, 1994–2004.

[b] na = no trend could be calculated for the species because average annual counts were <20 birds per year.

[c] §$P \leq 0.50$, †$P \leq 0.10$, ‡$P \leq 0.05$, *$P \leq 0.01$.

Table 6. Temporal patterns in trends across all watchsites.

Species	1974–2004 (seven sites)	1980–1990 (seven sites)	1990–2000 (eight sites)	Overall pattern
Black Vulture	Increase	Increase	Increase	Monitored at few sites; uniformly increasing
Turkey Vulture	Increase	Increase	Increase	Uniformly increasing
Osprey	Increase	Increase	Variable	Increase slowed or reversed in 1990s
Bald Eagle	Increase	Increase	Increase	Uniformly increasing
Northern Harrier	Unclear	Variable	Unclear	Counts highly variable; trends vary over space and time
Sharp-Shinned Hawk	Variable	Variable	Variable	Slight decline at most sites since 1980
Cooper's Hawk	Increase	Increase	Variable	Increase may be slowing
Northern Goshawk	Variable	Unclear	Unclear	Irruptive migrant; pattern unclear
Red-shouldered Hawk	Unclear	Increase or unclear	Variable	Mixed trends; perhaps stable overall
Broad-winged Hawk	Unclear	Decrease or unclear	Variable	Stable or possibly declining, but unclear
Red-tailed Hawk	Variable	Variable	Variable	No patterns; perhaps stable overall
Rough-legged Hawk	Unclear	Unclear	Decrease or unclear	Monitored at few sites; evidently declining
Golden Eagle	Increase	Increase	Increase	Overall increase
American Kestrel	Variable	Variable	Variable	Decline in east; stable or increase in Great Lakes
Merlin	Increase	Increase	Increase or unclear	Eastern increase slowed or reversed in 1990s
Peregrine Falcon	Increase	Increase	Increase or unclear	Eastern increase slowed or reversed in 1990s

Note: Decrease indicates significant or marginally significant decrease at majority of sites and no significant increases. Increase indicates significant or marginally significant increase at majority of watchsites and no significant decreases. Unclear indicates some significant increases or decreases (but not both) and majority of trends nonsignificant. Variable indicates at least one significant increase and one significant decrease.

significance eastward across the northeast. A similar pattern occurred for Broad-winged Hawks, but significant decreases occurred only in the Inland subregion; American Kestrels showed primarily negative trends in Atlantic Coast and Inland subregions and positive trends in the Great Lakes.

From 1990 to 2000, trends for Northern Harriers, Sharp-shinned Hawks, Cooper's Hawks, Northern Goshawks, Red-shouldered Hawks, Broad-winged Hawks, Red-tailed Hawks, and American Kestrels varied across the region, but generally were negative in the Atlantic Coast and Inland subregions and positive in the Great Lakes. Osprey counts continued to increase in the Great Lakes but decreased at all watchsites to the east of this subregion, with statistically significant declines recorded at Lighthouse Point and Hawk Mountain. We discuss each species below, highlighting important regional and temporal differences in their trends. Further discussion and evaluation of status can be found in species-specific Conservation Status Reports (Chapter 9), along with trend maps that illustrate geographic patterns.

Patterns within Subregions

Atlantic Coast.—The two watchsites in this subregion recorded increases in counts of seven species from 1974 to 2004, nine species in the 1980s, and four species in the 1990s. Three species declined at both Atlantic Coast watchsites from 1974 to 2004 as well as during the 1980s, and six species declined at both watchsites in the 1990s (Tables 2–4). Differences between long-term (1974–2004) and 1990s trends suggest a slowing or reversal of historic population increases in this subregion for Ospreys, Cooper's Hawks, Merlins, and Peregrine Falcons. Trends were not more positive in the 1990s than in the previous decade for any species in this subregion and were primarily negative in all periods for Sharp-shinned Hawks, Red-shouldered Hawks, and American Kestrels.

Inland.—Seven species increased at all watchsites in this subregion from 1974 to 2004 and in the 1980s; six species did so during the 1990s (Tables 2–4). The number of species declining at all watchsites was three from 1974 to 2004, five in the 1980s, and one in the 1990s. Ospreys increased from 1974 to 2004 and in the 1980s before decreasing at all sites in the 1990s, which suggests that source populations began to decline in similar fashion to those along the Atlantic Coast over the last decade. Long-term (1974–2004) trends were mixed among watchsites for four species, whereas mixed trends were recorded for two species in the 1980s and nine species in the 1990s. The increase in mixed patterns in the 1990s was attributable to the appearance of nonsignificant increasing trends for species that showed declines in the 1980s (e.g., Northern Harrier, Sharp-shinned Hawk, Broad-winged Hawk, Red-tailed Hawk, American Kestrel) and the addition of a new watchsite (Tadoussac) for the 1990s (Merlin).

Great Lakes.—Eight species increased at both watchsites within this subregion from 1974 to 2004. In the 1980s, 11 species increased at both watchsites, but only 7 species did so in the 1990s. Four of the species that increased at both watchsites in all three periods (Turkey Vulture, Osprey, Golden Eagle, and Merlin) had trends of decreased magnitude and statistical significance in the 1990s versus the 1980s. Over the long term (1974–2004), only Rough-legged Hawks declined at both watchsites, although Red-shouldered Hawks declined at the only watchsite (Hawk Ridge) with high enough average counts to permit trend estimation. Five, three, and six species had a mix of positive and negative trends at the two watchsites 1974–2004, 1980–1990, and 1990–2000, respectively. Three species (Cooper's Hawk, Broad-winged Hawk, and American Kestrel) increased at both watchsites in the 1980s, but decreased at Holiday Beach in the 1990s.

Species Trends

Black Vulture.—Black Vultures were regularly counted in all periods only at Cape May, where significant increases were recorded throughout the study period. Precision of the long-term trend at Cape May was moderate (Table 3). Precision of estimates for shorter periods ranged from low to moderate (Tables 4 and 5). Numbers at Waggoner's Gap and Hawk Mountain rose during the 1980s and continued to do so at the former site to 2004 (Fig. 2). Trends only could be calculated for the period 1990–2000 for Waggoner's Gap because most annual counts in the 1980s were zero.

Turkey Vulture.—This species increased significantly at strong and steady rates after 1980. A significant decline occurred in recent years (i.e., late 1990s) at Cape May (Fig. 3), but that followed a dramatic short-term increase, and current counts there are about the same as during the 1980s. This species was not counted consistently at several sites (Montclair, Hawk Mountain, and Waggoner's Gap) because of changes in how migrants were identified throughout the period, but overall trajectories for the species clearly indicate increase. Precision of long-term trends was moderate to high (Table 3), becoming low to moderate for shorter-term trends. The qualitative pattern in counts at Tadoussac was consistent with the increases recorded at other watchsites and suggested a northward range expansion. Turkey Vultures began to appear at Tadoussac in 1999, and counts increased from 5 in 1999 to a high of 22 in 2003 (unpublished data, available at www.explos-nature.qc.ca/oot).

Osprey.—Trends at all sites were positive and mostly significant over the long term (1974–2004) and during the 1980s (Tables 3 and 4).

