PREFACE

Each autumn, millions of birds of prey migrate past more than 100 migration watchsites across North America. Many of these watchsites have been counting outbound migrants in the fall for decades. Two watchsites, Cape May Point and Hawk Mountain Sanctuary, began counting migrants in the 1930s. To a lesser extent, the same thing happens during return migration each spring. Long heralded as a potential source of useful information for raptor conservation, counts from individual watchsites tracked declines in raptor populations during the DDT era of the 1940s through the 1970s, as well as rebounds in many populations since then.

The idea of using a network of migration watchsite counts to monitor the status of continental populations of birds of prey dates from the 1950s. An international meeting sponsored by Hawk Mountain Sanctuary and the National Audubon Society in Syracuse, New York, in 1974 led to the formation of the Hawk Migration Association of North America (HMANA), which began publishing summaries of counts from dozens of migration watchsites soon thereafter. The formation of HawkWatch International (HWI) in 1986, with project origins dating back to 1977, and the establishment of Golden Gate Raptor Observatory in 1984 set the stage for development of a network of western migration watchsites. After much discussion, Hawk Mountain Sanctuary and the Hawk Migration Association of North America signed a memorandum of understanding (MOU) in the spring of 2003 pledging to work together to create a Raptor Population Index (RPI) that would provide regularly updated conservation status reports of North America's birds of prey based on trend analyses from a network of migration watchsite counts and other types of bird counts, including Breeding Bird Surveys and Christmas Bird Counts. HawkWatch International signed on to the MOU in the autumn of 2003. RPI received a challenge grant from the National Fish and Wildlife Association to initiate work on the project in 2004, and Hawk Mountain Sanctuary committed a full-time employee to RPI at the same time.

Today, under the guidance of its management and science-advisor committees, RPI is working to produce a series of conservation status report for 20 species of North America's birds of prey. *State of North America's Birds of Prey* represents the proceedings of an RPI symposium held at a joint meeting of the Raptor Research Foundation and the Hawk Migration Association of North America in Foglesville, Pennsylvania, in September 2007 hosted by Hawk Mountain Sanctuary. The editors of this report include representatives from RPI's three lead organizations, and the authors of chapters therein include representatives from more than a dozen migration watchsites. As such, this report represents the state of knowledge of the raptor-migration community in North America.

Overall, *State of North America's Birds of Prey* contains much good news. Populations of most species of North American raptors are increasing, and only one, the California Condor (*Gymnogyps californianus*) remains on the federal Endangered Species List, and its numbers, too, are increasing. That said, challenges to many species of raptors lie ahead as humanity co-opts more land, and its impact on climate change increases. RPI and its sponsoring organizations remain committed to raptor protection in general, and to population monitoring in particular. Those interested in keeping abreast of the conservation status of North America's birds of prey should visit the web sites of Hawk Mountain Sanctuary, HawkWatch International, and the Hawk Migration Association of North America for updates.

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Works such as these are never really completed, and we look forward to comments and suggestions on how to improve subsequent reports.

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A Brief History of Raptor Conservation in North America

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Abstract.—The conservation of North American raptors has changed considerably since European settlement. Historically, raptors were treated with indifference or outright hostility by most people of European descent, including ornithologists and conservationists. Shooting-era declines of many populations of birds of prey in the early 20th century energized segments of the scientific and conservation communities and led to special protection efforts on behalf of Bald Eagles (*Haliaeetus leucocephalus*) via the U.S. Bald Eagle Protection Act of 1940, and, eventually, to protection efforts for all species of raptors once they had been included within the jurisdiction of the Migratory Bird Treaty Act with Mexico in 1972. Catastrophic declines in regional populations of many birds of prey, including high-profile species such as Bald Eagles and Peregrine Falcons (*Falco peregrinus*) during the DDT-era of mid-20th-century North America, refocused protection efforts on the new threat of environmental contaminants. Today, the most significant human threats to raptors appear to be (1) a growing number of environmental contaminants, many of whose potential effects remain unknown and unexplored, (2) land-use change, including the loss of natural landscapes and the erection of harmful structures, and (3) potential conflicts between humans and birds of prey as raptor populations rebounding from reduced persecution and pesticide-era lows reassert themselves as significant predators in both natural and human landscapes. I first review the largely historic threats of direct persecution and pesticide contamination, and then discuss new and old environmental contaminants, the current and likely potential threats of land-use change, and the growing potential for raptor-human conflict as populations of both increase. The bulk of the paper focuses on direct persecution for two reasons: (1) the history of human persecution of raptors in North America is largely unknown among today's conservationists, and (2) this history played a major role in the creation of raptor-migration watchsites and the sport of hawkwatching.

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The History of Human Persecution

Although the history of raptor–human interactions in North America clearly predates that of European settlement (Tyler 1979, Broughton 2004), regionally significant impacts date largely from the mid-1800s. Improvements in shotguns and the development of breech-loading rifles increased the popularity of game hunting in North America and elsewhere (Newton 1990), and this, together with increasing human populations, conspired to reduce raptor numbers in many parts of the continent, particularly in the eastern United States (Hornaday 1914, Bildstein 2001). Perhaps not surprisingly, the same factors and attitudes also reduced raptor populations in Western Europe, where the threat was such that several species were extirpated from large portions of the continent. (Those interested in the history of raptor persecution in the Old World should consult Bijleveld's [1974] meticulously detailed and, at times, mind-numbing account of the situation there.)

The "problem" of raptor persecution did not become part of mainstream nature conservation in North America until well into the 20th century, when a small but dedicated and initially ostracized group of raptor conservationists began to speak up for the birds (Broun 1949, Bildstein 2001). Although mainstream raptor conservation happened early enough to protect all but one of the continent's distinct populations of diurnal birds of prey—the Guadalupe Caracara (*Caracara lutosus*) became extinct in the early part of the 20th century as a result of an all-too-lethal combination of local goatherds and overzealous skin collectors (Greenway 1958, Bildstein 2006)—the fight to protect "common" raptors offers a quintessential example of single-species management gone awry.

Given the often incessant and indiscriminate nature of human persecution (Broun 1949; Newton 1990; Bildstein et al. 1993, 2006), it is small wonder that by the middle of the 20th century most raptor strongholds in North America were in relatively remote and unpopulated areas of the continent. The phenomenon of "wilderness raptor strongholds" convinced many conservationists that birds of prey selected such habitats because of superior prey- or nest-site availability, rather than because many of these places served as essential (human) predator-free zones. That the latter was the principal driving force in shaping raptor distributions is evidenced by recent expansions of many of the same species into human-dominated landscapes (e.g., Rosenfield et al. 1996, Cade and Burnham 2003) following reduced persecution there.

The twin histories of raptor persecution and protection in North America are best told through the writings of those involved, and below I quote heavily from the historical record. Specifically, I detail: (1) the role that ornithologists and, more recently, conservationists played in shaping

North Americans' attitudes toward birds of prey, (2) how persecution-era effects were quickly overshadowed by pesticide-era concerns, and (3) the extent to which widespread human persecution reshaped habitat use in many populations of North America's birds of prey.

Attitudes toward Bald Eagles.—In addition to being the national emblem of the United States, as well as its most recognizable raptor, the Bald Eagle (*Haliaeetus leucocephalus*) has been one of the nation's most heavily persecuted birds of prey (Beans 1996). The love–hate relationship with Bald Eagles dates from colonial times, and the writings of colonial and postcolonial ornithologists shed significant light on how the relationship came to be.

Writing in the early 1700s, Mark Catesby described the species not only as having "*...great strength and spirit...*" and as "*formidable to all birds, yet suffer*[ing] *them to breed near his royal nest without molestation*," but also as regularly "*...prey*[ing] *on pigs, lambs, and fawns...*" (Catesby 1731–1743). These discordant themes would shadow the Bald Eagle for the next 200 years. For example, Alexander Wilson, writing in *American Ornithology* (Wilson 1808–1814), not only characterized the species as "[A] *distinguished bird, the most beautiful of its tribe*," that was both "*contemplative*" and "*daring*," but also as frequently retiring "*inland in search of young pigs....*" And John James Audubon in *The Birds of America* not only portrayed the Bald Eagle as "*a noble bird... well known throughout the civilized world...*" that possessed "*great strength, daring, and cool courage*," but also as a species that was hated by many and that had been "*forced to seek refuge from the persecution of man*" because it was considered vermin (Audubon 1840).

That Bald Eagles regularly preyed upon both farm and game animals, however, was not the only reason people disliked them. At a time when human traits were routinely ascribed to birds and other animals, Bald Eagles were judged by many to be dishonorable bullies. Both Wilson and Audubon described the species as "*tyrannical*," with Audubon suggesting that it also "*exhibited a great degree of cowardice.*" The most damning condemnation of the species, however, can be found in a letter from Benjamin Franklin to his daughter Sarah in 1784. Writing from Paris, while contemplating a recently arrived medal honoring Revolutionary War heroes that included an image of the Bald Eagle, Franklin stated,

> *"For my own part, I wish the Bald Eagle had not been chosen as the representative of our country: he is a bird of bad moral character; he does not get his living honestly... too lazy to fish for himself, he watches the labor of the Fishing Hawk* [Osprey]*; and, when that diligent bird at length has taken a fish, and is bearing it to his nest for the support of his mate and young ones, the Bald Eagle*

> *pursues him and takes it from him. With all this injustice he is never in good case; but, like those among men who live by sharping and robbing, he is generally poor, and often very lousy. Besides, he is a rank coward; the little* [Eastern] *Kingbird* [*Tyrannus tyrannus*], *not bigger than a sparrow, attacks him boldly and drives him out of the district. He is therefore by no means a proper emblem for the brave and honest* [war heroes] *who have driven all the kingbirds* [i.e., British] *from our country….*" (Franklin 1987)

Franklin's oft-quoted negative depiction of the species, albeit somewhat correct ornithologically, established an unfortunate moral condemnation of the bird that was to remain in place for more than a century.

An early birdwatcher and founder of the Connecticut Audubon Society, Mabel Osgood Wright, in *Birdcraft*, called the Bald Eagle "*an inveterate bully*, [that obtained] *a great part of its food by robbing the* [Osprey], *while perfectly able to fish for itself*," and went on to characterize adults as "*cowardly parents*" that although "*known to carry off lambs and young pigs*, [have] *been vanquished in a fair fight by a rooster*" (Wright 1895). Neltje Blanchan, in the highly regarded and widely read *Birds that Hunt and are Hunted* (1898), called the Bald Eagle "*…neither the most intelligent nor enterprising of birds, nor the bravest*," as well as an "*unsportsmanlike hunter*." A quarter of a century later, National Association of Audubon Societies President, T. Gilbert Pearson, described the bird as being "*very shrewd*" and "*having no inconvenient scruples, whatsoever…*" and noted that that "*in regions where these birds become a serious loss to sheep-raisers, we cannot well blame men for occasionally killing these raiders of the sheep-fold*." Pearson also described in detail an encounter near the mouth of the Suwannee River in Gulf Coast Florida in which he intervened to protect the "*new-born progeny of an old hog*" that was being set upon by three eagles; all of this in an Audubon educational leaflet meant to discourage "*wanton*" shooting (Pearson 1921).

Later still, William T. Hornaday, the Director of the New York Zoo and President of the Wildlife Conservation Society, remarked in *Thirty Years War for Wildlife* (1931) that "*The* [Bald] *Eagle* [was], *in a few places in Alaska, too numerous; and* [that] *there it should be thinned out*." And in 1937, noted ornithologist Witmer Stone, writing in *Bird Studies at Old Cape May*, characterized the species as both "*a coward and a parasite*" and a "*degenerate member of the eagle tribe*" that had achieved recognition as our national emblem only "*through the machinations of ignorant politicians*." Although Pearson, Hornaday, and Stone did argue for saving the species from outright extinction, rants such as these from leading ornithologists and conservationists did little to protect healthy populations of the species in early-20th-century North America, especially when others were accusing it of baby snatching.

One of the earliest and perhaps most effective narratives in what would become a genre of tall tales describing this supposed phenomenon appeared in a grammar-school reader published in 1857. McGuffey's *New Sixth Eclectic Reader* (Anonymous 1857) included among its many stories the tale of "The Eagle's Nest," a spell-binding thriller for young readers set in the mountains of far-off Scotland (Fig. 1). One can only imagine the impact that a story in which a young girl is carried off by an eagle, and thereafter laid in a bloody and bone-strewn nest in front of an eaglet, only to be rescued by her mother at the last minute, must have had on decades of American school children. Although the species in question was a Golden Eagle (*Aquila chrysaetos*) rather than a Bald Eagle, the conservation status of both suffered for decades, as year after year, hundreds of thousands of children "learned" just how cruel eagles really were. An early film by Thomas Edison, whose special effects graphically portrayed a variation on this theme, certainly helped fan the flames of such fears (Fig. 2).

Unfortunately, many turn-of-the-century conservationists did little to assuage these concerns. The popular natural-history writer Neltje Blanchan, for example, suggested that whereas "*scientists raise their eyebrows at tales of children being borne away by eagles… it would seem that some rare instances* [of baby snatching by eagles] *are well authenticated*" (Blanchan 1898). In 1921, the best that then National Association of Audubon Societies President T. Gilbert Pearson could offer was to suggest that such instances were improbable, if only because "*babies* [that were] *small enough to be carried by an eagle* [were] *not usually left unguarded in* [such] *situations*" (Pearson 1921). As a result of these and other stories, Pennsylvania's State Ornithologist, George Miksch Sutton, writing in *The Auk* in 1929, felt it necessary to remind "*bird-lovers*" that "*even today the eagle which carries off babies has not been forgotten...*" (Sutton 1929). As late as 1938, the Associated Press reported as fact an incident in which two Bald Eagles tried to carry off a three-year-old Maryland toddler, and that the event was forestalled only because one of the birds had been shot by a passerby and the other driven off. The reported "fact" that the dead bird weighed in at 50 pounds, or about four times the actual mass of a Bald Eagle (Buehler 2000), clearly demolishes the veracity of the report. That a leading news service was willing to carry this story, however, hints at its lasting impact.

Given such sentiments, it is not surprising that despite reported declines throughout much of its range in early-20th-century North America, the Bald Eagle remained unprotected in 24 of the United States as late as 1935 (May 1935). It was in the then territory of Alaska that the species was most heavily persecuted, at least in absolute terms. Between 1917 and 1952, Alaska paid 50-cent to two-dollar bounties on more than 128,000 Bald Eagles—an average daily take of 10 birds, each and every day, for 35 years. The birds were shot for many reasons, probably most often because

Fig. 1. Illustration from *McGuffey's New Sixth Eclectic Reader*, a grammar-school reading text published in 1857 (Anonymous 1857) depicting a young girl being carried by a Golden Eagle (*Aquila chrysaetos*) to its nest. The impact of this image on young readers was probably significant. (Photo: Hawk Mountain Sanctuary Archives.)

Fig. 2. Still photograph from an early film by Thomas Edison whose "special effects" included an eagle carrying off a baby. (Photo: Hawk Mountain Sanctuary Archives.)

they were considered threats to the salmon (Salmonidae) industry (Beans 1996). Alaska, however, was not the only place where eagles were shot in large numbers at the time. Charles Broley, a retired bank manager from Winnipeg, Manitoba, began banding Bald Eagles in central Florida in the late 1930s and continued to do so into the late 1940s. Forty-eight of the more than 800 nestling eagles that Broley banded were later recovered. More than half had been shot or otherwise killed by humans (Broley 1952). Shooting—some of it from airplanes—was just one way that Bald Eagles were dispatched by humans. In the 1920s and 1930s, poultry farmers in southern New Jersey regularly cut potential nest trees for eagles whenever they happened upon them (Stone 1937).

As Bald Eagle numbers continued to decline in the early 1900s, public sentiment for the species began to grow. The Bald Eagle Protection Act first introduced in Congress in 1930 was enacted 10 years later. With several specific and notable exceptions, the new law made it a crime—with penalties including both fines and imprisonment—to take Bald Eagles or their eggs or nests (Bean 1983). The Act, which at first excluded the territory of Alaska from its provisions, was amended in 1959—the year Alaska gained statehood—to include that jurisdiction. The Act was again amended in 1962 to extend protection to the Golden Eagle because of the latter's resemblance to juvenile Bald Eagles. One exception in the Act that remains in force even today permits eagles to be taken for "*the protection of wildlife or of agricultural or other interests at a particular locality*" (Bean 1983). The Act also allows the Secretary of the Department of the Interior to issue permits for take for several other reasons, most notably for religious and cultural purposes by native Americans. Regulations authorizing some forms of take allowed by the Act have not been promulgated, but that may change upon de-listing from the Endangered Species Act.

The Bald Eagle Protection Act, together with bans on the widespread use of DDT in 1972, enabled the species to undergo a remarkable comeback beginning in the late 1970s that continues today. Although the Bald Eagle remained listed as federally "threatened" in the contiguous 48 states (the species does not occur in Hawaii) in early 2007, most populations were stable or increasing.

"Good" versus "bad" hawks.—Most hawks were totally unprotected in the United States and Canada throughout the 18th and 19th centuries. By the mid-1930s a hodgepodge of state laws protected some species, particularly vultures and Ospreys (*Pandion haliaetus*), in some states, whereas no protections were afforded in others. In states that protected some but not all species, Sharp-shinned Hawks (*Accipiter striatus*), Cooper's Hawks (*A. cooperii*), Northern Goshawks (*A. gentilis*), and, to a lesser extent, Merlins (*Falco columbarius*) and Peregrine Falcons (*F. peregrinus*), typically were singled out as unprotected (May 1935), as were Great Horned Owls (*Bubo virginianus*) among nocturnal raptors. At the federal level, except for the two eagles mentioned above and the Peregrine Falcon in 1970 (Cade 2003), raptors remained unprotected in the United States until March 1972, when the Migratory Bird Treaty Act with Mexico at last was amended and ratified to include them (Senner 1984).

Raptor persecution, which had been largely episodic and unorganized throughout most of the 18th and early 19th centuries, increased substantially in the decades following the American Civil War as the availability of breech-loading guns increased small-game hunting, and as human populations continued their spread across much of North America. As animosity for raptors grew, organized persecution reached a fever pitch in Pennsylvania, with local newspapers reporting that the overwhelming majority of rural residents considered raptors highly injurious. In response to such feelings, the Pennsylvania state General Assembly enacted the so-called "Scalp Act of 1885," which placed a 50-cent bounty on the "head" of all birds of prey except for Northern Saw-whet Owls (*Aegolius acadicus*), Eastern Screech Owls (*Megascops asio*), and Barn Owls (*Tyto alba*). Pennsylvania's general public, 90% of which supported the Act, overwhelmingly embraced it. Within two years, the Commonwealth had paid bounties on 180,000 birds of prey. Fraudulent claims were common, and funding for the program was quickly exhausted. One estimate suggested that chicken farmers saved about one dollar for each $1,205 paid in bounties (Hornaday 1913). Increased populations of rodents and insects also sapped public support for the program, and the legislature repealed what by then was being characterized by many, including the state veterinarian and author of *Diseases and Enemies of Poultry*, as unjust, uneconomic, foolish, and simply wrongheaded (Pearson 1897, Hornaday 1914).

When, at the behest of so-called "sportsmen," bounties on predators were reinstated in Pennsylvania in 1913, only the three species of accipiters were included. Although fraudulent claims continued to inflate the numbers of raptors killed for bounty—one individual, for example, swore to have killed 102 Northern Goshawks in just four days of summertime culling—Pennsylvania Game Commission employees alone were said to have killed more than 600 hawks in 1921, and to have destroyed dozens of nests (Kosak 1995). Presumably, state workers focused their efforts entirely on bountied species.

Predator control, and raptor conservation in turn, took something of a small step forward in 1893 with the publication of A. K. Fisher's *The Hawks and Owls of the United States in Their Relation to Agriculture* (Fisher 1893). Having evaluated food habits of 73 species by examining the contents of their digestive tracts, Fisher concluded that only six species of hawks and owls were, in fact, "injurious" to agriculture. Unfortunately Fisher's work did little to protect species such as Sharp-shinned Hawks and Cooper's Hawks and may have served to confirm the worst fears of proponents of predator control by demonstrating the problem "scientifically."

The notion that some raptors were beneficial, and as such were "good" hawks, whereas others were destructive, and as such were "bad" hawks, and that the "goodness" of a species could disappear with an increase in its abundance, reflects the pervasive "single-species" management mindset of the late 1800s and early 1900s, when the majority of mainstream bird conservationists and wildlife managers converged on largely indiscriminant predator control in which "bad" species were targeted for destruction in an attempt to control nature (Hornaday 1914, 1931; Worster 1977; but see Leopold 1933, Errington 1946). As expected, bird conservationists focused principally on protecting "*valuable wild* [song] *birds*," whereas farmers and hunters focused on protecting poultry and game birds. Only a handful of so-called "sentimentalists" (Holt 1926) rallied in support of all raptors, regardless of the prey taken. One was Warren F. Eaton, founder of the Hawk and Owl Society (Anonymous 1933a); another was Rosalie Barrow Edge, creator of Hawk Mountain Sanctuary (Edge 1936, Broun 1949).

Although Eaton and Edge championed the plight of birds of prey, the general conservation stature and treatment of common bird-eating hawks and falcons in the first three decades of the 20th century is best reflected in the words of those closer to the "center" of natural-resource conservation at the time.

The following is from John Muir's autobiography, published in 1913:

> "*When I went to the stable to feed the horses, I noticed a big white-breasted hawk* [most likely a Northern Goshawk or Red-tailed Hawk (*Buteo jamaicensis*)] *on a tall oak tree in front of our chicken house, evidently waiting for a chicken breakfast… I ran to the house for a gun, and when I fired, he fell… then managed to stand erect. I fired again to put him out of pain. He flew off… but then died suddenly in the air, and dropped like a stone.*"

Although the episode that Muir refers to took place in the 1850s when he was still a young Wisconsin farm boy, the founder of the Sierra Club expressed absolutely no remorse (other than finishing off the culprit in short order) when recalling the event more than 50 years later (Muir 1913).

And John Muir was not alone in his thoughts concerning "*chicken hawks*." William T. Hornaday, the eventual founder of the Permanent Wild Life Protection Fund, had this to say on the subject in the widely read *Our Vanishing Wild Life*:

> "*… 'chicken hawk or hen hawk' are usually applied to the* [Red-shouldered (*Buteo lineatus*)] *or the* [Red-tailed Hawk] *species. Neither of these is really very destructive to poultry, but both are very destructive to mice, rats and other pestiferous creatures…. Neither of them should be destroyed—not even though they do once in a great while, take a chicken or wild bird, however* [t]*here are several species of birds that may at once be put under the sentence of death for their destructiveness of useful birds, without any extenuating circumstances worth mentioning. Four of these are Cooper's Hawk, the Sharp-shinned Hawk, Pigeon Hawk* [i.e., Merlin] *and Duck Hawk* [i.e., Peregrine Falcon]." (Hornaday 1913)

The Peregrine Falcon, in particular, drew Hornaday's ire. "*Each bird of this species deserves treatment with a choke-bore gun. First shoot the male and female, then collect the nest, the young or the eggs, whichever may be present. They all look best in collections*" (Hornaday 1914).

Like many at the time, Hornaday drew his distinctions in both moral and utilitarian tones: "*The ethics of men and animals are thoroughly comparative…. Guilty animals, therefore, must be brought to justice*"

(Hornaday 1922). The National Association of Audubon Societies spoke similarly, and it was not until wildlife biologist Aldo Leopold joined the Association's board in 1935 that things began to change within that organization. "*When we attempt to say an animal is 'useful,' 'ugly,' or 'cruel,'*" Leopold wrote, "*we are failing to see it as part of the land. We do not make the same error of calling a carburetor 'greedy.' We see it as part of a functioning motor*" (Leopold 1949).

By 1931, William T. Hornaday had dropped the Merlin from his list of "*bad*" hawks, presumably because of its increased rarity. He did, however, retain the others, together with the Great Horned Owl, Barred Owl (*Strix varia*), and, amazingly enough, the diminutive Eastern Screech-Owl. Moreover, although Hornaday was quick to caution against killing other species by mistake, the lack of decent field guides at the time meant that most shooters, including the majority of "experienced" birdwatchers, were ill equipped to make the necessary distinctions.

Leading conservationists were not the only group that thought this way about birds of prey. The scientific and birdwatching communities of the era also carefully selected the raptors they were concerned about. Widely respected ornithologist and renowned bird artist Louis Agassiz Fuertes had this to say in the ever-popular *National Geographic Magazine* in 1920: "*The whole genus* Accipiter, *consisting of* [Northern] *Goshawk, Cooper's Hawk, and Sharp-shinned Hawk, are savage, bloodthirsty, and cold-hearted slaughterers, and are responsible in large measure for the anathema that is portion to all hawks*" (Fuertes 1920). Pennsylvania's official State Ornithologist, George Miksch Sutton, remarked in his *Introduction to the Birds of Pennsylvania* (1928a) that "[t]*he sharpshin is the enemy of all small birds...*[and it] *and* [the] *Cooper's Hawk, both bird killers, are fairly common and are rated as our most objectionable birds of prey.... They are not protected in Pennsylvania.*" Similar condemnations appeared in numerous state accounts of the era, including these from *The Raptorial Birds of Iowa* (Bailey 1918):

> "*These destructive little hawks* [sharpshins] *are common to all parts of the state...; Cooper's Hawk is without doubt the most destructive of our residential birds of prey.... Its dash and daring in securing poultry and game are well known....*"

and

> "*The evidence in hand shows that* [the Northern Goshawk] *is the most destructive of Iowa hawks, and that it would be a matter of serious concern if these birds should become as common every winter as they have been during the past season* [1916]."

The shooting and trapping that resulted from this line of reasoning were especially prominent along traditional migration corridors and at well-established migration bottlenecks. Premiere shooting galleries in the late 1920s and early 1930s included Cape May Point, in coastal southern New Jersey, where recent prohibitions on shooting Northern Flickers (*Colaptes auratus*) refocused shooting efforts on migrating accipiters. At Hawk Mountain, in the central Appalachians of eastern Pennsylvania, a $5 bounty on Northern Goshawks fostered a "shoot-first-and-ask-questions-later" mentality (Bildstein 2001). In places where migratory movements failed to concentrate birds, other measures were taken. Alabama's Conservation Commission, for example, promulgated a special "hawk-killing week" as well as broader anti-vermin campaigns, in which it attempted to enlist the support of sporting-goods houses and conservation clubs who, in press releases, were asked to "*put up prizes or awards to be given to individuals and clubs for work accomplished in the destruction of vermin*" (Holt 1926). The State of Virginia had similar campaigns (McAtee 1926).

Poultry-, game-, and bird-eating hawks, in particular, were heavily persecuted in early-20th-century North America. Compounding the problem was the fact that many shooters were often unable or unwilling to distinguish the "bad" or destructive hawks from the "good" or "beneficial hawks," putting all birds of prey at risk (Broun 1949, Kosak 1995). The impact of the shooting, which occurred outside the gaze of mainstream conservation, was relatively little studied at the time, save at raptor conservation hotspots such as Hawk Mountain and Cape May Point, where thousands of hawks, eagles, and falcons were being shot annually (Sutton 1928b, Allen and Peterson 1936). The overall impact of the onslaught appears to have been significant. Banding recoveries of Cooper's Hawks, for example, indicate that first-year mortality from shooting ranged from 28% to 47% in 1929–1940, and from 12% to 21% in 1946–1957 (Henny and Wight 1972).

The tide against "bad" hawks began to turn, albeit incrementally, in the late 1920s, as indiscriminant shooting began to reduce the distributions and abundances of both targeted and non-targeted raptors. Writing in *The Auk* in 1926, Henry R. Carey pointed to the "*marked absence*" of hawk records in a recent issue of *Bird Lore* (the predecessor to *North American Birds*) as evidence of successful extermination campaigns and suggested that all states pass laws prohibiting hawk shooting except when an individual bird was "*caught in the act of attacking domestic fowl or game birds on private reservations*" (Carey 1926). The U.S. Biological Survey's Waldo Lee McAtee amplified Carey's comments in a second General Note in *The Auk* later in 1926 (McAtee 1926). Carey and McAtee's comments, although lauded by many, sparked much debate in the ornithological community, including this response from Ernest G. Holt, who feared for his collecting rights:

> "*Some conservationists are so blinded by sentimentalism that they become as extreme as the* [shooters], *and would absolutely prohibit all bird shooting, even for the purposes of scientific investigation…* [consequently] *between sentimentalists and* [shooters] *we seem to be placed as 'between the devil and the deep blue sea,' for one would stop our collecting by process of law, while the other would leave us with nothing to collect.*" (Holt 1926)

Witmer Stone's editorial in *The Auk* in 1930 summarized the so-called "hawk question" from the standpoint of the American Ornithologists' Union:

> "*Unless drastic measures are taken at once our hawk and eagle population will be a thing of the past: exterminated because some hawks interfere with the raising of game birds for sportsmen to kill; and because some eagles may occasionally kill lambs. While some hawks must be controlled—i.e., shot if actually engaged in killing young chickens or game birds; it is of the utmost of importance that they not be exterminated.*" (Stone 1930)

The 10-page editorial, which went on to urge passage of a Bald Eagle Protection Act, as well as the protection of all species of hawks excepting those "*in the act of destroying game or poultry,*" closed with "*Do not write to* The Auk *about* [the hawk question] *but make your appeal where it will reach those who do not know about the facts,*" effectively shutting the door to additional comments on the subject at least in that journal.

Despite the position of the American Ornithologists' Union, many in the conservation community continued to heap coals on the burning debate well into the 1930s. Writing in the National Association of Audubon Societies' *The Hawks of North America: Their Field Identification and Feeding Habitats*, John Bichard May characterized the Northern Goshawk as "*at times… persistent and destructive about poultry farms and game rearing establishments,* [and at such times] *control measures may be necessary,*" the Sharp-shinned Hawk as "*one of the most persecuted of our hawks, due to its habit of feeding upon small birds,*" and the Cooper's Hawk as "*when common… extremely destructive to small birds, young poultry, and game birds*" (May 1935). Although the same volume expressed the National Association of Audubon Societies' official policy as opposing the "*extermination of any species of bird,*" advocating "*under all conditions*" the protection "*of rare hawks… and of all beneficial hawks and owls*" and condemning bounties and pole traps, it also specifically limited its advocated "*protection, under all circumstances*" "[to] *rare hawks, such as the Duck Hawk* [Peregrine Falcon], *and… beneficial hawks and owls, such as the Broad-winged Hawk* [*Buteo platypterus*] *and the Barn Owl,*" and indicated that it did not oppose the killing of "*individual* [hawks and owls] *known to be damaging property*" (May 1935).

In 1936, the ninth edition of Mabel Osgood Wright's widely read *Birdcraft* was still referring to the Cooper's Hawk as a "*Chicken Hawk*" and characterizing it as a "*mischievous harrier of all birds*." It also continued to suggest that one could help songbirds by "*shooting some of their enemies*," including "*one of two* [species of] *hawks and owls*" (Wright 1936). In 1933, George E. Hix, a scoutmaster from Brooklyn, New York, writing in *Birds of Prey for Boy Scouts*, noted that "*the beneficial hawks are the larger, slower species*, [and] *the smaller swifter hawks are the ones which are destructive to wildlife…* [and these include] *the* [Northern] *Goshawk, Cooper's, Sharp-shinned, and Pigeon hawks* [Merlin]" (Hix 1933).

