

MONITORING WITH A CONSERVATION GOAL: PRINCIPLES AND PRACTICE OF RAPTOR MIGRATION MONITORING

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Abstract. Open-ended ecological monitoring has been criticized for failing to address specific questions regarding the biological objective of interest or the extrinsic variables that may be affecting it. To enhance the contribution of monitoring to conservation, programs must address three central questions: 1) why monitor?, 2) what (parameters) should be monitored?, and 3) how should monitoring be done?

The Raptor Population Index Partnership was conceived to produce scientifically sound, timely, and regularly updated assessments of the continental status of raptor populations using migration count data, in accordance with recommendations of the Partners in Flight North American Landbird Conservation Plan.

To achieve this, the partnership has set up an on-line system to collect data using a standardized protocol. Our data analysis methodology is a two-step process that involves the calculation of an annual index of abundance, and the estimation of an annual rate of change over the length of the time series of data available.

The recent completion of a first continental-scale assessment of population status of raptors also provided a set of recommendations to improve the operation of the complete system. These include 1) improvements and modifications to the existing data-collection protocol, 2) systematic documentation of additional site metadata, 3) improvements to the geographic and seasonal coverage of data-contributing sites, particularly outside the northeastern US, and 4) the development of data-analysis techniques to improve estimates of species that are rare or recorded in very large numbers.

The greatest improvement of monitoring for conservation is setting up goal-oriented, targeted monitoring, with a focus on crucial information that addresses the three central questions outlined above. A clear plan for implementation of monitoring goals, including a timeline for its completion, is an essential tool. Assessing whether targets and objectives have been met should be the primary objective of monitoring.

Key Words: migration counts, North America, population monitoring, raptors.

MONITOREO CON METAS DE CONSERVACIÓN: PRINCIPIOS Y MÉTODOS PARA EL MONITOREO DE RAPACES EN MIGRACIÓN

Resumen. El monitoreo ecológico sin propósito definido ha sido criticado por no atender preguntas específicas relacionadas al objetivo biológico de interés o las variables extrínsecas que pueden afectar sus estimaciones. Para mejorar la contribución del monitoreo para la conservación, estos programas deben responder a tres preguntas 1) ¿para qué monitorear?, 2) ¿qué (parámetros) deben ser monitoreados? y 3) ¿cómo debe hacerse el monitoreo?

El proyecto Índice de Poblaciones de Rapaces (RPI por sus siglas en inglés) fue creado para producir estimaciones del estatus de las poblaciones de rapaces que sean científicamente rigurosos, generados a tiempo y que sean regularmente actualizados, de acuerdo con el Plan de Conservación de Aves Terrestres de PIF.

Para lograrlo, hemos establecido un sistema en línea para coleccionar datos de campo en sitios que utilizan un protocolo estandarizado. Nuestra metodología de análisis de datos es un proceso de dos pasos que entraña el cálculo de un índice anual de abundancia y la estimación de la tasa anual de cambio sobre la serie de tiempo según los datos disponibles.

La publicación reciente de la primera evaluación del estado poblacional de las rapaces a escala continental, también nos aportó una serie de recomendaciones para mejorar la operación del sistema completo. Estas incluyen 1) mejoras y modificaciones al protocolo estandarizado de colecta de datos, 2) la documentación sistemática de metadatos de sitio, 3) mejoras a la cobertura geográfica y estacional de los sitios que contribuyen datos, particularmente los que están fuera de la región noreste de

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los EU y (4) el desarrollo de algunas técnicas de análisis de datos que mejoren las estimaciones para especies raras o que ocurren en grandes cantidades.

La mayor mejora a programas de monitoreo para la conservación es establecer metas y objetivos claros, con un enfoque especial para la información que responda las tres preguntas centrales que se refieren arriba. El objetivo principal del monitoreo debe ser determinar si las metas y objetivos han sido alcanzados.

INTRODUCTION

Effective, continental-scale conservation of migratory birds requires several key components to be successful over the long-term. The ingredients of a comprehensive strategy include accurate estimations of current population size, population goals, current trend data, diagnoses of issues affecting species' conservation, and a suite of measurable conservation and management programs to achieve target population levels.