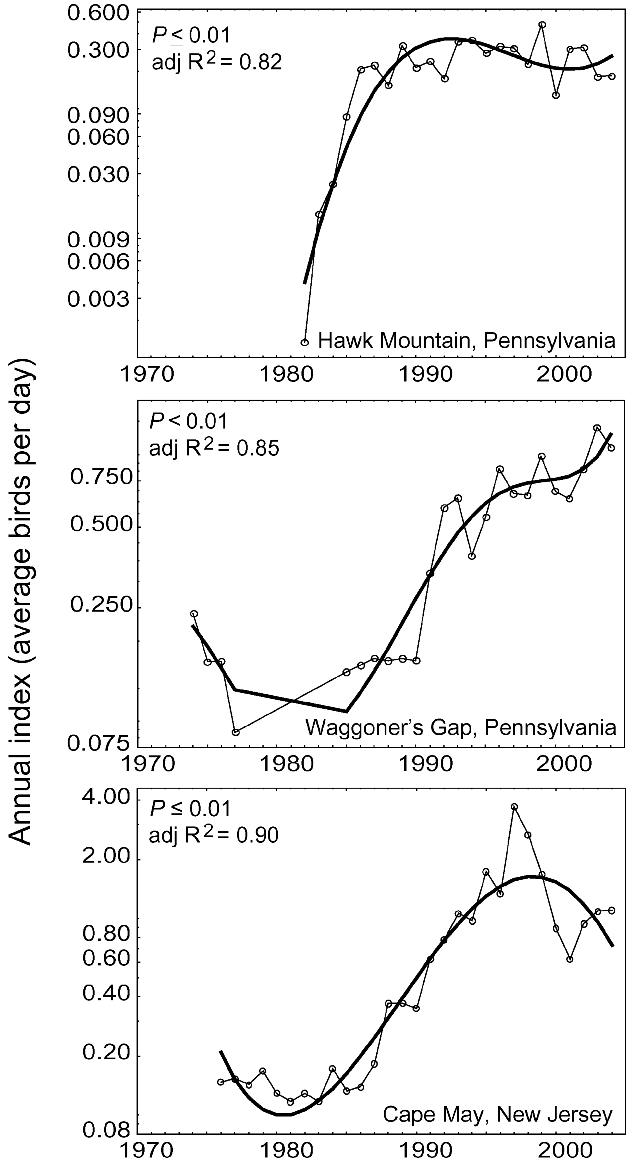

Fig. 2. Population indexes and trajectories for Black Vultures (*Coragyps atratus*) at three watchsites in northeastern North America. Index values are represented by open circles connected by thin lines to highlight patterns of interannual variation. Thick solid ($P \leq 0.10$) or dashed ($P > 0.10$) lines indicate fitted trajectories. P-values and adjusted R^2 are shown for fitted trajectories.

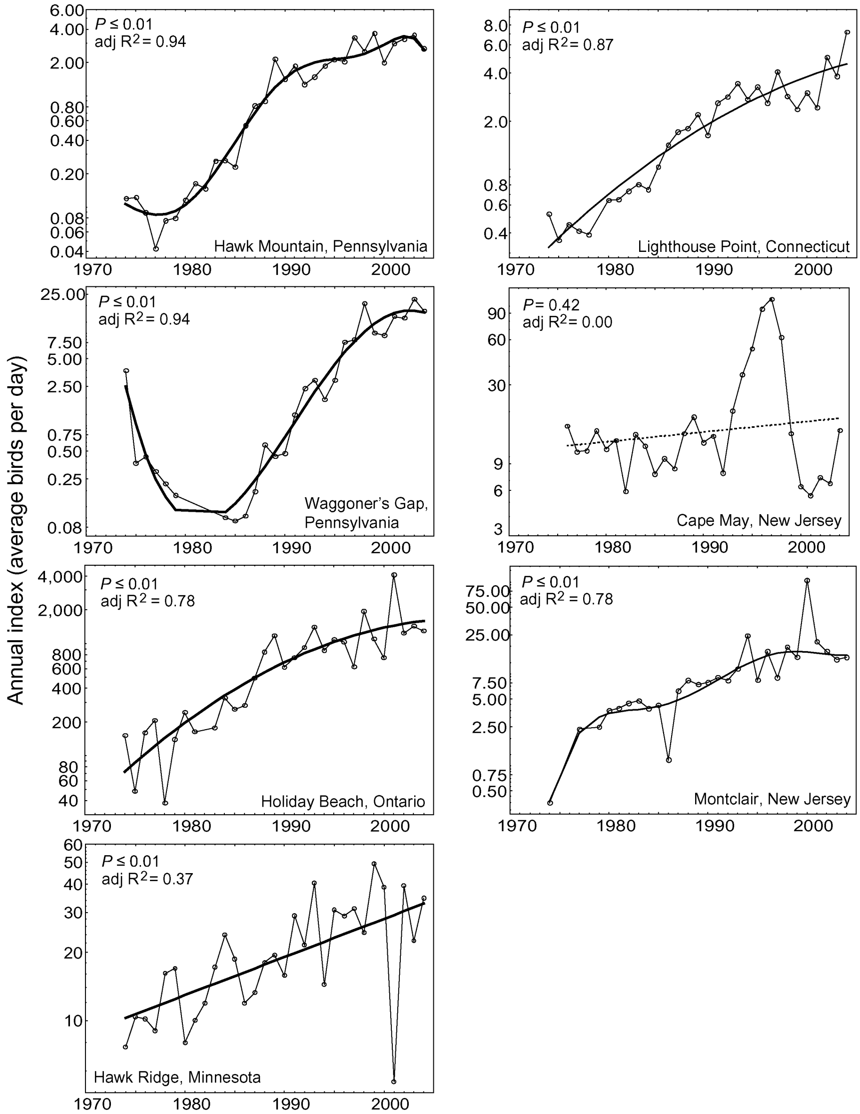

Fig. 3. Population indexes and trajectories for Turkey Vultures (*Cathartes aura*) at seven watchsites in northeastern North America. Index values are represented by open circles connected by thin lines to highlight patterns of interannual variation. Thick solid ($P \leq 0.10$) or dashed ($P > 0.10$) lines indicate fitted trajectories. P-values and adjusted R^2 are shown for fitted trajectories.

During the 1990s, rates of increase were reduced, and there were marked shifts from significantly positive to significantly negative trends at Hawk Mountain and Lighthouse Point (Table 5). These reversals did not negate long-term gains, however (Table 3), and trajectories for many sites suggest that population levels may have begun to stabilize after a period of increase (Fig. 4). Precision of long-term trends was moderate to high at all watchsites (Table 3), and shorter-term trend estimates were of low to moderate precision (Tables 4 and 5).

Bald Eagle.—Rates of increase for Bald Eagles in all periods were significant and positive throughout the region (Tables 3–5). Precision of long-term trends was moderate to high at most sites, but low at Lighthouse Point and Holiday Beach, which had low average counts (Table 3). Precision tended to be lower for shorter-term trends but remained high for all trend estimates at Hawk Mountain (Tables 4 and 5). Population trajectories (Fig. 5) show that all sites tracked the long-term pattern of exponential population increase that started in about 1980. Trajectories at some watchsites (e.g., Cape May and Hawk Ridge; Fig. 5) indicate the population may have begun to stabilize recently.

Northern Harrier.—Long-term trends were nonsignificant at most watchsites, but significant declines occurred at Holiday Beach and Hawk Mountain (Table 3). Trends at most sites during the 1990s were similar to the long-term trends (Table 5). During the 1980s, a significant increase occurred at Holiday Beach, making the change to a significant decline during the 1990s particularly striking. Lighthouse Point showed a similar pattern. Precision of long-term trends was moderate to high at all watchsites (Table 3), and shorter-term trends were of low to moderate precision at most watchsites (Tables 4 and 5). No obvious groupings of site trends, either geographically or temporally, were evident. However, common patterns of interannual variation occurred across nearly all watchsites in the region (Fig. 6). This suggests a high degree of synchrony in migration volume of this species in northeastern North America, presumably from fluctuations in prey abundance that affect reproductive success (Hamerstrom et al. 1985, Simmons et al. 1986) and dispersion (Craighead and Craighead 1956, Grant et al. 1991).

Sharp-shinned Hawk.—Negative trends (often significant) occurred at all sites during the 1980s except at Hawk Ridge, where there was a significant increase (Table 4). In the 1990s, this pattern was still present, although less strong (Table 5), except there was a temporary increase in numbers at Cape May (Fig. 7). The 1974–2004 trends showed no patterns of agreement across watchsites, but taken together, the trajectories (Fig. 7) suggest modest decline at most sites since about 1980. This suggests that there is considerable spatial structure in the regional population or that migration geography varies within subregions. Precision of long-term trends was