Two events in the early 1930s hastened the rate at which all birds of prey came to be protected. The first was the founding of the Hawk and Owl Society by Warren F. Eaton and others in 1932 (Anonymous 1933a). The second was the creation of Hawk Mountain Sanctuary, the world's first refuge for birds of prey (Broun 1949, Bildstein and Compton 2000).

The Hawk and Owl Society, in cooperation with the National Association of Audubon Societies, published a series of five newsletter-like "Bulletins" and "Annual Reports" during its brief existence from 1932 through 1935 (Fig. 3). The Society, which opposed bounties and the use of pole traps and poisons for controlling raptors, believed that "*economically beneficial or harmless hawks should receive legal protection*," that "*generally harmful* [species] *should be controlled in any particular situation only after thorough and impartial study*," and that "*no species should be exterminated or extirpated from any part of its habitat*" (Anonymous 1933b). Although the Society had ceased to exist by the late 1930s, its influential newsletters helped move the mainstream conservation community in the direction of a more robust form of raptor protection.

Hawk Mountain Sanctuary was established in the summer of 1934 by Rosalie Barrow Edge, the founder and head of the Emergency Conservation Committee. Edge founded the refuge after hearing photographer Richard Pough speak about the slaughter of raptors there at a joint meeting of the Hawk and Owl, Linnaean, and National Association of Audubon societies at the American Museum of Natural History in New York City the previous October. Unlike the Hawk and Owl Society, Hawk Mountain Sanctuary favored the protection of all birds of prey, "common" and "uncommon," "beneficial" and "bad," in an adamant and unmitigated fashion, and in doing so treaded into unknown territory.

In August of 1934, Mrs. Edge hired Maurice Broun as "ornithologist-in-charge" of the new refuge. Broun, who had acquired his first pair of real binoculars in May of that year, spent most of September posting

Annual Report

OF

The Hawk and Owl Society

BULLETIN No. 4

JUNE 1934

HAWKS KILLED AT DREHERSVILLE, PENNA., ON "HAWK MOUNTAIN". SHOWING ARCHIE E. SMITH, PENNSYLVANIA STATE GAME PROTECTOR.
[It is this sort of wholesale killing the Hawk and Owl Society wants to stop.]

Fig. 3. The cover of the Annual Report of the Hawk and Owl Society, published in 1934. The Society, which existed as a cooperator with the National Association of Audubon Societies for several years in the mid-1930s, helped move raptor conservation closer to "mainstream" bird conservation.

the Sanctuary's boundaries and on 30 September began counting migrating raptors from what he then called Observation Rocks, a job he would continue to enjoy for the next 32 years. Although local opposition to a refuge for birds of prey was intense—after all, Hawk Mountain was the best place in all of Pennsylvania to shoot the then state-bountied Northern Goshawk—news of the new sanctuary spread quickly among the birding community, and an estimated 1,250 enthusiasts flocked to the "Mountain" during its second year of operation. By the late 1940s to early 1950s, tens of thousands were visiting the site (Fig. 4), and in recent years as many as 60,000 people, including thousands of school children, watch the flight each autumn.

By the mid-1930s, the activities of the Hawk and Owl Society and Hawk Mountain Sanctuary helped foster a newfound appreciation for all birds of prey in mainstream conservation, and this, in turn, energized the community to act on behalf of the birds. Consequently, whereas in 1899 only five of the United States protected some raptors, 42 states did so in 1949 and, by 1963, all birds of prey were protected in 19 states and only four states were protecting none (Phillips 1949, Jahn et al. 1963, Clement 1965). Although several states were quick to pass bills protecting beneficial birds of prey and, subsequently, all raptors, other states, including Pennsylvania, were slower to respond. Although the Pennsylvania Game Commission's own biologists were calling into question the usefulness of "vermin" bounties in game management as early as 1937 (Gerstell 1937, Latham 1950), Pennsylvania retained a $5 bounty on Northern Goshawks until 1951 (Fig. 5), and one on Great Horned Owls until 1965. Indeed, the act that removed the bounty on the goshawk in 1951 specifically left all three "bird-killing" accipiters unprotected. As a result, dozens of shooting blinds remained along the Kittatinny Ridge migration corridor in eastern Pennsylvania well into the mid-1950s, where estimates from the era suggested that as many as 1,500 hawks, many of them "protected" *Buteo*s, were killed on single favorable days (Broun 1956). The situation would not be remedied completely until 1970, when state-wide, year-round protection was extended to include these three species (Senner 1984, Kosak 1995). The Great Horned Owl would remain unprotected until covered by federal law in 1972.

Notwithstanding Pennsylvania and a few other states, most widespread raptor shooting faded into history in mid-20th-century North America as bounties were extinguished and protections were extended to most species across much of the United States. Estimates of first-year shooting mortality in Cooper's Hawks are particularly instructive in this regard (see above; Henny and Wight 1972). Although raptor shooting in North America continues even today, it is largely local and episodic and, for the most part, of little ecological consequence (Bildstein 2001).

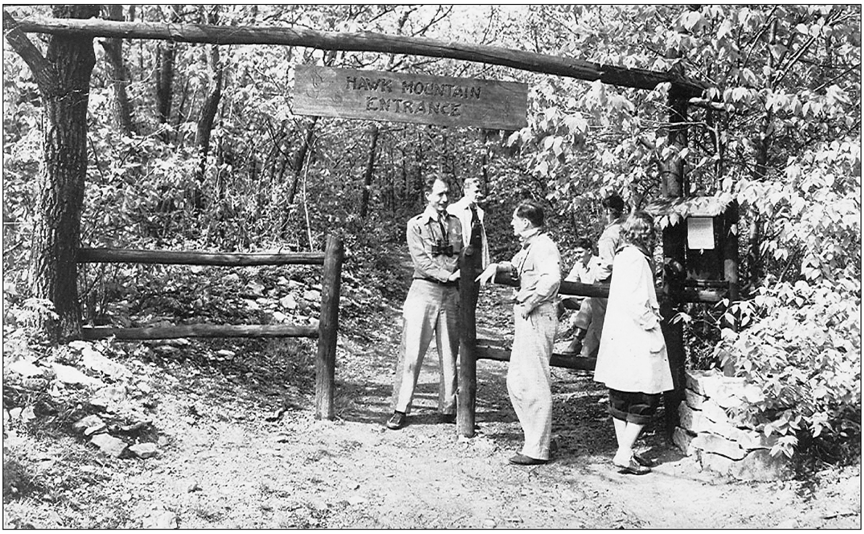

Fig. 4. Photographs from the 1940s depicting visitors at the trailhead to Hawk Mountain (above) and hawkwatching at the Sanctuary's North Lookout (below). Both as science and as recreation, hawkwatching took off on the heels of Hawk Mountain's founding in 1934. Today, in North America alone, more than 100 watchsites routinely count migrating raptors. And more than 100 additional watchsites do so internationally (Zalles and Bildstein 2000). (Photo: Hawk Mountain Sanctuary Archives.)

Fig. 5. Work Progress Administration posters from the late 1930s produced for the Pennsylvania Game Commission as part of the latter's attempts to help hunters separate "good" hawks (e.g., the Duck Hawk (Peregrine Falcon) [*Falco peregrinus*]) from "bad" hawks (e.g., the Goshawk (Northern Goshawk) [*Accipiter gentilis*]). Note that the "bad" goshawk is specifically labeled "unprotected." (Hawk Mountain Sanctuary Archives.)

The DDT Era

As the threat of large-scale shooting began to fade in the 1940s, another important human threat to raptors began to take hold: the misuse of second-generation agricultural organchlorine biocides. Inexpensive, broad-spectrum, and long-lasting, these manufactured organic biocides were far less toxic to vertebrates than the inorganic biocides they replaced. The best known of the modern biocides, DDT (dichloro-diphenyl-trichloroethane), was so warmly received that it earned its developer and principal proponent, Paul Muller, a Nobel Prize in Physiology or Medicine in 1948. Heralded as a 20th-century "wonder chemical," the widespread and often indiscriminant use of this new agricultural chemical and other organochlorines began to raise alarms among conservationists as early as the late 1940s (Gabrielson et al. 1950). Nevertheless, these modern weapons in the fight against agricultural pests quickly became the insecticidal agents of choice in the 1950s and 1960s. Their unintended effects on North American raptors are detailed below.

The so-called DDT Era began in earnest in North America at the end the Second World War, when DDT and a few related organochlorine compounds came into widespread use in agriculture and the control of insect vectors of human disease. It ended in the early 1970s when the governments of Canada and the United States banned most widespread use of DDT. A second main type of organochlorine compounds, the cyclodiene biocides, which included aldrin, dieldrin, and heptachlor, also came into use during this era. Both types of organochlorines are neurotoxins. DDT and closely related compounds act mainly on sodium channels, prolonging action potentials and disrupting nerve impulses; cyclodienes act on so-called GABA, or inhibitory receptors, and lead to convulsions (Walker 2004).

Although warnings about DDT's impacts on bird populations date from the mid-1940s (Hotchkiss and Pough 1946, Gabrielson et al. 1950), it was not until the mid- to late 1950s that organochlorine pesticide impacts on raptors received serious attention (e.g., Broley 1958). Unfortunately, by that time, populations of many North American birds of prey were already in free fall (Hickey 1969). Species that fed in aquatic environments, where pesticide runoff tends to accumulate, and those that fed at higher trophic levels, where biological magnification plays a role in increasing exposure to these environmental contaminants, were particularly affected (Henny and Wight 1972).

Rachel Carson's bestseller, *Silent Spring*, placed the "pesticide problem" in the minds of most Americans in the early 1960s (Carson 1962), and in 1965 a group of concerned scientists and raptorphiles met in Madison, Wisconsin, to discuss the demise of eastern populations of Peregrine Falcons (Hickey 1969). The scientists at the meeting focused on the growing misuse of the modern synthetic biocides in agriculture and the ability of these chemicals to be magnified biologically in organisms along food chains. High levels of biocides in wild Peregrine Falcons suggested a link, and recent evidence of eggshell breakage at peregrine eyries in England (Ratcliffe 1958) suggested a mechanism for the declines.

Things happened quickly after this watershed meeting (Cade et al. 1988, Cade and Burnham 2003). Derek Ratcliffe published a benchmark analysis that clearly established the coincidental timing of widespread DDT misuse and eggshell thinning in English Peregrine Falcons (Ratcliffe 1967). Two years later, controlled experimental studies involving American Kestrels (*Falco sparverius*) demonstrated the cause-and-effect relationship between the two (Porter and Wiemeyer 1969, Wiemeyer and Porter 1969). With this new information in hand, Canada and the United States banned the widespread use of DDT in the early 1970s (Bildstein 2006). In most cases, the bans led to reductions in contaminant levels and a reversal in eggshell thinning. By the mid-1980s, many species of raptors were recovering from pesticide-era lows (Cade et al. 1988, Bednarz et al. 1990, Bildstein 1998, Cade and Burnham 2003). The widespread use of many cyclodienes, which had been linked to secondary poisoning in raptors in Britain (Walker 2004) was banned soon thereafter.

New and additional contaminant threats.—Unfortunately, the biocides that replaced organochlorine pesticides created their own set of problems for birds of prey (Henny and Elliott 2007). Organophosphate pesticides, which include parathion, monocrotophos, famphur, and fenthion, came into use in the 1960s and 1970s in response to concerns regarding the persistent nature of organochlorine pesticides, as well as to declines in the effectiveness of the latter as insect pests adapted to them. Although far less persistent than the organochlorine pesticides they replaced, organophosphates kill insects by inhibiting cholinesterase, a neurotransmitter common to the nervous system of both insects and vertebrates. Developed as part of nerve-gas research in the 1940s, these so-called safe replacements are 10 to 100 times as toxic to vertebrates, including raptors, as are organochlorines. Carbamates, a second popular class of organochlorine replacements, share many of the same properties, including anticholinesterase action. Because both classes of biocides are absorbed through the skin and lungs, as well as through the digestive tract, contact with them sometimes poses a considerable threat to birds of prey.

Perhaps the best-known example of the extent to which organophosphates have affected populations of North American raptors involves the highly migratory Swainson's Hawk (*Buteo swainsoni*). While on their wintering grounds in 1995–1996, 6,000 to 20,000 Swainson's Hawks were killed by the organophosphates monocrotophos and dimethoate. First-hand accounts indicated that the birds died immediately after being sprayed by the biocides while hunting grasshoppers (Orthopterans) in agricultural fields (England et al. 1997, Goldstein et al. 1999). Although the problem appears to have been solved in parts of Argentina (Goldstein et al. 1999), these pesticides continue to be used elsewhere in Latin America.

In addition to biocides directed at insects, North American populations of raptors also continue to be threatened by environmental contaminants used to control rodent and bird populations in agricultural and urban landscapes (Henny and Elliott 2007). The risk is potentially greatest for species that prey on poisoned rodents and birds, as well as for species that scavenge the carcasses of such "pest" species. The indiscriminant use of rotenone and other "piscicides" poses a potential threat to raptors that prey upon fishes through the loss of local food resources. PCBs, PBDEs (flame retardants), and other persistent organic pollutants, as well as sulfonated perfluorochemicals used in the manufacture of Teflon and Scotchgard, appear in raptor eggs and may be a concern to some populations of North American raptors (Henny and Elliot 2007).

Finally, heavy metals, including lead, continue to threaten many species of birds of prey, particularly those that scavenge some or all of their food (Hunt et al. 2006). Lead poisoning is especially problematic where lead bullets and pellets are used in sport and subsistence hunting. In North America, many raptors, including Bald Eagles, Golden Eagles, and Peregrine Falcons, have been diagnosed with lead poisoning (McBride et al. 2004), and lead has been linked to the initial demise and limited recovery of the California Condor (*Gymnogyps californianus*; Snyder and Schmitt 2002). In addition, researchers have suggested that growing urban populations of Sharp-shinned Hawks and Merlins, too, may be at risk from lead as a result of their selectively feeding on contaminated urban House Sparrows (*Passer domesticus*; Chandler et al. 2004). The historical use of lead in gasoline, its past and current use in sport and subsistence hunting, and the increased urbanization of several species of raptors and their potential exposure to localized urban sources of lead (McBride et al. 2004, Hunt et al. 2006) suggest that lead poisoning is likely to threaten raptors for some time. Bald Eagles figured heavily in the ban on the use of lead shot in waterfowl hunting in 1991 (cf. Feierabend and Myers 1984). Although lead poisoning of Bald Eagles did not decline following this ban (Kramer and Redig 1997), the use of birds of prey in bringing about the change suggests a potentially important role for raptors in eliminating the widespread use of lead for other purposes as well.

Given the rate at which new and inadequately tested chemicals continue to appear in the marketplace, environmental contaminants are likely to continue to threaten at least some populations of North American raptors for some time. Henny and Elliott (2007) provide a useful and well-referenced overview of these threats.

Land-use Change

Human-induced land-use change has had, and continues to have, an enormous impact on the conservation status of North American birds of prey. Although the full impact of land-use change on the continent's raptors will never be known, as much of it happened prior to conservation interest in raptors, there is ample evidence that human actions, particularly agricultural and forestry practices, limited populations of birds of prey in many parts of North America throughout much of the 19th and 20th centuries. Although many of the impacts were straightforward (e.g., loss of nest sites for obligate tree-nesting species when forests were cut; loss of feeding areas for insectivorous species when grasslands were plowed and planted in row crops), many acted synergistically with other human threats, including environmental contaminants and direct persecution. What follows is a sample of the many ways in which widespread land-use change has affected North American raptors.

Deforestation.—Estimates suggest that 45% of the coterminous United States was originally forested and that 80% of this original forest cover was east of the Great Plains. By 1920, agricultural clearing, lumbering, and other human impacts had reduced the original forest to less than 10% of what it had been at the time of European settlement (Williams 1989). Raptors that depend on forests, either for feeding areas or the nest sites they provide, or for both, most certainly were affected by this extensive forest loss. Widespread cutting of forest coincidentally combined with the increased human persecution of many obligate tree-nesting species—including, most notably, North America's three accipiters—placed many of these birds within a "conservation vice." The only safe place to nest during the period of intense human persecution was in large forests away from human activity, but this habitat type was shrinking rapidly as forests were being cut for forestry and agriculture. The fact that Sharp-shinned Hawks and Cooper's Hawks are now nesting increasingly in human-dominated, wooded landscapes, including many suburban and urban areas (Rosenfield and Bielefeldt 1993, Boal and Mannan 1999, Coleman et al. 2002), indicates the extent to which the impact of land-use change on raptors depends not only on changes in vegetative cover but also on ongoing human attitudes toward birds of prey. That said, populations of raptors that are associated with so-called "old-growth" forest (e.g., Spotted Owls [*Strix occidentalis*]; Gutiérrez et al. 1995) may remain particularly vulnerable to vegetative change regardless of human attitudes. Bird et al. (1996) provide additional examples of the extent to which North American raptors have taken advantage of human-dominated landscapes when they are no longer heavily persecuted.

Other land-use changes.—The construction of numerous impounded reservoirs and the new aquatic habitats they have created throughout non-glaciated North America have provided new breeding and feeding areas for piscivorous raptors, including Ospreys and Bald Eagles. In South Carolina, for example, Bald Eagles colonized major reservoirs completed in the 1940s as ecological succession proceeded at the sites and fish and waterbird communities developed there (Bryan et al. 1996), and the same is true elsewhere. On the other hand, Bald Eagle use of the Flathead catchment region in and around Glacier National Park in northwestern Montana, as a wintering feeding site, which grew from 37 individuals in 1935 to more than 600 in 1981, collapsed precipitously to 25 birds in 1989 when the numbers of land-locked Kokanee salmon (*Oncorhynchus nerka*) at the site crashed in response to competition from introduced opossum shrimp (*Mysis relicta*; Spencer et al. 1991, McClelland et al. 1994). The ephemeral nature of this important winter feeding area for migratory Bald Eagles exemplifies the potential impact of even apparently innocuous human actions on populations of North American birds of prey.

An additional example of the extent to which seemingly inconsequential human actions affecting "land use" can influence populations of migratory raptors involves the Sharp-shinned Hawk. Having rebounded from pesticide-era lows of the mid-20th century, this species began to show evidence of declines in the northeastern United States in the 1980s. The so-called sharpshin "decline" was deduced from a drop in numbers of migrating Sharp-shinned Hawks at numerous migration watchsites in the Northeast. At first, the drop was explained simply as evidence that the species had reached its natural carrying capacity following a period of explosive post-pesticide-era growth in the 1970s. As the decline in numbers continued into the early 1990s, more nefarious explanations began to take root, including pesticide misuse, acid precipitation, and tropical-deforestation-associated decreases in the species' Neotropical songbird prey-base. In the end, none of these explanations proved correct. Rather than reflecting a shift in population numbers, the drop in the number of Sharp-shinned Hawks seen at migration watchsites reflected a shift in the species' migration behavior brought about by increased numbers of backyard bird feeders. By attracting numerous songbirds, the proliferation of feeders was short-stopping migrating Sharp-shinned Hawk north of their traditional wintering grounds, thereby reducing their numbers at the migration watchsites (Duncan 1996, Viverette et al. 1996, Bildstein 2006). That backyard bird feeders could change the migratory behavior and overwinter distribution of one of North America's most prominent partial migrants indicates the extent to which even small shifts in land-use patterns can affect North American birds of prey.

Land use on southern wintering grounds.—Each autumn, as many as 10 million of North America's raptors travel between breeding areas in the United States and Canada and wintering grounds in Mexico and Central and South America. The flight, which in Mesoamerica is made up of 32 species of North and Central American raptors, is dominated by hundreds of thousands to millions of Turkey Vultures (*Cathartes aura*), Mississippi Kites (*Ictinia mississippiensis*), Broad-winged Hawks, and Swainson's Hawks, and by lesser numbers of Ospreys, Swallow-tailed Kites (*Elanus forficatus*), Northern Harriers (*Circus cyaneus*), Sharp-shinned Hawks, Cooper's Hawks, American Kestrels, Merlins, and Peregrine Falcons, among others (Bildstein and Zalles 2001). Although few of these birds overwinter in the region's rapidly disappearing old-growth forest (Bildstein 2004), all of them face different land-use practices and rates of land-use change while wintering in Latin America, and the plight of overwintering Swainson's Hawks mentioned above is just one of the many threats faced by these birds. Unfortunately, studies of

North American migrants in Latin America, and the monitoring of their conservation status there, appears to have fallen from the "radar screen" of most raptor conservationists, leaving a critical gap in North American raptor-conservation efforts. The recent establishment of several full-season raptor-migration counts in Latin America (Bildstein 2006) offers the potential of narrowing this gap, especially if these sites were to begin monitoring the movements of return migrants in spring as well as those of outbound migrants in autumn.

Creation and distribution of electrical energy.—One human activity that has been problematic for raptors in North America and that continues to be so is the generation and distribution of electrical energy. Large raptors, including Ospreys, large hawks, and eagles, are particularly vulnerable to electrocution because their wing spans allow them to contact conducting and ground wires simultaneously (Harness 2007). Although some utility companies have redesigned and retrofitted powerlines to reduce the threat of electrocution (APLIC 2006), many have not. Deregulation of the power industry in the United States, and an increased focus on cost-cutting practices, suggests that this problem will be around for a long time (Bildstein 2006).

The generation of electricity at wind facilities threatens raptors in two ways, first via collisions with the turbines themselves, and second via habitat disturbance brought about by construction and maintenance. Although the peer-reviewed literature concerning this threat remains small, key factors for reducing these interactions include (1) situating turbines away from high-density raptor populations and known migration corridors, (2) avoiding sites that displace existing populations from important resources, and (3) using on–off cycles to reduce or eliminate collisions during periods of peak vulnerability (Bildstein 2006).

The Future

North American raptor populations have increased substantially during the past 25 years (Bednarz et al. 1990, Bildstein 1998, Hoffman and Smith 2003). In some instances, the increases may have returned populations to levels similar to or greater than those of one hundred years ago. As a result, across most of North America birds of prey are no longer the endangered and ecologically dysfunctional "boutique" predators (i.e., predatory species whose populations are so low that they fail to influence the behavior and ecology of their prey) that they were at the end of the DDT Era in the 1960s and 1970s. Rather, they are decidedly more common and again fully functional predators in many natural and, increasingly, human-dominated landscapes. As such, raptor conservationists are facing many of the same management concerns their predecessors faced at the turn of the last century, when expanding human populations were coming into contact with what were then still-functional populations of birds of prey. Keeping common raptors common in the 21st century may prove as challenging now (see, for example, Garrott et al. 1993) as it was for conservationists in the 1920s and 1930s.

In 1999, for example, the Pennsylvania Game Commission held hearings on a proposal brought forward by its President (Commissioners are appointed by the Governor of Pennsylvania) regarding the need to "experimentally" control Red-tailed Hawks and Great Horned Owls on several state-owned wildlife management areas to increase the survivorship of Ring-necked Pheasants (*Phasianus colchicus*; Riegner 1999). Although a heavily attended public hearing demonstrated widespread opposition to the proposal, which was later withdrawn, letters to several newspapers suggested substantial support for the idea among rural residents (e.g., Riegel 1999).

North American hunters are not the only ones noticing the change in raptor numbers. Birdwatchers, particularly those with backyard birdfeeders, regularly call Hawk Mountain Sanctuary and, I suspect, other nature reserves to express outrage regarding songbird predation by Sharp-shinned Hawks and Cooper's Hawks, both of which are increasingly willing to hunt in suburban and even urban areas, presumably because of reduced human predation there. Although many callers appear somewhat resigned to the situation, particularly when reminded that removing a single hawk from their backyard is as likely to be as ineffective as removing a single gray squirrel (*Sciurus carolinensis*), others suggest that they are willing to "take things into their own hands" should we fail to act (Bildstein 2001).

Whether or not the increased numbers of accipiters in suburban backyards is affecting regional populations of birds overwintering at bird feeders in North America is unknown. Evidence from England, however, indicates that it is not likely (Newton et al. 1997). Regardless of the ecological situation, accipiters once again are becoming the "enemies of all small birds," at least in the minds of some people.

Another increasingly common event that has caught the attention of raptor conservationists is aggressive nest-guarding behavior by several species of raptors breeding in human-dominated landscapes. Although the behavior appears to be more common in some species than in others, Mississippi Kites, in particular, are prone to attacking humans (Gennaro 1988); instances involving Northern Goshawks (several instances in Massachusetts), Cooper's Hawks, Broad-winged Hawks, and Red-shouldered Hawks also have been reported (K. L. Bildstein pers. obs., B. Millsap pers. obs.).

Perhaps the most serious conflict situation, and, to date, the only one that has resulted in a relatively large-scale lethal response, involves Black Vultures (*Coragyps atratus*) and Turkey Vultures in the southeastern

United States. As the numbers of both species have increased in North America (Kiff 2000) in the latter part of the 20th century, so have the numbers of complaints against them (Lowney 1999). Concerns involve livestock and pet depredation, property damage, and threats to human health. In 1994 through 1999, 12 counties in Virginia alone reported Black Vultures killing, injuring, or otherwise harassing pets. Although nonlethal methods, including suspending vulture carcasses and taxidermy effigies, have been used to disperse roosts at communications towers (Avery et al. 2002), in 2002 the U.S. Fish and Wildlife Service issued a permit allowing the take of up to 400 vultures, and a more recent request involved thousands of individuals (Anonymous 2003). Given that these vultures were two of the most heavily persecuted of all raptors in the first half of the 20th century (Parmalee 1954, Snyder and Rea 1998), these more recent federal actions are particularly ominous.

My experience at Hawk Mountain Sanctuary suggests that (1) raptor-focused, science-based conservation education extending from primary schools through the adult general public, and (2) public opportunities to see large numbers of migrating raptors during their seasonal movements, are two of the most effective tools for building local, regional, and national support for birds of prey. Education, in particular, has the potential for reaching large audiences, but it should be emphasized that its effectiveness rests upon the veracity of its science. As populations of North America's birds of prey continue to grow and expand, the use of both of these important tools is likely to become an increasingly essential part of the raptor conservationist's tool kit. Finally, the old palliatives that raptors prey only upon the old and sick and that they do not frequently shape the behavior, distribution, and abundance of their prey must be put aside, and birds of prey must be portrayed as the effective predatory entities they are.

Final Thoughts

Populations of most species of North American raptors are now higher than they have been at any time during the modern raptor-conservation era that began in the 1930s. Although most species are likely to face new and unexpected problems in the future, the inclusion of raptors in the Migratory Bird Treaty Act with Mexico in 1972—the most comprehensive law protecting birds of prey within these jurisdictions—together with the inherent resiliency of the birds themselves, an increased understanding of their biological needs, and a growing cadre of young, willing, and able raptor conservationists and educators, suggest that large numbers of North American birds of prey will be captivating the general public, as well as hawkwatchers and raptor conservationists, for some time.

Acknowledgments

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2

Raptor Migration in North America

Laurie J. Goodrich[1] *and Jeff P. Smith*[2]

Abstract.—Many migrating raptors follow distinct routes during autumn and spring migrations. Topography and water barriers largely define these routes, which vary among species and are influenced by ecological and meteorological factors. The paths that migrants follow and the geographic patterns they demonstrate vary among species and populations. Some species tend to move almost entirely across a *broad front*, with concentrations occurring rarely or with regional or seasonal specificity. Others routinely concentrate along *leading lines* and *diversion lines.* Here we describe the general patterns and variability for both outbound movements in autumn and return movements in spring. We also provide a synopsis of migration behavior and ecology, and identify regions and watchsites where each species concentrates. Our overview provides a background for understanding migration trends presented elsewhere in this work, and the future roles that migration counts will play in monitoring populations of North America's raptors.

In North America, most outbound migrants travel primarily south to nonbreeding areas from the mid-latitudes of the United States as far south as southern South America. From February through early May, the birds reverse their autumn movements. These round-trip migrations range from several hundred to more than 15,000 km annually.

Some migrating raptors follow distinct routes during their outbound and return journeys. Topography and water barriers, in combination with behavioral, ecological, and meteorological factors, define these routes (Kerlinger 1989, Bildstein 2006). The paths the migrants follow and the geographic patterns they demonstrate vary across species and populations. In autumn,

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outbound migration begins as a *broad-frontal* movement with migrants setting out from dispersed breeding areas. In many species, dispersed individuals gradually converge along well-defined, predictable routes as they move south, with primary concentrations often influenced by *leading lines* and *diversion lines* that act to group migrants along prominent landscape features. Some individuals collect along coastlines to avoid crossing large expanses of open water on their journeys. Mountains, lakes, rivers, deserts, and habitat boundaries funnel and concentrate other streams of migrants. In some areas, species movements remain dispersed and unpredictable, and sometimes vary among years depending on habitat suitability and prevailing weather patterns. As a result, whereas many migration routes and concentration points are well known, others remain to be discovered and described.

The distribution of migration watchsites across the continent indicates geographic areas where raptors concentrate, particularly in areas with high human densities such as the northeastern United States (Figs. 1A–D). The numbers of migrants observed at individual watchsites illustrate how birds move across the landscape while tending to concentrate along coastlines, mountain ridges, and other geographic barriers (Table 1).

Historical knowledge of raptor migration in North America derives largely from raptor migration counts and band-recovery data, and, to a lesser extent, conventional VHF radio tracking. Recently, satellite tracking telemetry has been used to track the movements of individual migrants undertaking intercontinental and even transoceanic journeys (Bildstein 2006). Tracking raptors by satellite has both confirmed and challenged earlier ideas regarding migration geography and has demonstrated considerable variation within populations, as well as individual flexibility in inter-annual migration patterns. Satellite tracking also has revealed new geographic routes for long-distance migrants and confirmed that short-distance raptor migrants may be highly opportunistic and flexible in their routes (e.g., Strandberg et al. in press). Many believe that the behavioral plasticity in migration patterns found in many raptors may enhance their ability to exploit the wide variety of conditions they encounter en route (Kerlinger 1989).

Here we review the geography of raptor migration across North America and provide individual accounts for 36 species typically detected at watchsites. We describe the migratory tendencies, patterns, behavior, and distributions of each species, and where primary concentrations occur. Throughout, we use “region” to denote broad migrant source areas and “corridor” to denote well-known and consistent regional routes taken by migrants across the landscape (e.g., the Veracruz coastal-plain corridor, Central Appalachian Mountains corridor, Rocky Mountains corridor, etc.). Within each corridor, there may be several individual “pathways” or “flight lines” (e.g., the Kittatinny Ridge flight line within the Central Appalachian Mountains corridor).