The geographic scale at which these elements are required is difficult to achieve. For example, the first Partners in Flight (PIF) North American population size estimates were produced only four years ago (Rich et al. 2004). The comprehensive networks and coverage required for effective monitoring are still largely undeveloped and address species with different levels of adequacy. Finally, the conservation and population management tools capable of delivering measurable results for a single species or a group of them are not available across all taxa.

Here I present an on-going effort for regional- to continental-scale monitoring conducted through the Raptor Population Index Project (hereafter RPI). I also summarize results to date, discuss how these results and operations have dictated changes and improvements in the operation of RPI, and conclude with some remarks showing how RPI has addressed three fundamental questions related to targeted, conservation-oriented monitoring.

MONITORING HAWK MIGRATION

Yoccoz et al. (2001) and Nichols and Williams (2006) have criticized the failure of many monitoring programs to address three key questions that, in their view, largely determine the failure or success of long-term monitoring for conservation. Addressing the questions "why?" "what?" and "how?" with regard to monitoring is as a crucial step in designing and executing targeted monitoring.

WHY MONITOR RAPTORS?

Diurnal raptors are at the top of many food chains and are sensitive indicators of ecosystem

health (Bildstein 2006). Paradoxically, raptors are an underserved group in landbird monitoring programs. The Breeding Bird Survey (BBS), the backbone of bird monitoring across the continent, does not cover raptors adequately (Farmer et al. 2007). Due to their secretive habits and occurrence at low densities, these birds are difficult to survey and consequently the precision of population estimates and trend data are often low.

However, accurate knowledge of population status and change is a fundamental first step towards species conservation, if scarce resources are to be used wisely. The migration season offers a unique opportunity to monitor raptor populations and deliver biologically valid estimates of their population levels. RPI uses long-term migration counts from a network of independent monitoring sites to generate annual indices of abundance and population trend estimates.

WHAT PARAMETERS SHOULD BE MONITORED?

The proper analysis and interpretation of trend results require a clear understanding of factors affecting populations at all stages of their annual cycle (Hussell and Ruelas 2008). A targeted monitoring program should provide two types of information: 1) an estimate/sample of population size, including, when possible, details of population structure such as data on sex and age classes, and 2) a measure of the environmental, sampling-related, or any other extrinsic variables believed to affect the first estimate (e.g., Hutchinson 1978, Ralph et al. 1993). Reducing and controlling for variation in counts from sources unrelated to population change is a key to extracting the true population change signal out of migration count data.

HOW SHOULD HAWK MIGRATION MONITORING BE DONE?

Monitoring sites must ensure consistency in the seasonal coverage period, the length of the daily count period, the number and skill of observers, and the location of observations. A written protocol (e.g., HMANA 2008) must give clear instructions on what and how to count

and what to record, so that different observers can collect daily data as consistently as possible. Dunn et al. (2008) outlined the contents of a field protocol and emphasized the need to archive the specifics of the protocol in use each field season (documentation of seasonal metadata).

Changes in protocols must be avoided, but if absolutely necessary, there are procedures for changeover that can allow data from both before and after the change to be pooled for analyses. The adoption of recommended procedures reduces variation in counts to a great extent. Clearly, variation can produce biases in the calculation of annual indices of abundance and resulting long-term population trend estimations.

THE RAPTOR POPULATION INDEX PROJECT

RPI was conceived to contribute to the conservation, knowledge, and public understanding of raptors and raptor migration through a collaborative population monitoring program. RPI produces scientifically sound, timely, and regularly updated assessments of the status of raptor populations using migration count data, in accordance with recommendations of the PIF North American Landbird Conservation Plan (Rich et al. 2004).

Specifically, the objectives of RPI are to: 1) produce statistically robust indices of annual abundance and long-term demographic trends for each species of migratory raptor from as many North American count sites as possible, 2) provide frequently updated, scientifically sound assessments of the status of each species, and 3) make this information widely available to participating raptor migration monitoring sites, the scientific community, conservation and wildlife management agencies, and the public.