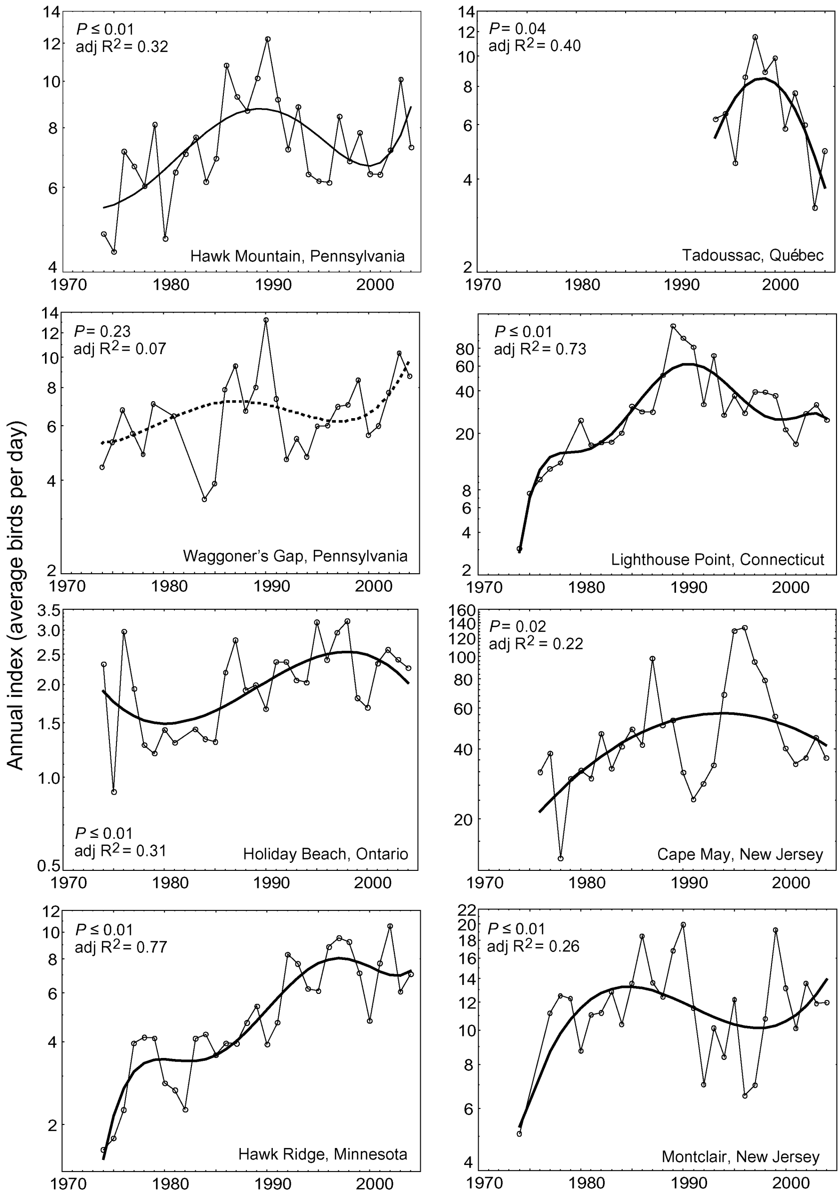

Fig. 4. Population indexes and trajectories for Ospreys (*Pandion haliaetus*) at eight watchsites in northeastern North America. Index values are represented by open circles connected by thin lines to highlight patterns of interannual variation. Thick solid ($P \leq 0.10$) or dashed ($P > 0.10$) lines indicate fitted trajectories. P-values and adjusted R^2 are shown for fitted trajectories.

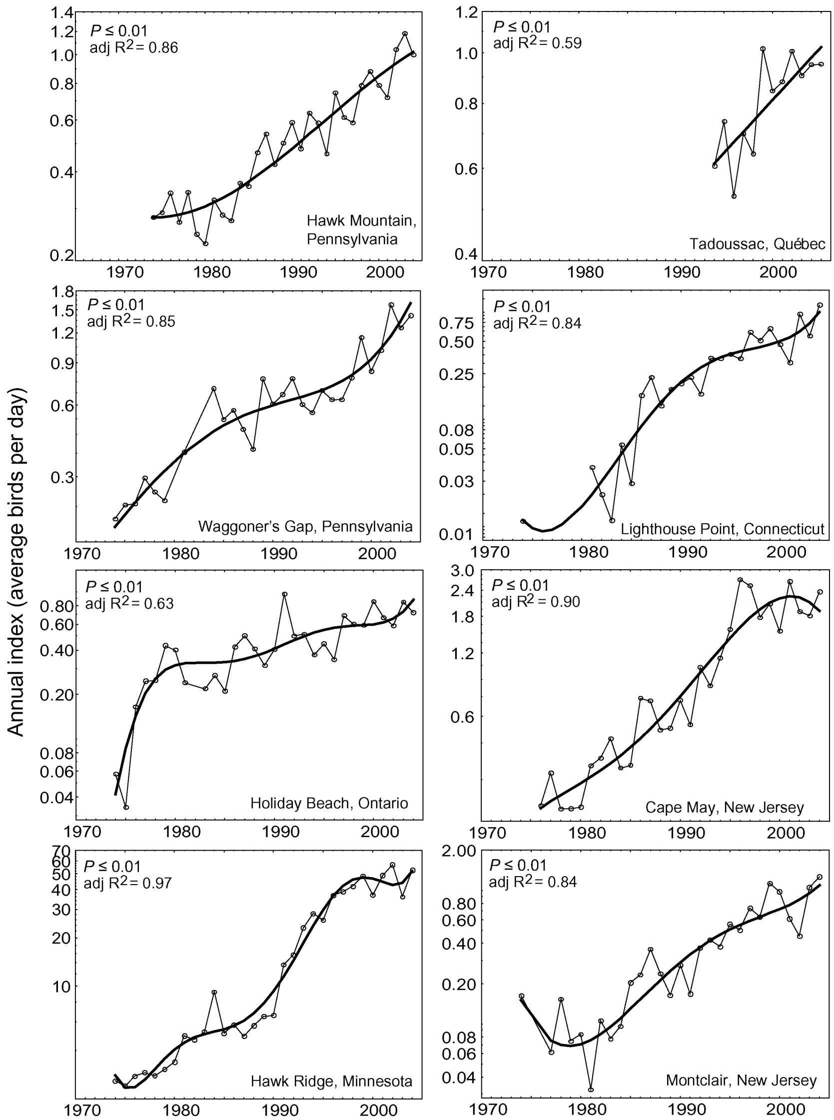

Fig. 5. Population indexes and trajectories for Bald Eagles (*Haliaeetus leucocephalus*) at eight watchsites in northeastern North America. Index values are represented by open circles connected by thin lines to highlight patterns of inter-annual variation. Thick solid ($P \leq 0.10$) or dashed ($P > 0.10$) lines indicate fitted trajectories. P-values and adjusted R^2 are shown for fitted trajectories.

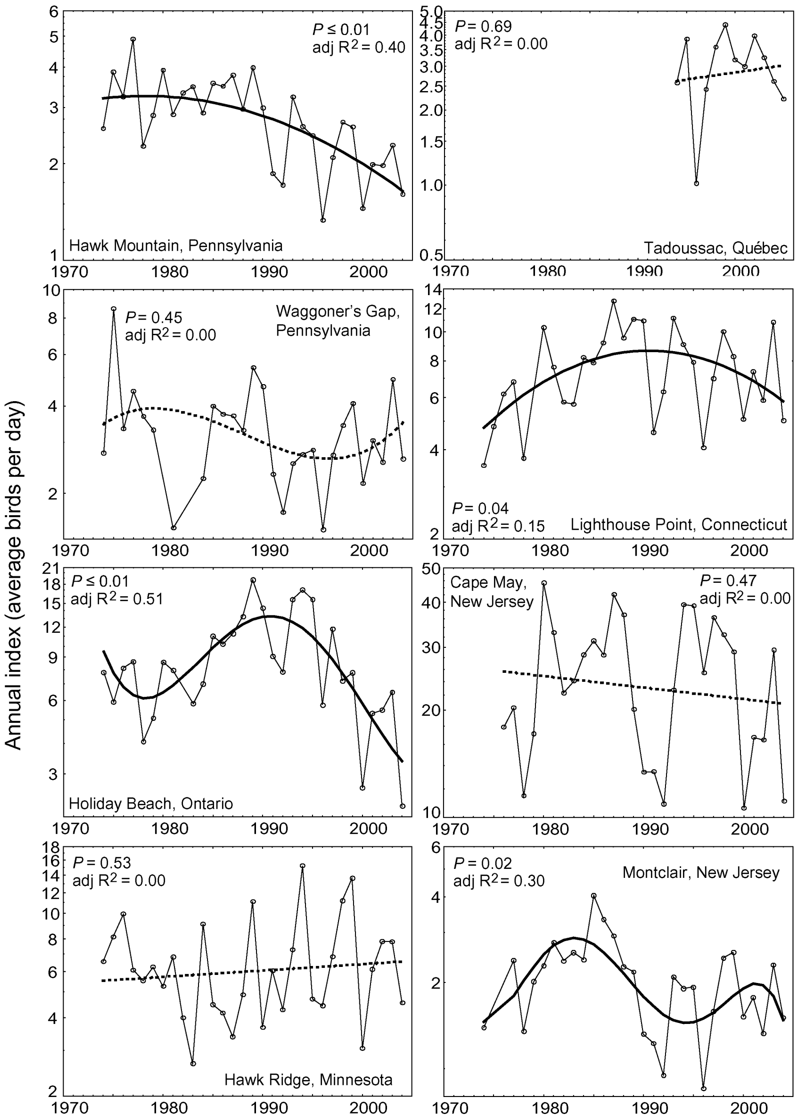

Fig. 6. Population indexes and trajectories for Northern Harriers (*Circus cyaneus*) at eight watchsites in northeastern North America. Index values are represented by open circles connected by thin lines to highlight patterns of interannual variation. Thick solid ($P \leq 0.10$) or dashed ($P > 0.10$) lines indicate fitted trajectories. P-values and adjusted R^2 are shown for fitted trajectories.