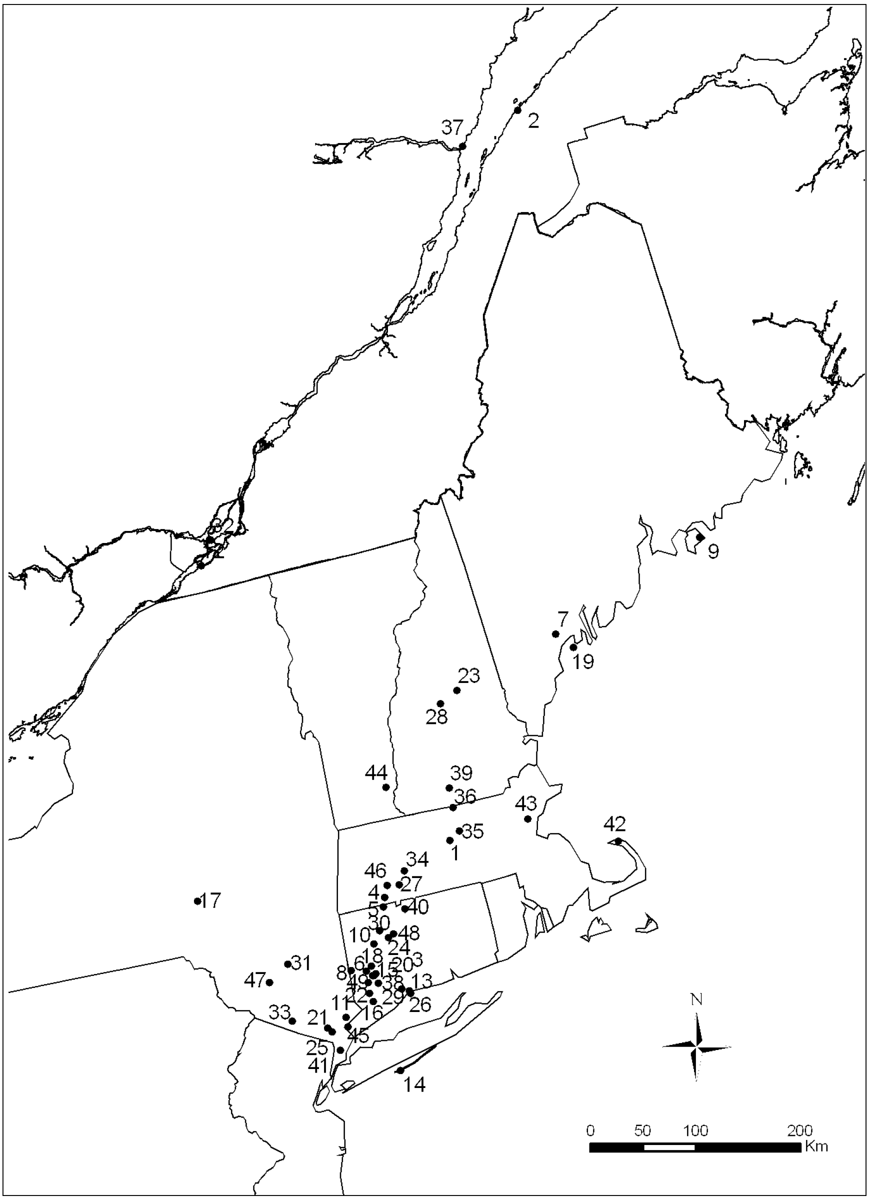

Fig. 1. (A) North American migration watchsites in the Eastern region of the continent (Atlantic corridor). Site numbers correspond to those listed by section in Table 1. *Figure 1 is continued on the following page.*

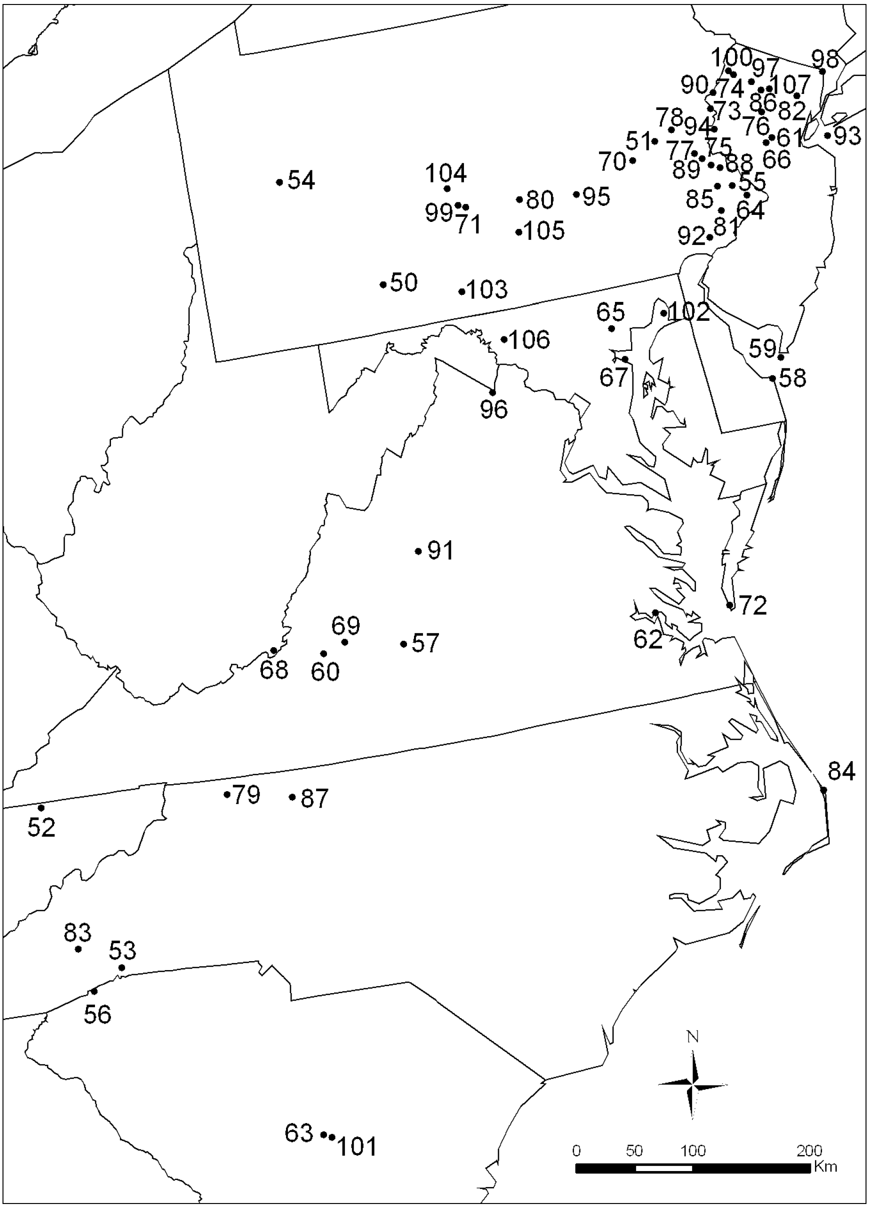

Fig. 1. (B) North American migration watchsites in the Eastern region of the continent (Appalachian corridor). Site numbers correspond to those listed by section in Table 1. *Figure 1 is continued on the following page.*

Fig. 1. (C) North American migration watchsites in the Central region of the continent. Site numbers correspond to those listed by section in Table 1 (Central region includes the Eastern and Western Great Lakes and Gulf Coast corridors). *Figure 1 is continued on the following page.*

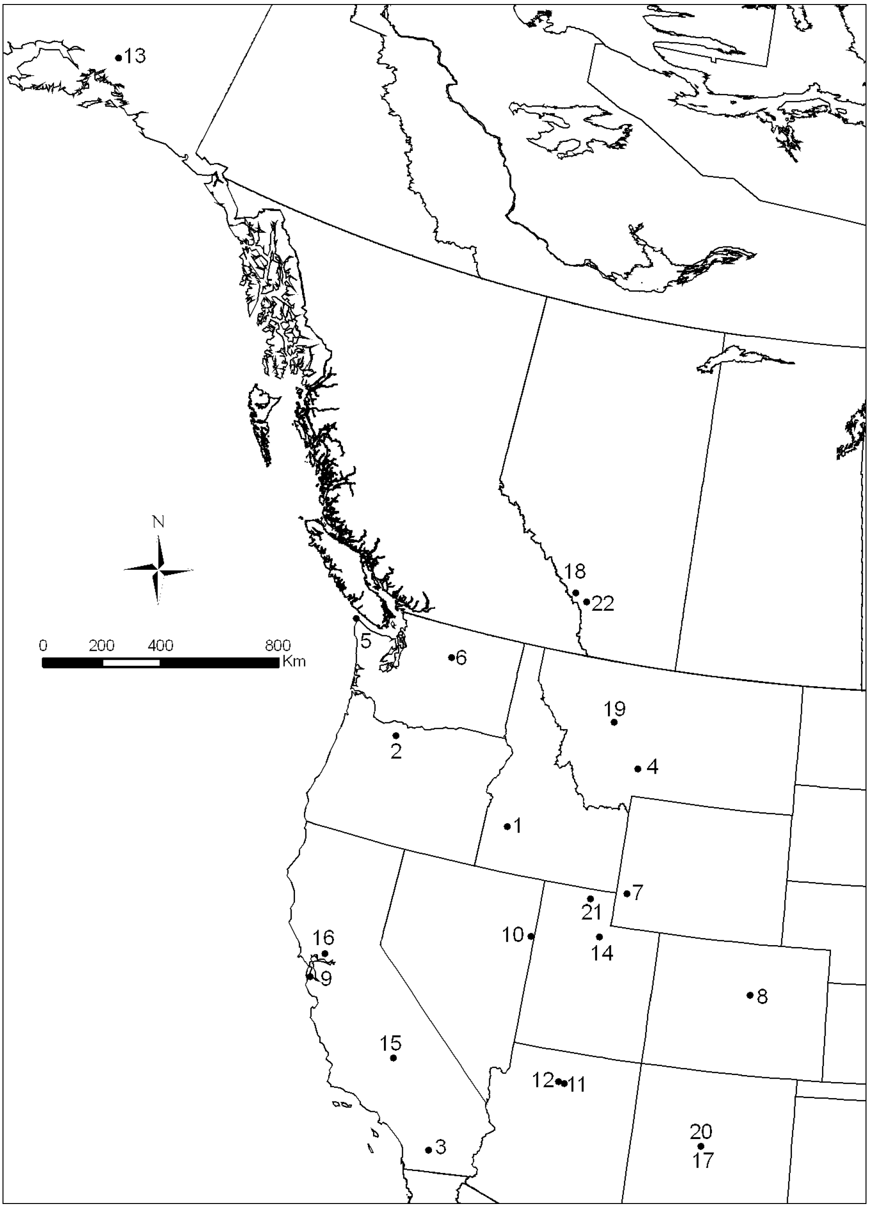

Fig. 1. (D) North American migration watchsites in the Western region of the continent. Site numbers correspond to those listed by section in Table 1 (the western region includes the Rocky Mountain, Intermountain, and Pacific Coast corridors).

Table 1. Average spring and autumn counts (1997–2006) for all raptors combined and for the three most abundant species of raptors at watchsites in North America. Sites are organized by regions represented in Figure 1 (A–C).

Region Watchsite [a]	Year founded	Number of species	Average spring count	Average autumn count	Most abundant species (average count) [b]
Northeast (Fig. 1A)					
Barre Falls, Massachusetts* (1)		16	1,618	8,326	Broad-winged Hawk (6,411) Sharp-shinned Hawk (1,264) Red-tailed Hawk (597)
Belvédère Raoul-Roy, Parc National du Bic, Québec (2)	1981	18	4,278	–	Red-tailed Hawk (3,019) Sharp-shinned Hawk (599) Rough-legged Hawk (238)
Bent of the River, Connecticut* (3)		15	–	1,761	Broad-winged Hawk (1,672) Sharp-shinned Hawk (33) Osprey (20)
Blueberry Hill, Massachusetts* (4)	1972	16	879	5,794	Broad-winged Hawk (3,659) Sharp-shinned Hawk (900) Red-tailed Hawk (595)
Booth Hill, Connecticut* (5)		11	–	2,893	Broad-winged Hawk (2,827) Sharp-shinned Hawk (35) Osprey (13)
Botsford Hill, Connecticut* (6)	1989	13	–	927	Broad-winged Hawk (814) Sharp-shinned Hawk (59) Osprey (24)
Bradbury Mountain State Park, Maine* (7)		14	1,235	–	Broad-winged Hawk (673) Sharp-shinned Hawk (223) Osprey (149)
Briggs Hill, Connecticut* (8)		12	–	176	Broad-winged Hawk (145) Turkey Vulture (6) Red-tailed Hawk (5)
Cadillac Mt., Acadia National Park, Maine* (9)		16	–	2,606	Sharp-shinned Hawk (975) American Kestrel (616) Broad-winged Hawk (448)
Chestnut Hill, Connecticut* (10)	1973	13	–	3,778	Broad-winged Hawk (3,639) Sharp-shinned Hawk (60) Osprey (34)
Chestnut Ridge, New York* (11)		15	–	2,226	Broad-winged Hawk (1,050) Sharp-shinned Hawk (512) Turkey Vulture (188)
Eagle Crossing, Québec (12)	1975	15	2,543	–	Red-tailed Hawk (1,026) Broad-winged Hawk (517) Turkey Vulture (199)
East Shore Park, Connecticut* (13)	1987	16	–	1,514	Sharp-shinned Hawk (711) Broad-winged Hawk (355) American Kestrel (134)

Table 1. Continued.

Region Watchsite [a]	Year founded	Number of species	Average spring count	Average autumn count	Most abundant species (average count) [b]
Fire Island, New York* (14)	1982	11	–	2,441	Sharp-shinned Hawk (266) American Kestrel (592) Merlin (1,109)
Flat Hill, Connecticut* (15)		11	–	733	Broad-winged Hawk (628) Sharp-shinned Hawk (57) American Kestrel (14)
Flirt Hill, Connecticut* (16)		15	–	799	American Kestrel (253) Broad-winged Hawk (236) Sharp-shinned Hawk (94)
Franklin Mountain, New York (17)	1989	16	–	3,742	Red-tailed Hawk (1,684) Broad-winged Hawk (779) Sharp-shinned Hawk (402)
Good Hill, Connecticut* (18)		10	–	531	Broad-winged Hawk (499) Osprey (9) Cooper's Hawk (6)
Harpswell Peninsula, Maine* (19)	1965	13	–	4,534	Sharp-shinned Hawk (2,410) Broad-winged Hawk (873) American Kestrel (565)
Heritage Village, Connecticut * (20)		10	–	850	Broad-winged Hawk (777) Sharp-shinned Hawk (28) Red-tailed Hawk (15)
Hook Mountain, New York (21)	1971	15	1,579	7,541	Broad-winged Hawk (3,196) Sharp-shinned Hawk (1,371) Turkey Vulture (277)
Huntington State Park, Connecticut* (22)	1987	11	–	198	Broad-winged Hawk (174) Sharp-shinned Hawk (11) Osprey (4)
Interlakes Elementary School, New Hampshire* (23)	1980	8	–	160	Broad-winged Hawk (108) Sharp-shinned Hawk (25) Turkey Vulture (13)
Johnycake Mountain, Connecticut* (24)	1992	13	–	2,004	Broad-winged Hawk (1,817) Sharp-shinned Hawk (78) American Kestrel (41)
Lenoir Wildlife Sanctuary, New York* (25)		16	–	2,991	Broad-winged Hawk (1,124) Turkey Vulture (736) Sharp-shinned Hawk (428)
Lighthouse Point, Connecticut (26)	1979	19	64	13,795	Sharp-shinned Hawk (6,699) American Kestrel (1,776) Osprey (1,283)
Little River Lookout, Massachusetts (27)		13	–	1,384	Broad-winged Hawk (743) Sharp-shinned Hawk (201) American Kestrel (128)

Table 1. Continued.

Region Watchsite [a]	Year founded	Number of species	Average spring count	Average autumn count	Most abundant species (average count) [b]
Little Round Top, New Hampshire* (28)	1970	13	–	1,989	Broad-winged Hawk (1,743) Sharp-shinned Hawk (88) Osprey (46)
Maltby Lakes, Connecticut* (29)	1994	13	–	3,909	Broad-winged Hawk (3,248) Sharp-shinned Hawk (173) Osprey (312)
Middle School, Connecticut* (30)		14	–	3,445	Broad-winged Hawk (3,249) Sharp-shinned Hawk (67) Osprey (37)
Mohonk Preserve, New York* (31)	1954	16	–	1,387	Broad-winged Hawk (951) Sharp-shinned Hawk (220) Red-tailed Hawk (78)
Montreal West Island Hawkwatch, Québec (32)	1975	16	–	4,331	Broad-winged Hawk (1,951) Red-tailed Hawk (1,336) Sharp-shinned Hawk (432)
Mount Peter, New York* (33)	1958	16	–	5,315	Broad-winged Hawk (3,418) Sharp-shinned Hawk (857) Red-tailed Hawk (410)
Mount Tom, Massachusetts* (34)	1935	12	–	1,563	Broad-winged Hawk (1,466) Sharp-shinned Hawk (48) American Kestrel (13)
Mount Wachusett, Massachusetts* (35)	1976	15	–	5,924	Broad-winged Hawk (5,517) Sharp-shinned Hawk (153) Osprey (130)
Mount Watatic, Massachusetts* (36)	1988	15	–	5,673	Broad-winged Hawk (4,989) Sharp-shinned Hawk (280) Osprey (114)
Observatoire d'oiseaux de Tadoussac, Québec (37)	1993	17	–	10,523	Sharp-shinned Hawk (3,822) Red-tailed Hawk (3,083) Broad-winged Hawk (1,028)
Osborne Hill, Connecticut* (38)		13	–	1,835	Broad-winged Hawk (1,727) Sharp-shinned Hawk (49) Osprey (28)
Pack Monadnock Raptor Observatory, New Hampshire* (39)		15	–	4,864	Broad-winged Hawk (3,730) Sharp-shinned Hawk (518) Osprey (142)
Peak Mountain, Connecticut* (40)	2003	17	1,238	1,890	Broad-winged Hawk (1,611) Sharp-shinned Hawk (227) Red-tailed Hawk (212)
Pelham Bay Park, New York* (41)	1990	14	–	5,000	American Kestrel (2,440) Sharp-shinned Hawk (1,850) Merlin (546)

Table 1. Continued.

Region Watchsite [a]	Year founded	Number of species	Average spring count	Average autumn count	Most abundant species (average count) [b]
Pilgrim Heights, Massachusetts (42)	1982	18	1,880	–	Turkey Vulture (512) Sharp-shinned Hawk (382) Broad-winged Hawk (275)
Pinnacle Rock, Massachusetts (43)		9	–	60	Broad-winged Hawk (15) Sharp-shinned Hawk (14) Osprey (11)
Putney Mountain, Vermont (44)		15	–	4,548	Broad-winged Hawk (3,254) Sharp-shinned Hawk (681) Osprey (158)
Quaker Ridge, Connecticut (45)	1984	17	–	14,164	Broad-winged Hawk (8,666) Sharp-shinned Hawk (2,632) Osprey (609)
Shatterack Mountain, Massachusetts* (46)		15	443	3,228	Broad-winged Hawk (2,182) Sharp-shinned Hawk (558) Red-tailed Hawk (272)
Summitville Hawkwatch, New York* (47)		16	–	1,413	Broad-winged Hawk (762) Sharp-shinned Hawk (217) Red-tailed Hawk (152)
Taine Mountain, Connecticut* (48)		6	–	1,620	Broad-winged Hawk (1,588) Sharp-shinned Hawk (16) Osprey (14)
Whippoorwill Hill, Connecticut* (49)	1980	11	–	3,593	Broad-winged Hawk (3,246) Sharp-shinned Hawk (142) Osprey (79)
Mid-Atlantic and Southeast Atlantic Coast (Fig. 1A)					
Allegheny Front, Pennsylvania (50)	1989	17	1,733	10,421	Broad-winged Hawk (5,893) Red-tailed Hawk (2,530) Sharp-shinned Hawk (1,349)
Bake Oven Knob, Pennsylvania (51)	1961	19	–	16,561	Broad-winged Hawk (7,250) Red-tailed Hawk (3,049) Sharp-shinned Hawk (3,040)
Big Bald, North Carolina (52)	2004	14	–	911	Broad-winged Hawk (430) Sharp-shinned Hawk (161) Turkey Vulture (109)
Bird Mountain, South Carolina* (53)	1989	11	–	3,240	Broad-winged Hawk (3,170) Sharp-shinned Hawk (36)
Brady's Bend, Pennsylvania* (54)		16	–	333	Turkey Vulture (104) Sharp-shinned Hawk (65) Broad-winged Hawk (52)
Buckingham, Pennsylvania* (55)		15	–	2,519	Broad-winged Hawk (2,281) Sharp-shinned Hawk (77) Osprey (55)

Table 1. Continued.

Region Watchsite [a]	Year founded	Number of species	Average spring count	Average autumn count	Most abundant species (average count) [b]
Caesars Head Hawk Watch, South Carolina* (56)	1988	16	–	7,327	Broad-winged Hawk (4,939) Turkey Vulture (2,058) Sharp-shinned Hawk (122)
Candler Mountain, Virginia (57)		12	–	6,131	Broad-winged Hawk (5,996) Osprey (42) Sharp-shinned Hawk (41)
Cape Henlopen Hawk Watch, Delaware* (58)		16	851	3355	Osprey (2,007) Sharp-shinned Hawk (1,038) American Kestrel (326)
Cape May, New Jersey (59)	1976	18	–	45,591	Sharp-shinned Hawk (21,350) American Kestrel (6,563) Cooper's Hawk (4,162)
Carvins Cove, Virginia (60)		10	94	–	Osprey (50) Broad-winged Hawk (19) Red-tailed Hawk (13)
Chimney Rock, New Jersey (61)	1990	15	–	9,343	Broad-winged Hawk (4,804) Sharp-shinned Hawk (2,000) American Kestrel (559)
College Creek, Virginia (62)		16	1,342	–	Turkey Vulture (611) Osprey (124) Bald Eagle (59)
Congaree Bluffs, South Carolina* (63)		16	–	443	Black Vulture (220) Turkey Vulture (78) Mississippi Kite (47)
Core Creek, Pennsylvania* (64)		15	–	817	Broad-winged Hawk (667) Sharp-shinned Hawk (31) Osprey (59)
Cromwell Valley Park, Maryland* (65)	1999	13	423	4,579	Broad-winged Hawk (3,678) Sharp-shinned Hawk (377) Red-tailed Hawk (239)
Duke Farms, New Jersey* (66)	2005	16	–	5,945	Broad-winged Hawk (3,899) Sharp-shinned Hawk (783) Turkey Vulture (253)
Fort Smallwood Park, Maryland (67)	1981	18	10,598	–	Turkey Vulture (4,192) Sharp-shinned Hawk (2,485) Broad-winged Hawk (1,348)
Hanging Rock Tower, West Virginia (68)		14	–	3,001	Broad-winged Hawk (2,284) Sharp-shinned Hawk (310) Red-tailed Hawk (135)
Harvey's Knob, Virginia (69)		14	–	5,875	Broad-winged Hawk (3,636) Red-tailed Hawk (803) Sharp-shinned Hawk (778)

Table 1. Continued.

Region Watchsite [a]	Year founded	Number of species	Average spring count	Average autumn count	Most abundant species (average count) [b]
Hawk Mountain Sanctuary, Pennsylvania (70)	1934	18	817	17,331	Broad-winged Hawk (6,952) Sharp-shinned Hawk (3,988) Red-tailed Hawk (3,358)
Jacks Mountain, Pennsylvania* (71)	1993	17	–	4,884	Broad-winged Hawk (3,018) Red-tailed Hawk (677) Sharp-shinned Hawk (568)
Kiptopeke State Park, Virginia (72)	1963	17	–	22,065	Sharp-shinned Hawk (6,269) American Kestrel (3,788) Turkey Vulture (3,089)
Kirkridge, Pennsylvania* (73)		14	–	918	Red-tailed Hawk (540) Sharp-shinned Hawk (258) Cooper's Hawk (61)
Kittatinny Mountain, New Jersey* (74)	1980	14	–	3,538	Broad-winged Hawk (1,545) Sharp-shinned Hawk (806) Red-tailed Hawk (619)
Lake Nockamixon, Pennsylvania* (75)		14	–	1,617	Broad-winged Hawk (1,440) Sharp-shinned Hawk (41) Osprey (36)
Lehigh Gap Hawkwatch, Pennsylvania* (76)	2002	15	614	–	Broad-winged Hawk (222) Turkey Vulture (180) Osprey (67)
Lehigh University, Pennsylvania* (77)		5	–	10	Broad-winged Hawk (7) Sharp-shinned Hawk (2) Osprey (1)
Little Gap, Pennsylvania (78)		18	–	16,241	Broad-winged Hawk (7,955) Sharp-shinned Hawk (3,101) Red-tailed Hawk (2,829)
Mahogany Rock, North Carolina* (79)	1986	13	–	3,740	Broad-winged Hawk (2,692) Turkey Vulture (567) Black Vulture (165)
Meadowood Bird Observatory, Pennsylvania* (80)	2003	13	–	339	Broad-winged Hawk (185) Turkey Vulture (86) Red-tailed Hawk (24)
Militia Hill, Pennsylvania* (81)	1988	15	–	8,790	Broad-winged Hawk (6,376) Sharp-shinned Hawk (1,020) Osprey (294)
Montclair Hawk Lookout, New Jersey (82)	1957	18	2,269	13,870	Broad-winged Hawk (7,576) Sharp-shinned Hawk (2,743) Turkey Vulture (1,196)
Mount Pisgah, North Carolina* (83)	1995	15	–	2,287	Broad-winged Hawk (1,888) Turkey Vulture (261) Sharp-shinned Hawk (37)

Table 1. Continued.

Region Watchsite [a]	Year founded	Number of species	Average spring count	Average autumn count	Most abundant species (average count) [b]
Pea Island NWR, North Carolina* (84)	1983	12	–	409	Sharp-shinned Hawk (168) American Kestrel (102) Peregrine Falcon (40)
Peace Valley, Pennsylvania* (85)		13	–	1,019	Broad-winged Hawk (842) Sharp-shinned Hawk (46) Osprey (41)
Picatinny Peak, New Jersey (86)	1992	17	430	8,285	Broad-winged Hawk (5,641) Sharp-shinned Hawk (1,450) Red-tailed Hawk (335)
Pilot Mountain State Park, North Carolina* (87)		13	–	3,719	Broad-winged Hawk (3,523) Sharp-shinned Hawk (45) Osprey (30)
Pipersville, Pennsylvania* (88)		13	–	1,291	Broad-winged Hawk (1,179) Sharp-shinned Hawk (60) Osprey (13)
Pleasant Valley, Pennsylvania* (89)		14	–	2,558	Broad-winged Hawk (2,330) Sharp-shinned Hawk (71) Osprey (43)
Raccoon Ridge, New Jersey* (90)	1987	15	–	5,180	Red-tailed Hawk (2,089) Sharp-shinned Hawk (1,205) Broad-winged Hawk (908)
Rockfish Gap Hawk Watch, Virginia (91)	1976	17	–	10,370	Broad-winged Hawk (7,716) Red-tailed Hawk (1,077) Sharp-shinned Hawk (989)
Rose Tree Park, Pennsylvania (92)	1999	18	2,382	7,383	Broad-winged Hawk (4,093) Sharp-shinned Hawk (1,911) Turkey Vulture (822)
Sandy Hook, New Jersey (93)	1979	13	6,270	–	Sharp-shinned Hawk (3,310) American Kestrel (1,710) Broad-winged Hawk (162)
Scotts Mountain, New Jersey (94)	1973	15	–	8,869	Broad-winged Hawk (5,466) Sharp-shinned Hawk (1,477) Red-tailed Hawk (957)
Second Mountain, Pennsylvania (95)	1984	19	59	10,064	Broad-winged Hawk (4,259) Sharp-shinned Hawk (1,978) Red-tailed Hawk (1,512)
Snickers Gap, Virginia (96)	1991	14	–	10,919	Broad-winged Hawk (6,441) Sharp-shinned Hawk (1,632) Red-tailed Hawk (1,516)
Sparta Migration Watch, New Jersey* (97)	2003	11	–	173	Broad-winged Hawk (59) Sharp-shinned Hawk (9) Osprey (5)

Table 1. Continued.

Region Watchsite [a]	Year founded	Number of species	Average spring count	Average autumn count	Most abundant species (average count) [b]
State Line Hawkwatch, New Jersey* (98)		11	–	2,266	Broad-winged Hawk (1,546) Sharp-shinned Hawk (376) American Kestrel (117)
Stone Mountain, Pennsylvania* (99)		18	–	4,292	Broad-winged Hawk (1,339) Red-tailed Hawk (1,285) Sharp-shinned Hawk (889)
Sunrise Mountain, New Jersey* (100)	1958	17	–	4,302	Broad-winged Hawk (2,615) Sharp-shinned Hawk (644) Red-tailed Hawk (366)
Trezevant's Landing, South Carolina* (101)	2004	13	–	183	Black Vulture (102) Sharp-shinned Hawk (7) Turkey Vulture (43)
Turkey Point, Maryland* (102)	1994	17	–	3,340	Sharp-shinned Hawk (1,504) Red-tailed Hawk (430) Turkey Vulture (383)
Tuscarora Summit, Pennsylvania (103)	1973	16	553	4,236	Broad-winged Hawk (2,061) Sharp-shinned Hawk (800) Red-tailed Hawk (730)
Tussey Mountain, Pennsylvania (104)	1995	16	2,006	–	Red-tailed Hawk (581) Broad-winged Hawk (392) Turkey Vulture (362)
Waggoner's Gap, Pennsylvania (105)	1952	16	–	18,349	Sharp-shinned Hawk (5,343) Broad-winged Hawk (5,058) Red-tailed Hawk (4,116)
Washington Monument State Park, Maryland* (106)		14	639	4,228	Broad-winged Hawk (2,252) Red-tailed Hawk (890) Sharp-shinned Hawk (776)
Wildcat Ridge, New Jersey (107)	1997	15	949	6,153	Broad-winged Hawk (4,500) Sharp-shinned Hawk (992) Red-tailed Hawk (328)
Great Lakes, Central and Gulf Coast (Fig. 1B)					
Beamer Conservation Area, Ontario (1)	1975	19	13,381	–	Turkey Vulture (4,103) Broad-winged Hawk (3,226) Red-tailed Hawk (2,425)
Bentsen Rio Grande State Park, Texas* (2)	2002	21	41,021	19,807	Broad-winged Hawk (31,913) Turkey Vulture (11,372) Swainson's Hawk (1,603)
Braddock Bay, New York* (3)	1977	19	42,723	–	Broad-winged Hawk (23,325) Turkey Vulture (11,404) Red-tailed Hawk (2,855)

Table 1. Continued.