Similar to many other citizen science monitoring programs, RPI consists of a network of independent watch sites operated by volunteers and/or paid staff and an organizing group with professional staff. RPI was launched in 2004 by a partnership of three organizations: the Hawk Migration Association of North America (HMANA), Hawk Mountain Sanctuary (HMS), and HawkWatch International (HWI). Each of these partners has designated professional staff to perform specific project functions. RPI is guided by the three organizations and by Steering and Science Advisory Committees. These committees are comprised of members from federal and state agencies, academic institutions, and non-profit conservation organizations (including the three partners, see Acknowledgments section).

From 2004 through 2008, RPI focused on a pilot project to establish the feasibility of a continent-wide program to monitor raptor population status and trends based on migration counts. The first three years of operations were partially funded by a grant from the National Fish and Wildlife Foundation (NFWF) and a second grant from the US Fish and Wildlife Service's Neotropical Migratory Bird Conservation Act. Matching funds came from private donors of HMS, HMANA, and HWI.

The three RPI partners agreed to perform the following functions:

HMANA. Founded in 1974 to advance scientific knowledge and promote conservation of raptor populations through study, enjoyment, and appreciation of raptor migration, this RPI partner has been responsible for 1) count data standardization and collection protocols, 2) serving as liaison to monitoring sites, 3) data entry and submission facilities (<http://www.hawkcount.org>), 4) data management and storage, 5) dissemination of results via various media, 6) scientific interpretation and publication of results, and 7) raising funds for cash match (organizational background at <http://www.hmana.org>).

HMS. Founded in 1934 to conserve birds of prey worldwide by providing leadership in raptor conservation science and education, and by maintaining Hawk Mountain Sanctuary as a model observation, research and education facility. HMS has been RPI's analysis unit and has been responsible for 1) trend analysis 2) acquisition and preparation of key data sets, 3) scientific interpretation and publication of results, 4) dissemination of results via various media, 5) addressing other research questions, and 6) providing substantial in-kind matching funds (organizational background at: <http://www.hawkmountain.org>).

HWI. Founded in 1986 to conserve our environment through education, long-term monitoring, and scientific research on raptors as indicators of ecosystem health, this RPI partner has contributed 1) coordination and operation of western and Gulf Coast sites, including data entry and submission, 2) serving as a liaison and providing feedback to its monitoring sites, 3) dissemination of results via various media, 4) scientific interpretation and publication, and 5) contribution of matching funds (organizational background at <http://www.hawkwatch.org>).

HOW ARE RAPTOR POPULATIONS DOING? A CONTINENTAL ASSESSMENT

In the early summer of 2008, the RPI Partnership produced a scientific peer-reviewed

