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Raptor population monitoring: examples from migration watchsites in North America

Keith L. Bildstein[1], Christopher J. Farmer[1], Reuven Yosef[2]

[1] *Acopian Center for Conservation Learning, Hawk Mountain Sanctuary - 410 Summer Valley Road, Orwigsburg, PA, USA 17961. (Bildstein@hawkmtn.org)*
[2] *International Birding & Research Centre in Eilat - P. O. Box 774 Eilat, 88000 Israel*

Abstract – Raptors are popular birds and they often serve as flagship species for broader conservation efforts. Unfortunately, they are secretive, wide-ranging, and area-sensitive species that can be logistically difficult and financially prohibitive to survey and monitor. Raptors often congregate during migration however, and one cost-effective way of monitoring them is to sample their numbers at "migration bottlenecks" along migration corridors. The value of doing so is exemplified by counts at Hawk Mountain Sanctuary in Pennsylvania, USA. These counts, begun in 1934, tracked "Pesticide Era" declines in regional populations of Bald Eagles (*Haliaeetus leucocephalus*) and Peregrine Falcons (*Falco peregrinus*), as well as recoveries in both species after DDT was banned in 1972. Today, migration hotspots at Hawk Mountain; Cape May, New Jersey; Veracruz, Mexico; and Talamanca, Costa Rica; together with > 50 additional sites, monitor migratory populations of North American raptors. The Raptor Population Index (RPI), a collaboration involving Hawk Mountain Sanctuary, Hawkwatch International, and the Hawk Migration Association of North America, is analyzing count data from sites throughout North America. In 2008 RPI published a "State of North America's Birds of Prey" that uses these analyses, together with data from Breeding Bird Surveys and Christmas Bird Counts, to summarize the conservation status of North American raptors. The counts also will be used to track shifts in the timing of migration that may be linked to climate change. Many of the data used in these analyses have been collected by amateur raptor watchers. Similar efforts in Europe and the Mediterranean should yield similar results. Migration watchsites such as Falsterbo, Organbidexka, Tarifa, Gibraltar, Col de Bretolet, the Straits of Messina, Burgas, Istanbul, the Northern Valleys (Israel), Eilat, and others -together with data from additional censuses and surveys- offer the chance to build a large-scale monitoring scheme for Europe's 38 species of migratory birds of prey. We suggest ways for establishing large-scale raptor monitoring in Europe and the Mediterranean region.

INTRODUCTION

Raptors and their migrations have intrigued humanity for millennia. Curiosity for the birds themselves, an urgent need to protect them, falconry, and an array of high-tech tools to study them, all have shaped raptor-migration science and conservation. As is true in much of ornithology, armies of dedicated amateurs, working together with professional biologists, have made, and continue to make, important contributions to the field (Bildstein 2006).

Serious studies of migrating raptors date from the early 13th Century when Holy Roman Emperor Friedrich II of Hohenstaufen (1194-1250) writing in *De arte venandi cum avibus* (The Art of Falconry), became the first of many to describe a direct link between raptor migration and weather (Wood and Fyfe 1943). By the middle of the 16th Century, Spanish historian Gonzalo Fernández de Oviedo y Valdés was describing large-scale migrations of raptors in the Caribbean Basin (Baughman 1947), and French zoologist Pierre Belon was describing similar movements of Black Kites *Milvus migrans* over the Bosporus in Istanbul, Turkey (Nisbet and Smout 1957).

In spite of such observations, the study of raptor migration remained an ornithological backwater well into the late 1800s, when 2x- 4x field glasses and, soon thereafter, 7x- 10x prismatic binoculars came into widespread use among birdwatchers (Kastner 1986). This revolution in field equipment allowed observers to "see" the high-flying, soaring-bird component of raptor migration and, almost immediately, ornithologists and birders began documenting their observations. In 1911, for example, ornithologist Frank Burns devoted 16 pages of a 180-page monograph on Broad-winged Hawks to migration in the species, a bird that several decades earlier had been thought to be sedentary (Burns 1911).

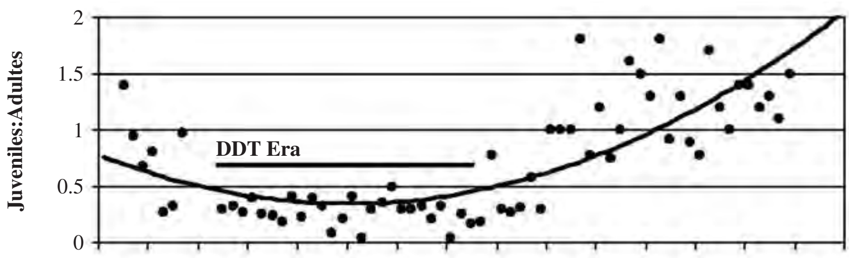
Properly equipped, nature lovers flocked to raptor watching, particularly in eastern North America where migrants concentrated along the Atlantic Coast. By the late

1920s, both the timing and geography of raptor migration, as well as its association with local and regional weather patterns, were well established in the Mid-Atlantic region (Trowbridge 1895, Burns 1911, Ferguson and Ferguson 1922; see Robbins 1975 and Heintzelman 1986 for additional details).