Region Watchsite [a]	Year founded	Number of species	Average spring count	Average autumn count	Most abundant species (average count) [b]
Cedar Grove, Wisconsin (4)	1950	14	4,819	9,366	Broad-winged Hawk (7,462) Sharp-shinned Hawk (2,343) Merlin (248)
Chequamegon Bay, Wisconsin (5)	1999	16	5,205	–	Broad-winged Hawk (1,738) Red-tailed Hawk (1,362) Bald Eagle (724)
Concordia, Wisconsin* (6)	1984	17	–	5,433	Broad-winged Hawk (3,094) Sharp-shinned Hawk (942) Red-tailed Hawk (603)
Corpus Christi, Texas (7)	1988	28	–	714,867	Broad-winged Hawk (677,518) Turkey Vulture (21,123) Mississippi Kite (6,599)
Cranberry Marsh, Ontario (8)	1990	16	–	6,622	Turkey Vulture (1,968) Sharp-shinned Hawk (1,462) Red-tailed Hawk (1,371)
Curry Hammock State Park, Florida (9)	1999	17	–	15,036	Broad-winged Hawk (3,893) Sharp-shinned Hawk (3,300) American Kestrel (2,800)
Derby Hill Bird Observatory, New York (10)	1963	17	31,609	–	Broad-winged Hawk (12,538) Turkey Vulture (8,367) Red-tailed Hawk (5,086)
Fort Morgan Alabama* (11)	1993	16	–	2,040	American Kestrel (738) Broad-winged Hawk (435) Sharp-Shinned Hawk (325)
Grassy Key, Florida* (12)	1995	16	–	11,400	Broad-winged Hawk (2,780) Sharp-shinned Hawk (1,500) American Kestrel (1,580)
Guana Reserve, Florida* (13)	1997	3	–	310	Peregrine Falcon (282) Merlin (25) American Kestrel (4)
Hamburg Hawk Watch, New York* (14)	1988	16	13,661	–	Turkey Vulture (8,420) Broad-winged Hawk (2,530) Red-tailed Hawk (1,366)
Hawk Cliff Hawkwatch, Ontario (15)	1931	17	–	69,248	Broad-winged Hawk (32,973) Turkey Vulture (14,699) Sharp-shinned Hawk (9,313)
Hawk Ridge, Minnesota (16)	1972	20	–	89,957	Broad-winged Hawk (55,212) Sharp-shinned Hawk(16,462) Red-tailed Hawk (8,934)
High Park, Ontario* (17)	1993	16	–	7,139	Red-tailed Hawk (1,841) Turkey Vulture (1,617) Sharp-shinned Hawk (1,593)

Table 1. Continued.

Region Watchsite [a]	Year founded	Number of species	Average spring count	Average autumn count	Most abundant species (average count) [b]
Hitchcock Nature Center, Iowa (18)	1992	21	–	11,295	Red-tailed Hawk (3,333) Turkey Vulture (2,571) Swainson's Hawk (1,985)
Holiday Beach, Ontario (19)	1974	16	–	70,871	Broad-winged Hawk (25,991) Turkey Vulture (24,364) Sharp-shinned Hawk(10,995)
Illinois Beach State Park, Illinois* (20)	2000	16	–	5,443	Broad-winged Hawk (1,693) Red-tailed Hawk (1,416) Sharp-shinned Hawk (1,182)
Indiana Dunes, Indiana* (21)	1960s	15	3000+	–	Sharp-shinned Hawk (1,090) Broad-winged Hawk (932) Turkey Vulture (458)
Kekoldi, Costa Rica (22)	2000	14	800,000	1,950,000	Turkey Vulture (911,659) Broad-winged Hawk (655,313) Swainson's Hawk (293,432)
Lake Erie Metropark, Michigan* (23)	1983	20	–	165,649	Broad-winged Hawk (76,036) Turkey Vulture (67,567) Sharp-shinned Hawk (8,604)
Muskegon, Michigan* (24)	1998	15	–	1,344	Sharp-shinned Hawk (439) Red-tailed Hawk (330) American Kestrel (144)
Pointe Mouillee State Game Area, Michigan* (25)		17	–	91,783	Broad-winged Hawk (79,012) Turkey Vulture (9,897) Red-tailed Hawk (1,264)
Port Huron, Michigan* (26)	1990	15	3,993	–	Broad-winged Hawk (2,046) Sharp-shinned Hawk (715) Turkey Vulture (536)
Ripley Hawk Watch, New York (27)	1985	17	20,391	–	Turkey Vulture (10,229) Broad-winged Hawk (6,436) Red-tailed Hawk (1,349)
Smith Point, Texas (28)	1992	24	–	51,214	Broad-winged Hawk (38,646) Mississippi Kite (4,324) Sharp-shinned Hawk (2,917)
Thunder Cape Bird Observatory, Ontario (29)	–	15	–	3,530	Sharp-shinned Hawk (1,939) Bald Eagle (288) Broad-winged Hawk (287)
Tlacotalpan, Veracruz, Mexico* (30)	2003	20	114,835	4	Broad-winged Hawk (84,948) Mississippi Kite (23,683) Swainson's Hawk (4,203)
Veracruz River of Raptors, Veracruz, Mexico (31)	1991	30	230,663	5,073,750	Turkey Vulture (2,036,360) Broad-winged Hawk (1,916,980) Swainson's Hawk (988,766)

Table 1. Continued.

Region Watchsite [a]	Year founded	Number of species	Average spring count	Average autumn count	Most abundant species (average count) [b]
West Skyline Hawk Count, Minnesota (32)		21	25,046	–	Broad-winged Hawk (12,363) Red-tailed Hawk (5,343) Bald Eagle (2,844)
Whitefish Point, Michigan* (33)	1979	17	17,000	–	Sharp-shinned Hawk (9,860) Broad-winged Hawk (3,840) Red-tailed Hawk (1,370)
Western (Fig. 1C)					
Boise Ridge, Idaho (1)	1994	17	4,000	6,123	Sharp-shinned Hawk (1,197) Red-tailed Hawk (1,016) Turkey Vulture (992)
Bonney Butte, Oregon (2)	1994	18	–	2,908	Sharp-shinned Hawk (1,187) Red-tailed Hawk (624) Cooper's Hawk (343)
Borrego Valley, California* (3)	2002	14	3,862	14	Swainson's Hawk (2,921) Turkey Vulture (920) Red-tailed Hawk (15)
Bridger Mountains, Montana (4)	1979	18	–	2,420	Golden Eagle (1,424) Sharp-shinned Hawk (350) Cooper's Hawk (177)
Cape Flattery, Washington (5)	1985	12	5,360	–	Red-tailed Hawk (4,007) Bald Eagle (769) Golden Eagle (36)
Chelan Ridge, Washington (6)	1998	18	–	1,813	Sharp-shinned Hawk (796) Red-tailed Hawk (302) Cooper's Hawk (212)
Commissary Ridge, Wyoming (7)	2002	17	–	3,469	Red-tailed Hawk (942) Sharp-shinned Hawk (770) Cooper's Hawk (451)
Dinosaur Ridge, Colorado (8)	1990	17	–	3,908	Red-tailed Hawk (1,019) American Kestrel (745) Turkey Vulture (674)
Golden Gate Raptor Observatory, California (9)	1982	19	–	29,256	Red-tailed Hawk (4,160) Sharp-shinned Hawk (3,490) Turkey Vulture (1,620)
Goshute Mountains, Nevada (10)	1983	18	–	16,615	Sharp-shinned Hawk (5,280) Red-tailed Hawk (3,660) Cooper's Hawk (3,561)
Grand Canyon (Lipan Point), Arizona (11)	1991	18	–	5,067	Red-tailed Hawk (1,343) Sharp-shinned Hawk (1,330) American Kestrel (1,050)

Table 1. Continued.

Region Watchsite [a]	Year founded	Number of species	Average spring count	Average autumn count	Most abundant species (average count) [b]
Grand Canyon (Yaki Point), Arizona (12)	1991	19	–	4,870	Sharp-shinned Hawk (1,682) Cooper's Hawk (1,073) Red-tailed Hawk (1,015)
Gunsight Mountain, Alaska* (13)	1984	14	1,588	–	Red-tailed Hawk (551) Rough-legged Hawk (302) Golden Eagle (278)
Jordanelle Reservoir, Utah (14)	1997	16	3,858	–	Turkey Vulture (1,201) Red-tailed Hawk (1,029) Cooper's Hawk (262)
Kern River Valley, California* (15)	1999		–	28,591	Turkey Vulture (28,391) Osprey (19) Red-tailed Hawk (38)
Lagoon Valley, California* (16)		18	–	6,027	Turkey Vulture (4,543) Red-tailed Hawk (1,158) American Kestrel (110)
Manzano Mountains, New Mexico (17)	1985	18	–	5,391	Sharp-shinned Hawk (1,655) Cooper's Hawk (1,263) Red-tailed Hawk (785)
Mount Lorette, Alberta (18)	1992	18	3,799	4,348	Golden Eagle (3,492) Bald Eagle (346) Sharp-shinned Hawk (208)
Rogers Pass, Montana (19)	1988	2	2,220	–	Golden Eagle (1,271) Bald Eagle (141) Red-tailed Hawk (37)
Sandia Mountains, New Mexico (20)	1984	16	–	3,030	Turkey Vulture (932) Coopers Hawk (638) Sharp-shinned Hawk (426)
Wellsville Mountains, Utah (21)	1977	17	–	3,272	Sharp-shinned Hawk (843) Red-tailed Hawk (630) American Kestrel (608)
Windy Point, Alberta (22)	1967	18	–	4,466	Golden Eagle (1,022) Sharp-shinned Hawk (1,005) Bald Eagle (436)

[a] An asterisk indicates that limited seasonal coverage occurs (<60 days in spring; <75 days in autumn).

[b] Counts represent the season with the most numerous counts.

[c] No recent numbers obtained; counts shown are from the 1960s.

Data sources: most data from www.hawkcount.org; other data from Zalles and Bildstein 2000; Sherrington 2003, 2006; Bildstein 2006; Lott 2006; A. Fish, Golden Gate Raptor Observatory unpubl. data; Tony Leukering, Rocky Mountain Bird Observatory unpubl. data.

Migration Ecology

Some species of raptors, including the Broad-winged Hawk (*Buteo platypterus*) are *complete migrants* (*sensu* Bildstein 2006), in which more than 90% of the entire world population vacates its breeding range for a separate wintering area. Most North American raptors, however, are *partial migrants*, in which less than 90% of the population migrates, and the species' winter and summer ranges broadly overlap. Examples of partial migrants include Red-tailed Hawks (*B. jamaicensis*) and American Kestrels (*Falco sparverius*). A few species, including the Northern Goshawk (*Accipiter gentilis*), may display *irruptive* or *local* movements, which occur irregularly or sporadically in response to changes in food resources (Mueller et al. 1977, Kerlinger 1989, Bildstein 2006). Others, including Turkey Vultures (*Cathartes aura*) in Florida and White-tailed Kites (*Elanus leucurus*), are generally nomadic. Migration may be a relatively new behavior in species that recently have expanded their ranges north (e.g., Hook-billed Kites [*Chondrohierax uncinatus*] and Black Vultures [*Coragyps atratus*]). In other species, traditional pre-migratory staging areas are an important aspect of migration behavior (e.g., Swallow-tailed Kites [*Elanoides forficatus*] in Florida).

Although most North American migratory raptors undertake latitudinal movements, longitudinal and altitudinal movements also occur (Kerlinger 1989, Bildstein 2006). *Loop migrations*, which are characteristic of some Ferruginous Hawks (*B. regalis*) and Prairie Falcons (*F. mexicanus*), for example, incorporate both longitudinal and latitudinal movements (Steenhof et al. 2005, Watson and Banasch 2005). Movements of the Northern Goshawk in the lower 48 states provide one of the best examples of limited *altitudinal migrations*, with many individuals in places such as the Wasatch Mountains of Utah moving from high-mountain breeding areas to the surrounding lowlands during winter (Sonsthagen et al. 2006).

Distances traveled vary substantially both among and within species. Broad-winged Hawks and Swainson's Hawks (*B. swainsoni*), for example, are complete, long-distance, *trans-equatorial* migrants whose one-way journeys exceed 5,000 km, whereas Red-tailed Hawks and Red-shouldered Hawks (*B. lineatus*) are short- to moderate-distance migrants, some of which migrate less than 500 km. *Leap-frog migration*, in which northern populations overwinter farther south than southern populations, occurs in Turkey Vultures, Red-tailed Hawks, and Peregrine Falcons (*F. peregrinus*) (Kerlinger 1989, Schmutz et al. 1991), and, probably, other species as well (Bildstein 2006). *Chain migration*, in which northern and southern populations migrate similar distances, occurs among Sharp-shinned Hawks (*A. striatus*) in western North America (Smith et al. 2003). As a result of these differences, different populations may converge at watchsites at different times of the year (Smith et al. 2003, Mueller et al. 2004).

Age and sex differences also influence the timing and geography of migrations. Female American Kestrels, for example, winter farther south than do males (Smallwood and Bird 2002), and females migrate earlier as well, at least in eastern North America (Stotz and Goodrich 1989). On the other hand, at least in western North America, female Rough-legged Hawks (*B. lagopus*) winter farther north than males (Olson and Arsenault 2000). Red-tailed Hawks and Sharp-shinned Hawks show age differences in timing of migration in both eastern and western North America, with juveniles migrating before adults in autumn, and female Sharp-shinned Hawks migrating earlier than males in autumn in western North America (DeLong and Hoffman 1999). Where age or sex classes exhibit differences in their wintering ranges, migration counts can be skewed toward certain classes of birds. Such differences can be important in interpreting count trends.

Flights at coastal watchsites tend to be dominated by juvenile birds, whereas adults are relatively more common at inland sites. This may be a function of inexperienced individuals whose poor navigational skills allow them to be more easily diverted by winds or other factors (Mueller and Berger 1967a, Kerlinger 1989, Viverette et al. 1996, Bildstein 2006). Coastal sites also offer more abundant prey (Buler et al. 2007). In any case, autumn counts from coastal sites may track annual variations in productivity more closely than inland sites.

Migration behavior and patterns also may change over time. Sharp-shinned Hawks and Red-tailed Hawks recently have exhibited "*short-stopping*" in the northeastern United States, a phenomenon in which a proportion of the population overwinters farther north than in previous years (Viverette et al. 1996, Bolgiano 2006). Increasingly mild winter weather, abundant birdfeeders, and an increased abundance of birdfeeder birds may contribute to this pattern.

Migration Geography

Breeding Ranges and Migration Corridors

Although only 3% of banded raptors are subsequently encountered and reported, recovery data can provide useful information on migration routes and timing of migration, as well as on the breeding and wintering areas used by raptors banded on migration (Bildstein 2006). The overall distribution of Sharp-shinned Hawk band recoveries from banding stations across the continent (Figs. 2A–G) illustrates a geographic pattern shared by many intermediate-distance, partial migrants in North America.

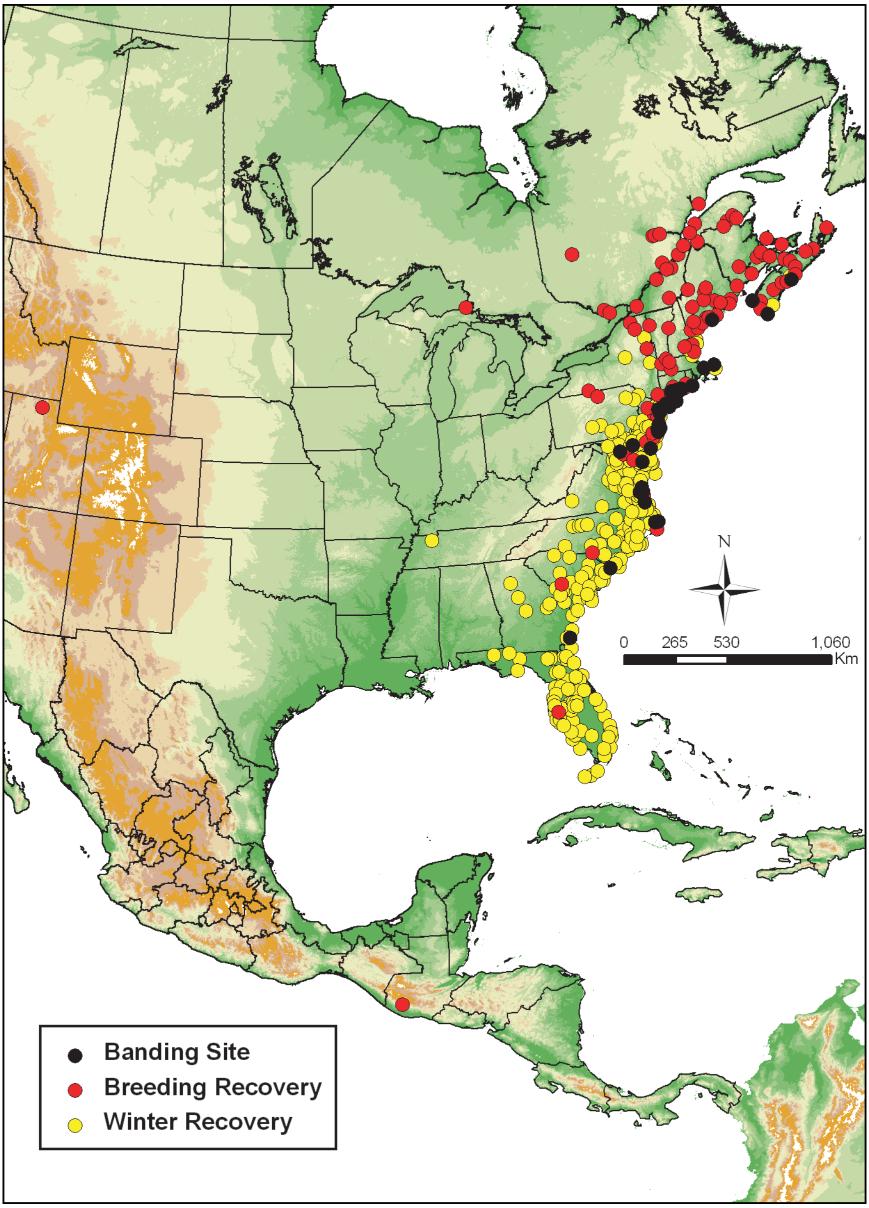

Fig. 2. (A) Breeding season and winter band recoveries of Sharp-shinned Hawks (*Accipiter striatus*) trapped during migration (1 September to 30 November) on the Atlantic Coast (red = breeding season: 15 May to 15 August; yellow = winter season: 15 December to 1 March; blue = banding sites). *Figure 2 is continued on the following page.*

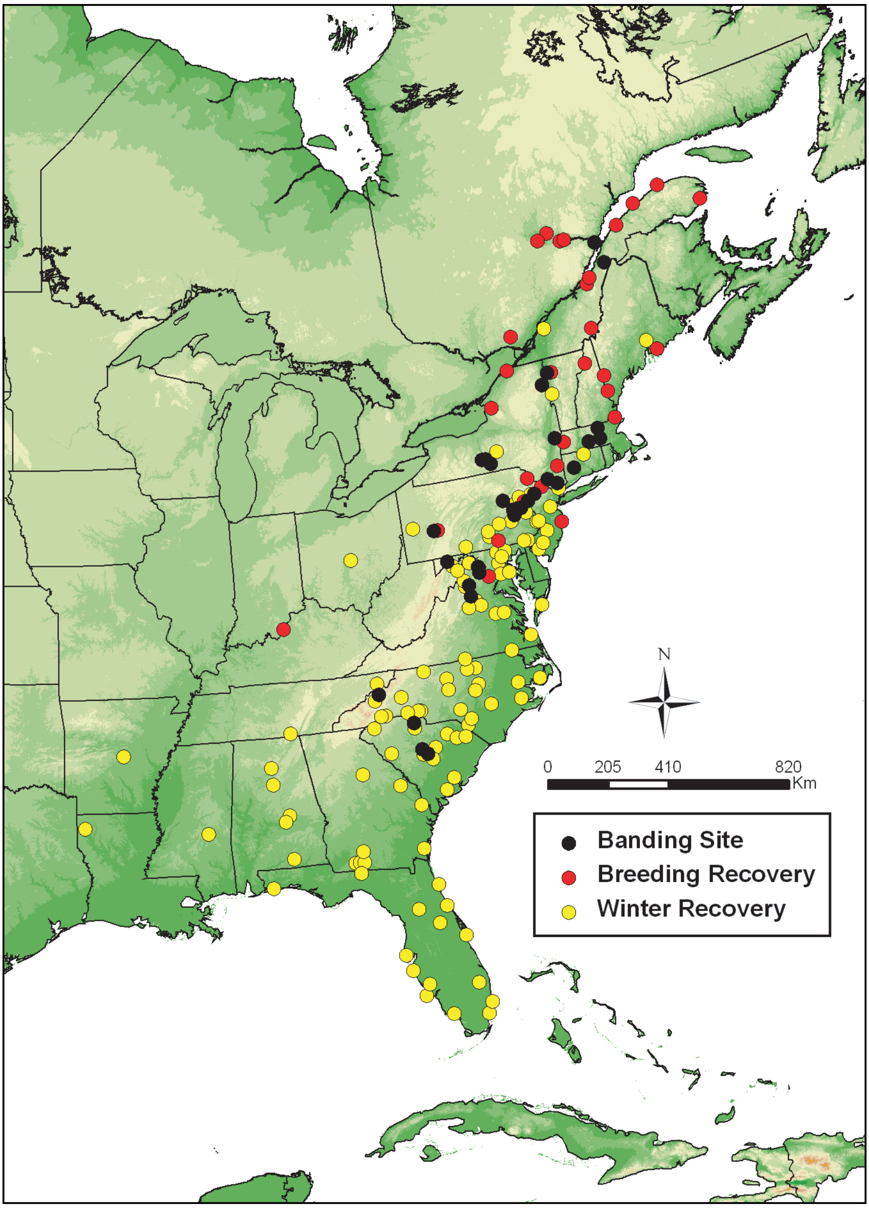

Fig. 2. (B) Breeding season and winter band recoveries of Sharp-shinned Hawks (*Accipiter striatus*) trapped during migration (1 September to 30 November) in the Appalachian Mountains (red = breeding season: 15 May to 15 August; yellow = winter season: 15 December to 1 March; blue = banding sites). *Figure 2 is continued on the following page.*

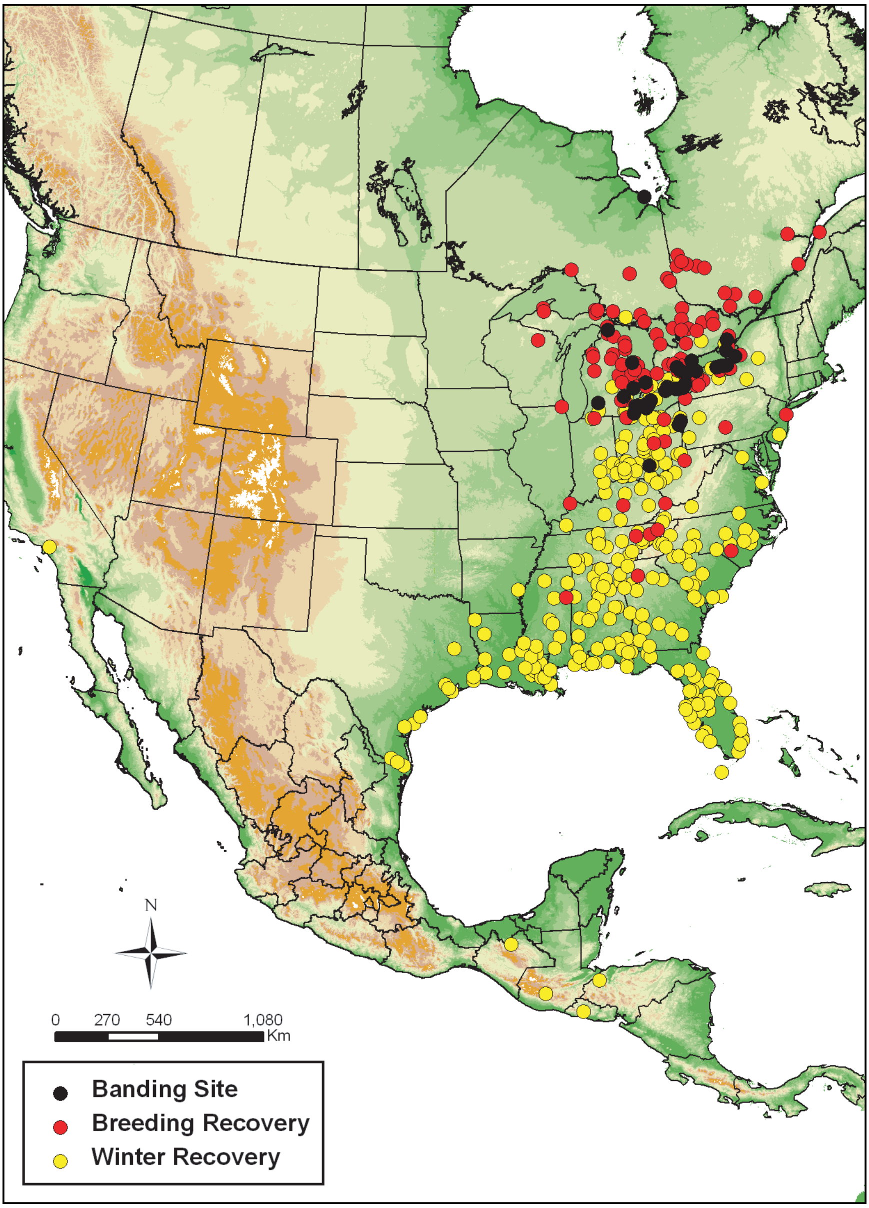

Fig. 2. (C) Breeding season and winter band recoveries of Sharp-shinned Hawks (*Accipiter striatus*) trapped during migration (1 September to 30 November) around the eastern Great Lakes (red = breeding season: 15 May to 15 August; yellow = winter season: 15 December to 1 March; blue = banding sites). *Figure 2 is continued on the following page.*

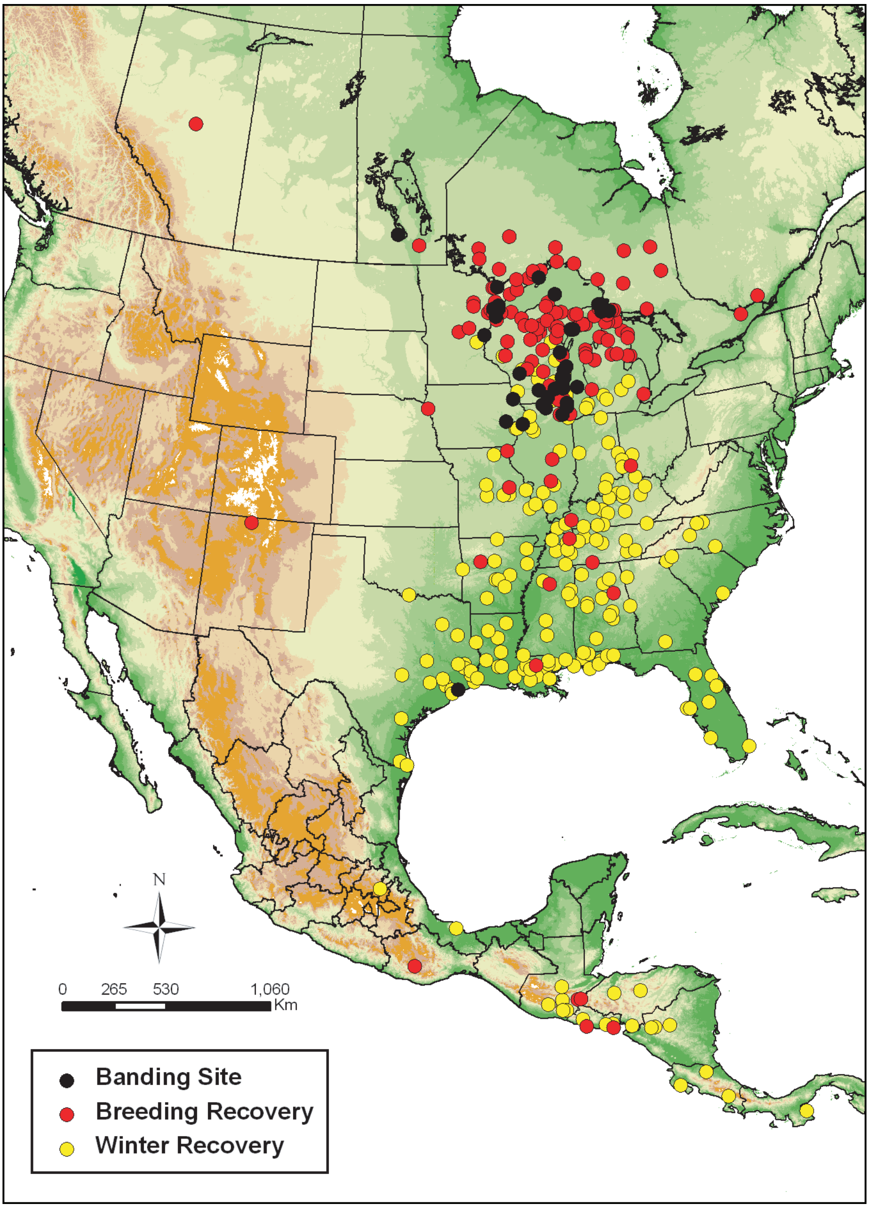

Fig. 2. (D) Breeding season and winter band recoveries of Sharp-shinned Hawks (*Accipiter striatus*) trapped during migration (1 September to 30 November) around the western Great Lakes (red = breeding season: 15 May to 15 August; yellow = winter season: 15 December to 1 March; blue = banding sites). *Figure 2 is continued on the following page.*

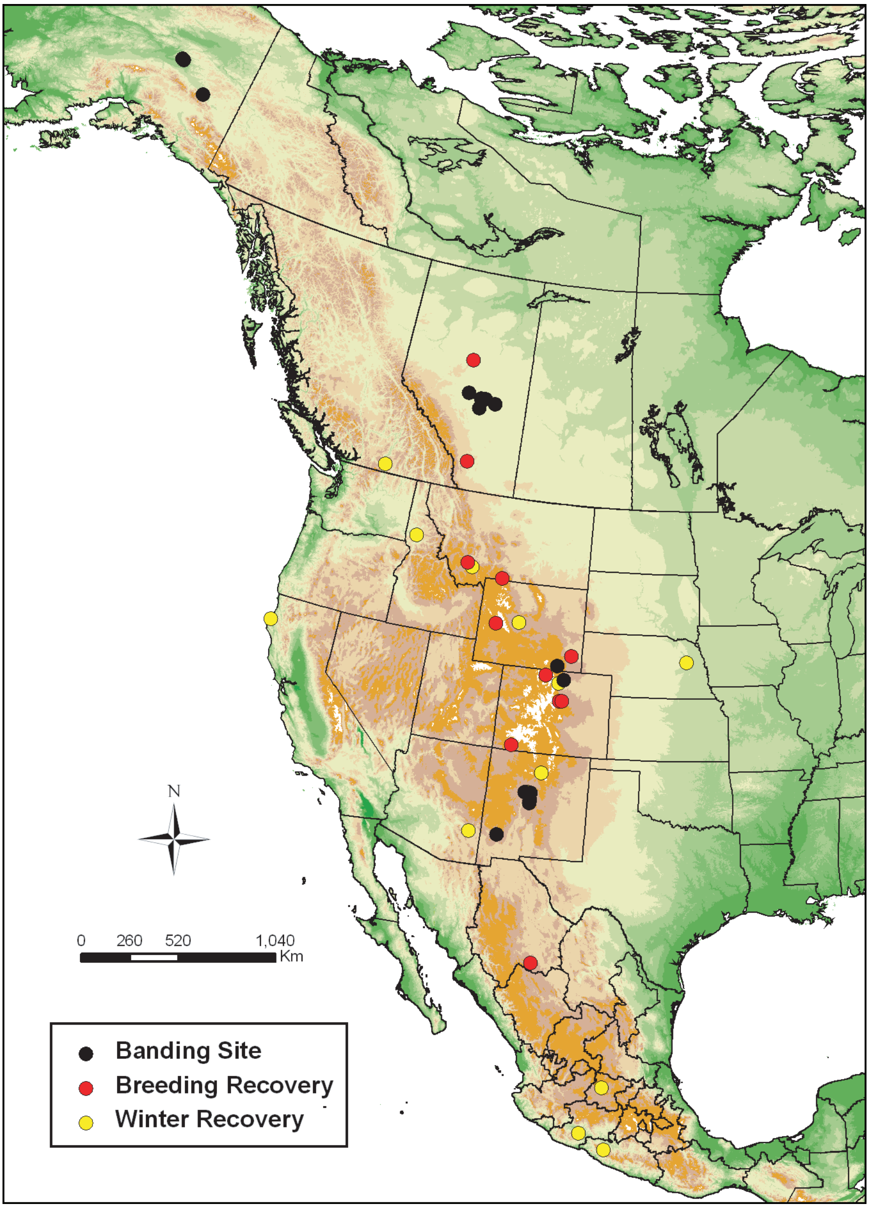

Fig. 2. (E) Breeding season and winter band recoveries of Sharp-shinned Hawks (*Accipiter striatus*) trapped during migration (1 September to 30 November) in the Rocky Mountains (red = breeding season: 15 May to 15 August; yellow = winter season: 15 December to 1 March; blue = banding sites). *Figure 2 is continued on the following page.*