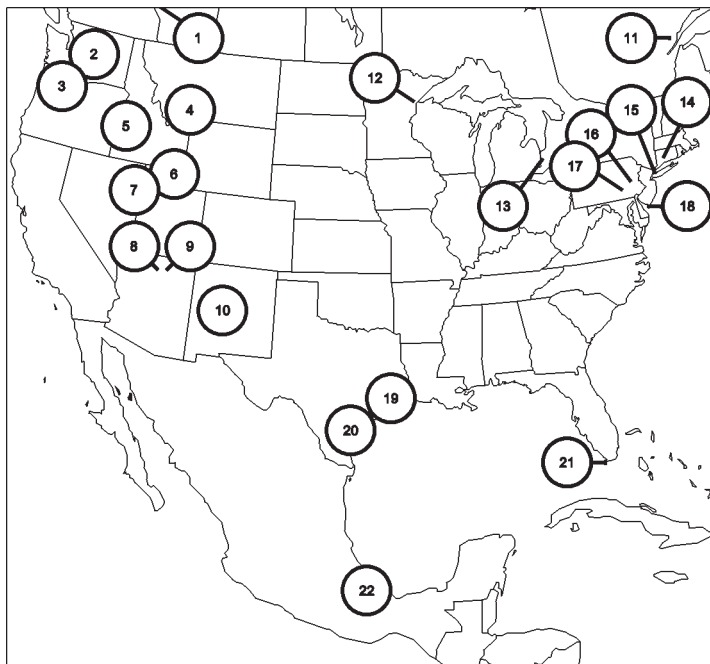


FIGURE 1. Migration monitoring sites used in continental-scale analysis of Bildstein et al. (2008a). Western sites are (1) Mount Lorette, AB; (2) Chelan Ridge Raptor Migration Project, WA; (3) Bonney Butte Raptor Migration Project, OR; (4) Bidger Mountains Raptor Migration Project, MT; (5) Boise Ridge, ID; (6) Wellsville Mountains Raptor Migration Project, UT; (7) Goshute Mountains Raptor Migration Project, NV; (8) and (9) Grand Canyon Raptor Migration Project (Yaki Point and Lipan Point, respectively), and (10) Manzano Mountains Raptor Migration Project, NM. Eastern sites (including those around the Great Lakes) are: (11) Observatoire d'oiseaux de Tadoussac, QC; (12) Hawk Ridge Bird Observatory, MN; (13) Holiday Beach Migration Observatory, ON; (14) Lighthouse Point Hawk Watch, CT; (15) Montclair Hawk Lookout, NJ; (16) Hawk Mountain Sanctuary, PA; (17) Audubon's Hawk Watch at Waggoner's Gap, PA, and (18) Cape May Bird Observatory, NJ. Gulf coast sites are: (19) Smith Point Raptor Migration Project, TX; (20) Corpus Christi Raptor Migration Project, TX; (21) Florida Keys Raptor Migration Project, FL, and (22) Veracruz River of Raptors, Mexico. For more information on these raptor migration monitoring sites, see Ruelas (2008).

report on the status and trends of migratory raptor populations breeding in North America, based on a network of migration count sites (Bildstein et al. 2008a). Here I summarize those results and other information output of RPI.

POPULATION TRENDS IN THE NORTHEAST AND GREAT LAKES

Farmer et al. (2008a) used counts from seven monitoring sites with 30 or more years of counts to calculate annual population indices for 16 species of migrant raptors. The seven sites were at similar latitude along an east-to-west transect from the Atlantic coastline of Connecticut to the western shore-line of Lake Superior (Ruelas 2008, Fig. 1). These authors also calculated population indices for a shorter-term count at l'Observatoire d'oiseaux de Tadoussac, which receives migrants primarily from northeastern Quebec and Newfoundland.

Farmer and collaborators (2008a) estimated geometric rates of change in the population indices. Results show that counts increased or remained stable for seven species and decreased for one species throughout the region from 1974 to 2004 (Table 1). Eight other species showed variable long-term trends across the region.

Precision of long-term trend estimates from migration monitoring was generally good ($n=107$ species/site combinations), with 45 estimates rated with high ($\pm 1.8\%$ per year), 51 with moderate ($\pm 1.8-3.5\%$ per year), and 11 with low ($>3.5\%$ per year) precision. Trends often were not linear, and several species that increased significantly during the 1980s, Merlin (*Falco columbarius*), Peregrine Falcon (*F. peregrinus*), and Osprey (*Pandion haliaetus*) ceased to do so in the 1990s (Tables 1-3). A few species showed geographic patterns in trends, which suggests either that different source populations were monitored in the eastern and western portions

TABLE 1. PERCENTAGE OF ANNUAL CHANGE IN POPULATIONS OF MIGRATORY RAPTORS, FROM EASTERN NORTH AMERICA, 1990–2000. TRENDS FOR TADOUSSAC ARE FOR THE PERIOD 1994–2004. RESULTS MARKED (–) HAVE DECREASING POPULATIONS; RESULTS NOT MARKED INDICATE POSITIVE CHANGE. STATISTICAL SIGNIFICANCE OF TREND RESULTS IS MARKED WITH ASTERISKS (* $P \leq 0.05$). MODIFIED FROM FARMER ET AL. (2008A).