Serious hawk counts from this era date from 1886 when C. C. Trowbridge (1895) began monitoring the southbound movements of birds of prey in southern Connecticut. Trowbridge kept meticulous daily records that documented the numbers of individuals of each species seen, along with aspects of their flight behavior, and was the earliest to assess the impact of northwesterly winds on the numbers of birds seen, as well as the first to recognize the role that the region's east-west coastline plays in concentrating southbound migrants. His benchmark contributions established standardized visual counts along major corridors as an effective technique in the study of raptor migration (Bildstein 2006).

A second spurt of activity in the field occurred in the 1920s-1930s when raptor conservationists attempted to reverse the increasing problem of raptor persecution. Most birds of prey were considered vermin at the time -even by birdwatchers and conservationists- and large numbers of hawks, eagles, and falcons were being shot along traditional flyways. Premiere "shooting galleries" included Cape May Point, New Jersey, where a recent prohibition on targeting Northern Flickers *Colaptes auratus* had focused the shooters' attention on Sharp-shinned Hawks *Accipiter striatus* and other raptors; and Hawk Mountain, Pennsylvania, where a $ 5 bounty on Northern Goshawks fostered a "shoot-first-and-identify-later" mentality (Bildstein 2006). First operated to document the magnitude of the overall flight and to halt the carnage associated with it, additional values associated with full-season counts at migration hotspots quickly became apparent. A 39-bird flight of Golden Eagles *Aquila chrysaetos* at Hawk Mountain in 1934 led to the discovery of a previously unrecognized migration corridor for this species, and the arrival of 1,250 visitors at the Sanctuary in the autumn of 1935 led to the idea that concentrated raptor migration could be used to introduce the general public to these secretive birds (Broun 1949).

Raptor watching continued to expand in mid-20th century North America and, as it did, conservationists began to use watchsite counts to track population change over time. Important examples include Rachel Carson, who used declines in the ratios of juvenile-to-adult Bald Eagles seen at Hawk Mountain Sanctuary in the 1940s-1950s in her book *Silent Spring*, to help make her case against the widespread use of organochlorine pesticides (Carson 1962) (Fig. 1); and Walter R. Spofford used 32 years of counts from the



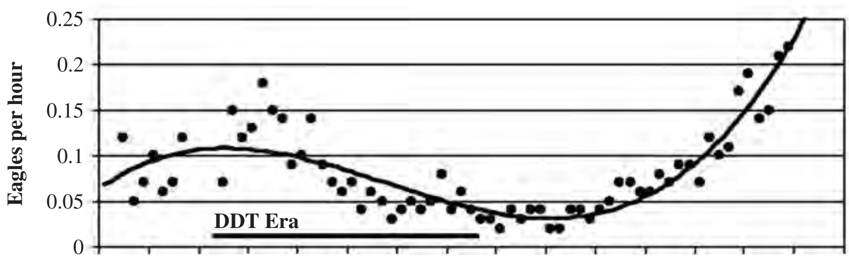


Figure 1. Shifts in the ratios of juvenile to adult Bald Eagles counted at Hawk Mountain Sanctuary, Pennsylvania, 1934-2003 (above), together with shifts in the annual passage rates for the species during the same period (below). (After Figure 6 in Bildstein 2006).

same site to track population of 12 species from the mid-1930s through the mid 1960s (Spofford 1969).

At first raptor watching spread mainly along major migration corridors and bottlenecks in the northeastern United States. By the 1980s, however, it had expanded throughout most of the United States and southern Canada. A conference on raptor watching led to the creation of the Hawk Migration Association of North America (HMANA) in 1974. HMANA attempted to standardize counts at watchsites shortly thereafter. By 1999 North American raptor watchers were reporting counts from more than 1800 watchsites, 60 of which had been active for a decade or more (Robbins 1975, McCarty *et al.* 2000, Bildstein 2006).