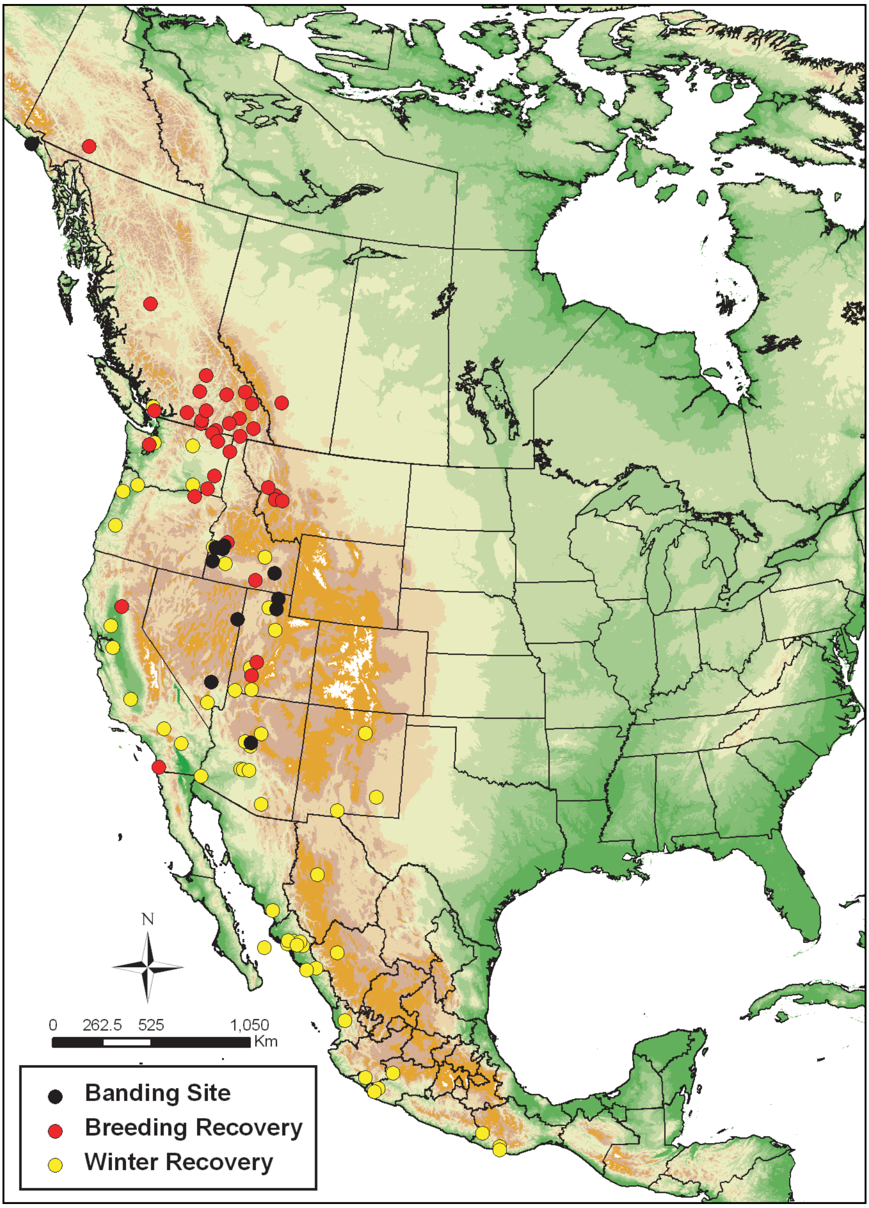

Fig. 2. (F) Breeding season and winter band recoveries of Sharp-shinned Hawks (*Accipiter striatus*) trapped during migration (1 September to 30 November) in the Intermountain West (red = breeding season: 15 May to 15 August; yellow = winter season: 15 December to 1 March; blue = banding sites). *Figure 2 is continued on the following page.*

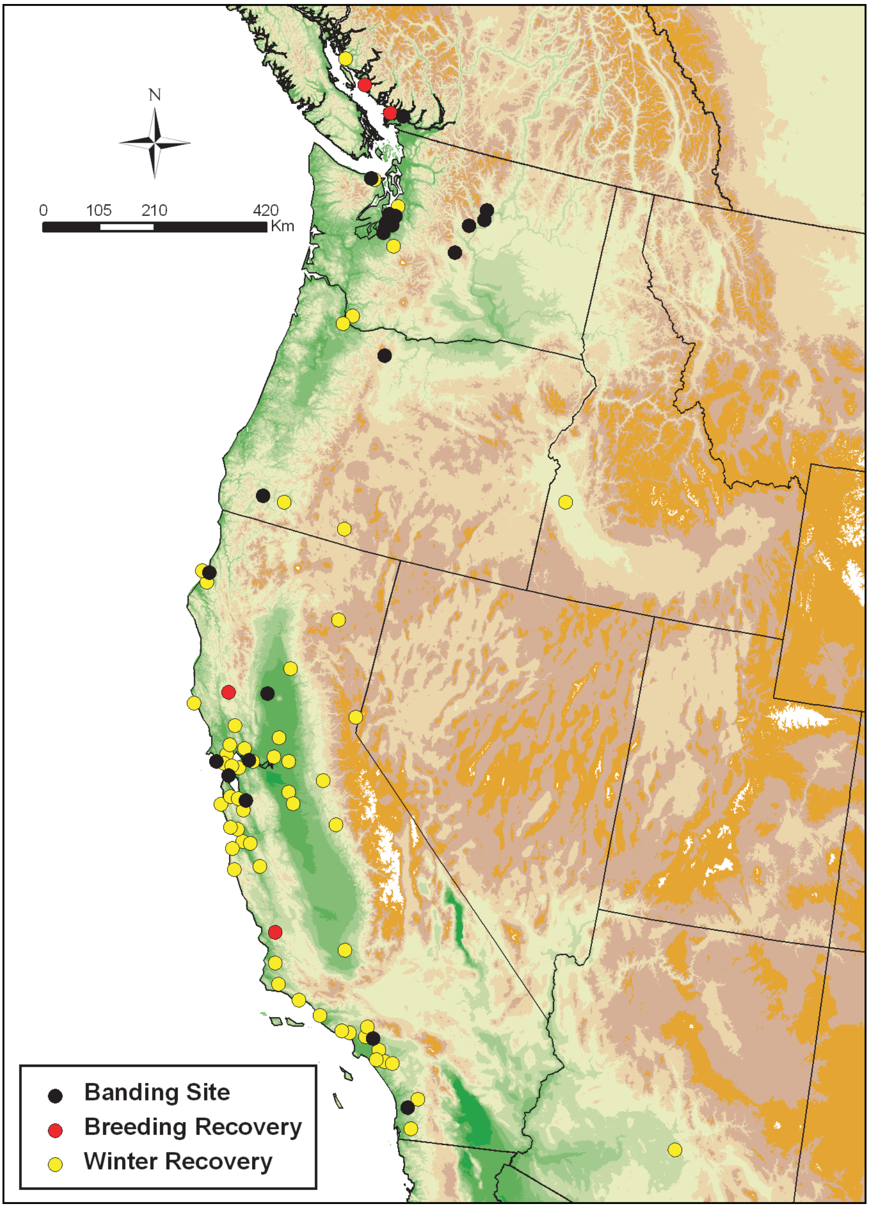

Fig. 2. (G) Breeding season and winter band recoveries of Sharp-shinned Hawks (*Accipiter striatus*) trapped during migration (1 September to 30 November) on the Pacific Coast (red = breeding season: 15 May to 15 August; yellow = winter season: 15 December to 1 March; blue = banding sites).

The distribution of recoveries during breeding and nonbreeding seasons illustrates distinct longitudinal differentiation of migration corridors, with significant overlap of regional populations on the nonbreeding range. In addition, the breeding range sampled by each set of watchsites across the continent indicates both regular overlap and differences east-to-west.

Migrants from the Atlantic Coast and Appalachian Mountain corridors follow similar south and southwest routes; most Atlantic Coast migrants remain along the coastal plain and piedmont until reaching Gulf Coast states (Figs. 2A, B). The breeding ranges of species using these two eastern corridors largely overlap, except that the former corridor appears to draw more heavily from the Maritime Provinces west to eastern Québec in Canada, whereas the Appalachian Mountain corridor draws more heavily from eastern Québec west through central Ontario (Figs. 2A, B). The winter ranges of both groups of migrants also appear to overlap significantly. The ranges of eastern and western Great Lakes birds also overlap significantly, but have a more westerly distribution than Appalachian Mountain migrants. Great Lakes migrants also regularly over-winter in eastern Mexico and Mesoamerica (Figs. 2C, D), with band returns confirming that the probability of long-distance travel into Mexico increases east-to-west (Mueller and Berger 1967b, Evans and Rosenfield 1985).

A similar pattern occurs in Sharp-shinned Hawks in western North America, where the overall range of Pacific Coast migrants is more restricted and northerly than that of inland migrants traveling along the Intermountain and Rocky Mountain corridors (Figs. 2E–G). For example, birds banded in the Rocky Mountains originate from Alaska south through the Rockies of eastern British Columbia, western Alberta, and farther south, and follow the Rockies and Sierra Madre Oriental south to winter ranges extending from Montana and Wyoming south into eastern and southern Mexico. In contrast, Intermountain migrants appear to come from slightly farther west, travel primarily between the Rockies to the east and Sierra–Cascade range to the west, and then farther south along the Sierra Madre Occidental, and winter primarily from Arizona south along the west coast of Mexico. Finally, Pacific Coast migrants originate primarily from southwestern British Columbia south through northern California, and winter primarily along the Pacific Coast north of Mexico.

Satellite-tracking has revealed several different patterns among long-distance migrants. Ospreys (*Pandion haliaetus*) and Peregrine Falcons from Alaska and northwestern Canada, for example, move east before migrating south and may be detected at Florida and Texas watchsites (Fuller et al. 1998, Martell et al. 2001).

Outbound or Autumn Migration

Eastern Region.—In autumn the Atlantic Coast acts as a *diversion line* that concentrates hydrophobic southbound migrants (Kerlinger 1989). However, raptors vary considerably in water-crossing behavior (Kerlinger 1985a, Bildstein 2006). Some species, such as the Peregrine Falcon and Osprey, routinely make over-water crossings of hundreds of kilometers (e.g., across the Gulf of Mexico). Most other species are reluctant to cross expanses exceeding 10–20 km, and even then do so only when favorable wind patterns increase the likelihood of a successful crossing (Bildstein 2006). As a result, migrants tend to concentrate at the tips of peninsulas that shorten water crossings. Well-known peninsula watchsites include Lighthouse Point Hawk Watch, Connecticut, Cape May Bird Observatory, New Jersey, Kiptopeke Hawkwatch, Virginia, Smith Point Raptor Migration Project, Texas, and Golden Gate Raptor Observatory's site in the Marin Headlands, California (Table 1). Even at such sites, many migrants turn around and retrace their flights northward to avoid making long water crossings (Kerlinger 1989).

Several species naturally concentrate more along coastlines than along inland pathways for reasons other than those mentioned above. These include Osprey, Northern Harrier (*Circus cyaneus*), accipiters in some areas, and many falcons (Table 2). In coastal Texas, the Smith Point watchsite is on the coastline, whereas the Corpus Christi Raptor Migration Project is 8 km inland. Although many species are considerably more abundant at Corpus Christi, counts of Northern Harriers, Sharp-shinned Hawks, Cooper's Hawks (*A. cooperii*), American Kestrels, and Merlins (*F. columbarius*) are about twice as numerous at Smith Point, in part due to the propensity of these species to migrate along coast lines (Smith et al. 2001b).

The Great Lakes act as *diversion lines* for outbound Canadian migrants (Zalles and Bildstein 2000). Because of this, sites such as Holiday Beach Migration Observatory and Hawk Cliff Hawkwatch, Ontario; Hawk Ridge Bird Observatory, Minnesota; and Cedar Grove Ornithological Station, Wisconsin, all receive large numbers of migrants. Some central Canadian nesters also move east on prevailing westerly winds and around the eastern edge of the Great Lakes, whereupon they enter the Appalachian Mountain or Atlantic Coast corridors.

In eastern North America, the Appalachian Mountains, whose extent and northeast-to-southwest orientation act as a major *leading line*, attract many migrants that use *slope soaring* there to reduce the cost of their migratory flights. This is particularly true in the central Appalachian Mountains, whose ridges run northeast to southwest from southern New York and western New Jersey into eastern Pennsylvania, before turning south in western Maryland and northern Virginia. In

Table 2. North American watchsites with the five highest average (1997–2006) counts of migrating raptors by species and season.

Species Season Site [a]	Years [b]	Mean count season^{-1} (range)
Turkey Vulture		
Autumn		
Veracruz River of Raptors, Veracruz, Mexico	2002–2006	1,971,299 (2,677,355–1,346,704)
Kekoldi, Costa Rica	2004–2006	911,659 (≤1,158,396)
Lake Erie Metro Park, Michigan	2002–2006	67,567 (104,538–36,861)
Kern River Valley, California*	2004–2006	26,359 (32,926–16,479)
Holiday Beach, Ontario	1997–2006	24,364 (41,543–14,752)
Spring		
Veracruz River of Raptors, Veracruz, Mexico*	2002–2006	162,652 (323,881–1,423)
Braddock Bay, New York	2002–2006	11,404 (16,706–4,671)
Ripley Hawk Watch, New York	2003–2006	10,229 (12,091–8,068)
Bentsen Rio Grande State Park, Texas*	2005–2006	9,343 (14,066–4,620)
Hamburg Hawk Watch, New York*	2002–2006	8,420 (9,160–7,723)
Black Vulture		
Autumn		
Corpus Christi, Texas	1998–2005	539 (1,398–138)
Kiptopeke State Park, Virginia	2002–2006	492 (962–181)
Second Mountain, Pennsylvania	2002–2006	399 (807–132)
Bake Oven Knob, Pennsylvania	2002–2006	283 (330–195)
Bentsen Rio Grande Park, Texas*	2004–2006	182 (450–41)
Spring		
Fort Smallwood Park, Maryland	1997–2006	228 (324–149)
Bentsen Rio Grande Park, Texas*	2005–2006	85 (111–59)
College Creek, Virginia*	2003–2006	61 (117–22)
Rose Tree Park, Pennsylvania	2002–2006	44 (74–13)
Derby Hill Bird Observatory, New York	2002–2005	2 (4–1)
Osprey		
Autumn		
Veracruz River of Raptors, Veracruz, Mexico	2002–2006	2,673 (3,002–2,098)
Cape May, New Jersey	1997–2006	2,462 (4,631–1,643)
Kiptopeke State Park, Virginia	2002–2006	1,986 (2,772–1,464)
Cape Henlopen, Delaware	2002–2006	1,873 (2,950–286)
Kekoldi, Costa Rica	2004–2005	1,201 (≤1,698)

Table 2. Continued.

Species Season Site [a]	Years [b]	Mean count season^{-1} (range)
Spring		
Fort Smallwood Park, Maryland	1997–2006	485 (824–355)
Derby Hill Bird Observatory, New York	2003–2006	390 (503–278)
Tlacotalpan, Veracruz, Mexico*	2003–2006	268 (343–145)
West Skyline Hawk Count, Minnesota*	2000–2005	205 (271–88)
Pilgrim Heights, Massachusetts*	2003–2006	199 (286–132)
Hook-billed Kite		
Autumn		
Veracruz River of Raptors, Veracruz, Mexico	2002–2006	145 (190–104)
Corpus Christi, Texas	1998–2006	0 (1–0)
Smith Point, Texas	1998–2005	0 (1–0)
Spring		
Veracruz River of Raptors, Veracruz, Mexico *	2005–2006	3 (5–1)
Tlacotalpan, Veracruz, Mexico*	2003–2006	1 (1–0)
Swallow-tailed Kite		
Autumn		
Kekoldi, Costa Rica	2004–2005	278 (≤427)
Veracruz River of Raptors, Veracruz, Mexico	2002–2006	211 (272–141)
Smith Point, Texas	1998–2005	82 (150–34)
Spring		
Bentsen Rio Grande Park, Texas*	2005–2006	4 (6–1)
Tlacotalpan, Veracruz, Mexico*	2003–2006	2 (4–1)
Fort Smallwood Park, Maryland	1997–2006	0 (2–1)
Rose Tree Park, Pennsylvania	2002–2006	0 (1–0)
White-tailed Kite		
Autumn		
Golden Gate Raptor Observatory, California	1997–2006	76 (204–9)
Veracruz River of Raptors, Veracruz, Mexico	2002–2006	52 (260–0)
Lagoon Valley, California*	2005–2006	19 (23–14)
Smith Point, Texas	1998–2005	17 (26–7)
Bentsen Rio Grande Park, Texas*	2004–2006	14 (40–3)

Table 2. Continued.

Species Season Site[a]	Years[b]	Mean count season^{-1} (range)
Spring		
Bentsen Rio Grande Park, Texas*	2005–2006	11 (14–8)
Borrego Valley, California*	2003–2006	2 (5–1)
Snail Kite		
Autumn		
Veracruz River of Raptors, Veracruz, Mexico	2002–2006	1 (5–0)
Mississippi Kite		
Autumn		
Veracruz River of Raptors, Veracruz, Mexico	2002–2006	210,279 (306,274–171,059)
Kekoldi, Costa Rica	2004–2005	75,190 (≤118,379)
Corpus Christi, Texas	1998–2005	6,599 (10,155–2,974)
Congaree Bluffs, South Carolina*	2005–2006	47 (76–18)
Curry Hammock State Park, Florida	1999–2004	21 (57–14)
Spring		
Tlacotalpan, Veracruz, Mexico*	2003–2006	23,683 (49,062–4,962)
Veracruz River of Raptors, Veracruz, Mexico*	2005–2006	1,333 (2,663–3)
Bentsen Rio Grande Park, Texas*	2005–2006	1,057 (1,317–796)
Fort Smallwood Park, Maryland	1997–2006	4 (11–1)
Pilgrim Heights, Maryland*	2003–2006	3 (6–2)
Plumbeous Kite		
Autumn		
Kekoldi, Costa Rica	2004–2005	583 (≤2,245)
Veracruz River of Raptors, Veracruz, Mexico	2002–2006	1 (2–1)
Spring		
Veracruz River of Raptors, Veracruz, Mexico	2005–2006	0 (5–0)
Bentsen Rio Grande Park, Texas*	2005–2006	0 (3–0)
Northern Harrier		
Autumn		
Cape May, New Jersey	1997–2006	1,570 (2,458–743)
Hawk Cliff, Ontario	2002–2006	1,170 (1,966–531)
Lake Erie Metropark, Michigan	2002–2006	821 (1,372–224)
Golden Gate Raptor Observatory, California	1997–2006	815 (1,369–352)

Table 2. Continued.

Species Season Site[a]	Years[b]	Mean count season^{-1} (range)
Kiptopeke State Park, Virginia	2002–2006	642 (734–5370)
Spring		
Braddock Bay, New York	2003–2006	638 (1,022–89)
Derby Hill Bird Observatory, New York	2003–2006	511 (596–423)
Gunsight Mountain, Alaska*	2003–2006	274 (493–150)
Ripley Hawk Watch, New York	2003–2006	211 (239–179)
Fort Smallwood Park, Maryland	1997–2006	126 (188–77)
Bald Eagle		
Autumn		
Hawk Ridge, Minnesota	1997–2006	3,161 (4,276–1,860)
Hitchcock Nature Center, Iowa*	2002–2006	886 (1,058–729)
Mt. Lorette, Alberta	1993–2005	383 (628–276)
Kiptopeke State Park, Virginia	2002–2006	240 (414–172)
Cape May, New Jersey	1997–2006	206 (340–131)
Spring		
West Skyline Hawk Count, Minnesota*	2000–2006	2,844 (3,415–2,338)
Chequamegon Bay, Wisconsin*	2005–2006	724 (826–622)
Derby Hill Bird Observatory, New York	2003–2006	232 (363–137)
Jordanelle Reservoir, Utah	1997–2002	227 (347–860)
Mt. Lorette, Alberta	1993–2005	221 (276–163)
Northern Goshawk		
Autumn		
Hawk Ridge, Minnesota	1997–2006	584 (1,112–104)
Observatoire d'oiseaux de Tadoussac, Québec	2004–2005	179 (335–79)
Cedar Grove, Wisconsin	1960s	119
Waggoner's Gap, Pennsylvania	1997–2006	90 (218–29)
Goshute Mountains, Nevada	1997–2005	87 (241–11)
Spring		
Whitefish Point, Michigan		124
Belvédère Raoul-Roy, Parc Nat'l du Bic, Québec	2002–2006	51 (95–26)
Derby Hill Bird Observatory, New York	2002–2006	42 (58–26)
Mt. Lorette, Alberta	1993–2005	33 (90–11)
Sandia Mountains, New Mexico	1997–2005	11 (31–2)

Table 2. Continued.

Species Season Site[a]	Years[b]	Mean count season^{-1} (range)
SHARP-SHINNED HAWK		
Autumn		
Cape May, New Jersey	1997–2006	21,350 (48,992–12,927)
Hawk Ridge, Minnesota	1997–2006	16,462 (21,352–8,9730
Holiday Beach, Ontario	1997–2006	10,995 (15,719–5,506)
Hawk Cliff, Ontario	2002–2006	9,313 (14,916–5,396)
Lighthouse Point, Connecticut	1997–2006	6,695 (8,213–4,605)
Spring		
Whitefish Point, Michigan		9,860
Braddock Bay, New York	2003–2006	2,810 (5,888–49)
Derby Hill Bird Observatory, New York	2003–2006	2,692 (3,821–1,510)
Fort Smallwood Park, Maryland	1997–2006	2,485 (3,547–1,792)
Sandia Mountains, New Mexico	1997–2005	560 (1,280–311)
COOPER'S HAWK		
Autumn		
Cape May, New Jersey	1997–2006	4,162 (6,927–1,874)
Goshute Mountains, Nevada	1997–2005	3,713 (6,736–2,260)
Golden Gate Raptor Observatory, California	1997–2006	2,388 (3,370–1,201)
Veracruz River of Raptors, Veracruz, Mexico	2002–2006	1,950 (2,309–1,294)
Kiptopeke State Park, Virginia	2002–2006	1,920 (2,301–1,634)
Spring		
Sandia Mountains, New Mexico	1997–2005	715 (1,157–486)
Fort Smallwood Park, Maryland	1997–2006	504 (674–409)
Dinosaur Ridge, Colorado	1991–2001	475 (803–254)
Derby Hill Bird Observatory, New York	2002–2006	391 (452–330)
Braddock Bay, New York	2002–2006	293 (499–43)
COMMON BLACK HAWK		
Autumn		
Veracruz River of Raptors, Veracruz, Mexico	2002–2006	5 (7–1)
Spring		
Veracruz River of Raptors, Veracruz, Mexico	2005–2006	1 (1–0)
HARRIS'S HAWK		
Autumn		
Corpus Christi, Texas	1998–2005	14 (28–5)

Table 2. Continued.

Species Season Site [a]	Years [b]	Mean count season^{-1} (range)
Veracruz River of Raptors, Veracruz, Mexico	2002–2006	11 (25–4)
Bentsen Rio Grande Park, Texas*	2003–2006	10 (23–8)
Spring		
Bentsen Rio Grande Park, Texas*	2005–2006	3 (5–1)
Veracruz River of Raptors, Veracruz, Mexico*	2005–2006	2 (3–0)
GRAY HAWK		
Autumn		
Veracruz River of Raptors, Veracruz, Mexico	2002–2006	524 (1,220–95)
Spring		
Veracruz River of Raptors, Veracruz, Mexico	2005–2006	10 (20–20)
RED-SHOULDERED HAWK		
Autumn		
Lake Erie Metropark, Michigan	2002–2006	970 (1,109–869)
Hawk Cliff, Ontario	2002–2006	811 (1,090–496)
Holiday Beach, Ontario	1997–2006	623 (1,042–403)
Cape May, New Jersey	1997–2006	496 (723–232)
Golden Gate Raptor Observatory, California	1997–2006	380 (677–145)
Spring		
Derby Hill Bird Observatory, New York	2003–2006	683 (930–501)
Beamer Conservation Area, Ontario	2001–2006	554 (679–455)
Braddock Bay, New York	2003–2006	409 (898–187)
Fort Smallwood Park, Maryland	1997–2006	210 (413–134)
Tussey Mountain, Pennsylvania	2003–2006	57 (82–36)
BROAD-WINGED HAWK		
Autumn		
Veracruz River of Raptors, Veracruz, Mexico	2002–2006	1,904,261 (2,386,232–1,512,816)
Corpus Christi, Texas	1998–2005	677,518 (989,957–263,101)
Lake Erie Metropark, Michigan	2002–2006	76,036 (106,417–27,359)
Hawk Ridge, Minnesota	1997–2006	55,212 (160,703–9,410)
Smith Point, Texas	1998–2005	38,648 (103,612–16,137)
Spring		
Tlacotalpan, Veracruz, Mexico*	2003–2006	84,948 (150,350–22,211)

Table 2. Continued.

Species Season Site [a]	Years [b]	Mean count season^{-1} (range)
Veracruz River of Raptors, Veracruz, Mexico	2005–2006	31,798 (61,283–2,313)
Bentsen Rio Grande Park, Texas	2005–2006	28,197 (41,775–14,619)
Braddock Bay, New York	2003–2006	23,325 (47,180–16,294)
Derby Hill Bird Observatory, New York	2003–2006	12,538 (19,121–8,928)
SHORT-TAILED HAWK		
Autumn		
Curry Hammock State Park, Florida	1999–2004	295 (38–16)
Veracruz River of Raptors, Veracruz, Mexico	2002–2006	1 (3–0)
Spring		
Tlacotalpan, Veracruz, Mexico*	2003–2006	5 (18–0)
WHITE-TAILED HAWK		
Autumn		
Smith Point, Texas	1998–2005	11 (24–0)
Corpus Christi, Texas	1998–2005	9 (25–4)
Bentsen Rio Grande Park, Texas*	2004–2006	1 (2–0)
Spring		
Veracruz River of Raptors, Veracruz, Mexico	2005–2006	1 (1–0)
Bentsen Rio Grande Park, Texas*	2005–2006	1 (1–0)
SWAINSON'S HAWK		
Autumn		
Veracruz River of Raptors, Veracruz, Mexico	2002–2006	974,951 (1,216,153–467,533)
Kekoldi, Costa Rica	2004–2005	293,432 (414,742 – ?)
Corpus Christi, Texas	1998–2006	6,036 (14,751–300)
Hitchcock Nature Center, Iowa	2002–2006	1,985 (3,648–1,059)
Goshute Mountains, Nevada	1997–2006	373 (908–91)
Spring		
Veracruz River of Raptors, Veracruz, Mexico*	2005–2006	34,537 (59,926–9,148)
Tlacotalpan, Veracruz, Mexico*	2003–2006	4,203 (12,022–576)
Borrego Valley, California*	2003–2006	2,921 (5,228–1,605)
Bentsen Rio Grande Park, Texas*	2005–2006	2,010 (3,214–805)
Jordanelle Reservoir, Utah	1997–2002	78 (115–22)

Table 2. Continued.

Species Season Site [a]	Years [b]	Mean count season^{-1} (range)
Zone-tailed Hawk		
Autumn		
Veracruz River of Raptors, Veracruz, Mexico	2002–2006	189 (276–137)
Corpus Christi, Texas	1998–2005	3 (10–0)
Manzano Mountains, New Mexico	1998–2005	1 (3–0)
Spring		
Veracruz River of Raptors, Veracruz, Mexico*	2005–2006	17 (31–2)
Tlacotalpan, Veracruz, Mexico*	2003–2006	8 18–3)
Bentsen Rio Grande Park, Texas*	2005–2006	2 (2–0)
Sandia Mountains, New Mexico	1998–2005	3 (10–0)
Red-tailed Hawk		
Autumn		
Golden Gate Raptor Observatory, California	1997–2006	9,340 (13,303–4,102)
Hawk Ridge, Minnesota	1997–2006	8,934 (12,696–4,843)
Lake Erie Metropark, Michigan	2002–2006	8,125 (12,161–6,149)
Hawk Cliff, Ontario	2002–2006	4,924 (6,377–2,612)
Waggoner's Gap, Pennsylvania	1997–2006	4,116 (5,731–3)
Spring		
West Skyline Hawk Count, Minnesota*	2000–2006	5,343 (7,398–2,556)
Derby Hill Bird Observatory, New York	2002–2006	5,086 (6,760–4,022)
Belvédère Raoul-Roy, Parc Natl. du Bic, Québec*	2002–2006	3,019 (5,253–1,221)
Jordanelle Reservoir, Utah	1997–2002	1,029 (1,631–444)
Dinosaur Ridge, Colorado	1991–2001	982 (1,900–488)
Ferruginous Hawk		
Autumn		
Golden Gate Raptor Observatory, California	1997–2006	23 (37–14)
Goshute Mountains, Nevada	1997–2006	17 (25–8)
Manzano Mountains, New Mexico	1997–2005	9 (14–3)
Corpus Christi, Texas	1998–2005	4 (14–0)
Hitchcock Nature Center, Iowa	2002–2006	2 (2–0)
Spring		
Dinosaur Ridge, Colorado	1991–2001	74 (241–25)
Sandia Mountains, New Mexico	1997–2005	12 (23–5)
Jordanelle Reservoir, Utah	1997–2002	8 (14–5)

Table 2. Continued.