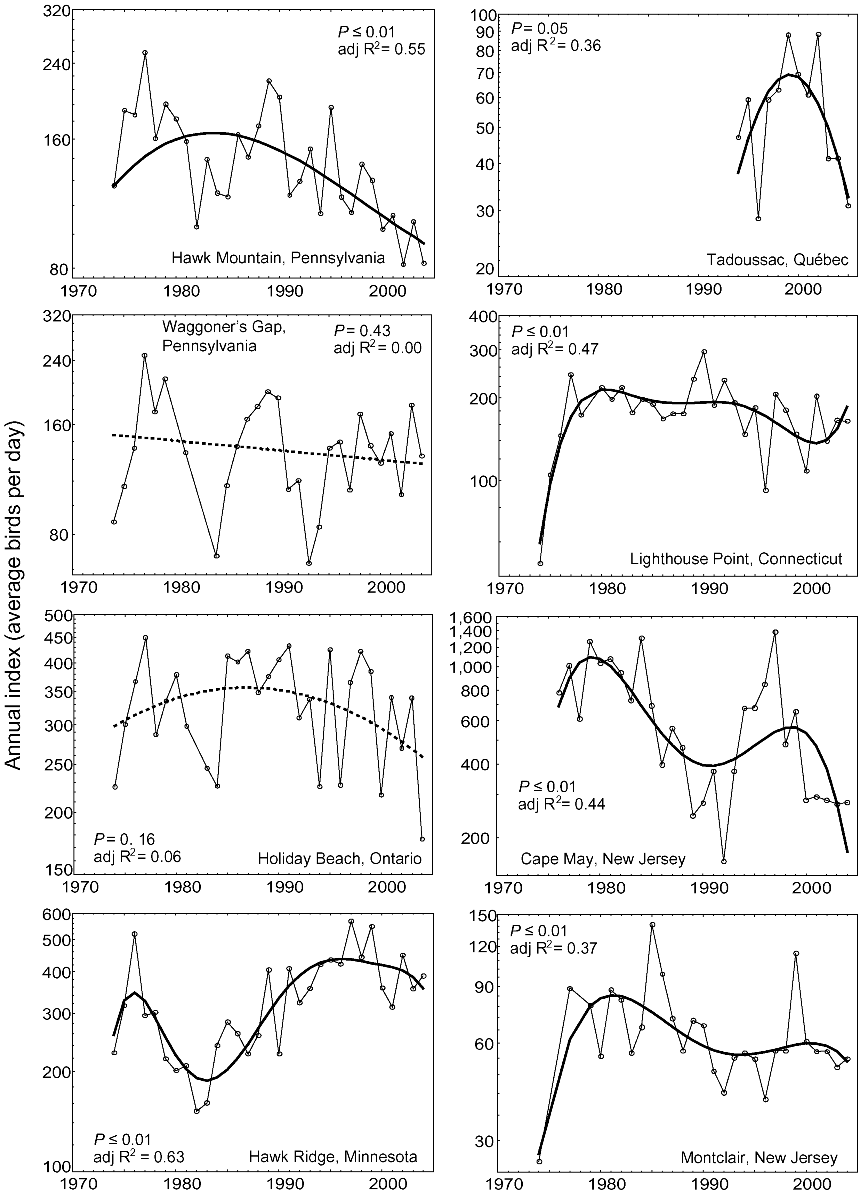

Fig. 7. Population indexes and trajectories for Sharp-shinned Hawks (*Accipiter striatus*) at eight watchsites in northeastern North America. Index values are represented by open circles connected by thin lines to highlight patterns of interannual variation. Thick solid ($P \leq 0.10$) or dashed ($P > 0.10$) lines indicate fitted trajectories. P-values and adjusted R^2 are shown for fitted trajectories.

moderate to high at all watchsites, and short-term estimates ranged from low (Cape May, Montclair, Tadoussac) to high (Hawk Mountain, Waggoner's Gap) precision (Tables 3–5).

Cooper's Hawk.—This species increased significantly at all sites, both during the 1980s and from 1974 to 2000 (Tables 3 and 4). During the 1990s, changes varied by region. Increases slowed or even reversed at the two Great Lakes and the two Atlantic Coast watchsites but continued at the three Inland sites (Table 5). Index trajectories (Fig. 8) suggest that the long period of increase in Cooper's Hawks may have begun to slow or stabilize. Precision of long-term trends was moderate to high at all watchsites (Table 3), but low at Atlantic Coast watchsites for short-term trends (Tables 4 and 5).

Northern Goshawk.—Long-term trends were positive at Great Lakes watchsites and nonsignificant or negative farther east (Table 3). This pattern was weakly evident in the 1990s as well, but not in the 1980s (Tables 4 and 5). Precision of trend estimates was generally moderate for all periods but tended to be lower for shorter-term trends (Tables 3–5). The irruptive migratory behavior and short migration distance typical of this species complicates the interpretation of trends. Irruption episodes are apparent in most of the population indexes at these sites (Fig. 9), and the fitted trajectories and estimated trends should be interpreted with caution (see Chapter 6).

Red-shouldered Hawk.—Trends for this species showed no geographic patterns in any time period. Long-term trends and those from the 1980s included a few significant increases and no significant declines. In the 1990s there was a brief, significant decline at Holiday Beach (Fig. 10). Precision of long-term trends was moderate to high at all watchsites (Table 3), but low at Holiday Beach and Lighthouse Point for shorter-term trends (Tables 4 and 5).

Broad-winged Hawk.—Trends were slightly to strongly negative at most sites, in both decades, and over the long-term (Tables 3–5), except that a marginally significant increase occurred at Waggoner's Gap during the 1990s. Only Hawk Ridge (the westernmost watchsite) showed a positive trend throughout (although nonsignificant). This also is the watchsite that counts, by far, the most Broad-winged Hawks (Fig. 11). Precision of long-term trends was generally moderate, but Hawk Mountain and Lighthouse Point had high precision, and Holiday Beach had low precision (Table 3). Trend precision was low to moderate for most shorter-term trends, but remained high at Hawk Mountain in all periods (Tables 4 and 5).