Species	Cape May NJ	Hawk Mountain PA	Hawk Ridge MN	Holiday Beach ON	Light-house Point CT	Mont-clair NJ	Tadous-sac QC	Wag-goner's Gap PA
Turkey Vulture <i>Cathartes aura</i>	1.5	7.0*	3.9*	7.1*	6.9*	8.5*	–	29.8*
Osprey <i>Pandion haliaetus</i>	-0.7	-2.6*	3.6	2.0*	-9.0*	-1.2	-4.7	-0.9
Bald Eagle <i>Haliaeetus leucocephalus</i>	10.8*	5.9*	16.1*	3.8	8.8*	9.2*	3.3	4.4*
Northern Harrier <i>Circus cyaneus</i>	-0.7	-3.0*	0.6	-8.2*	-1.9	0.7	-0.6	-0.8
Sharp-shinned Hawk <i>Accipiter striatus</i>	3.0	-3.3*	2.3	-1.8	-3.3*	0.2	-1.0	-0.6
Cooper's Hawk <i>A. cooperii</i>	3.3	4.1*	8.1*	-1.2	-4.0	10.2*	–	5.1*
Red-shouldered Hawk <i>Buteo lineatus</i>	-0.3	-0.6	-0.7	-5.0*	-2.1	1.3*	–	1.0
Broad-winged Hawk <i>B. platypterus</i>	-1.4	-3.1*	1.1	-2.2	-2.3	-6.4*	-1.7	4.1
Red-tailed Hawk <i>B. jamaicensis</i>	0.3	-1.9*	6.1*	-3.4	3.1*	-2.8	1.6	4.3*
Golden Eagle <i>Aquila chrysaetos</i>	0.2	2.1*	5.7*	1.1	4.7*	1.1	-3.2	3.0*
American Kestrel <i>Falco sparverius</i>	-4.5*	0.1	5.3*	-2.6	-7.1*	-3.3*	-5.8	3.1
Merlin <i>F. columbarius</i>	0.2	4.1*	3.7*	3.0	-3.7	4.0	-3.7	11.0*
Peregrine Falcon <i>F. peregrinus</i>	3.4	1.6	7.8*	4.6*	-0.5	3.3	3.5	2.1

of the study area, or that migration geography changed over the course of the study period (Farmer et al. 2008a).

POPULATION TRENDS IN THE WEST

Smith et al. (2008a) estimated trends in counts of migrating diurnal raptors from 10 sites in western North America. Counts spanned variable periods between 1983 and 2005. Average counts at these sites ranged from ~2000 to 15 000 migrants per autumn season, with up to 21 species represented depending on the site. Five species consistently constituted more than 80% of the annual combined-site count totals: Sharp-shinned Hawk (*Accipiter striatus*, 25–30% of the total in a given year), Cooper's Hawk (*A. cooperii*, 15–22%), Red-tailed Hawk (*Buteo jamaicensis*, 13–20%), American Kestrel (*Falco sparverius*, 8–13%), and Golden Eagle (*Aquila chrysaetos*, 9–14%).

Sites included Chelan Ridge, WA (1998–2005) and Bonney Butte, OR (1995–2005) in

the Pacific Northwest; Boise Ridge, ID (1995–2005), Goshute Mountains, NV (1983–2005), in the Intermountain region; and two sites in the Grand Canyon, AZ (Yaki Point: 1997–2005; Lipan Point: 1991–2005), Mt. Lorette, Alberta (1993–2005), Bridger Mountains, MT (1992–2005), Wellsville Mountains, UT (1987–2005), and Manzano Mountains, NM (1985–2005) in the Rocky Mountains (Fig. 1).

Smith and collaborators (2008a) estimated geometric-mean rates of change in annual count indices for 16 species, with species representation varying by site. Turkey Vulture (*Cathartes aura*) was the only species for which at least a slight positive rate of change in the annual indices occurred at all analyzed sites over the relevant periods of record, whereas Northern Goshawk (*Accipiter gentilis*) was the only species for which at least a slight negative rate of change occurred at all analyzed sites (significant declines at 2 of 6 sites).

Other species for which only significant increases or non-significant rates of change

TABLE 2. PERCENTAGE OF ANNUAL CHANGE IN POPULATIONS OF MIGRATORY RAPTORS IN WESTERN NORTH AMERICA 1998–2005. MOUNT LORETTE AB, REPORTS A GOLDEN EAGLE DECREASE OF -2.2% PER YEAR OVER THE SAME PERIOD. RESULTS MARKED (-) HAVE DECREASING POPULATIONS; RESULTS NOT MARKED INDICATE POSITIVE CHANGE. STATISTICAL SIGNIFICANCE OF TREND RESULTS IS MARKED WITH ASTERISKS (* $P \leq 0.05$). MODIFIED FROM SMITH ET AL. (2008A).