Species Season Site [a]	Years [b]	Mean count season^{-1} (range)
ROUGH-LEGGED HAWK		
Autumn		
Hawk Ridge, Minnesota	1997–2006	487 (814–200)
Observatoire d'oiseaux de Tadoussac, Québec	2004–2006	236 (295–177)
Thunder Cape Bird Observatory, Ontario*	2004–2006	136 (244–39)
Cranberry Marsh, Ontario	2002–2006	105 (322–30)
Mt. Lorette, Alberta	1993–2005	64 (80–34)
Spring		
Whitefish Point, Michigan		859
Derby Hill Bird Observatory, New York	2002–2006	346 (461–251)
Braddock Bay, New York	2003–2006	340 (738–37)
Gunsight Mountain, Alaska*	2003–2006	302 (368–219)
Mt. Lorette, Alberta	1993–2005	20 (29–4)
GOLDEN EAGLE		
Autumn		
Mt. Lorette, Alberta	1993–2005	3,897 (4,753–3,475)
Bridger Mountains, Montana	1997–2005	1,470 (1,871–1,061)
Goshute Mountains, Nevada	1997–2005	265 (344–130)
Waggoner's Gap, Pennsylvania	1997–2006	199 (277–1)
Allegheny Front, Pennsylvania	2002–2006	160 (222–89)
Spring		
Mt. Lorette, Alberta	1993–2005	3,305 (4,213–2,461)
Rogers Pass, Montana*	1993–2002	1,352 (1,836–916)
Sandia Mountains, New Mexico	1997–2005	451 (897–304)
Tussey Mountain, Pennsylvania	2003–2006	172 (199–150)
West Skyline Hawk Count, Minnesota	2000–2006	72 (127–48)
CRESTED CARACARA		
Autumn		
Corpus Christi, Texas	1998–2006	11 (21–1)
Smith Point, Texas	1998–2005	10 (26–3)
Bentsen Rio Grande State Park, Texas*	2004–2006	7 (19–2)
Spring		
Bentsen Rio Grande Park, Texas*	2005–2006	3 (4–2)
Tlacotalpan, Veracruz, Mexico	2004–2006	2 (7–0)

Table 2. Continued.

Species Season Site [a]	Years [b]	Mean count season^{-1} (range)
AMERICAN KESTREL		
Autumn		
Cape May, New Jersey	1997–2006	6,563 (11,768–2,672)
Kiptopeke State Park, Virginia	2002–2006	3,788 (5,455–2,643)
Hawk Cliff, Ontario, Canada	2002–2006	3,918 (5,076–2,677)
Veracruz River of Raptors, Veracruz, Mexico	2002–2006	3,551 (4,296–2,977)
Curry Hammock State Park, Florida	1999–2004	800 (4,338–825)
Spring		
Dinosaur Ridge, Colorado	1991–2001	712 (1,287–216)
Fort Smallwood Park, Maryland	1997–2006	544 (970–254)
Ripley Hawk Watch, New York	2003–2005	277 (359–192)
Braddock Bay, New York	2003–2005	237 (359–44)
Derby Hill Bird Observatory, New York	2003–2006	236 (354–158)
MERLIN		
Autumn		
Cape May, New Jersey	1997–2006	1,805 (2,694–1,085)
Kiptopeke State Park, Virginia	2002–2006	1,353 (1,609–877)
Fire Island, New York	2003–2006	1,109 (1,620–275)
Curry Hammock State Park, Florida	1994–2004	54 (834–317)
Illinois Beach State Park, Illinois*	2000–2006	305 (513–10)
Spring		
Cape Henlopen Hawk Watch, Delaware	2002–2006	121 (168–78)
Fort Smallwood Park, Maryland	1997–2006	67 (106–30)
Pilgrim Heights, Massachusetts*	2003–2006	54 (60–49)
Whitefish Point, Michigan		43
Derby Hill Bird Observatory, New York	2003–2006	31 (39–24)
PEREGRINE FALCON		
Autumn		
Curry Hammock State Park, Florida	1999–2004	1,827 (2,858–432)
Kekoldi, Costa Rica	2004–2005	1,696 (≤2,319)
Cape May, New Jersey	1997–2006	1,051 (1,793–588)
Veracruz River of Raptors, Veracruz, Mexico	1997–2006	658 (860–450)
Kiptopeke State Park, Virginia	2002–2006	628 (726–490)
Spring		
Tlacotalpan, Veracruz, Mexico*	2003–2006	99 (165–43)

Table 2. Continued.

Species Season Site [a]	Years [b]	Mean count season^{-1} (range)
Sandia Mountains, New Mexico	1997–2005	65 (105–27)
Dinosaur Ridge, Colorado	1991–2001	20 (50–8)
Braddock Bay, New York	2003–2006	18 (45–1)
Ripley Hawk Watch, New York	2003–2006	10 (15–8)
Gyrfalcon		
Autumn		
Mt. Lorette, Alberta	1993–2005	4 (9–0)
Observatoire d'oiseaux de Tadoussac, Québec	2004–2006	1 (2–0)
Spring		
Mt. Lorette, Alberta, Canada	1993–2005	2 (4–0)
Whitefish Point, Michigan		2
Belvédère Raoul-Roy, Parc National du Bic, Québec	2002–2006	1 (4–0)
Prairie Falcon		
Autumn		
Goshute Mountains, Nevada	1997–2005	28 (50–9)
Manzano Mountains, New Mexico	1997–2005	27 (58–16)
Wellsville Mountains, Utah	1997–2005	21 (33–13)
Corpus Christi, Texas	1998–2005	9 (33–2)
Hitchcock Nature Center, Iowa	2002–2006	5 (7–2)
Spring		
Dinosaur Ridge, Colorado	1991–2001	25 (39–8)
Sandia Mountains, New Mexcio	1997–2005	24 (59–13)
Jordanelle Reservoir, Utah	1997–2002	9 (21–2)

[a] An asterisk indicates limited seasonal coverage; i.e., the mean number of days of observation was <60 in spring or <75 in autumn.

[b] Blanks indicate that specific data were unavailable.

Pennsylvania, the Kittatinny Ridge, the southeastern-most ridge in the central Appalachians, is used by a greater number of outbound migrants due to its more prominent relief, continuous aspect, and "last-ridge" location (Van Fleet 2001). Ridge-top forest and valley-floor farmland also provide abundant sites for resting and feeding en route. The extent to which migrants use or follow *leading lines* or ridges varies with weather, species migration behavior, and seasonal timing. Some individuals follow the Kittatinny for up to 200 km or more, whereas others may follow it for as few as several kilometers under certain conditions (L. Goodrich unpubl. data).

Major river valleys also act as *leading lines* for outbound migrants. The Susquehanna Valley and associated cliffs from southern New York across eastern Pennsylvania appear to funnel both Bald Eagles (*Haliaeetus leucocephalus*) and Golden Eagles (*Aquila chrysaetos*), and possibly Red-shouldered Hawks. The Franklin Mountain Hawkwatch near Oneonta, New York, reports large numbers of these species, as do Council Cup near Berwick, Pennsylvania, and several sites along the Kittatinny Ridge, including Audubon's Hawk Watch at Waggoner's Gap near Carlisle, Pennsylvania, which lies west of the Susquehanna River. Birds appear to follow the Kittatinny, Tuscarora, and other western Appalachian ridges south and west toward southern Pennsylvania, where watchsites such as Allegheny Front Hawk Watch, Johnstown, Tuscarora Summit, Chambersburg, and others farther south, report migrants. A comparison of counts among sites in the Appalachian Mountains suggests that Golden Eagles may migrate farther west through the mountains than many other species (Table 1). This may reflect the locations of their breeding and wintering areas; however, in western North America, migrating Golden Eagles also tend to remain inland (McIntyre et al. 2006, HawkWatch International [HWI] unpubl. satellite-tracking data—see www.hawkwatch.org).

South of Pennsylvania where Appalachian ridges are more fragmented, the flight disperses across many ridges and valleys. For many species, the volume of migrants counted along the southern Appalachians lessens, presumably as shorter-distance migrants reach their wintering areas. Even so, consistent and noteworthy flights dominated by long-distance migrants such as Broad-winged Hawks are recorded at several southern watchsites (Zalles and Bildstein 2000), including Snickers Gap Hawkwatch and Harvey's Knob Overlook, Virginia; Mount Pisgah, North Carolina; Soddy Mountain, Tennessee; and Bird Mountain, Georgia (Table 1; Fig. 1A).

The pathways for migrants south of the Carolinas and north of the Gulf of Mexico are less well defined. Modest flights have been recorded at points along both the Atlantic and Gulf coasts of Florida at the Guana Reserve on the northeast coast and at St. Joseph Peninsula State Park in the Panhandle (Heintzelman 1986). Sizeable concentrations of falcons and accipiters also are recorded each autumn at the Florida Keys Raptor Migration Project, including annual counts averaging more than 1,800 Peregrine Falcons (Lott 2006). This last site counts migrants both from eastern and western locations, depending upon the species. Satellite tracking has demonstrated that Ospreys passing through the Keys on the way to winter ranges in Central and South America converge from east-central Canada and the western Great Lakes east to Maritime Canada (Martell et al. 2001), and that Peregrine Falcons passing there may come from across the entire northern North American range (Fuller et al. 1998). Recovery locations of birds banded at the Florida Keys watchsite include the Great Lakes east to the Atlantic Coast from Virginia to Nova Scotia. Small numbers of Broad-winged Hawks and Swainson's Hawks overwinter in southern Florida each year, either having been wind-drifted from more western flight lines that would have taken them to wintering areas in Central and South America (Hagar in Palmer 1988), or because they are prospecting new wintering areas there (R. Veit pers. comm.).

Southern Florida also is an important staging area for most of the continental population of Swallow-tailed Kites, which aggregate in August near Lake Okeechobee before crossing the Gulf of Mexico to the Yucatan (Meyer 1995). Other long-distance migrants, including Ospreys, Merlins, and Peregrine Falcons, travel to South America by island-hopping through the Greater and Lesser Antilles before making landfall in Colombia, Venezuela, Guyana, Surinam, and French Guiana (Fuller et al. 1998; Zalles and Bildstein 2000; Rodriguez et al. 2001, 2003). A globally important flight of several thousand Ospreys occurs in Cuba where birds concentrate along the southeastern coast of the island before crossing to Central and South America (Rodriguez et al. 2003).

Most long-distance migrants avoid the Gulf water-crossing by traveling west and south around the Gulf Coast through Alabama, Mississippi, Louisiana, Texas, and eventually eastern Mexico (Smith et al. 2001b, Woltmann and Cimprich 2003). Counts in Texas and Veracruz, Mexico indicate that the majority of Mississippi Kites (*Ictinia mississippiensis*), Broad-winged Hawks, Swainson's Hawks, and Turkey Vultures follow the coastal plain through to wintering grounds in Central and South America (Ruelas et al. 2000, Smith et al. 2001a, Ruelas 2005). In Veracruz, the Sierra Madre Oriental converges on the Gulf of Mexico, narrowing the coastal plain to a 30-km bottleneck for soaring migrants, creating one of the most concentrated raptor migrations in the world (Zalles and Bildstein 2000).

As migrants enter southern Mexico, some species, including Broad-winged Hawks, begin settling out on winter ranges (Goodrich et al. 1996), and overall flight volume begins to thin. The continuing flight splits between the Pacific and Atlantic coastal plains of the Mesoamerican region. Birds travel on two flight lines through Guatemala and Honduras, converging again in southern Honduras and northern Nicaragua before passing into northwestern Costa Rica. In Panama, the main flight line largely follows the Pacific slope into Colombia, after which different species take different routes depending upon their destinations and ecology (Bildstein and Zalles 2001, Bildstein 2006).

Central Region.—Many outbound migrants from central Canada skirt the western edge of the Great Lakes and concentrate at Hawk Ridge near Duluth, Minnesota (Evans and Rosenfield 1985). Most migrants appear to use thermal soaring and disperse across a *broad front* over the central states, although concentrations have been noted along major river valleys, including the Mississippi and Iowa. Other sites counting significant numbers of outbound migrants in the region include Cedar Grove, Wisconsin, Illinois Beach State Park, Illinois, and Hitchcock Nature Center, Iowa (Table 1). Broad-winged Hawks satellite-tracked from Minnesota flew nearly due south to Texas before turning to follow the Gulf Coast (Haines et al. 2003).

Short-distance migrants spread out across winter ranges in the southern states and along the Gulf Coast. Flight lines from eastern and central regions merge along the Gulf Coast in Texas before continuing south along the Mesoamerican corridor. By Corpus Christi, eastern Rocky Mountain and western plains flight lines also have merged in, adding thousands of western Swainson's Hawks and Turkey Vultures to the mix (Smith et al. 2001b). Recoveries of birds banded on migration in Veracruz, Mexico, indicate a regular migration of accipiters and falcons from as far north as central Canada (Pronatura Veracruz unpubl. data). Band returns from Hawk Ridge, Minnesota, and Cedar Grove, Wisconsin show similar distributions for species such as Sharp-shinned Hawks, except that winter recoveries for birds banded at these sites also include the southern states of Alabama, Mississippi, and Texas (Mueller and Berger 1967b, Evans and Rosenfield 1985). Counts in Veracruz confirm annual movements of several thousand Sharp-shinned Hawks and Cooper's Hawks as far south as southern Mexico (Ruelas et al. 2000, Ruelas 2005).

Western Region.—In western North America, migrants from mainland Alaska that were tracked by satellite initially converged along routes such as the Tanana and Yukon rivers (e.g., McIntyre and Ambrose 1999, C. McIntyre pers. comm.), and then merged and flowed southeast down through the central Yukon Territory and into northern British Columbia. Some migrants may then divert eastward again to follow pathways such as the Liard River through the northern Rockies, and then turn south to follow the eastern Rockies into Alberta. Other migrants from the Brooks Range and North Slope may first head east across the northern Yukon Territory before turning south and following the eastern Rockies and Mackenzie River down through the western Northwest Territories before converging with flight lines from farther west. These migrants comprise the initial flows of the Rocky Mountain migration corridor (Fig. 3; Hoffman et al. 2002).

Farther south along the Rocky Mountain corridor, broad-frontal migrants from west-central Canada converge with other migrants along the northeastern Rockies, and then continue south through the central and southern Rockies and adjacent prairies. Relevant watchsites include the Wellsville Mountains Raptor Migration Project, Utah; Commissary Ridge, Wyoming; the Manzano Mountains Raptor Migration Project, New Mexico

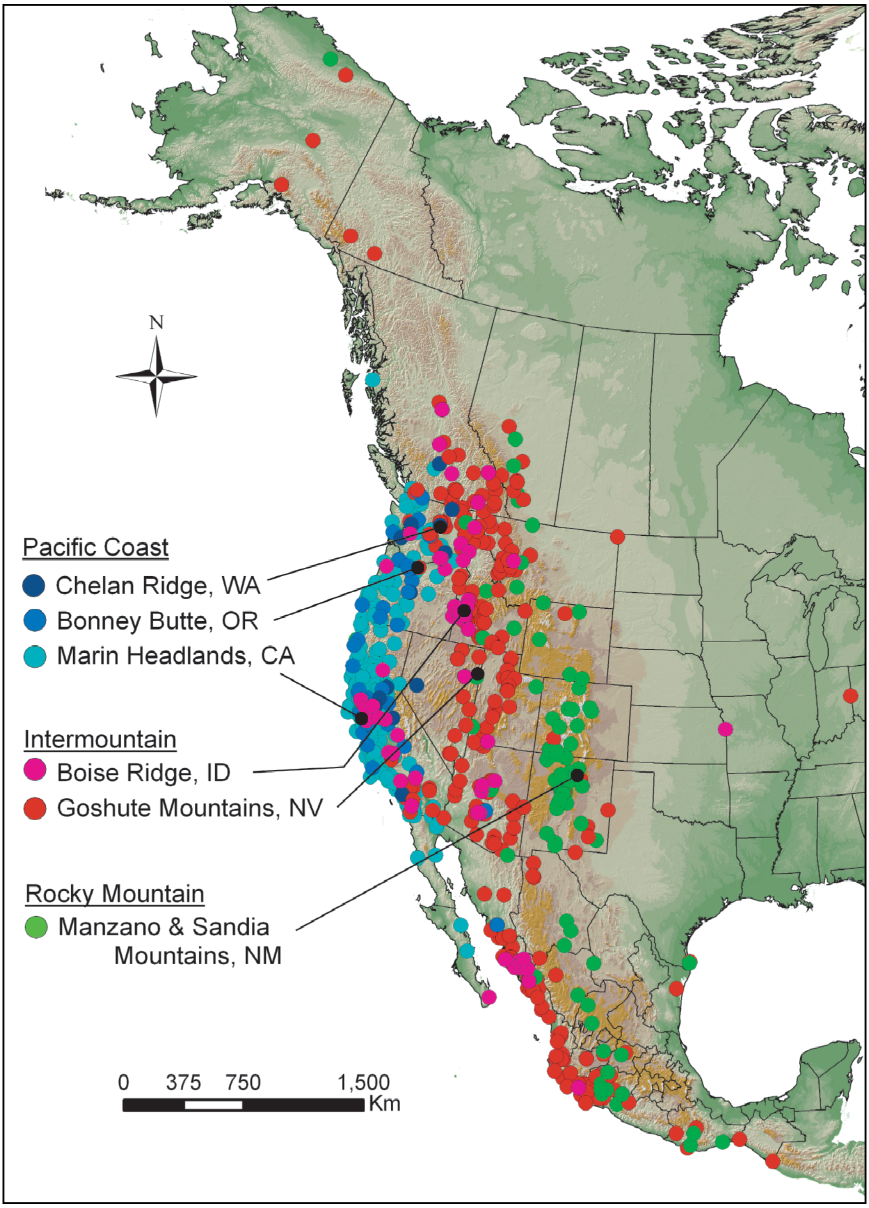

Fig. 3. Combined-species (primarily Sharp-shinned Hawks [*Accipiter striatus*], Cooper's Hawks [*A. cooperii*], Red-tailed Hawks [*Buteo jamaicensis*], and American Kestrels [*Falco sparverius*]) band-recovery patterns for six western raptor migration banding stations (1980–2006).

(Table 1, Fig. 1C), and the Franklin Mountains in west Texas (J. Kiseda pers. comm.). Depending on the species and geographic origin of the individuals involved, Rocky Mountain migrants begin spreading out onto winter ranges as far north as southern Alberta and Saskatchewan, with others continuing south along the Rockies and Sierra Madre Oriental to points farther south. The northeastern Rocky Mountains are particularly noteworthy for the convergence and passage of thousands of Golden Eagles at sites such as Mount Lorette, Alberta (Sherrington 2003) and Bridger Mountains Raptor Migration Project, Montana (Omland and Hoffman 1996, Hoffman and Smith 2003).

The many lakes and bays of western Canada provide diversion lines that funnel otherwise broad-frontal movements of eagles and other species (Zalles and Bildstein 2000). Satellite tracking has confirmed that Bald Eagles routinely travel between large lakes and along large river corridors, moving in response to seasonal availability of key prey species (McClelland et al. 1994, 1996; J. Watson pers. comm.).

The east slope of the Rockies and adjacent western plains provide favorable thermals and productive habitat for soaring migrants such as Swainson's Hawks, as well as for other open-country species such as Prairie Falcons, Ferruginous Hawks, and Golden Eagles. Band recoveries and satellite tracking have revealed the attractiveness of this corridor for all four species (Schmutz and Fyfe 1987, Schmutz et al. 1991, Fuller et al. 1998, McIntyre 2005, Steenhof et al. 2005, Watson and Banasch 2005). Except for Hitchcock Nature Center, Iowa (Table 2), few watchsites north of Texas routinely record substantial numbers of Swainson's Hawks. Large numbers of Swainson's Hawks in Corpus Christi, Texas (Smith et al. 2001b) suggest a substantial and as yet unstudied passage of this species through the central and western plains. Further work along the Great Plains–Rocky Mountain ecotone should provide additional important information on flight patterns and numbers of raptors migrating in this region.

Other migrants moving south from Alaska and the Yukon Territory continue south through central British Columbia along the western Rockies, eventually moving into eastern Washington and Idaho along the Okanogan, Columbia, and, eventually, Snake rivers. These migrants comprise the initial flows of activity along the Intermountain corridor, which continues south through the continental United States between the Cascade–Sierra Nevada ranges to the west and Rocky Mountains to the east (Hoffman et al. 2002). The corridor attracts some migrants from as far north as northern Alaska and draws heavily from the northwestern Rockies, interior British Columbia, the Columbia Basin, and the Great Basin (Figs. 2F and 3). Known concentration points include Boise Ridge in west-central Idaho, the Goshute Mountains in northeastern Nevada, and the Grand Canyon in northern Arizona (Table 1, Fig. 1C). Migrants pass along the many parallel ranges of the Great Basin, and begin to spread out across winter ranges from southern California across southern Arizona, south into Baja California, and along the Pacific coastal plain of Mexico (Hoffman et al. 2002).

The most significant known concentration area in the Intermountain west is in the Goshute Mountains, Nevada (Table 1), where autumn counts have reached as high as 25,000 migrants as a result of birds avoiding the inhospitable Great Salt Lake and Salt Lake Desert complex (Hoffman 1985, Hoffman et al. 2002, Hoffman and Smith 2003). Migrants moving south from northern Idaho cross the broad Snake River plains, where the river funnels migrants from the northeast and northwest towards the southernmost loop of the river valley, which lies immediately north of the Utah–Nevada border and serves to direct migrants south towards the Goshute range. Other migrants moving south out of eastern Idaho are diverted southwest by the Salt Lake Desert complex to the Goshute range, which is the first available pathway for continuing south along the west edge of the desert. Farther south, the Grand Canyon and Painted Desert also act to concentrate migrants, which seek to cross the narrowest parts of the canyon at watchsites such as the Grand Canyon Raptor Migration Projects at Lipan Point and Yaki Point, which together count as many as 11,000 migrants annually (Table 1; Hoffman and Smith 2003).

Band recoveries and satellite tracking indicate that several common, short- to moderate-distance, partial migrants, including Sharp-shinned Hawks, Cooper's Hawks, Red-tailed Hawks, and American Kestrels, occupy a relatively restricted range along the Pacific Coast (Figs. 2–4). For most species, the Pacific Coast corridor extends from southwestern British Columbia to northwestern Mexico from the Sierra Nevada and Cascade ranges west to the coast (Hoffman et al. 2002). Sites where noteworthy concentrations have been recorded include Chelan Ridge, Diamond Head, and Entiat Ridge in the Cascades of Washington, Bonney Butte and Green Ridge in the Cascades of Oregon, and in the Marin Headlands on the central coast of California. Available data suggest that Sharp-shinned Hawks, Red-tailed Hawks, Golden Eagles, and American Kestrels from mainland Alaska and northwestern Canada rarely continue south along the Pacific Coast into California, but instead overwinter either in the Pacific Northwest or on the prairies of southern Canada, or continue farther south through the Intermountain or Rocky Mountain corridors (e.g., Figs. 2–4; and see McIntyre 2005). Because California, in particular, comprises both rich breeding and wintering habitat, as well as a migration corridor, the dynamics of seasonal movements in the Pacific Coast corridor can be complex, especially in central California where Golden Gate Raptor Observatory's Marin Headlands watchsite is located north of San Francisco. For example, Red-tailed Hawks raised in southern California are known to disperse in many directions, including

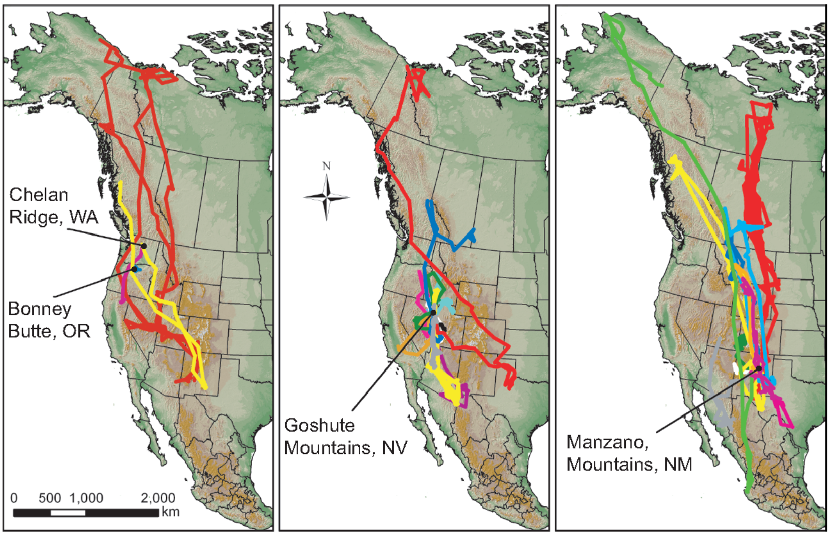

Fig. 4. Movements of immature and subadult Golden Eagles (*Aquila chrysaetos*) as determined by satellite tracking of birds outfitted at autumn migration-banding sites in Washington (n = 2), Oregon (n = 2), Nevada (n = 13), and New Mexico (n = 12) between 1999 and 2006. On each map, tracks of different colors represent individual birds.

as far northeast as Wyoming, whereas breeders in the region are mostly permanent residents (Bloom 1985).

Although many species winter in California, individuals of other species including Turkey Vultures, Broad-winged Hawks, and Swainson's Hawks move south along the Pacific Coast corridor through southern California, but then divert east-southeast across southern Arizona, New Mexico, and northern Mexico, where they join other western and eastern migrants and continue south along the Mesoamerican corridor (e.g., see Fuller et al. 1998). At least one Northern Harrier satellite-tracked from the Chelan Ridge watchsite in the northeast Cascades of Washington followed a similar path in reaching southern New Mexico (J. Watson pers. comm.). Ospreys west of the Cascade Mountains also move south through the Pacific Coast corridor and continue on to winter in western Mexico (Martell et al. 2001). Soaring, open-country migrants such as Swainson's Hawks and Turkey Vultures appear to follow an inland path south through California along the thermal-rich Central Valley and western foothills of the Sierra Nevada. Vulture concentrations numbering in the tens of thousands occur along the Kern River at the southern end of the Central Valley, where convergence of the Sierra Nevada and Coast ranges forces migrants to seek an efficient route through the mountains (Rowe and Gallion 1996).

Despite these general patterns, several species follow different pathways and migration strategies, which by example illustrate the variety of migration strategies that occur in this region. Band returns and satellite tracking, for example, indicate that many Prairie Falcons and Ferruginous Hawks, in particular, follow unique migration routes. Long-term studies in the Snake River Birds of Prey National Conservation Area in southwest Idaho indicate that most Prairie Falcons there begin vacating their breeding grounds in late summer after chicks have fledged and ground squirrels (*Spermophilus* spp.) begin aestivating to survive the hot summer (Steenhof et al. 1984, 2005). They then head northeast to the prairies of southeastern Alberta, southern Saskatchewan, and central and eastern Montana, where emergent ground squirrels and other suitable prey remain available. Then, as autumn and winter progress and ground squirrels begin hibernating, the birds gradually move south through the plains states tracking seasonally available prey until they eventually settle in areas where prey remain available throughout the winter (e.g., prairie-dog [*Cynomys* spp.] towns in Texas and Oklahoma). Once spring arrives, the birds return directly to their breeding range, completing a *loop migration*. Similar loop migrations have been demonstrated for Ferruginous Hawks breeding in the Great Basin of southeastern Washington; however, birds breeding in the plains region of Alberta and Saskatchewan follow a more typical, linear migration pattern, whereby they remain year-round within the plains region and move north and south with the seasons (Schmutz and Fyfe 1997, Watson and Banasch 2005).

The Northern Goshawk also exhibits complex migration patterns in this as well as other regions of North America. Northern populations tend to be more migratory than southern populations, with the largest migration counts recorded at northern watchsites such as Hawk Ridge, Minnesota (Tables 1 and 2). However, northern populations also display *irruptive migration* in response to cyclical abundance patterns of key prey species (e.g., grouse [*Bonasa* spp], ptarmigan [*Lagopus* spp.], and snowshoe hares [*Lepus arcticus*]; Mueller et al. 1977, Squires and Reynolds 1997, Hoffman and Smith 2003), which complicates detection of underlying population trends (Chapter 4). At southern latitudes, such as in the Wasatch Mountains of Utah, satellite tracking of breeding adults illustrates considerable variability in migration behavior (Sonsthagen et al. 2006). Some birds appeared to be permanent residents on their breeding territory; others were altitudinal migrants that moved to lower elevations in winter; and still others undertook more typical north–south migrations of up to 200 km. Other satellite tracking of mostly first-year Northern Goshawks outfitted at autumn migration sites in Oregon, Washington, Nevada, Wyoming, and New Mexico, demonstrated that the majority of individuals seen at these watchsites are regional residents that remain within 150 km of where they were trapped.

The Bald Eagle is another species that exhibits regionally complex migration ecology. Birds from California and the Pacific Northwest travel north in late summer, whereas birds from places such as Glacier National Park and the Greater Yellowstone ecosystem move northwest to converge with the others and spend the fall and winter along the northern Pacific Coast feeding on salmon (McClelland et al. 1982, 1996; Swenson et al. 1986; Buehler 2000). More generally, in the northwest and northern Intermountain Region, migratory movements frequently track salmon migrations along major river corridors and connections between major lakes that provide food resources.

Mesoamerican Land Corridor.—The largest concentration of migrating raptors in the world occurs in funnel-shaped southern North America and Central America. Migration corridors from across North America converge along the Gulf Coast of eastern Mexico (Ruelas et al. 2000). In Veracruz, a *narrow front* of <30 km between the Sierra Madre Oriental and the Gulf of Mexico concentrates 4–6 million raptors each autumn, including effective global populations of Mississippi Kites, Broad-winged Hawks, and Swainson's Hawks, along with many western Turkey Vultures (Bildstein and Zalles 2001, Ruelas et al. 2000, Ruelas 2005). At least 33 species of migratory raptors have been recorded using the Mesoamerican Land Corridor.

The corridor splits at the Isthmus of Tehuantepec in southern Mexico, with one branch following the Pacific and the other the Caribbean slopes southeast. Broad-winged Hawks predominate in the eastern branch, where they have been recorded passing through Chiapas, Mexico and Peten, Guatemala. Turkey Vultures, Mississippi Kites, Swainson's Hawks, and some Broad-winged Hawks travel along the western branch into Guatemala and El Salvador (Bildstein and Zalles 2001).

The two branches converge again on the Pacific slope of southernmost Honduras, before crossing the Caribbean slope in northwestern Costa Rica, where migrants follow the coastal plain into Panama. In central Panama, the main flight line shifts to the Pacific slope, although many migrants, particularly Broad-winged Hawks, fly over the Panama Canal across the entire isthmus (Bildstein and Zalles 2001, Bildstein 2006).

Many Ospreys, Merlins, and Peregrine Falcons crossing from Florida into Cuba and Hispaniola and, thereafter, across the Caribbean Sea, join the corridor south of Mexico. Finally, because Broad-winged Hawks and several other species overwinter in Central America, the flight line thins before reaching South America, where it also then broadens as different species take different routes to their wintering areas (Bildstein 2006).

Return or Spring Migration

Mesoamerican Corridor.—Although the details differ, many birds returning from their South American wintering areas largely retrace their autumn routes. Some pathways vary along the Mesoamerican Land Corridor, presumably due to prevailing winds (Bildstein 2006). Migrants moving through eastern Panama, for example, tend to concentrate along the Caribbean slope in spring, whereas many Swainson's Hawks enter Costa Rica along the Pacific slope, with flight lines converging in central Costa Rica along the Caribbean slope into southwestern Nicaragua, where the flight again concentrates on the Pacific slope. Broad-winged Hawks in Chiapas in March appear to retrace their autumn flight lines. Migrants are more dispersed across the Gulf coastal plain in southern Veracruz in spring, apparently because of differences in thermal conditions (Ruelas 2005). North-bound Swallow-tailed Kites also retrace their autumn route from the Yucatan across the Gulf of Mexico to the southern United States (Rodriguez 2006, K. Meyer pers. comm.). Regular spring use of the Cuba–Hispaniola, trans-Caribbean flight line, although less documented, also appears to occur (Fuller et al. 1998, Martell et al. 2001, K. Meyer pers. comm.).