Red-tailed Hawk.—Long-term trends tended to be slightly negative at most stations (significantly so at Hawk Mountain), but significantly positive at the easternmost site (Lighthouse Point; Table 3). This pattern also held true for the 1980s (Table 4). But during the 1990s, there were

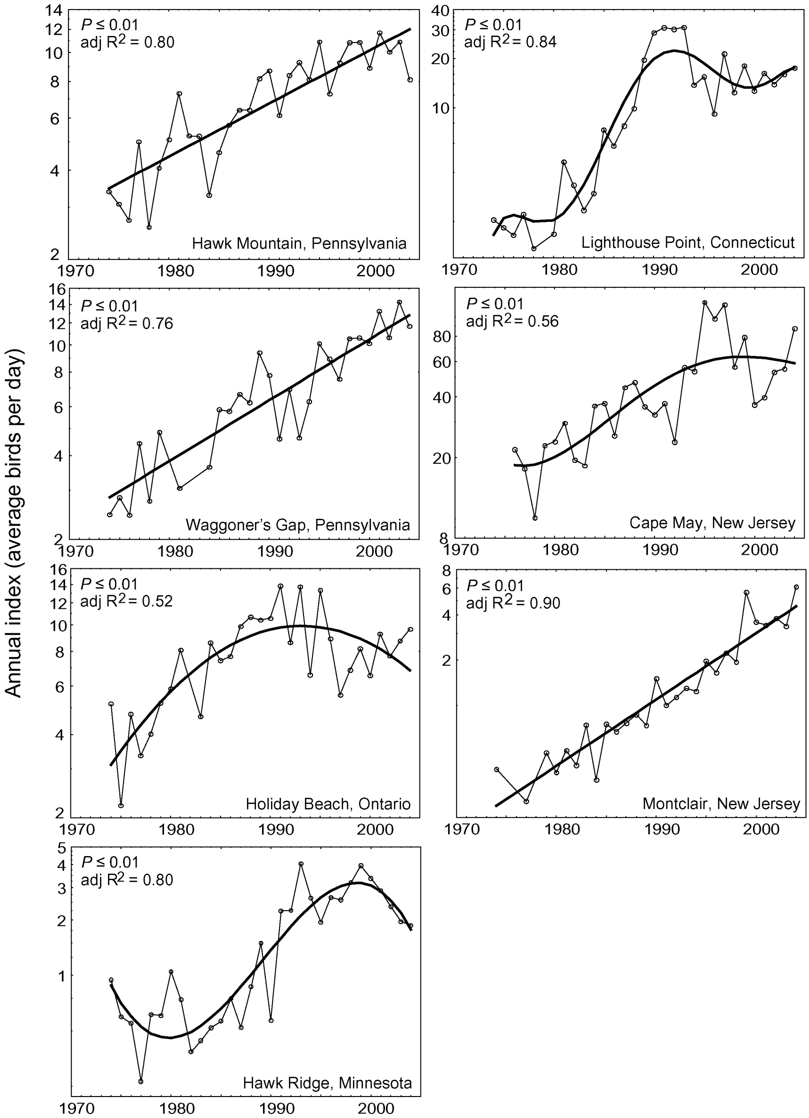

Fig. 8. Population indexes and trajectories for Cooper's Hawks (*Accipiter cooperii*) at seven watchsites in northeastern North America. Index values are represented by open circles connected by thin lines to highlight patterns of inter-annual variation. Thick solid ($P \leq 0.10$) or dashed ($P > 0.10$) lines indicate fitted trajectories. P-values and adjusted R^2 are shown for fitted trajectories.

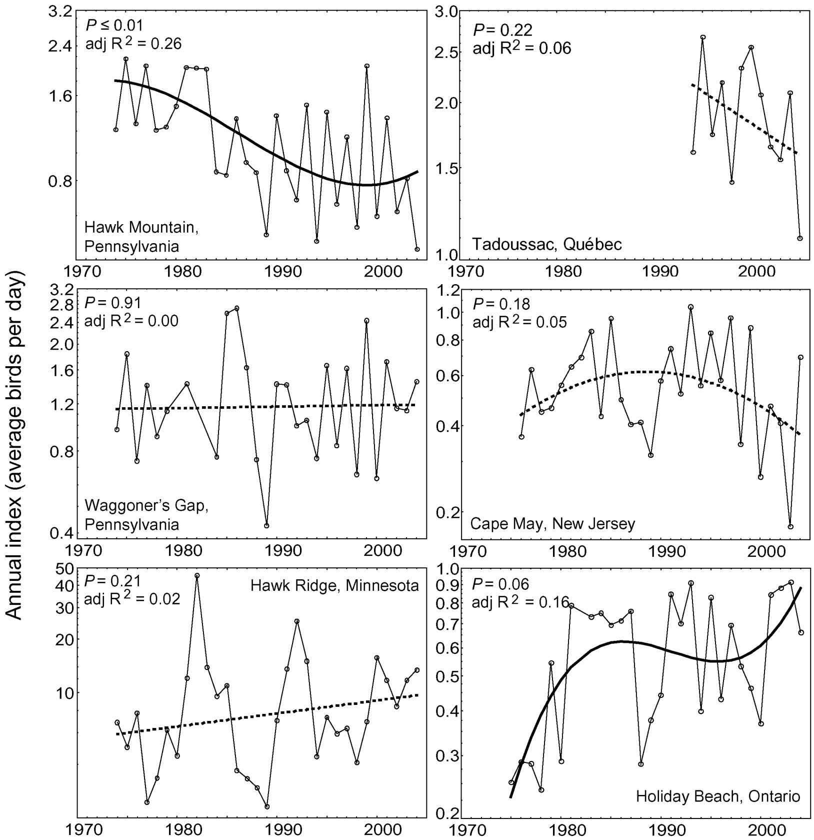

Fig. 9. Population indexes and trajectories for Northern Goshawks (*Accipiter gentilis*) at six watchsites in northeastern North America. Index values are represented by open circles connected by thin lines to highlight patterns of interannual variation. Thick solid ($P \leq 0.10$) or dashed ($P > 0.10$) lines indicate fitted trajectories. P-values and adjusted R^2 are shown for fitted trajectories. Because of the irruptive migratory behavior of this species in North America, trajectories fitted to the indexes should be interpreted with caution.

switches to significant increase at Hawk Ridge and Waggoner's Gap (Table 5, Fig. 12). No clear regional patterns were evident. Long-term trends were of moderate to high precision at all watchsites, but precision was a mix of low to high across the region in shorter periods (Tables 3–5).

Rough-legged Hawk.—Average counts were sufficiently high to support trend analyses only at the three more northerly watchsites (Tadoussac, Holiday Beach, and Hawk Ridge), and Tadoussac data are available only for the most recent 10-year period. Migration at the remaining watchsites

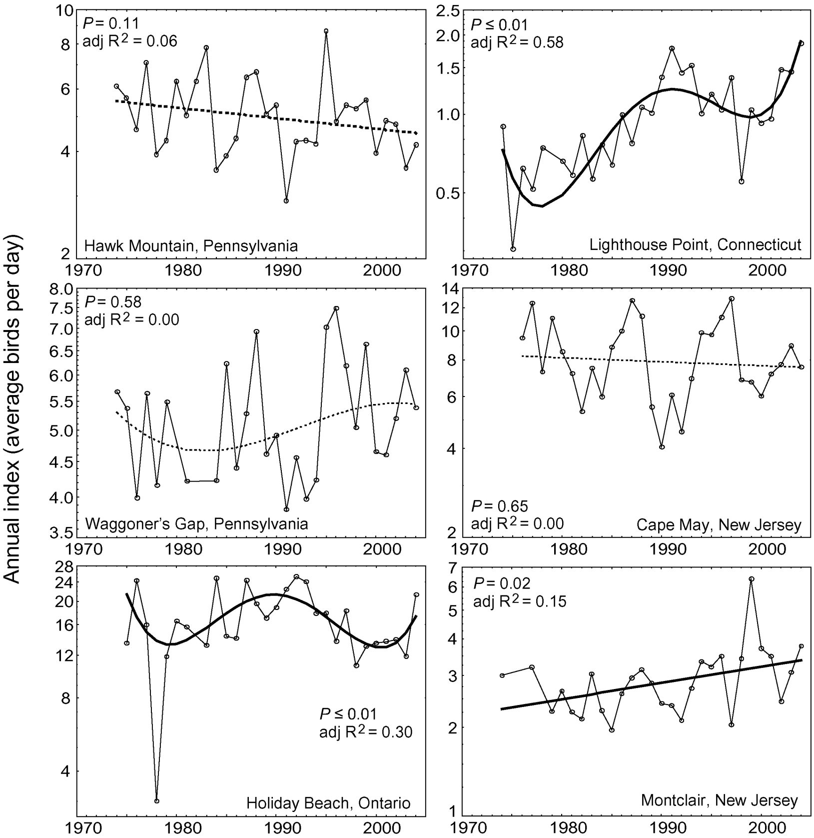

Fig. 10. Population indexes and trajectories for Red-shouldered Hawks (*Buteo lineatus*) at six watchsites in northeastern North America. Index values are represented by open circles connected by thin lines to highlight patterns of interannual variation. Thick solid ($P \leq 0.10$) or dashed ($P > 0.10$) lines indicate fitted trajectories. P-values and adjusted R^2 are shown for fitted trajectories.

yields average annual counts <20 birds per year. The species declined at the two Great Lakes sites (Tables 3–5, Fig. 13). Precision of trends was low at Holiday Beach and Tadoussac, and moderate at Hawk Ridge.