Species	Boise Ridge ID	Bonney Butte OR	Bridgers MT	Chelan Ridge WA	Goshutes NV	Grand Canyon AZ (combined)	Manzanos NM	Wells-villes UT
Turkey Vulture	18.3*	5.5	-	5.0	2.3	-	-12.9	0.3
Osprey	4.4	2.2	-	-6.0	-2.3	-4.4	-1.1	-10.0*
Northern Harrier	0.3	-3.3	-2.4	-10.1	-10.6*	-10.6*	-8.2*	0.3
Sharp-shinned Hawk	0.7	-0.1	-6.3	-12.8*	-8.3	-5.6	2.2	-5.7
Cooper's Hawk	2.1	-0.9	-5.6	-6.3	-9.3*	-16.0*	4.5*	-14.3
Northern Goshawk <i>Accipiter gentilis</i>	-3.9	-2.3	-4.6	-12.9	-13.9*	-	-	-0.2
Swainson's Hawk <i>Buteo swainsoni</i>	-2.3	-	-	-	5.4*	8.7	-7.3	-13.1
Red-tailed Hawk	7.3*	-1.7	-2.2	-5.0	2.0	-6.2	2.1	-6.1
Golden Eagle	1.2	-3.8	1.3	4.5	-12.6*	-11.6	-9.6*	-5.3
American Kestrel	-1.9	-7.9*	-13.8	-11.7	-8.2*	-2.8	0.1	-10.5*
Merlin	6.3	2.1	-	-0.4	-11.6*	-5.7	-1.7	-

TABLE 3. PERCENTAGE OF ANNUAL CHANGE IN POPULATIONS OF MIGRATORY RAPTORS AROUND THE GULF OF MEXICO, 1995/1998–2005. RESULTS MARKED (-) HAVE DECREASING POPULATIONS; RESULTS NOT MARKED INDICATE POSITIVE CHANGE. STATISTICAL SIGNIFICANCE OF TREND RESULTS IS MARKED WITH ASTERISKS (* $P \leq 0.05$). MODIFIED FROM SMITH ET AL. (2008B).

Species	Corpus Christi TX	Florida Keys FL	Smith Point TX	Veracruz MX
Black Vulture <i>Coragyps atratus</i>	1.9	-	0.3	-
Turkey Vulture	16.9	-	0.0	5.7
Osprey	7.2	9.0*	4.7*	2.8
Swallow-tailed Kite <i>Elanoides forficatus</i>	13.1	-	7.6	7.3*
Mississippi Kite <i>Ictinia mississippiensis</i>	5.4	-	10.0	15.4*
Northern Harrier	-2.9	-8.4	-6.2	-8.4
Sharp-shinned Hawk	-2.6	-12.8*	-4.2	-7.5
Cooper's Hawk	3.2	7.3	-1.0	1.9
Red-shouldered Hawk	-8.6	-	1.4	-
Broad-winged Hawk	-6.7	6.1	8.2	3.1
Swainson's Hawk	18.5*	-	10.0*	13.6*
Red-tailed Hawk	-2.6	-	-0.4	-3.3
American Kestrel	6.7	-8.8	-2.9	0.0
Merlin	2.3	-13.4*	4.6	0.4
Peregrine Falcon	3.2	6.9	5.8	3.2

occurred included Swainson's Hawk (*Buteo swainsoni*), Merlin, and Peregrine Falcon. Other species for which only significant decreases or non-significant rates of change occurred included Northern Harrier (*Circus cyaneus*) (significant declines at 2 of 8 sites) and Golden Eagle (declines at 5 of 9 sites). Species for which a mix of significant decreases and increases occurred included Osprey, Broad-winged Hawk (*Buteo*

platypterus), Sharp-shinned Hawk, Cooper's Hawk, Red-tailed Hawk, American Kestrel, and Prairie Falcon (*Falco mexicanus*). Rough-legged Hawk (*Buteo lagopus*) (at 2 sites) and Bald Eagle (*Haliaeetus leucocephalus*) (at 3 sites) were the only species for which no significant trends occurred. Especially within the Great Basin/Intermountain region since the late 1980s, for many species count trends correlate well with

variation in regional precipitation levels and drought severity (Smith et al. 2008a).