The development of raptor watching has had a somewhat similar history in Europe, particularly in the Mediterranean region, where widespread shooting and trapping inspired conservation efforts similar to those in North America (Bildstein 2006). Recently, count activities have increased in the Middle East as a result of concerns about bird-aircraft collisions (Shirihai *et al.* 2000, Zalles and Bildstein 2000). Globally, more than 110 of these migration watchsites count at least 10,000 raptors annually, 18 sites count at least 100,000 raptors, and three of the sites, including Elat in southern Israel, count more than one million migrants annually (Bijlsma 1987, Shirihai *et al.* 2000, Zalles and Bildstein 2000). Many active raptor-watches are organized and run by trained expert volunteers who provide important, high-quality, low-cost count data to scientists and conservationists.

Because raptors often are secretive and, therefore, difficult to survey and monitor, counts at migration watchsites can help track the status of regional and, sometimes, continental populations of birds of prey (e.g., Yosef and Fornasari 2004), particularly when counts are used in conjunction with banding efforts and satellite tracking that help delineate the geographic sources and destinations of the migrants. Information from geographic networks of raptor-watches is especially useful in this regard, particularly when counts extend over many years. And recent analyses suggest that migration counts can be useful even when the numbers of individual birds are small. At Hawk Mountain Sanctuary, for example, where, until recently, fewer than 100 Bald Eagles and 50 Peregrine Falcons have been counted each autumn, long-term trends of both of these species clearly tracked Pesticide Era declines in the middle 20th century, as well as subsequent post-Pesticide Era rebounds in the 1970s through 1990s (Bildstein 1998).

Although counts often vary considerably among years because of annual differences in the weather and other factors, a growing body of evidence suggests that over the long haul, numbers of raptors reported at migration watchsites typically reflect the long-term status of the source populations (Newton 1979, Bildstein 1998, Hoffman *et al.* 2002).

To reduce biases associated with annual differences in count effort, data are usually standardized prior to analysis. Standardization involves several steps. In most instances, raw counts are converted to numbers of raptors seen per hour of observation, and the counts themselves usually are truncated on a species-by-species basis to the time period in days when 95% of a species' passage occurs. Long-term trends can be unduly influenced by exceptionally high single-day or single-season counts, and observers often *log-transform* their counts to reduce the impact of this potential bias. Most analyses assume that whereas weather can affect the magnitude and detectability of migrants at particular sites, such effects are likely to be random and, as such, not likely to affect long-term trends, other than to make such trends more difficult to detect. An additional statistical concern, positive autocorrelation, which involves the likely correlation of sequential counts in a time series resulting from population persistence across years, is often tested for during analysis and dealt with statistically thereafter. Overall, such techniques substantially increase the validity of resulting analyses of migration counts to determine long-term population trends (Bednarz *et al.* 1990, Dunn and Hussell 1995, Hoffman and Smith 2003).

Counts at migration watchsites also can be used to study migration behavior and ecology, such as flocking and soaring dynamics, speed of travel, intra- and interspecies interactions, roosting and feeding, energy management and habitat use en route, weather effects, and interannual shifts in the seasonal timing of flights. The counts also are useful in introducing students and the general public to the whys and wherefores of raptor biology and conservation.

This said counts of visible migrants at watchsites are not perfect. Even short-term counts are biased toward low-flying individuals and by observer fatigue and long-term counts can be compromised by improved optics and shifts in count protocols. In addition, because most raptor-watches are along major flyways, count results tend to reflect the narrow- and not necessarily broad-frontal movements of migrating raptors. Even so, statistical treatments of migration count data continue to improve, and preliminary evaluations suggest that counts at traditional raptor-watches will continue to provide important information on raptor migration and population status for some time (Bildstein 1998, Farmer *et al.* 2007).

Below we lay out the operational principles behind the recently created Raptor Population Index (RPI) in North

America, and suggest how a similar coalition of migration watchsites could be used to help monitor populations in Europe and the Mediterranean region.

METHODS

RPI: a brief history

The Raptor Population Index (RPI) owes its origins to a meeting about raptor migration organized by several members of Hawk Mountain Sanctuary's board of directors and other raptor-watchers in Syracuse, New York, in 1974. That meeting, which was attended by more than 300 scientists, conservationists, and raptor-watchers, led directly to the formation of a "volunteer, non-profit organization" the Hawk Migration Association of North America 1974 (Roberts 2001), and, indirectly, to the creation of HawkWatch International in 1985. The first organization (HMANA) established a coalition of raptor-watchers and migration watchsites, and a newsletter to inform its members of what others were seeing. Most importantly, it also created a daily report form based on hourly data entry that simplified and codified how migration-count data should be collected (Fig. 2). Adoption and use of this daily report form, in turn, eventually enabled conservation scientists to analyze data from different sites similarly, and to use these analyses in continent-wide assessments of population change. The second organization (HWI) established more than a dozen watchsites in the western United States in the 1980s and 1990s, and has since monitored raptor populations in that region of North America (Hoffman and Smith 2003).