Golden Eagle.—Average counts across the region show that migration of this species occurs primarily in the Great Lakes and Inland subregions (Table 2). Consequently, there were insufficient numbers for trend analysis at Atlantic Coast watchsites and Montclair. Trends were positive and mostly significant at all analyzed sites across all time periods (Fig. 14, Tables 3–5), except at Tadoussac. Precision of trend estimates was moderate to high at all watchsites in all periods (Tables 3–5).

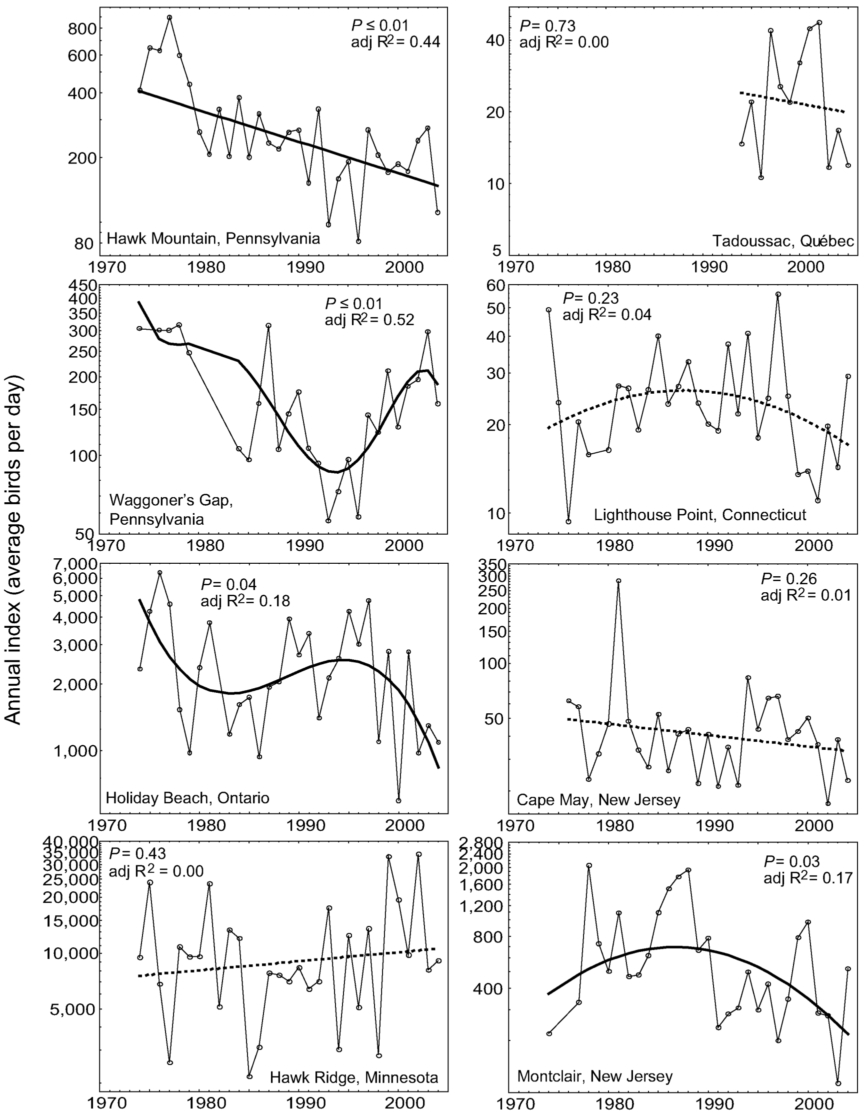

Fig. 11. Population indexes and trajectories for Broad-winged Hawks (*Buteo platypterus*) at eight watchsites in northeastern North America. Index values are represented by open circles connected by thin lines to highlight patterns of inter-annual variation. Thick solid ($P \leq 0.10$) or dashed ($P > 0.10$) lines indicate fitted trajectories. P-values and adjusted R^2 are shown for fitted trajectories.

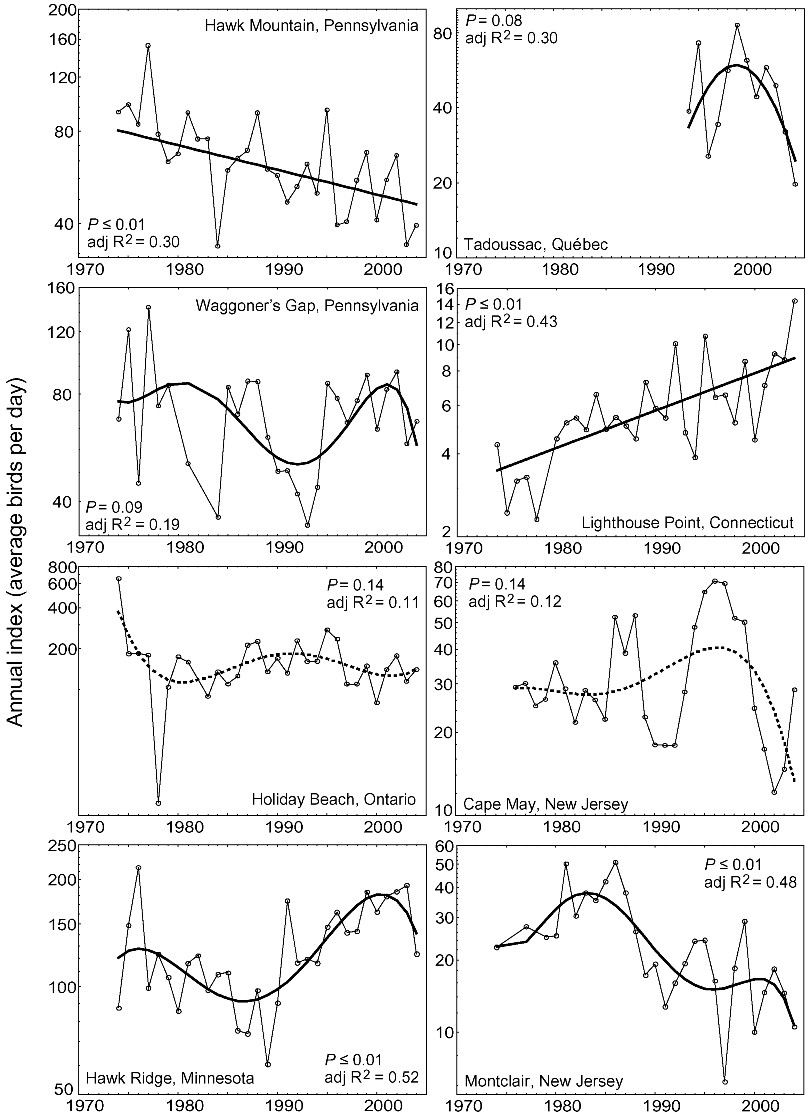

Fig. 12. Population indexes and trajectories for Red-tailed Hawks (*Buteo jamaicensis*) at eight watchsites in northeastern North America. Index values are represented by open circles connected by thin lines to highlight patterns of inter-annual variation. Thick solid ($P \leq 0.10$) or dashed ($P > 0.10$) lines indicate fitted trajectories. P-values and adjusted R^2 are shown for fitted trajectories.

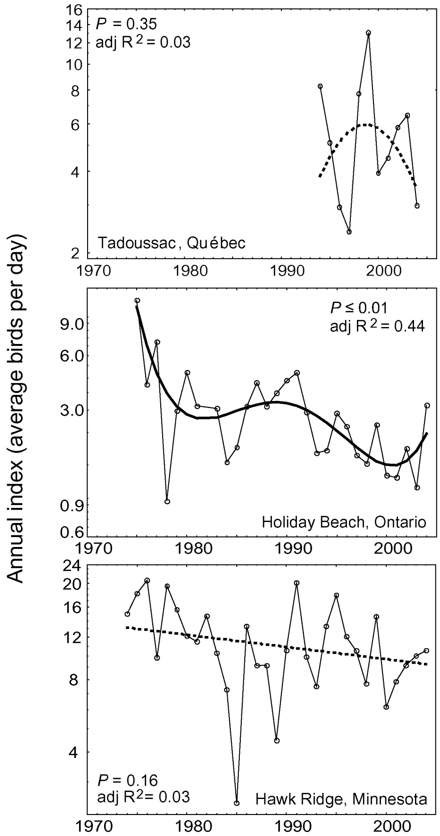

Fig. 13. Population indexes and trajectories for Rough-legged Hawks (*Buteo lagopus*) at three watchsites in northeastern North America. Index values are represented by open circles connected by thin lines to highlight patterns of interannual variation. Thick solid ($P \leq 0.10$) or dashed ($P > 0.10$) lines indicate fitted trajectories. P-values and adjusted R^2 are shown for fitted trajectories. Because of the northerly winter range and irruptive migration geography of this species, trajectories fitted to the indexes should be interpreted with caution.