POPULATION TRENDS IN THE GULF COAST

Smith et al. (2008b) estimated trends in autumn counts of migrating diurnal raptors collected at four watchsites around the Gulf of Mexico: Curry Hammock State Park, Florida Keys (1999–2005), Smith Point and Corpus Christi, Texas (1997–2005), and Cardel and Chichicaxtle, Veracruz, Mexico (1995–2005).

One fundamental difference in autumn migration counts from this region is magnitude. The Veracruz counts monitor the world's largest concentration of migratory raptors with 4–6 million per yr per season (Ruelas et al. 2000). The Corpus Christi count monitors the largest concentration in the United States and Canada (more than 1 million in 2004). The Florida Keys project monitors North America's largest known migratory concentration of Peregrine Falcons (average >1800 per yr per season). Flights are dominated by four species that consistently comprise >90% of the Texas and Veracruz totals: Broad-winged Hawk (35–40%), Turkey Vulture (35–40%), Swainson's Hawk (15–20%), and Mississippi Kite (*Ictinia mississippiensis*) (2–5%).

These authors estimated geometric-mean rates of change in annual count indexes for 17 species, with up to 15 species represented per site. Northern Harriers and Sharp-shinned Hawks were the only species for which negative rates of change were detected at all sites, with both showing significant declines in Florida and harriers also declining significantly in Veracruz. No significant increases were detected for American Kestrels and Merlins, but both declined significantly in Florida. Mixed trends were detected for Red-shouldered Hawks in Texas (no trend at Smith Point, marginally significant decline at Corpus Christi). No significant declines but significant increases at one or more sites were detected for seven other species. No significant trends were detected for Black Vultures in Texas, for Red-tailed Hawks in Texas and Veracruz, or for Cooper's Hawks at any site.

The precision of trend estimates was consistently low due to short monitoring periods, and in many cases relatively high interannual variability; nevertheless, for 53% of the analyzed site-species combinations, 95% confidence intervals were $\pm 10\%$ per year or less, which at least approached a designated moderate-precision threshold of $\pm 3.5\%$ per year.

The results from these analyses demonstrate the technical feasibility and value of using

migration counts to track population changes in migratory raptors. In doing so, RPI also provided a tool for federal, state, and local resource management and environmental conservation agencies and organizations with current information on site-specific, region-specific, and continent-wide population trends (Fig. 2).

Other products included papers on analysis methods (Farmer et al. 2007), species-specific conservation status reports (Farmer et al. 2008b), and annual reports (Anonymous 2005, 2006, 2007) that have been disseminated to cooperators, funding agencies, resource agencies, the media, and posted on the RPI website (<http://www.rpi-project.org/>).

ADDRESSING KEY QUESTIONS FOR GOAL-ORIENTED MONITORING

The continental-scale assessment of population status of raptors summarized above also provided a set of recommendations to improve the operation of the complete monitoring system. Because the importance of raptors as sentinels of environmental quality has been discussed extensively (e.g. Bildstein 2006), I will focus on recommendations of what and how raptor migration monitoring should be done.

These recommendations include 1) improvements and modifications to the existing data-collection protocol; 2) systematic documentation of additional site metadata; 3) improvements to the geographic and seasonal coverage of data-contributing sites, particularly outside the northeastern United States; and 4) the development of some data-analysis techniques to improve estimates of species that are rare or recorded in very large numbers (for a detailed discussion of these recommendations, see Bildstein et al. 2008b).

How will these recommendations be implemented? In a January 2008 meeting of RPI Management and Science Advisory committees, the RPI partners wrote a three-year strategic plan to carry on the project and incorporate the assessment of the "what" and "how" questions into the practice of raptor migration monitoring.