These two organizations partnered with Hawk Mountain Sanctuary to create the Raptor Population Index (RPI), which uses migration watchsite counts, together with other sources of population data, including the National Audubon Society's Christmas Birds Counts, and the U. S. Geological Survey's Breeding Bird Surveys, to assess the status of North American raptors. RPI published a document titled *State of North America's Birds of Prey* in 2008. Below we offer summaries of the operational details of the analyses that form the heart of RPI's migration watchsite monitoring effort.

RPI: analytical procedures

RPI is a "citizen science" project in that expert volunteers supervised by professionals collect most of the data. Protocols for collecting data are determined by professionals, and professionals analyze, interpret, and publish the results of their analyses (Farmer and Hussell 2008).

RPI is guided by a management committee from the three organizations, and is advised by an external science-advisory committee. The partnership uses the strengths of its partners to use counts of migrating raptors from a continent-wide network of watchsites to provide timely, science-based assessments of population status and trends of North America's raptors.

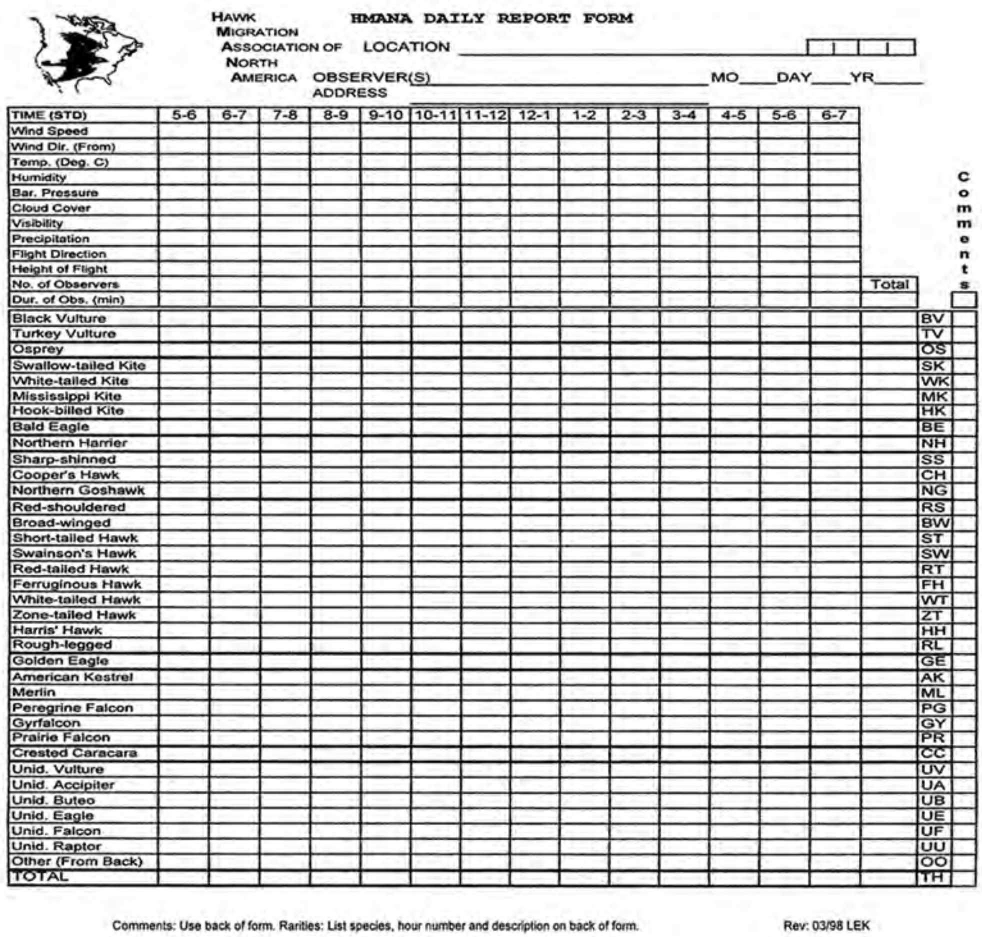
The Hawk Migration Association of North America is the primary contact with independent hawk counts and counters. It also maintains the electronic count database and provides feedback to count sites. Hawk Mountain Sanctuary analyzes, interprets, and summarizes RPI data for distribution. HawkWatch International contributes data from its network of western and Gulf Coast sites, and helps interpret and summarize the data.

About 10% of North American migration watchsites started counts before 1970 (Zalles and Bildstein 2000). Most follow field protocols and recording procedures first recommended by HMANA in 1975 and revised thereafter (Harwood 1975, Hawk Migration Association of North America 2006a, 2006b). Some sites have their own protocols that deal with site-specific concerns (Farmer and Hussell 2008). The primary objective of the common protocols is to achieve consistency in counting methods at sites both within and among years (Robbins 1975).