Eastern and Central regions.—Almost all Turkey Vultures, Broad-winged Hawks, and Swainson's Hawks re-enter the United States via southern Texas. Overall, *broad-frontal* migration is more common in spring than in autumn, and this, together with overwinter mortality and possibly higher-altitude flights in spring, means that counts during spring often are lower than in autumn. Southeasterly winds also may move flight lines away from traditional watchsites. Long-distance soaring migrants generally remain concentrated through southern Texas, but begin to disperse along numerous pathways farther north. As in autumn, the Great Lakes form major diversion lines for spring migrants returning to Canada (Bildstein 2006).

In the East, some soaring migrants, including Broad-winged Hawks, follow an elliptical migration path (Kerlinger 1989). In eastern North America, westerly winds prevail north of about 30° latitude and easterlies prevail to the south. In the autumn, westerlies initially push southbound migrants east, then, as they reach the realm of prevailing easterlies farther south, they head west to proceed around the Gulf Coast. Conversely, in spring, easterlies initially push returning migrants west in Mexico and Texas, then as they continue north they compensate by riding the now prevailing westerlies eastward to their final destinations, completing the elliptical pathway. Elliptical migration also is seen in Golden Eagles, which concentrate along the northwestern ridges of the central Appalachians (e.g., Tussey Mountain and Bald Eagle Ridge, Pennsylvania) during their return flight, but along the southeastern ridges of the Appalachians during autumn migration (Brandes 1998). Peregrine Falcons also exhibit a more westerly return than outbound migration (Fuller et al. 1998).

As in autumn, returning migrants concentrate along diversion lines and leading lines in many areas. In the eastern and central regions, the southern shorelines of the Great Lakes host the highest concentrations of returning migrants north of Mexico and southern Texas. Watchsites such as Whitefish Point Bird Observatory, Michigan; Hawk Ridge, Minnesota; and Braddock Bay and Derby Hill Bird Observatory, New York, record thousands of migrants returning to Canadian breeding areas (Table 1). Other inland concentrations occur in Pennsylvania along the western Appalachian ridges, which act as leading lines for birds heading north and east into New England and eastern Canada.

Western Region.—In the West, spring migration counts are few and knowledge of the geography of spring migration is less well developed than in the East. That said, significant insight has been generated from studies in the Sandia Mountains of northern New Mexico, at Dinosaur Ridge Raptor Migration Station along the eastern Rockies of Colorado, in the Wasatch Mountains of northern Utah, at Roger's Pass Raptor Migration Project in west-central Montana, at Mt. Lorette, Alberta in the northeastern Rockies, and at Cape Flattery in northwestern Washington (Hoffman et al. 2002, Hoffman and Smith 2003, Sherrington 2003, Rocky Mountain Bird Observatory unpubl. data, HWI unpubl. data). Additional insight about movements through Alaska and northwestern Canada derives from studies by Mindell and Mindell (1984), Swem (1985), and C. Fritz in McDermott (2005). In addition, a significant spring concentration area for returning Turkey Vultures and Swainson's Hawks recently was discovered in Borrego Valley, California (McDermott 2005).

The Sandia Mountains Migration Project, ongoing since 1985, is matched with an autumn project on the same flight line in the Manzano Mountains, New Mexico. Forty-four exchanges of banded Sharp-shinned Hawks and Cooper's Hawks between the two sites from more than 12,000 (0.4%) banded birds suggest that the two sites monitor at least small parts of the same populations of these species (Hoffman et al. 2002); intriguingly, the outbound Manzano counts of these species average substantially higher than the return Sandia counts (Hoffman and Smith 2003). But counts average lower at the spring Sandias site (expected if the same flight is reduced by over-winter mortality) for only half of the 18 species commonly recorded at the two New Mexico sites, and average substantially higher in spring for Turkey Vultures, Ospreys, Bald Eagles, Golden Eagles, Broad-winged Hawks, and Red-tailed Hawks. This suggests that the populations monitored at the two sites differ for these species, perhaps reflecting differences in spring and fall migration routes.

Dinosaur Ridge, Colorado, is particularly noteworthy for the largest known concentrations of migrating Ferruginous Hawks (average 74, maximum 241; Rocky Mountain Bird Observatory unpubl. data). Compared with the Sandia Mountains, this site also attracts about five times as many Bald Eagles, more than three times as many Red-tailed Hawks, and nearly four times as many American Kestrels. In contrast, the Sandia counts average roughly five times as high for Golden Eagles, more than twice as high for Turkey Vultures and Peregrine Falcons, and 25% and 60% higher for Sharp-shinned Hawks and Cooper's Hawks, respectively (Hoffman and Smith 2003).

Farther north in the Wasatch Mountains of north-central Utah, 6 years of counts (1997–2002) ranged from 2,200 to 5,100 total migrants, with Turkey Vultures and Red-tailed Hawks making up about 60% of the flight (HWI unpubl. data). An average count of 230 Bald Eagles comprised the most noteworthy concentration, ranking among the largest for this species at both autumn and spring watchsites in the West. Farther north still in the Rockies, more than 10 years of March-only counts at Rogers Pass, Montana, averaged 140 Bald Eagles, 1,300 Golden Eagles, and small numbers of other species (HWI unpubl. data). Counts of migrating Golden Eagles in Glacier National Park further confirm significant spring flights of this species through the Rocky Mountains of northern Montana (Yates et al. 2001). Still farther north in the eastern Rockies at Mt. Lorette, Alberta, Bald Eagles and especially Golden Eagles are again the most numerous migrants, with annual counts averaging 200 and 3,500 birds, respectively, with no other species averaging more than 100 birds (Rocky Mountain Eagle Research Foundation unpubl. data).

At Mt. Lorette, spring counts of Golden Eagles and Red-tailed Hawks were higher than autumn counts in 3 and 4 of 11 years, respectively, between 1993 and 2005 (Rocky Mountain Eagle Research Foundation unpubl. data). In contrast, spring counts of Bald Eagles, Sharp-shinned Hawks, and Rough-legged Hawks, routinely average at least 30% higher than autumn counts. These data appear to contradict conventional wisdom that spring flights are less concentrated than autumn flights.

Modest spring passages of dozens to several hundred individuals of species including Northern Harriers, Sharp-shinned Hawks, Northern Goshawks, Red-tailed Hawks, Rough-legged Hawks, and Golden Eagles occur at several watchsites in Alaska and northwest Canada, including near Eureka, Alaska, about 200 km northeast of Anchorage (C. Fritz in McDermott 2005), where migrants concentrate north of the Prince William Sound in a narrow valley between large ice fields (also see Mindell and Mindell 1984, Swem 1985).

Finally, limited spring counting has occurred along the Pacific Coast corridor in California and Washington. A significant spring concentration of several thousand returning Turkey Vultures and Swainson's Hawks occurs in the Borrego Valley of southern California (McDermott 2005), where flocks of both species are attracted to prey available in agricultural fields. Farther north, extended counting (1983–1997) at Cape Flattery in northwestern-most Washington demonstrated significant spring passage of Sharp-shinned Hawks and Red-tailed Hawks, together with smaller numbers of 10 other species (HWI unpubl. data).

Migration Timing

Migration timing varies considerably among species. Highly gregarious, super-flocking species (*sensu* Bildstein 2006) that winter primarily in Central and South America (e.g., Mississippi Kites, Broad-winged Hawks, and Swainson's Hawks) generally exhibit the most acute and often earliest passages during autumn and latest passages during spring. In general, long-distance, complete migrants appear to exhibit less interannual and regional variation in their migration timing and shorter passage periods at most latitudes than is seen in most short-distance, partial migrants (e.g., Broad-winged Hawk versus Sharp-shinned Hawk). Other long-distance migrants, such as Ospreys and Peregrine Falcons, also show concentrated passage periods compared with migrants that winter farther north (e.g., Northern Harrier).

Available evidence indicates that autumn passage averages 1–2 weeks earlier for most species in interior western North America than in eastern North America. Examination of median passage dates for various species monitored at Smith Point and Corpus Christi along the southern Gulf Coast of Texas clearly demonstrates this pattern (Smith et al. 2001b). For migrants originating in eastern North America that winter in Mexico or farther south, the Smith Point site in southeastern Texas is "upstream" of the Corpus Christi site, and hence may be expected to show earlier passages. This is true for Sharp-shinned Hawks, Red-shouldered Hawks, and Broad-winged Hawks (2–6 days earlier passage at Smith Point), whose disjunct forest-oriented distributions suggest that the majority of migrants passing through coastal Texas originate from the eastern part of the continent. In contrast, median passage dates for species such as Turkey Vultures, Northern Harriers, Red-tailed Hawks, and Swainson's Hawks average 1–2 weeks later at Corpus Christi than at Smith Point, presumably reflecting the influence of proportionately greater representation of western birds.

Although the causes of these east–west timing differences have not been evaluated, one possibility is that the earlier onset of winter conditions in the interior West compared with eastern North America forces western birds to vacate their breeding areas earlier. The same factor also is likely to be involved in broader passage periods of many species along the central coast of California compared with those at interior western sites where autumn weather is harsher. For example, significant movements of Red-tailed Hawks extend well into November and early December in the Marin Headlands of California (A. Fish pers. comm.), whereas the flight in the Goshute Mountains of northeastern Nevada tapers off to a trickle by early November. That long-distance migrants, such as Broad-winged Hawks and Swainson's Hawks, do not show east–west differences in timing suggests a less flexible pattern to their migration timing than occurs in other species.

Ospreys are relatively early autumn migrants, at least in the interior West (e.g., peak passage in mid-September in the Goshute Mountains, Nevada), perhaps because the availability of their prey declines rapidly in this region as winter begins. In contrast, late autumn and early spring migrants include Bald Eagles and Rough-legged Hawks, whose breeding ranges extend to the far north and whose southward movements depend to a large degree on current habitat and prey conditions at northern latitudes. Northern Goshawks, Red-tailed Hawks, and Golden Eagles also show relatively late passage in the interior West, especially for adults (early October overall, mid-October for adults), but movements of immature birds may begin as early as mid- to late August. Other species that typically show broad passage periods include broad-front migrants such as Northern Harriers.

Distinct age- and sex-specific differences in the timing of migratory movements also are apparent for many species, with patterns varying geographically. In eastern North America, for example, outbound male American Kestrels migrate before females (Stotz and Goodrich 1989), whereas in the Goshute Mountains of Nevada and Manzano Mountains of New Mexico, females precede males by 4–6 days (HWI unpubl. data). On the other hand, adult male Northern Harriers pass later than adult females in the Manzano Mountains, but no difference in the timing of adult males and females is evident in the Goshute Mountains (HWI unpubl. data).

For Sharp-shinned Hawks and Cooper's Hawks in the Goshute and Manzano mountains, juvenile females pass first, followed by juvenile males, adult females, and adult males (Fig. 5; and see DeLong and Hoffman 1999). Rosenfield and Evans (1980) reported a similar pattern for Sharp-shinned Hawks at Duluth, Minnesota. In the Goshute and Manzano mountains, immature Red-tailed Hawks and Golden Eagles also tend to precede adults by several days to 2 weeks (e.g., Fig. 5), which also is true of juvenile Sharp-shinned Hawks and Red-tailed Hawks at Hawk Mountain Sanctuary (Hawk Mountain Sanctuary [HMS] unpubl. data). In contrast, age-related differences in timing are not evident for long-distance migrants such as Broad-winged Hawks and Peregrine Falcons at the Goshutes and Hawk Mountain, although juvenile Peregrine Falcons

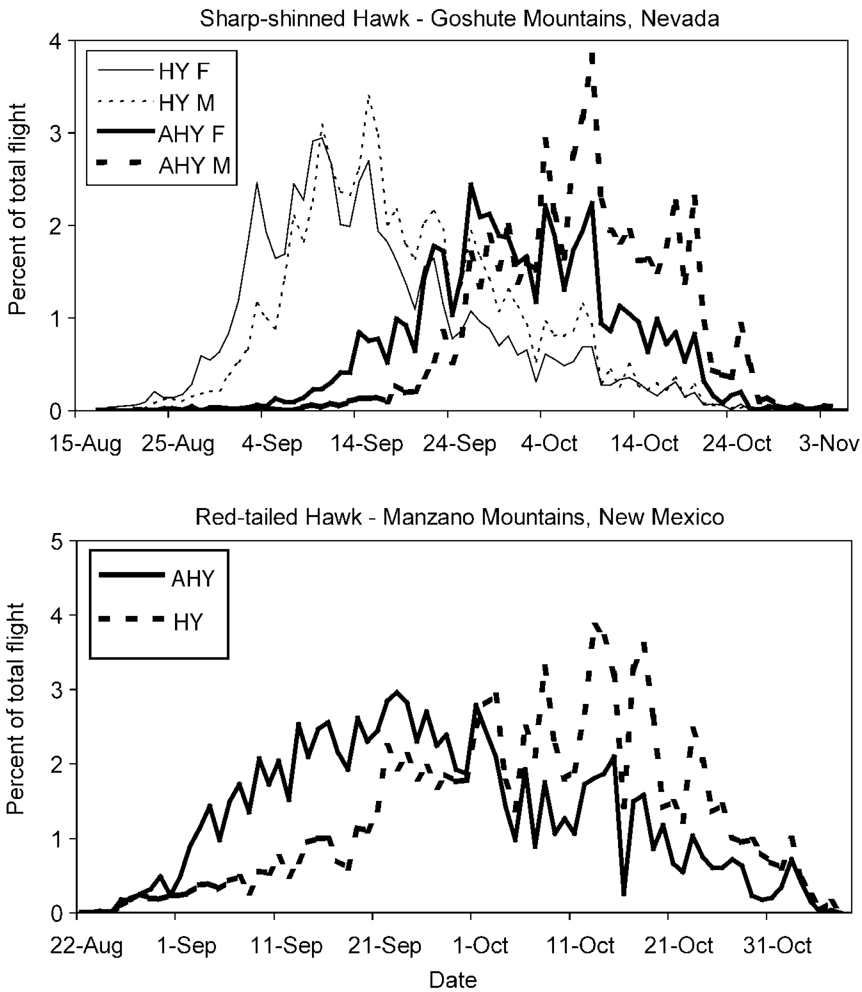

Fig. 5. Age-specific autumn passage patterns for Sharp-shinned Hawks (*Accipiter striatus*) in the Goshute Mountains, Nevada (based on aggregate capture data for 1990–2006), and for Red-tailed Hawks (*Buteo jamaicensis*) in the Manzano Mountains, New Mexico (based on aggregate count data for 1985–2006). HY = a bird in its first calendar year; AHY = a bird in *at least* its second calendar year.

do precede adults by about 1 week in the Manzanos. For Broad-winged Hawks, evidence suggests that juveniles closely follow adults during migration (Maransky and Bildstein 2001). More typically, though, among many partial migrants, juveniles precede adults by at least 1–2 weeks in autumn, and follow adults by a similar period in spring (Hoffman 1985, Mueller et al. 2000, Bildstein 2006).

Adults tend to winter farther north than juveniles, possibly because they can exclude the less experienced birds from nonbreeding territories or, perhaps, because they are more adept at foraging in harsher climates; females winter farther north than males in some species and farther south in others (Gauthreaux 1985, Hoffman et al. 2002, Smallwood and Bird 2002). Such differences may influence age- and sex-specific migration timing.

Weather and Migration

Weather influences migration counts in two ways, first by affecting the behavior of the birds themselves and second by affecting the ability of counters to detect birds. Separating the two effects can be difficult. We know, for example, that cold fronts can influence the timing and magnitude of flights (Allen et al. 1996). Windy days tend to produce greater flights along leading lines and diversion lines than windless days, either because migrants rely more on deflection updrafts than on thermal updrafts, are more dispersed, or are not migrating in large numbers (Haugh 1972, Titus and Mosher 1982, Millsap and Zook 1983, Kerlinger 1989, Allen et al. 1996). This is especially true late in the season when soaring migrants are particularly dependent on deflection updrafts (Maransky et al. 1997). Cold fronts also appear to enhance the detectability of migrants during autumn months in eastern North America by making some migrants fly lower and closer to watchsites (Allen et al. 1996). During autumn, passage of cold fronts also may serve as a primary stimulus for migration activity, with the specific effect varying by species and location.

The relationship of weather and migration patterns varies among sites and species. At Cedar Grove, Wisconsin, large autumn flights of Sharp-shinned Hawks follow passage of cold fronts when favorable westerly winds occur (Mueller and Berger 1967b). At Hawk Mountain, Pennsylvania, analyses indicate that falcons, which rely primarily on powered flight, moved more during cold fronts; accipiters, which sometimes soar on migration, moved more immediately after frontal passage when lighter, updraft-producing northwest winds and weak thermals provided favorable conditions; buteos and eagles, which rely even more on soaring flight, moved more 2–4 days after frontal passage during periods of stronger thermals; and Northern Harriers showed no obvious "weather effect" (Allen et al. 1996). In coastal Texas, most species, including Broad-winged Hawks, move more during times of rising barometric pressure and strong thermals (Smith et al. 2001b).

Although generally less well studied in the West than in the East, at interior western watchsites large movements tend to precede or coincide with frontal passage (Millsap and Zook 1983, Hoffman 1985), possibly because cold fronts there tend to precede periods of relatively cold temperatures and harsh winds. However, similar to Hawk Mountain, autumn passage of Golden Eagles at Glacier National Park increases with rising temperature and barometric pressure and decreasing humidity when warm, dry conditions produce deflection updrafts (Yates et al. 2001).

In coastal California, raptors were seen more during periods of increasing temperature, decreasing fog, and a lack of headwinds (Hall et al. 1992). Red-tailed Hawks appeared to display a strong negative response to fog (even so, detectability was lower at such times, which also may have contributed to the reduced counts), and a positive response to strong tail winds preceding frontal passages, but also favored periods following cold fronts with rising temperature and pressure. Immature accipiters favored strong tail winds before and after frontal passage, whereas adults moved more during fair-weather periods several days after frontal passages.

Weather also influences return migration. Spring migrants often appear to migrate across a broader front than autumn migrants, necessitating (or perhaps because of) greater reliance on thermal-soaring or use of powered flight. In many areas, south winds associated with warm fronts produce the largest concentrations of return migrants along diversion and leading lines (e.g., Haugh 1972).

Weather affects flight altitude as well, with migrants often flying higher during midday when strong thermals occur, making them more difficult to see (Kerlinger 1985b, 1989). Migrants also may be more likely to leave diversion and leading lines during such times, thereby contributing to the so called “noon-day lull” (Kerlinger 1989).

In spite of all this, recent analyses suggest that whereas weather may greatly affect within-season passage patterns, it has little measurable impact on interannual variation in counts at watchsites (Allen et al. 1996, Farmer et al. 2007).

Food Availability and Migration

The availability of suitable foraging and roosting habitat sometimes influences the timing and geography of raptor migration (Kerlinger 1989, Niles et al. 1996). Migrating Sharp-shinned Hawks and Cooper’s Hawks radio-tracked in central Pennsylvania interrupted their movements to feed and rest for up to 5 days at a time before continuing their migration, and sought out forests for roosting, which suggests that habitat is important during migration and may influence geographic patterns in some regions (L. Goodrich unpubl. data). Presumably, forest-dwelling accipiters traveling through the sparsely forested landscapes of the interior West also are attracted to forested corridors along mountain ranges. Overall, many species appear to time and direct their movements so that they coincide both spatially and temporally with those of their prey (Rosenfield and Evans 1980, Kerlinger 1989, Nicoletti 1997). Availability of suitable roosting habitat is a critical factor especially for super-flocking species, including Turkey Vultures, Swallow-tailed Kites, Mississippi Kites, Broad-winged Hawks, and Swainson's Hawks, which typically require large expanses of relatively undisturbed forest to accommodate thousands of birds in communal overnight roosts. Widespread deforestation is becoming a significant conservation issue in parts of Mexico where suitable roosting habitat for these species is dwindling rapidly (Ruelas et al. 2000).

Species Accounts

Thirty-six species of diurnal raptors regularly occur in North America north of Mexico. Five are *complete migrants*, 28 are *partial migrants*, and 3 are non-migratory or *nomadic* (Bildstein 2006). Below we describe the geographic range, habitat use, and migration behavior of each, and note the principal watchsites at which they concentrate (Table 2) and sites of regional importance for each species. We also cover each of the following subtopics:

Subspecies.—North American subspecies are briefly described and numbers of non-North American subspecies noted based on Ferguson-Lees and Christie (2001) and Wheeler (2003a, b);

Range.—Each species' range in North America is briefly described based on information in Ferguson-Lees and Christie (2001) and Wheeler (2003a, b);

Lifespan.—Unless otherwise noted, the maximum lifespan for wild birds known for each species is reported as listed in the database of the United States Geological Survey Bird Banding Laboratory (http://www.pwrc.usgs.gov; current as of July 2006).

Breeding habitat.—The main habitat types used by each species are described as noted in the most recent *Birds of North America* species accounts (http://bna.birds.cornell.edu/bna; May 2007).

Migrant type.—Species' migration strategies are noted (e.g., complete, partial, nomadic, irruptive) based on Bildstein (2006) and Ruelas (2005).

Migration ecology and behavior.—We briefly summarize salient features of each species' migration ecology and behavior where known and relevant, including length, altitude, and speed of migration; water-crossing, flocking, and other aspects of flight behavior; migration routes and timing; and age and sex differences in timing. For such information, we draw heavily from Kerlinger (1989), Bildstein (2006), and the *Birds of North America* accounts. Primary autumn migration timing data are presented for

Hawk Mountain, Pennsylvania, Florida Keys, Florida, Goshute Mountains, Nevada, Golden Gate, California, and Veracruz, Mexico (Bednarz et al. 1990, Ruelas 2005, Lott 2006, A. Fish pers. comm., HWI unpubl. data). Primary spring timing data are presented from Veracruz, Mexico, Derby Hill Bird Observatory, New York, and the Sandia Mountains, New Mexico (Haugh 1972, Ruelas 2005, HWI unpubl. data). Other timing data for selected sites are presented when relevant.

To illustrate patterns and the diversity of migration across North America, we list all major watchsites and those contributing data to the Hawk Migration Association of North America (HMANA) database (http://www.hawkcount.org) in Table 1, along with the average total raptor count during the recent decade (for most sites) and the top three most abundant species observed at each site. We also present in Table 2 the five highest average counts for each species and season at North American watchsites. In each species account, we also generally list the three highest average counts by geographic region and migration season.

Black Vulture (*Coragyps atratus*)

Subspecies.—Two in North America: *atratus* is most widespread; *brasiliensis* is smaller and occurs in Arizona and Mexico.

Range.—Expanding range northward in eastern United States. Nests throughout the southeastern United States, north to New York and southern New England, west to eastern Texas, and south into Mexico. A small disjunct population is found in southern Arizona and north-central Mexico.

Maximum lifespan.—25 years, 6 months.

Habitat.—Roosts in trees, sometimes in towns. Feeds in open areas, including dumps. Nests in caves and crevices, under logs, and in abandoned buildings (Buckley 1999). Concentrates along rivers, coastlines, and lake shores, and roosts communally on migration and in winter. Rarely found above 3,000 m.

Migrant type.—Partial. A primarily tropical species considered resident throughout most of its range; however, northern populations migrate. The species is known to be an altitudinal migrant in some regions and, although more research is needed to clarify the situation, evidence suggests that migration also occurs in Central and South America.

Migration ecology and behavior.—A soaring migrant that uses thermal and slope soaring to move locally and on migration. Wing loading is higher than in Turkey Vultures; hence, stronger thermals are needed for soaring (Clark and Wheeler 2001). Flaps with stiff, shallow wingbeats. Occasionally drops legs in flight, possibly to assist with maneuvering. Makes short water crossings. That said, why they are absent from Cuba, given the short water crossing involved, remains a mystery.

Migrates in small to medium-sized flocks in tight formations. Occasionally migrates with Turkey Vultures. Largest single flock at Hawk Mountain, Pennsylvania, was 42 individuals (HMS unpubl. data). Migration in northeastern North America peaks from mid-October through mid-November. Disperses northward as far as Maritime Canada, where it occurs from April to October, with spring migration recorded March–April. Migration distance is unknown, but suspected to be short (Wheeler 2003a). Some directed movements observed in Panama and Costa Rica may be migration (Ferguson-Lees and Christie 2001, Bildstein et al. 2007). Counts in Bolivia totaled 863 migrants, with most passing in October (Olivo 2005). Migration counts of Black Vultures are challenging, as migrants may be overlooked as local residents. In North America, the species probably migrates across a broad front, with local concentrations along leading and diversion lines.

Highest average autumn counts in the United States occur at Corpus Christ, Texas (539), Kiptopeke, Virginia (492), and Second Mountain, Pennsylvania (399). Highest average spring counts in the United States occur at Fort Smallwood Park, Maryland (228), and College Creek, Virginia (61). A few are sighted in the Great Lakes region in autumn and spring, but none are seen at western sites.

Turkey Vulture (*Cathartes aura*)

Subspecies.—Three in North America: *septentrionalis* in the eastern United States and Canada, west to Minnesota and Iowa, and south to eastern Texas; *aura* breeds in southern California, Arizona, southern Nevada, Texas, and Mexico, and winters from Mexico through Panama; *meridionalis* breeds in North America north of *aura* and west of *septentrionalis*, and winters from the southern United States south to Paraguay and Brazil.

Range.—Breeds across North America, north to southern Canada from British Columbia to Québec, and south throughout much of the United States, Central America, South America, and the Caribbean. Largely absent in the Great Plains and sparse in northern Montana and southwestern Saskatchewan. Rapidly expanding range northward into Canada, with increased counts at most northern watchsites. Winters from midlatitudes south into South America.

Maximum lifespan.—16 years, 10 months; but suspected to live longer.

Breeding habitat.—Mixed farmland, forests, and deserts. Nests primarily in forested areas with rock outcrops, fallen trees, or abandoned buildings. Also found on cliffs in desert areas in the western United States. Roosts on cliffs, in stands of trees, and on or in buildings, usually in hilly areas that provide updrafts and particularly near wooded areas (Kirk and Mossman 1998).

Migrant type.—Partial. Long-distance, trans-equatorial migrant. Northern populations are highly migratory, whereas southern populations are resident or move short distances. Eastern birds appear less migratory than western birds. Displays *leap-frog migration* (Kirk and Mossman 1998).

Migration ecology and behavior.—Thermal soars, slope soars, and glides on migration. Uses storm fronts and subtropical thermal streets to migrate (Kirk and Mossman 1998). Makes short water crossings, but generally avoids extensive crossings. Migrates in flocks of several to many thousands of birds. When thermals are not present, usually does not migrate. If winds or thermals provide updrafts, will fly before dawn. In both autumn and spring, notable concentrations occur along *leading* and *diversion lines*. Migration also involves open-country thermal soaring (K. Bildstein pers. comm.)

Sometimes migrates with other soaring birds, including Broad-winged Hawks and Swainson's Hawks (Kerlinger and Gauthreaux 1985). Known to form large roosts on migration and in winter. Duration of migration from 28 to 70 days, with an estimated flight speed of 55 km h^{-1} on ridge updrafts (Broun and Goodwin 1943) and 40 km h^{-1} for a satellite-tracked western bird (C. Houston pers. comm). Migration distance of at least 9,000 km; one individual averaged 163 km day^{-1}. Migrants sometimes alter destinations among years; one of nine satellite-tracked birds from Pennsylvania wintered in Florida one year and in North Carolina the next year (D. Barber pers. comm.). Will stop on migration for at least 4 days; evidence suggests feeding on migration in North America, but most individuals apparently do not feed during migration through Mesoamerica. Has fasted in captivity for up to 16 days (Kirk and Mossman 1998). Wing-beat frequency was higher for Turkey Vultures in spring than in autumn in eastern Mexico, indicating higher energy expenditure then (Ruelas 2005).

Migration timing varies regionally. In autumn, departs northern breeding ranges from late August through November, with peak migration in mid-October (Kirk and Mossman 1998). Three individuals tracked by satellite from Saskatchewan left on their outbound flights between 22 and 30 September (C. Houston pers. comm). Hawk Mountain, Pennsylvania, records peak counts between mid-October and mid-November, with movements occurring through December in mid-Atlantic and southern states. In contrast, most (80%) activity occurs between early September and early October in the Goshute Mountains, Nevada. With a peak in mid-October, 95% of flights pass through Veracruz, Mexico, between late September and mid-November. Very few migrants (<100) were recorded in Bolivia during one season's count (Olivo 2005). Nomadic flocks fly up and down the Florida Keys during most winter months (Wheeler 2003a) and small numbers may overwinter in the Caribbean.

In spring, birds depart Florida in March and April, and South America in February and early March (Kirk and Mossman 1998). Return flights pass through eastern Mexico between 21 February and 2 May, with a peak in late March. Peak spring flights in the east occur in April. Most (80%) activity occurs between late March and late April in the Sandia Mountains, New Mexico. First migrants arrive at northern breeding grounds from late February through early April.

In the United States and Canada, highest average autumn counts occur around the Great Lakes (e.g., 67,567 at Southeastern Michigan Raptor Research–Lake Erie Metropark, Michigan, and 24,364 at Holiday Beach, Ontario), in coastal Texas (e.g., 21,122 at Corpus Christi), and in California (e.g., up to 40,000 per autumn in the Kern River Valley given only limited seasonal counting [Rowe and Gallion 1994], and 9,177 in the Marin Headlands). The largest outbound flights in North America occur at Veracruz, Mexico (1,971,299), and Kekoldi, Costa Rica (911,659) (H. Wilson pers. comm.).

Highest recorded spring flights in the United States and Canada occur around the Great Lakes (e.g., 10,229 at Ripley Hawk Watch and 11,404 at Braddock Bay, New York in late March and early April, along Chesapeake Bay (4,192 at Fort Smallwood, Maryland) in mid-March and early April, in the Sandia Mountains, New Mexico (1,407) in early April, and at Borrego Valley in southern California (913) in February and March. The spring count at Veracruz, Mexico averages 162,652 with peak flight in late March.

California Condor (*Gymnogyps californianus*)

Subspecies.—Monotypic.

Range.—Formerly extirpated from the wild, but reintroduced into southern California and Arizona (Snyder and Schmitt 2002). Now nests again in the wild in small numbers, with captive breeding populations at several locations.

Maximum lifespan.—At least 45 years (Snyder and Schmitt 2002).

Breeding habitat.—Large open areas with cliffs for nesting, adequate and accessible food, and strong thermal updrafts (Snyder and Schmitt 2002). Nests in elevated caves and large cliff "potholes."

Migrant type.—Largely sedentary, but may disperse widely.

Migration ecology and behavior.—Considered sedentary by some, however, historical and recent satellite-tracking data suggests a regular, short-distance migration, with some individuals moving south into Mexico (Ferguson-Lees and Christie 2001). Considerable wandering occurs, particularly in summer (Wheeler 2003b). Longest exploratory journey recorded by radio-tracked bird was a 13-day, 1,100-km northward excursion from Arizona to Wyoming. This bird and others returned to their release-site area after dispersal flights (Wheeler 2003b).