FUTURE OF RPI: GOALS 2008–2011

RPI has identified two types of strategic goals needed to carry out its mission and achieve its vision:

Scientific and conservation goals.—RPI will focus on improving scientific and monitoring output and contribute results to conservation. RPI's research agenda is centered on improving our understanding of raptor migration to better interpret migration count data.

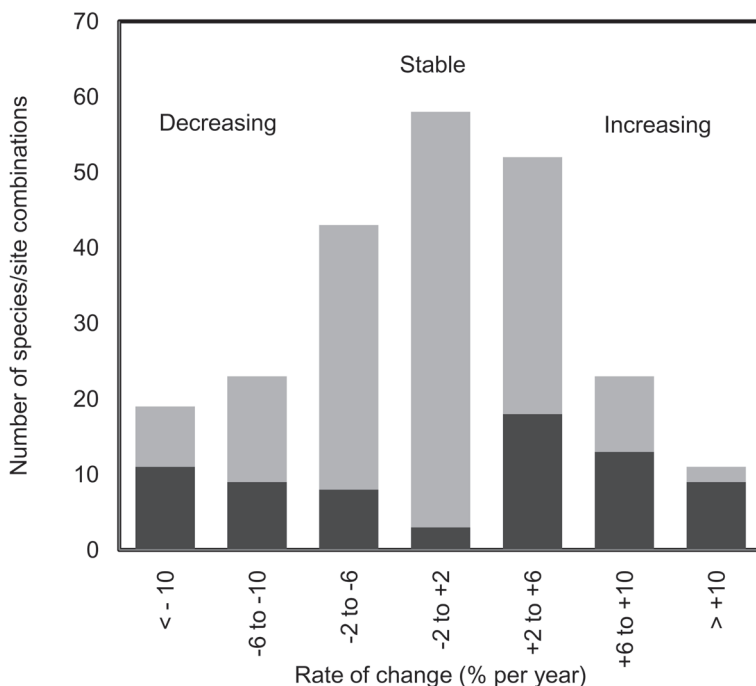


FIGURE 2. An overview of trends in raptor populations in North America over the last ten years. The continental, grand-scale picture of raptor population trends since the 1990s, looks moderately balanced. Fifty-eight species/site combinations were relatively stable (3 of them with statistically significant trends, depicted in dark gray). Farmer et al. (2008a), and Smith et al. (2008a, 2008b), found fewer species/site combinations showing declines ($n = 85$, 28 of them significant), than increases ($n = 86$, 40 of them significant).

Institutional goals.—RPI's overarching goal in the next three years is to establish itself as a permanent monitoring program producing timely and regularly updated information on the status of North America's raptors. To do so, RPI aims to strengthen the network of independent watchsites, work towards sustainability of RPI's monitoring program, and increase organizational capacity for science and research.

RPI will address these strategic goals through the following specific objectives:

1) Continue to develop and use the best-possible statistical analysis procedures and improve efficiency in order to facilitate frequent and timely updating of assessments of the status of raptors.

2) Develop and implement a frequency and mode of reporting status and trends of raptors that will effectively serve the conservation community, including meeting needs for raptor monitoring identified in the Partners in Flight North American Landbird Conservation Plan (Rich et al. 2004).

3) Conduct and promote relevant research on raptor migration: (e.g. via satellite tracking, radar ornithology, definition of catchment

areas, issues of detectability, etc.), to better understand and interpret count data.

4) Increase support for new and existing watch sites through more direct contact with site personnel, including annual or biennial conferences, and enhanced feedback of RPI results via the web and other media

5) Outreach to existing sites to assist them, if necessary, to develop and adhere to standardized data-collection protocols and to ensure long-term consistency of count data.

6) Continue to develop, enlarge, and update an inventory and description of watch sites and make it available on HawkCount.org and RPI-project.org.

7) Develop additional web analysis tools useful to hawk watches.

8) Identify gaps in geographic coverage for spring and fall migration monitoring, and begin to fill those gaps.

9) Develop the support, infrastructure, and organizational capacity to put RPI onto a maintain RPI as a permanent long-term raptor monitoring program.

RPI plans to become an essential component of raptor monitoring, migration research, and conservation planning in North America.

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