The standard protocol requires reporting of separate counts of each species and unidentified raptors for each hour of the day (local standard time), together with the number of observers, weather variables, and descriptions of flight altitude and direction.

Prior to 2002, counts were reported on the daily report forms and sent to an archive that is now administered by Hawk Mountain Sanctuary. In 2002 the Hawk Migration Association of North America created HawkCount.org, an online data entry and database system (Moulton and Weber 2001). The website allows users to enter their counts and other data online on an hourly or daily basis for storage in an electronic database. Data entered into the website are exported to Hawk Mountain Sanctuary for analysis.

Daily counts can be influenced by date and weather, and as such, counts typically exhibit a strongly skewed distribution, with many low and moderate daily counts and a few large counts. An annual index based on the sum or the arithmetic mean of the daily counts will be influenced by the size of the large counts in each year. However, in many circumstances, inter-annual population change is expected to affect all daily counts in the same way. Therefore, RPI uses the median of the daily counts as the annual index of population change, because it is more sensitive than the mean daily count to shifts in the distribution of all of the counts. Another key component of the RPI analysis is to log transform daily counts prior to calculating an-



Hawk Migration Association of North America — HMANA DAILY REPORT FORM

LOCATION ____________

OBSERVER(S) ____________ MO____DAY____YR____

ADDRESS

TIME (STD)	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-1	1-2	2-3	3-4	4-5	5-6	6-7			Comments
Wind Speed																	
Wind Dir. (From)																	
Temp. (Deg. C)																	
Humidity																	
Bar. Pressure																	
Cloud Cover																	
Visibility																	
Precipitation																	
Flight Direction																	
Height of Flight																	
No. of Observers															Total		
Dur. of Obs. (min)																	
Black Vulture																BV	
Turkey Vulture																TV	
Osprey																OS	
Swallow-tailed Kite																SK	
White-tailed Kite																WK	
Mississippi Kite																MK	
Hook-billed Kite																HK	
Bald Eagle																BE	
Northern Harrier																NH	
Sharp-shinned																SS	
Cooper's Hawk																CH	
Northern Goshawk																NG	
Red-shouldered																RS	
Broad-winged																BW	
Short-tailed Hawk																ST	
Swainson's Hawk																SW	
Red-tailed Hawk																RT	
Ferruginous Hawk																FH	
White-tailed Hawk																WT	
Zone-tailed Hawk																ZT	
Harris' Hawk																HH	
Rough-legged																RL	
Golden Eagle																GE	
American Kestrel																AK	
Merlin																ML	
Peregrine Falcon																PG	
Gyrfalcon																GY	
Prairie Falcon																PR	
Crested Caracara																CC	
Unid. Vulture																UV	
Unid. Accipiter																UA	
Unid. Buteo																UB	
Unid. Eagle																UE	
Unid. Falcon																UF	
Unid. Raptor																UU	
Other (From Back)																OO	
TOTAL																TH	

Comments: Use back of form. Rarities: List species, hour number and description on back of form. Rev: 03/98 LEK

Figure 2. Hawk Migration Association of North America daily report form in use since 1975 at most North American watch-sites. Note that data are recorded hourly. Electronic copies of this form are at www.hmana.org.

nual indexes (Farmer and Hussell 2008). For each species, RPI identifies a seasonal passage window during which the middle 95% of individuals is counted. For days with incomplete coverage during this period, RPI estimates the daily count as $N = C * H/h$, where C is the count during the standard hours, h is the number of hours of observation and H is the number of hours in the standard period.

RPI uses multiple regression to derive geometric-mean population indexes that compensate for missing days and, in some cases, weather covariates (e.g., wind speed, direction). (Details are in Hussell [1981], Francis and Hussell [1998], and Farmer *et al.* [2007].) The full regression model with all covariates is:

$$\ln(N_{ij} + 1) = a_0 + \sum_{j=1}^{J} a_j Y_j + \sum_{k=1}^{4} b_k i^k + \sum_{l=1}^{L} c_l W_{lij} + e_{ij} \qquad (1)$$

where N_{ij} is the number of one species counted (or estimated) during the standard hours on day i in year j, Y_j is a series of J dummy variables which are set equal to 1 when year = j and zero in all other years (values of j vary from 0 to J representing a series of J +1 years; there is no year dummy variable for year 0), i^k are 1st through 4th order terms in date, W_{lij} is the value of weather variable l on day i in year j, a_0 is the intercept estimated by the regression, a_j, b_k, and c_{jk} are coefficients estimated by the regression representing the effects of each independent variable on $\ln(N_{ij}+1)$, and e_{ij} represented unexplained variation. The regression model is a one-way ANCOVA with year terms as factors and all other independent variables as covariates.