American Kestrel.—There was a clear geographic pattern in trends for this species with mostly significant declines occurring at eastern watchsites (Montclair and the Atlantic Coast sites) in all time periods, and a significant long-term decline at Hawk Mountain (Fig. 15). By contrast, a sustained increase occurred at Hawk Ridge, the westernmost site. Trends at sites between Hawk Mountain and Hawk Ridge were largely nonsignificant. Precision of long-term trends was high except at Waggoner's Gap, where it was moderate (Table 3). Short-term trends primarily had

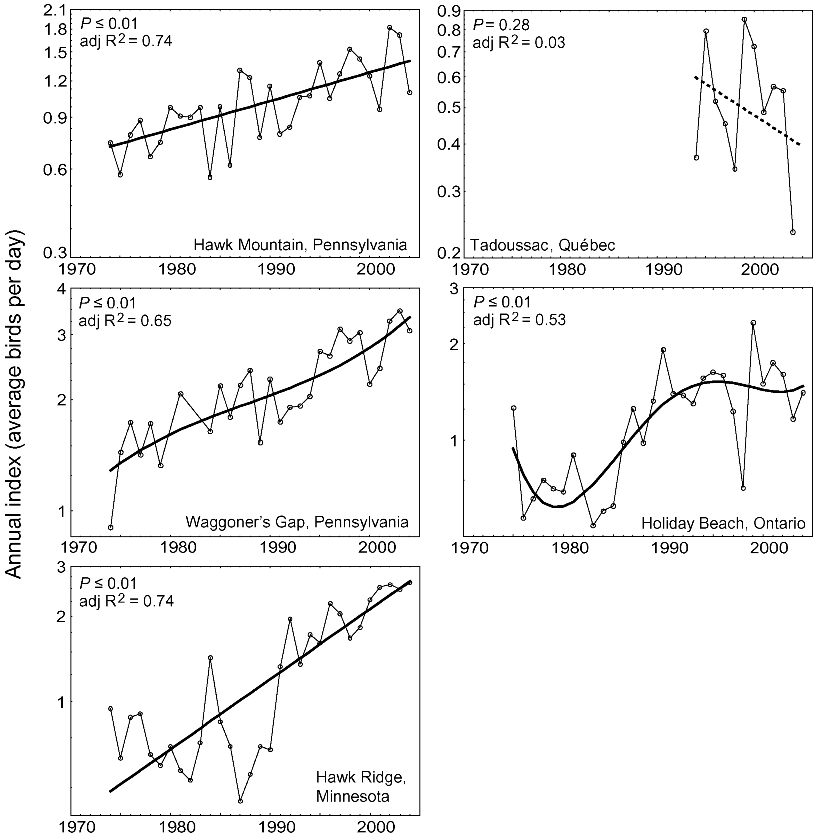

Fig. 14. Population indexes and trajectories for Golden Eagles (*Aquila chrysaetos*) at five watchsites in northeastern North America. Index values are represented by open circles connected by thin lines to highlight patterns of interannual variation. Thick solid ($P \leq 0.10$) or dashed ($P > 0.10$) lines indicate fitted trajectories. P-values and adjusted R^2 are shown for fitted trajectories.

moderate to high precision, but estimates for a minority of sites had low precision (Tables 4 and 5).

Merlin.—Strong increases were recorded at most sites in all time periods. Rates of increase were especially high in the 1980s (Table 4), but slowed considerably in the 1990s, particular at Atlantic Coast sites (Table 5). Trajectories (Fig. 16) suggest a recent stabilization at most watchsites. Cape May, which recorded 67% of the migrants in this region, stood out as showing small increases since the mid-1980s. Precision of long-term trends was moderate to high, with low to moderate precision for shorter-term trends (Table 3–5).

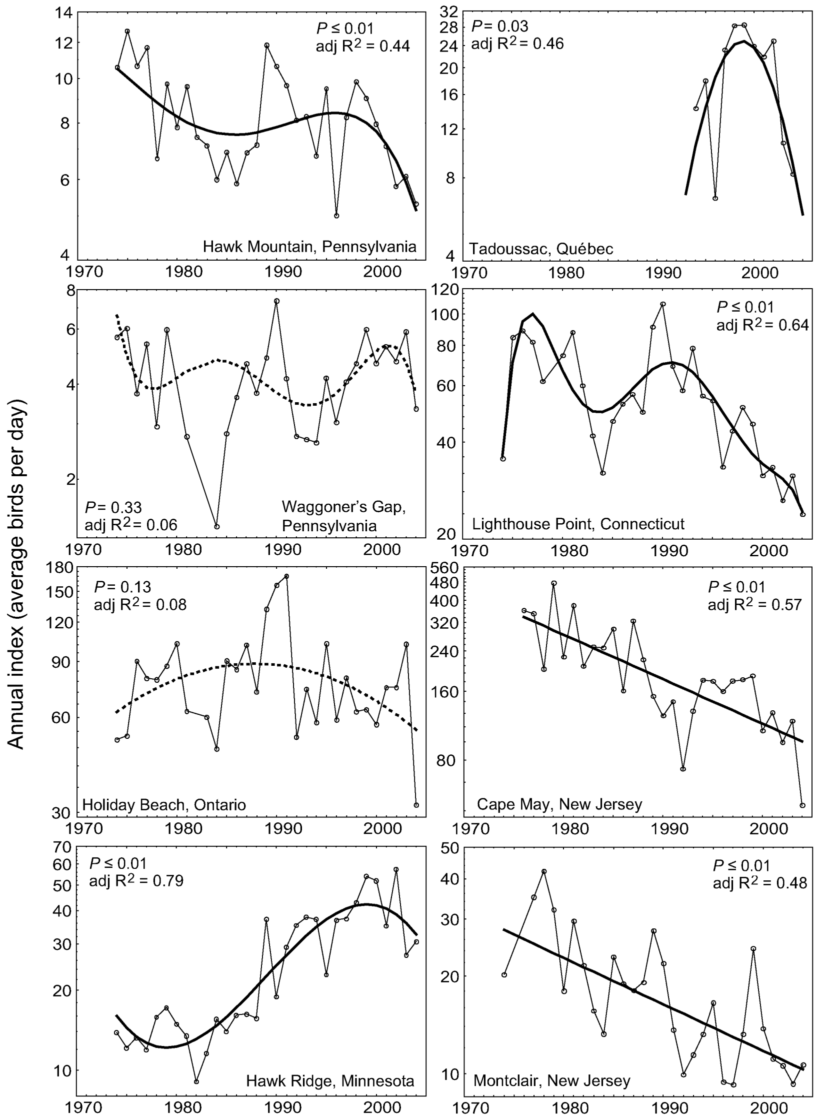

Fig. 15. Population indexes and trajectories for American Kestrels (*Falco sparverius*) at eight watchsites in northeastern North America. Index values are represented by open circles connected by thin lines to highlight patterns of inter-annual variation. Thick solid ($P \leq 0.10$) or dashed ($P > 0.10$) lines indicate fitted trajectories. P-values and adjusted R^2 are shown for fitted trajectories.