Regression analyses are weighted in proportion to the number of hours of observation on each day, h_{ij} (Farmer and Hussell 2008). RPI uses a date-adjusted index estimated from the regression model including year and date terms only. Wind speed and wind direction are thought to be the weather variables most directly affecting raptor numbers at watchsites (Mueller and Berger 1961, Haugh 1972, Richardson 1978, Newton 1979, Kerlinger 1989). Even so, recent analyses suggest that compensating for weather is not important for trend estimation (Allen *et al.* 1996, Farmer *et al.* 2007).

The estimated geometric-mean count (back-transformed) for each day in each year is calculated, summed each year over the migration period, and divided by the number of days in the season and re-transformed to obtain $(TDA)_j$. Then:

$$(\text{index})_j = e^{[(\text{TDA})j + V/2] - 1} \quad (3)$$

Details on how watchsites in which two or more count sites are used are in Farmer and Hussell (2008). Count trajectories are analyzed by fitting a polynomial regression to the log of the index. Each regression is centered at the mid-point year in the series to reduce correlations among polynomial terms. A best-fitting polynomial model is identified using a three-step process (Farmer *et al.* in press).

Trends in annual indexes are estimated as the geometric-mean rate of change over a specified time interval for each site (Link and Sauer 1997). Trend estimates and their significance are derived by re-parameterizing the year terms of the fitted trajectory (Francis and Hussell 1998). The first-order term then estimates the rate of change between the two sets of years and is equivalent to the slope of a log-linear regression. Mean indexes are compared for the three-year periods at either end of the period of interest (e.g., 1974-1976 and 2002-2004) to reduce the potential effect of extreme trajectories at the ends of each model. Similarly, tests of trend significance are based on the mean-squared deviation from the regression curve of all index values, not just those in the averaged years (Farmer and Hussell in press).

RESULTS

It is not currently feasible to combine data from multiple watchsites to derive a composite trend for the entire continental population of any species (Dunn and Hussell 1995). Nevertheless, an examination of consistencies and inconsistencies in estimated trends across the continent graphically demonstrates an overall pattern of regional and continental change or stability.

RPI indicates widespread declines in American Kestrels (*Falco sparverius*) at most watch sites between the mid 1990s and mid 2000s in North America (Fig. 3), in contrast to several other species that were relatively stable. On the other hand, several species, including Bald Eagle (*Haliaeetus leucocephalus*) increased rapidly at most sites in eastern North America following bans on DDT in 1971-1972 (Bednarz *et al.* 1990, Farmer and Hussell in press), and were still doing so in the mid 1990s through the mid 2000s (Fig. 4).

Overall, our results, considered together with data from the Breeding Bird Survey, Christmas Bird Counts, and other sources of population information, provide the best available assessments of the current status of North American migratory raptors.

The conservation usefulness of population trends estimated at migration watchsites continues to be limited by our relative ignorance of the breeding and wintering ranges of populations monitored. Analyses of banding encounters, ratios of stable isotopes in feathers, and tracking of individual birds by satellite all have contributed to a better understanding of the "catchment areas" and flyways used by individual species (e.g., Clark 1985, Fuller *et al.* 1998, Meehan *et al.* 2001, Hoffman *et al.* 2002, Smith *et al.* 2003, Houston 2006). Additional work aimed at delineating regional populations, identifying their flight lines, and establishing connectivity between breeding and wintering ranges, will increase the value of migration-trend estimates.

DISCUSSION

Initial analyses from RPI suggest that appropriately analyzed counts of migrating raptors from a geographically explicit network of watchsites can help conservationists assess trends in these species. Here we propose the establishment of a similar monitoring effort in Europe and the Mediterranean region that builds upon existing watchsites in the area, and that uses the charismatic nature of these species, together with the desire of many avid birdwatchers to work in service toward conservation, to create new migration watchsites in the region that can work together to help monitor migratory populations of raptors in the region.

All 38 of Continental Europe's breeding raptors migrate, at least to some extent. Most (27 species) are partial migrants (*sensu* Bildstein 2006), many of which remain in Europe year-round. Ten species are complete migrants, at least some of which over-winter in Africa, and one species (*Buteo lagopus*) is a complete migrant that over-winters in Europe and Asia (Zalles and Bildstein 2000).

The timing and geography of raptor migration in Europe and the Mediterranean region is as well known as that of any area in the Old World (cf. Thiollay 1968, Bernis 1975, Roberts 1979, Bijlsma 1987, Finlayson 1992, Kjellén 1992, 1998, Shirihai, *et al.* 2000, Bildstein 2006). Nevertheless the region lacks a continent-wide network of watchsites.

A round table on raptor population monitoring programs and techniques at the 17th International Conference of the European Bird Census Council in Chiavenna, Italy, in April 2007, attracted 25 participants from 14 countries. Participants at the round table unanimously endorsed the principle of establishing a European-Mediterranean network of raptor-migration watchsites specifically designed to monitor migratory populations of the region's birds of prey, and, possibly, other soaring migrants. Below we provide a road-map for the establishment of such a network.

Our experience in North America and elsewhere indicates that several over-arching principles are likely to increase the realization of such a network. They include (1) use of existing migration watch-sites as a basic framework for the new network; (2) establishment of a central office or secretariat for the new network; (3) flexibility in approach, including the development of collaborations in leadership as appropriate; (4) eventual establishment of a common protocol for data collection and analysis; and (5) rapid publication of existing databases and the analysis of those databases. We discuss each of these in turn below.

(1) Zalles and Bildstein (2000) describe more than 100 migration watchsites in more than 30 countries the European-Mediterranean region, one of which (Falsterbo, Sweden) has been active since 1950 (Karlsson 2004). Many of these watchsites are intermittently active, and data from the majority almost certainly have not been computerized. That said, a careful appraisal of existing watchsites should be made as soon as possible, and a small subset of them, perhaps as few as 10-20 should be invited to participate in the initial active network of sites. Data from this subset should be targeted for data entry and management under the auspices of the network. This task is likely to take upwards of 2-4 years and will require a good deal of human resources and cooperation. If necessary, agreements concerning use of the data will need to be made limiting their use to the original purposes of the network. Questions of authorship, too, may need to be decided in advance.

(2) A central office or secretariat should be established. This office will serve as the institutional headquarters of

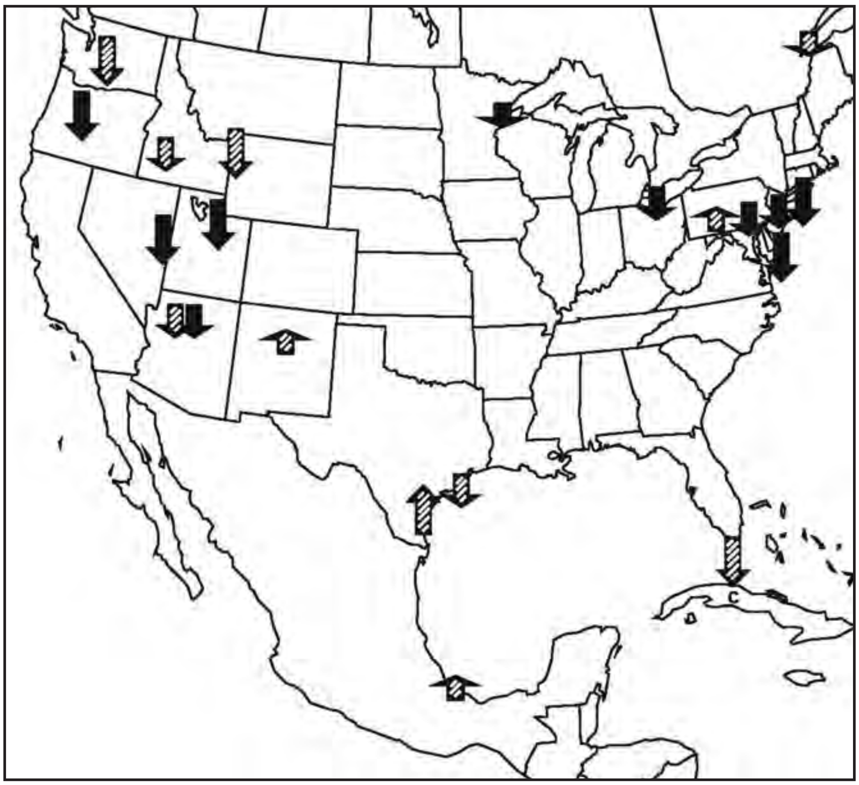


Figure 3. RPI trend-analysis results for the American Kestrel, a species whose populations appear to be declining in most of its range in Canada and the United States. Up-pointed and down-pointed solid and diagonally striped arrows indicate significant and non-significant increases and decreases during the mid 1990s through mid 2000s, respectively. (Note: a = sites with 9 years of count data; b = sites with 8 years of count data; c = sites with 7 years of count data; and no letter = sites with 10 years of count data.).