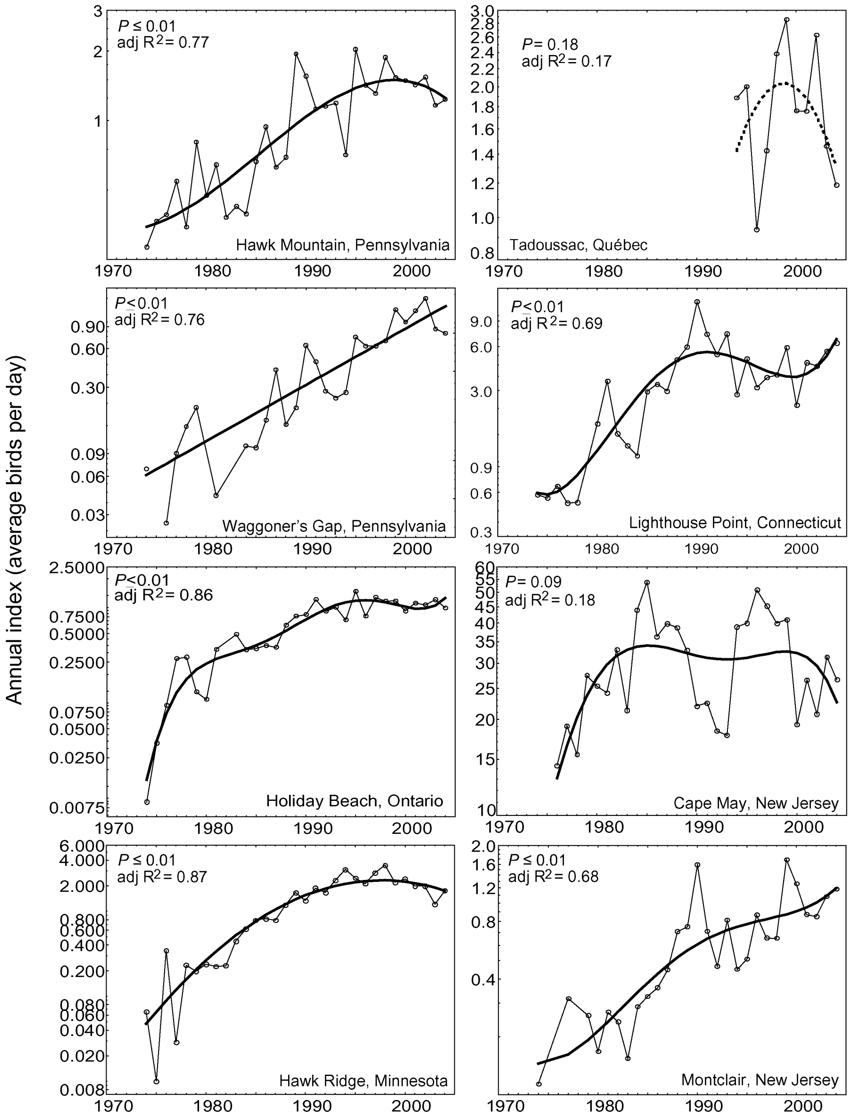

Fig. 16. Population indexes and trajectories for Merlins (*Falco columbarius*) at eight watchsites in northeastern North America. Index values are represented by open circles connected by thin lines to highlight patterns of interannual variation. Thick solid ($P \leq 0.10$) or dashed ($P > 0.10$) lines indicate fitted trajectories. P-values and adjusted R^2 are shown for fitted trajectories.

Peregrine Falcon.—Like the Merlin, this species showed strong, significant increases at all sites in the 1980s, and much reduced increases in the 1990s (remaining significant only at sites in the Great Lakes). The long-term trends are significantly positive, but the trajectories (Fig. 17) suggest populations have begun to stabilize. Precision of long-term trends was moderate to high at all watchsites (Table 3). Precision of shorter-term trends ranged from low to high (Tables 4 and 5).

Summary of Trends

Many populations of North American raptors were at or near historically low levels in the early 1970s as a result of widespread pesticide use and direct persecution (Wiemeyer and Porter 1970, Cade et al. 1971, Grier 1982, Fyfe et al. 1988, Kiff 1988, Chapter 1). For example, Bednarz et al. (1990) detected significant declines in counts of adult and immature Bald Eagles, Cooper's Hawks, and Peregrine Falcons between 1946 and 1972 (DDT era) at Hawk Mountain Sanctuary. Similarly, counts of Ospreys, Cooper's Hawks, American Kestrels, Merlins, and Peregrine Falcons declined at Cedar Grove Ornithological Station, Wisconsin, during the 1950s, and rebounded in the 1980s (Mueller et al. 2001). After being released from such pressure, many populations increased rapidly after 1974, and these increases were reflected in counts at watchsites. Migration counts of Turkey Vultures, Ospreys, Bald Eagles, Cooper's Hawks, Golden Eagles, Merlins, and Peregrine Falcons increased or remained stable in northeastern North America throughout the 30-year period from 1974 to 2004. Trends for Northern Harriers, Sharp-shinned Hawks, Northern Goshawks, Red-shouldered Hawks, and Red-tailed Hawks varied across the region, and American Kestrels exhibited a gradient of variation across the region, with significant long-term decreases in the Atlantic Coast and Inland subregions but increases in the Great Lakes. From 1990 to 2000, populations of several species that showed long-term increases (Osprey, Merlin, and Peregrine Falcon) stabilized or began to decrease in parts of the region recently, with these changes generally being most pronounced in the Atlantic Coast subregion.

Acknowledgments

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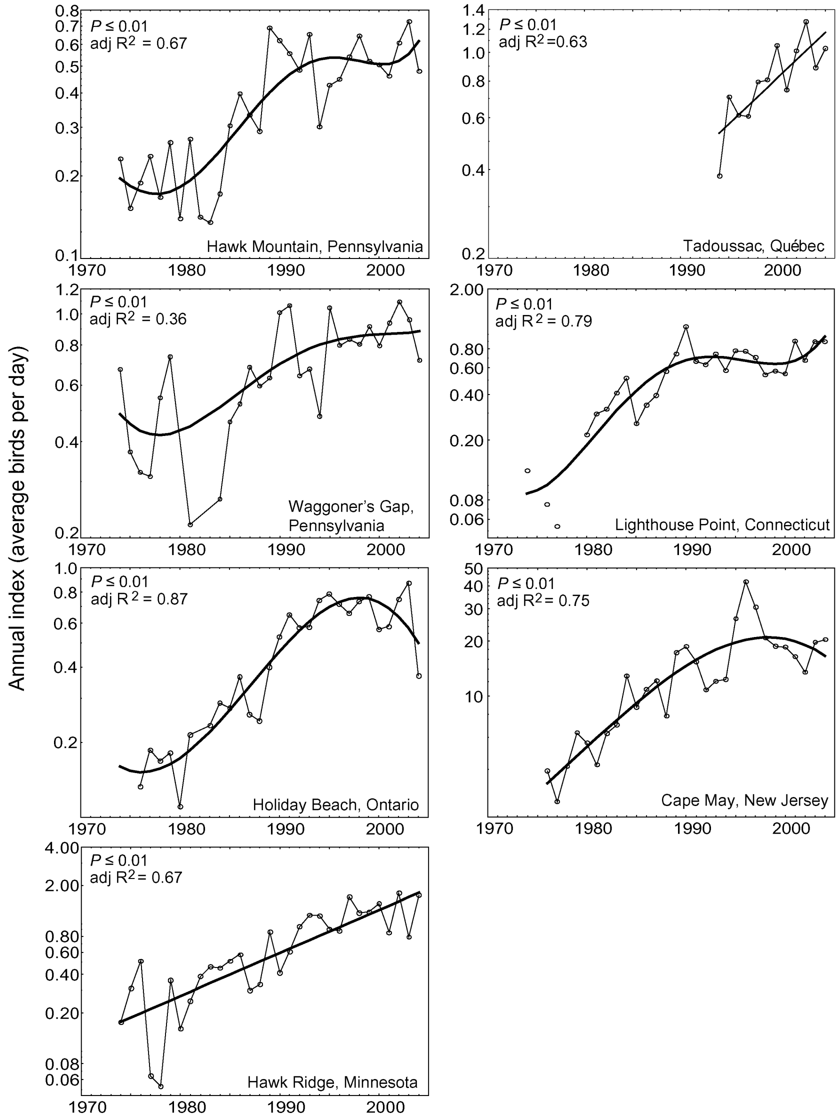

Fig. 17. Population indexes and trajectories for Peregrine Falcons (*Falco peregrinus*) at seven watchsites in northeastern North America. Index values are represented by open circles connected by thin lines to highlight patterns of interannual variation. Thick solid ($P \leq 0.10$) or dashed ($P > 0.10$) lines indicate fitted trajectories. P-values and adjusted R^2 are shown for fitted trajectories.

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