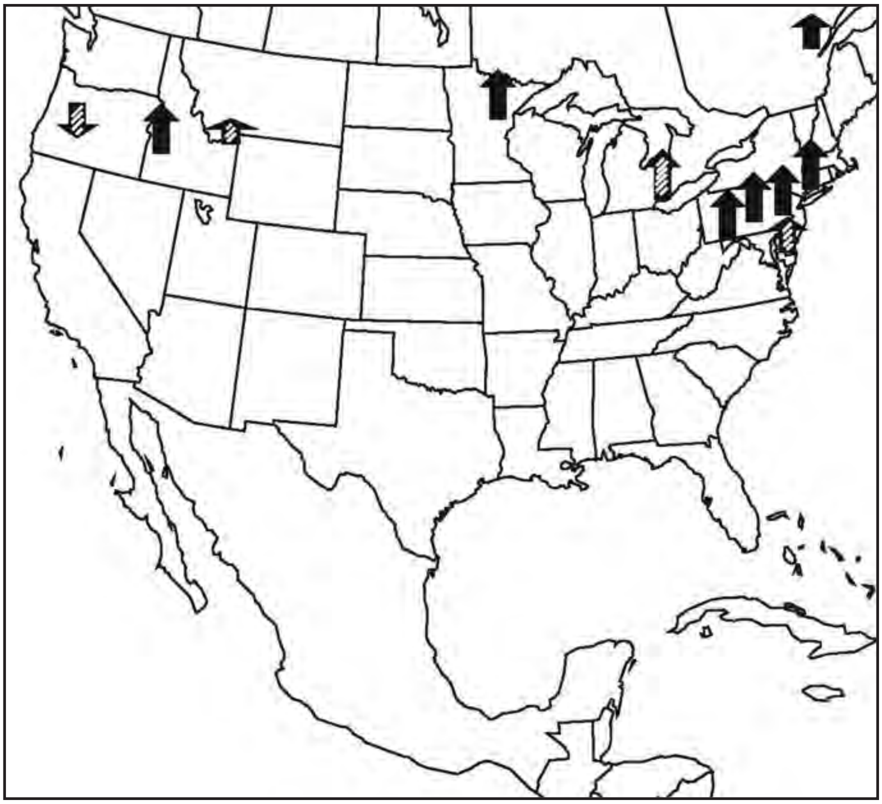


Figure 4. RPI trend-analysis results for the Bald Eagle, a species whose populations appear to be increasing in most of its range in Canada and the United States. Only sites that average at least 20 eagles per year are included. Up-pointed and down-pointed solid and diagonally striped arrows indicate significant and non-significant increases and decreases during the mid 1990s through mid 2000s, respectively.

the network and will be responsible for overseeing financial assistance acquired to support network activities. In North America the RPI network has two such offices, one at Hawk Mountain Sanctuary in Pennsylvania, where finances, analyses, and editorial processes are centralized, and where annual meetings of network committees occur; and one at the Dartmouth College where relations with independent watchsites are managed by the Hawk Migration Association of North America.

(3) In North America, the RPI network functions as a collaboration of the willing. The collaboration reflects the history of raptor migration monitoring in North America and functions on the basis of a renewable memorandum of understanding among the network's three lead organizations. Representatives of RPI's three organizations (i.e., Hawk Mountain Sanctuary, HawkWatch International, and the Hawk Migration Association of North America) meet annually for two and one half days at Hawk Mountain Sanctuary to review progress and determine immediate and long-term agendas. We recommend that a similar arrangement should be made for the European-Mediterranean region network. Trust and a willingness to empower each lead organization in actions that it is best suited to accomplish are essential features of any such arrangement. Active and constant communications are needed to reduce possible misunderstandings.

(4) Consistency, simplicity, and adaptive management are the most important attributes of a successful monitoring network. The establishment of a daily report form and basic operational protocols that are used by all members of the network is an essential feature of the network. Unless data are collected in a similar, if not identical fashion, both within sites among years and among sites across years, analyses will be severely limited. One of the initial tasks of the network should be to establish common daily report forms and data-collection protocols. Bildstein *et al.* (2007) and Dunn *et al.* (2007) provide details and considerations regarding this important network feature.

(5) The eventual success of the network will depend heavily upon its ability to provide conservation assessments of raptor populations to intended users. The RPI network achieved this goal first by presenting its analyti-

cal procedures and examples its initial results in a peer-reviewed paper in *The Auk* (Farmer *et al.* 2007), and second by publishing a detailed analysis of population trends for raptors counted at its 21 initial member watchsites as a monograph in 2008 (Bildstein *et al.* 2008).

Experience in North America suggests that the development of a network of raptor-migration watchsites is not a simple but rather a complex process that, if approached correctly, can yield useful information to conservation colleagues.

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Lorenzo Starnini