Osprey (*Pandion haliaetus*)

Subspecies.—One, *carolinensis*, in continental North America; one, *ridgewayi*, in the West Indies; three additional subspecies globally.

Range.—Central Alaska east across northern Canada, from tree line south to northern California, Nevada, Oregon, Montana, along the Great Lakes, Atlantic and Gulf coasts, and some river drainages south to southern Florida. Scattered numbers nest along inland rivers, lakes, and reservoirs.

Maximum lifespan.—26 years, 2 months.

Breeding habitat.—Found near water from boreal forests to subtropical coasts and desert lagoons. Needs adequate and accessible fish prey within 10 km of nest site, and an open nest site in a tree, on rocks, or on artificial structures such as utility poles, powerlines, channel markers, buoys, and artificial nest platforms (Poole et al. 2002).

Migrant type.—Complete. Some southern Florida and Caribbean birds are sedentary. Undertakes extensive water crossings (>100 km) and occasionally migrates at night. A trans-equatorial migrant with maximum flock size of 50 birds.

Migration ecology and behavior.—Many individuals migrate long distances, often using flapping flight, but also deflection updrafts and thermals to soar. Slope-soaring speeds measured at 33–120 km h^{-1}. Will flock with other birds. Large flocks are more likely in advance of long water crossings (Bildstein 2006). Groups of 4–5 birds are regularly seen migrating together in the Appalachians. Satellite-tracked individuals traveled 95–380 km day^{-1} in autumn. One female flew 2,052 km in 2 days. Western migrants take less time en route, travel farther per day, and may spend less time feeding at stopover sites than eastern birds (Martell et al. 2001).

Adult females depart breeding areas up to 30 days earlier and winter farther south than their mates (Martell et al. 2001, Poole et al. 2002). Juveniles leave breeding grounds after adults (Kerlinger 1989) and remain on nonbreeding areas through second and, sometimes, third winters. Some (<5% of individuals) carry fish in their talons during migration.

Autumn migration begins in late August and September. Hawk Mountain, Pennsylvania, records peak flights during mid- to late September, with 98% passing between late August and late October (Bednarz et al. 1990). Peak flights occur in the western Great Lakes and interior western North America in mid-September. Peak flights occur in early October in Veracruz, Mexico.

In spring, adults begin moving in February, with first arrivals on breeding grounds in late March. Peak movements occur in mid-April through northern latitudes. Migration of non-breeders may extend into late June. Most migrants pass through Veracruz, Mexico, from mid-March through early May.

Four primary autumn routes are used by Ospreys traveling south of the United States: (1) from Florida to Cuba and the Greater Antilles, and then to northern South America and beyond; (2) from Florida and the central Gulf Coast across to the Yucatan Peninsula, then south through Mesoamerica into northwestern South America and beyond; (3) south into northern Mexico, along the east coast of Mexico, and then south through Mesoamerica into South America and beyond; and (4) from the northwest along the Pacific Coast to wintering areas along the west coast of Mexico (Martell et al. 2001). Some birds overwinter along the Gulf Coast from Florida into Mexico (Wheeler 2003a). Other northwestern breeding birds move southeast across the continent to Florida to follow the route to the Greater Antilles and beyond (Martell et al. 2001, Wheeler 2003a, b).

Highest average counts in the United States and Canada occur along the Atlantic Coast (e.g., 2,462 at Cape May, New Jersey; 1,896 at Kiptopeke, Virginia; and 1,873 at Cape Henlopen Hawk Watch, Delaware), and in the Gulf Region (e.g., 2,673 at Veracruz, Mexico, and 1,254 in the Florida Keys). Other inland western and eastern sites, as well as Golden Gate in coastal California and sites in coastal Texas, typically record 100–800 migrants per autumn.

Highest recorded spring counts in the United States and Canada occur at Fort Smallwood, Maryland (485), Derby Hill, New York (390), West Skyline Hawk Count, Minnesota (205), Eagle Crossing, Québec (165), and Jordanelle Reservoir, Utah (132).

Hook-billed Kite (*Chondrohierax uncinatus*)

Subspecies.—One, *aquilonis*, in North America from south Texas to Mexico northwest of the Isthmus of Tehuantepec; three others farther south.

Range.—South Texas through Central America and south into Ecuador, Peru, Colombia, and Venezuela. Rare north of Mexico and in Cuba, Grenada, and Trinidad.

Maximum lifespan.—Not known.

Breeding habitat.—Semi-open riparian woodlands, mesquite woodlands, and thorn forest patches (Wheeler 2003b). Dependent on distribution of main prey, snails.

Migrant type.—Partial or *local*. No data, but believed to be largely sedentary except at northern limits of range. Limited observations suggest that the species is a short-distance migrant between the southern United States and northern Mexico south along the Gulf Coast into Central America (Wheeler 2003b), with regular passage of one to several hundred individuals at Veracruz, Mexico (Ruelas 2005). Altitudinal movements involving flocks of up to 30 birds also are observed along the Andes.

Migration ecology and behavior.—Little known. Most commonly seen soaring on thermals in Veracruz, Mexico, sometimes in small flocks (Ruelas 2005). Not known to cross water.

In Veracruz, Mexico, recent autumn counts averaged 145 birds (Ruelas 2005). Small numbers of autumn migrants also have been recorded in Guatemala. In spring, Santa Ana National Wildlife Refuge, Texas, records an average of 12 individuals (Zalles and Bildstein 2000) and Tlacotalpan, Mexico, four.

Swallow-tailed Kite (*Elanoides forficatus*)

Subspecies.—Two: *forficatus* breeds in the southeastern United States and migrates to South America; *yetapa* occurs from southern Mexico into South America.

Range.—Present range includes coastal-lowland and riparian areas in Florida, Georgia, and South Carolina, with disjunct populations west along the Gulf Coast to eastern Texas. Winters in south-central South America.

Maximum lifespan.—Not known.

Breeding habitat.—Semi-open habitat with tall trees for nesting, particularly open savannahs with scattered pines or cypress. Also found in semi-open, dry uplands with mixed pine and hardwoods, and in riparian and lakeside forests. Key resources include tall trees for nesting and nearby open areas for feeding (Meyer 1995).

Migrant type.—Partial. Trans-equatorial migrant that travels in flocks of up to 100 birds. The United States population is completely migratory, whereas southern populations are less so.

Migration ecology and behavior.—An early autumn migrant that forms large, pre-migration communal roosts in cypress or pine stands, behavior that may increase feeding opportunities (Meyer 1995). Disperses in summer prior to migration, with observations as far north and west as southern Canada and Colorado (Ferguson-Lees and Christie 2001, Wheeler 2003a). Undertakes up to 3-day, 1,500-km water crossings of the Gulf of Mexico (K. Meyer pers. comm.). Observed in multispecies flocks in southeastern Cuba (Bildstein et al. 2002) and southern Mexico (Ruelas 2005). Flaps and thermal soars on migration, and probably uses sea thermals for lift crossing the Gulf of Mexico (K. Meyer pers. comm.).

Departure from pre-migration roosts begins late July to early August. The median departure date for 39 birds tracked from Florida was 10 August, and their median arrival date on winter ranges was 22 October (K. Meyer pers. comm.). Stopovers were observed for cross-gulf migrants. Juvenile birds appear to migrate later than adults, with many remaining at pre-migration roosts through late August (Meyer 1995). Mortality during migration appears high, with 87% percent of satellite-tagged adults in one study succumbing during migration (K. Meyer pers. comm.). High winds over the Gulf of Mexico may pose a challenge to the birds.

In autumn, Swallow-tailed Kites use two main routes. One is from south Florida to western Cuba and down the Yucatan Peninsula of Mexico to the Mesoamerican corridor, and from there into northwestern South America, with most over-wintering in Brazil (Wheeler 2003a). The other is a circum-Gulf of Mexico route that joins the Mesoamerican corridor in southern Texas. As a result, Kekoldi, Costa Rica (high count of 1,319 in 2001), reports more Swallow-tailed Kites than Veracruz, Mexico (high count of 286 since 1991). Only 11 birds are recorded on average at the Florida Keys, where counts begin after peak movements of kites (Lott 2006). In coastal Texas, where the counts cover at least the second half of the species' migration, counts have ranged as high as 100–150 birds, with averages of 83 and 28 birds seen at Smith Point and Corpus Christi, respectively. In Concepción, Bolivia, 235 were reported in autumn 2001; however, whether these were intra-tropical migrants or long-distance North American birds was unclear (Olivo 2005).

Spring flights are not well monitored. Northbound individuals have been observed leaving the Yucatan Peninsula at high altitudes in February (Wheeler 2003a). Average spring flights of 54 birds have been recorded at Grassy Key, Florida. Veracruz, Mexico records an average of eight spring migrants between late March and mid-May (Ruelas 2005), and there is an increased incidence of the species in the northeastern United States between March and May.

White-tailed Kite (*Elanus leucurus*)

Subspecies.—Two: *majusculus* in the United States and Central America; *leucurus* from southern Central America to South America.

Range.—California west of the Sierra Nevada and south along the Pacific Coast to Baja California, and along the Gulf Coast of Texas south into Mexico. Expanding range in Arizona, as well as north along the Pacific Coast into Oregon and southern Washington. Also rare and local in Florida. Vagrants–dispersers have been recorded as far north as Massachusetts (Dunk 1995; Wheeler 2003a, b), and recently at Chelan Ridge Raptor Migration Project in the northeastern Cascade Mountains of Washington (HWI unpubl. data).

Maximum lifespan.—5 years, 11 months.

Breeding habitat.—Low-elevation grassland, agricultural, wetland, and savannah habitats, as well as riparian areas next to open fields. May feed in cultivated areas (Dunk 1995).

Migrant type.—Partial; maybe *irruptive or nomadic* during periods of low prey abundance. Most of North American population is sedentary, but populations at the northern and southern extents of range appear to move regularly (Dunk 1995, Bildstein 2006).

Migration ecology and behavior.—Migration is difficult to distinguish from dispersal and nomadic movements. Some dispersal in northern birds correlates with vole population cycles (Dunk 1995).

Average autumn counts along the Gulf Coast range from 4 to 52 birds, with highest numbers in Veracruz, Mexico. Counts average 71 birds in the Marin Headlands, California, with most of the flight there occurring between early September and late November. At Concepción, Bolivia, 14 individuals were recorded during autumn 2001 (Olivo 2005).

Spring counts average 11 at Bentsen Rio Grande Valley State Park, Texas.

Snail Kite (*Rostrhamus sociabilis*)

Subspecies.—Three: *plumbeus* in Florida and Cuba; *major* in eastern and southern Mexico, south to Guatemala; one other farther south.

Range.—Resident in central and southern Florida, Cuba, southeastern Mexico, Belize, Guatemala, and sporadically from southern Nicaragua south to central Argentina where appropriate habitat occurs.

Maximum lifespan.—Up to 17 years in the wild (Sykes et al. 1995). Mortality increases during droughts.

Breeding habitat.—Freshwater marsh and shallow lakes with marshy edges and open water. Nests and roosts on small to medium-height trees, bushes, and stout reeds. Perches near water when feeding. Canals, rivers, and aquatic impoundments area used for foraging during nonbreeding periods (Sykes et al. 1995). Often roosts communally and nests colonially.

Migrant type.—Nomadic or *partial.* Moves extensively in response to drought and diminished snail abundance (Sykes et al. 1995). Migration is observed at the northern and southern periphery of range. Birds in northern Florida move south during colder months, whereas those in central Argentina move north during the austral winter (Ferguson-Lees and Christie 2001).

Migration ecology and behavior.—Mainly *resident* or *nomadic* in North America, although small numbers may migrate within Florida each year (Wheeler 2003a). From one to five apparently migrating birds are recorded during autumn in Veracruz, Mexico. Migration appears more definitive in South America where birds in Argentina move north each winter (S. Seipke pers. comm.). Concepción, Bolivia, reported 51 migrants in October–November 2001 (Olivo 2005).

Plumbeous Kite (*Ictinia plumbea*)

Subspecies.—Monotypic.

Range.—From northeastern Mexico south through Central America, particularly along the Caribbean slope, into Panama, and south to Ecuador and east of the Andes through Colombia, Venezuela, Peru, Bolivia, Argentina, Paraguay and Brazil. Also occurs in Trinidad.

Maximum lifespan.—Not known.

Breeding habitat.—Forest-edge and wooded areas with openings or second growth, particularly in humid lowlands and riparian areas (Ferguson-Lees and Christie 2001).

Migrant type.—Partial. Moderate-distance migrant in northern part of range; sedentary or nomadic elsewhere.

Migration ecology and behavior.—Not known to make water crossings. May migrate in flocks of at least hundreds of birds (R. Ridgely pers. comm.), sometimes with Swallow-tailed Kites and other raptors. Often feeds on migration in groups (Ferguson-Lees and Christie 2001). Migrates in small numbers in Mexico, larger numbers farther south. Highest average autumn counts of 583 birds occur in Kekoldi, Costa Rica, with an average of four migrants recorded in Veracruz, Mexico. Flocks of 50 to several hundred birds are often seen in Panama, with a 1-day flight of thousands reported from Panama City (R. Ridgely pers. comm.). Concepción, Bolivia, recorded 285 migrants during September–October 2001. Some movements may pass undetected due to the species' similarity to the much more abundant Mississippi Kite.

Few observations of this species occur in spring (Table 2).

Mississippi Kite (*Ictinia mississippiensis*)

Subspecies.—Monotypic.

Range.—South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, Arkansas, north through the Mississippi River valley to Tennessee, Missouri, and southern Illinois, and west to Oklahoma and northeastern Texas. Also in coastal Texas, the Rio Grande valley, and west to New Mexico and Arizona. Scattered breeding in northern Virginia, North Carolina, Indiana, Illinois, Iowa, Missouri, Colorado, Nebraska. Individuals are regularly sighted as far north as the Great Lakes, but nesting attempts there are rare.

Maximum lifespan.—11 years, 2 months.

Breeding habitat.—Continuous bottomland and riparian forest, with open habitat for feeding nearby. Moving into urban and suburban woodlands.

Migrant type.—Complete. A long-distance, trans-equatorial, flocking migrant that is said to not cross water readily (but see below).

Migration ecology and behavior.—Thermal soars and flaps intermittently on migration. Autumn migrants appear to move on strong winds after frontal passage. Travels in loose flocks of up to 10,000 in Central and South America (Ruelas 2005, Areta and Seipke 2006). Smaller flocks numbering in the hundreds are seen regularly north of the Mesoamerican corridor. Individuals often roost together during migration and sometimes feed together before departure (Parker 1999).

Autumn migration begins in mid-August, with small flocks moving south from breeding concentrations towards the Gulf Coast. Pre-migration dispersal is apparent, as migrants are sighted regularly at autumn watchsites as far north as the northeastern United States (see www.hawkcount.org). Rare sightings occur as far west as central California (Binford 1979, A. Fish pers. comm.). A few individuals appear to island-hop across the Caribbean between Florida and South America through the Antilles (Wheeler 2003a).

Birds pass through Texas primarily between late August and mid-September (Smith et al. 2001a) and through eastern Mexico in early September, with 95% of the passage at Veracruz occurring between late August and late September (Ruelas 2005). Migrants move along both coasts through southern Mexico. The flight at Kekoldi, Costa Rica, occurs during mid-September (Porras-Penaranda et al. 2004), and the flight at Concepción, Bolivia, primarily in October and November (Olivo 2005). Migration counts in Bolivia are highest 1 to 3 days after passage of a cold front, possibly to take advantage of flying ants that emerge after frontal rains.

Birds depart wintering areas in mid-March. Spring migration is more dispersed through Mesoamerica, with many migrants following the foothills of the Sierra Madre Oriental in Mexico. Spring passage in Veracruz occurs primarily from early April to mid-May (Ruelas 2005).

The largest flights in North America occur in the Gulf region, with averages of 4,324 counted at Smith Point, Texas, 6,599 at Corpus Christi, Texas, and 210,279 at Veracruz, Mexico. No other regularly monitored sites in the United States record averages of more than 50 birds. Concepción, Bolivia, recorded 118,153 birds in 2001 (Olivo 2004).

Scattered spring sightings occur in the eastern United States at Fort Smallwood, Maryland (average four per season), and at other watchsites in Massachusetts, New Jersey, Pennsylvania, and around the Great Lakes (Table 2). Sightings at eastern watchsites increasing dramatically. The highest recorded spring counts occur at the Veracruz River of Raptors sites (21,063) and at Tlacotalpan, Veracruz (23,683). Single birds have been seen four times in 20 years at the Sandia Mountains, New Mexico (HWI unpubl. data).

Bald Eagle (*Haliaeetus leucocephalus*)

Subspecies.—Two: *alascanus* breeds north of 40°; *leucocephalus* to the south.

Range.—Coasts, rivers, lakes, and reservoirs throughout most of North America, with the largest populations in southeast Alaska and the Pacific Northwest. Migrants have been recorded as far south as central Mexico, but rare as a migrant even in the southern states.

Maximum lifespan.—30 years, 9 months.

Breeding habitat.—Forested areas near rivers or other large bodies of water. Nests in large trees and occasionally on rock pillars or outcrops relatively close to water (Buehler 2000). May also nest in large, lone trees or snags, sometimes near rural and suburban areas.

Migrant type.—Partial. A short-distance migrant with a complicated migration that varies with age and breeding latitude. Multi-directional, movements often track seasonal availability of salmonid fishes.

Migration ecology and behavior.—Soars on thermals and deflection updrafts. Migrates alone or in small groups (Buehler 2000). Some juveniles are nomadic for several years; others return to areas near natal sites in their second year. Hatch-year birds in Labrador and Glacier Park, Montana, migrated without siblings (McClelland et al. 1996, Laing et al. 2005). Refuels at stopover sites (Harmata 2002, Laing et al. 2005). Tends to move more during midday, except when flying in deflection updrafts. Altitude of spring migrants northbound from Colorado ranged from 1,500 to 3,050 m (Harmata 2002). Tracked birds flew 180–202 km day^{-1} (Buehler 2000).

In autumn, most northern Bald Eagles migrate south for the winter. Migration timing appears to be based on weather and food availability (Buehler 2000). Peak autumn migration occurs from mid-August to mid-December, with northern juveniles moving earlier and farther than adults (Buehler 2000). Juveniles departed Labrador, Canada, between early October and mid-November, with a median departure date of 26 October (Laing et al. 2005). In spring, northern adults move north before juveniles, and males move before females (Harmata 2002). Spring migration begins in February, with peak flights in March.

Southern adults may be largely sedentary, whereas southern juveniles frequently disperse northward. Eagles tracked from Florida routinely dispersed north in summer as far as southeastern Canada, returning south between August and November to breed (Wood 1992, Buehler 2000). Southbound movements of southern populations, returning to nest, peak in mid-September in northeast and mid-Atlantic states, whereas peak passage of northern populations occurs later in mid-November. Texas breeders also disperse north between the Rocky Mountains and Mississippi River, and then turn south again in autumn (Mabie et al. 1994). Eagles in the Pacific Northwest and California move north along the Pacific Coast, and birds from areas such as the Greater Yellowstone ecosystem also shift to the coast in late summer to feed on salmon as far north as the Chilkat River, Alaska (Hunt et al. 1992, Buehler 2000).

Across the continent, but particularly in the West, migration routes tend to track major river corridors or connections between major lakes, where foraging opportunities exist. Particularly significant stopover and winter concentration areas in the West include river inlets in coastal southeastern Alaska and British Columbia, the Skagit River in northwest Washington, the Klamath Basin in southern Oregon, and the Bear River inlet of the Great Salt Lake (Wilson 1999). Dozens of Bald Eagles also move into Carson Valley, Nevada, in February to feed on afterbirth following calving of cattle (A. Fish pers. comm.).

The highest known autumn migration count occurs at Hawk Ridge, Minnesota (average 3,161). Other representative, significant concentrations occur in the Great Lakes region at Hitchcock Nature Center, Iowa (886), and Thunder Cape Bird Observatory, Ontario (288), along the Atlantic Coast at Kiptopeke, Virginia (240), and Cape May, New Jersey (206), in the Appalachian Mountains at Snickers Gap, Virginia (194), in the interior West at Commissary Ridge, Wyoming (124), and the Bridger Mountains, Montana (85), and in the Cascade Mountains at Bonney Butte Raptor Migration Project, Oregon (50).

Highest recorded spring counts in the East and Midwest occur at West Skyline Hawk Count, Minnesota (2,844), Chequamegon Bay Hawkwatch, Wisconsin (724), and Derby Hill, New York (232), and in the West at Dinosaur Ridge, Colorado (75), and in the Sandias Mountains, New Mexico (43). Gunsight Mountain, Alaska, records an average of 13 spring migrants.

Northern Harrier (*Circus cyaneus*)

Subspecies.—One, *hudsonius*, in North America; one, *cyaneus*, in the Old World.

Range.—Alaska and Canada south to Baja California, Mexico, and east across the United States through northern Texas, Kansas, central Iowa, central Wisconsin, southern Michigan, northern Ohio, southern Pennsylvania, and probably northeastern North Carolina. Erratic farther south (MacWhirter and Bildstein 1996). Winters from the northern United States south throughout North America and the Caribbean.

Maximum lifespan.—16 years, 5 months.

Breeding habitat.—Open wetlands, marshland, pastures, old fields, and prairies, as well as shrub-steppe and riparian woods. Undisturbed areas with thick ground vegetation preferred.

Migrant type.—Partial. A moderate to long-distance migrant that will make long water crossings. More of a broad-front migrant than other species.

Migration ecology and behavior.—Usually migrates alone, sometimes at night; less commonly in small flocks of up to 10 individuals. Usually makes up less than 2–4% of all raptor migrants at most watchsites, which suggests a broad-front movement (MacWhirter and Bildstein 1996). Migrates lower and more slowly than other raptors, with a mean ground speed of 11 m s^{-1}. Exhibits a protracted autumn migration, with slightly more concentrated movements in the West. Often migrates in still air or inclement weather. Hunts regularly on migration, particularly at dusk and dawn (Beske 1982), and may form temporary use areas at stopovers (MacWhirter and Bildstein 1996).

Exhibits differential migration by age and sex; immatures migrate before adults in autumn and later than adults in spring, and males migrate earlier than females in spring (Kerlinger 1989). Juveniles make short exploratory flights prior to autumn migration (Beske 1982).

Migration timing similar east to west, with most migrants passing between late August and late November, peaking in late October (Bednarz et al. 1990, MacWhirter and Bildstein 1996, Hoffman and Smith 2003).

Spring migration less protracted than in autumn. Early migrants pass through Mesoamerica in March. At Derby Hill, New York, passage is from late February through late May. Most spring migrants are seen at Veracruz, Mexico, and in the Sandia Mountains, New Mexico, in March and April (Hoffman and Smith 2003, Ruelas 2005).

Highest average autumn counts in the East occur at Cape May, New Jersey (1,570), and Kiptopeke, Virginia (642); in the Great Lakes region at Hawk Cliff (1,170) and Holiday Beach, Ontario (875); in the Gulf region at Smith Point, Texas (331), and Veracruz, Mexico (279); and in the west in the Wellsville Mountains, Utah (308), Goshutes Mountains, Nevada (200), and Golden Gate, California (819).

Spring counts show a similar pattern, with the greatest concentrations around the Great Lakes. Highest counts occur in the east at Fort Smallwood, Maryland (126), and Rose Tree Park Hawk Watch, Pennsylvania (54); in the Great Lakes at Braddock Bay (638) and Derby Hill (511), New York; in the Gulf region at Veracruz, Mexico (28), and Bentsen Rio Grande, Texas (22); and in the west at Gunsight Mountain Alaska (274), Jordanelle Reservoir, Utah (75), and Dinosaur Ridge, Colorado (73).

Sharp-shinned Hawk (*Accipiter striatus*)

Subspecies.—Three in North America: *velox* occurs throughout most of the United States and Canada; *perobscurus* occurs in the Queen Charlotte Islands and limited areas of coastal British Columbia and southeast Alaska; *suttoni* occurs in Mexico, southern Arizona, and possibly southern New Mexico and Texas. Three others occur in Central and South America.

Range.—From central and southern Alaska east across Canada to southern Newfoundland, and south throughout the United States where suitable forested habitat occurs. Absent in southeast Alberta and southern Saskatchewan. Range extends south in the western United States to central California, Nevada, Arizona, New Mexico, southern Wyoming, and central Colorado in appropriate habitat. Range extends south in the eastern United States through Minnesota, Wisconsin, Michigan, northern Ohio, Pennsylvania, New Jersey, and south along the Appalachians through the Carolinas (Bildstein and Meyer 2000). Winters throughout much of lower 48 states, south through northern Central America.

Maximum lifespan.—19 years, 11 months.

Breeding habitat.—Large forests with dense understory, typically low- to mid-elevation conifer stands. Nests mainly in conifers.

Migrant type.—Partial. Moderate to long-distance migrant that makes short water crossings and displays altitudinal migration in some regions.

Migration ecology and behavior.—Migrates alone, sometimes in flocks of <10 individuals. Migrates with intermittent flapping and gliding flight, and occasional soaring. At Cape May, New Jersey, flew slower with a following wind than a head wind (Kerlinger 1989). At Veracruz, Mexico, flapped less in spring than in autumn (Ruelas 2005). Migrates at lower altitudes than soaring raptors (Kerlinger 1989). Often concentrates along *leading lines* and *diversion lines*, particularly on windy days. Autumn movements are greater after passage of a cold front in eastern North America (Bildstein and Meyer 2000) and coastal California (adults; Hall et al. 1992). However, in the interior west, and for juveniles on the Pacific Coast, highest concentrations usually precede or occur concurrently with frontal passage (Millsap and Zook 1983, HWI unpubl. data).

Females and juveniles migrate before males and adults, respectively, in autumn; adults migrate before juveniles in spring (Fig. 5) (Rosenfield and Evans 1980, Kerlinger 1989, DeLong and Hoffman 1999).

Sharp-shinned Hawks regularly feed on migration; at Hawk Mountain, Pennsylvania, 35% of migrating individuals showed distended crops (HMS unpubl. data). Radio-tracked individuals followed forested Appalachian Mountain ridges more than 60% of the time, and flew high over the valleys in thermals when not following ridges (L. Goodrich unpubl. data). Hawks traveled an average of 50 km day^{-1}. Tracked individuals migrated primarily from morning to early and mid-afternoon, after which they roosted in large forests and woodlots for 1–4 days between migration bouts. Autumn migrants tracked in southern New Jersey also stopped over in woodland areas more than in other habitats, and foraged regularly during several days of tracking (Holthuijzen et al. 1985).

In autumn, most Sharp-shinned Hawks pass Hawk Mountain, Pennsylvania, and the Goshute Mountains, Nevada, between early September and early November, with peak passage averaging 1–2 weeks earlier in the west (Fig. 5) (Bednarz et al. 1990, Hoffman and Smith 2003). In Veracruz, Mexico, most pass between late September and mid-November (Ruelas 2005). In spring, most pass Veracruz between mid-March and mid-May, with peak passage in mid-April (Ruelas 2005). Most pass the Sandia Mountains, New Mexico, between mid-March and early May (Hoffman and Smith 2003).

Juveniles concentrate along coastlines to a greater extent than adults, presumably because they are more susceptible to wind drift (Bildstein and Meyer 2000). Data suggest that Sharp-shinned Hawks, particularly juveniles, are *short-stopping* in the northeastern United States (Viverette et al.

1996), presumably in response to the increased prey availability of bird-feeder birds in the northeast.

Band-returns indicate that both Atlantic Coast and Appalachian Mountain migrants nest in eastern Canada and New England west to central New York, and overwinter east of the Appalachians south into Florida and the West Indies, although a few Appalachian Mountain migrants also breed and overwinter in the Appalachians and areas west into east Texas (Figs. 2A and B; e.g., see Clark 1985). Great Lakes migrants nest in Québec and Ontario and the Great Lakes states, and overwinter in western New York and Pennsylvania west through Illinois and south to the Gulf Coast (Figs. 2C and D; e.g., Mueller and Berger 1967b, Evans and Rosenfield 1985). Rocky Mountain migrants nest from Alaska south through the Rocky Mountains and overwinter from the central Rocky Mountains south through central and southern Mexico (Fig. 2E; see Hoffman et al. 2002). Intermountain migrants nest from Alaska south through the Intermountain West and Great Basin, and winter from the northern Intermountain West south along the west coast of Mexico (Fig. 2F; Hoffman et al. 2002). Pacific Coast migrants range from southwestern British Columbia to Baja California (Fig. 2G; Hoffman et al. 2002; B. Hull pers. comm.). Western birds appear to exhibit *chain migration* (Smith et al. 2003).

Highest average autumn counts in the East and Midwest occur along the Atlantic Coast at Cape May, New Jersey (21,350), and Lighthouse Point, Connecticut (6,695); in the Appalachian Mountains at Waggoner's Gap (5,343) and Hawk Mountain (3,948), Pennsylvania; and around the Great Lakes at Hawk Ridge, Minnesota (16,462), and Holiday Beach, Ontario (10,995). The highest count around the Gulf region occurs at Smith Point, Texas (2,917), with the average in Veracruz, Mexico, less than half that (1,106). Highest counts in the west occur in the Goshute Mountains, Nevada (5,280), Golden Gate, California (4,050), Grand Canyon, Arizona (3,012; two sites combined), and Manzano Mountains, New Mexico (1,655).

Spring flights appear more dispersed than autumn movements. The largest average counts occur in the Great Lakes at Whitefish Point, Michigan (9,860), and Braddock Bay (2,810) and Derby Hill (2,692) in New York. Other eastern counts average 2,485 at Fort Smallwood, Maryland, 382 at Pilgrim Heights Hawk Watch, Massachusetts, and 352 at Montclair Hawk Lookout, New Jersey. Limited counts recorded along the Gulf Coast range from 50 to 74 migrants per spring. Western counts include averages of 560 in the Sandia Mountains, New Mexico, and 401 at Dinosaur Ridge, Colorado.

Cooper's Hawk (*Accipiter cooperii*)

Subspecies.—Monotypic.

Range.—Across southern Canada and the United States, south into north-central Mexico. May be absent from prairie states and some southern regions where no suitable forest or woodland nesting habitat is found. Winters throughout the central and southern United States and Mexico.

Maximum lifespan.—20 years, 4 months.

Breeding habitat.—Wide variety of forest and woodland types, including wooded riparian corridors and increasingly suburban and urban woodlots and neighborhoods with trees. Sometimes nests in isolated trees. Tends to select older trees for nesting. Often nests in conifers, as do other accipiters, but routinely uses much broader range of tree species and habitats than either Sharp-shinned Hawks or Northern Goshawks.

Migrant type.—Partial. A moderate-distance migrant that will make short water crossings and may display altitudinal movements in some areas. Migrates alone or in small flocks of less than 10 individuals.

Migration ecology and behavior.—Like its close relative the Sharp-shinned Hawk, this species is one of the most ubiquitous raptors at watchsites across North America, routinely concentrating along *leading* and *diversion lines*. It uses updrafts along ridges, but also soars on thermals and uses flapping flight. Juveniles generally precede adults within sexes, and females precede males within age classes in autumn, with the reverse being true in spring (Kerlinger 1989, Rosenfield and Bielefeldt 1993, DeLong and Hoffman 1999, Mueller et al. 2000). The overall distribution patterns of this species appear similar to those of the Sharp-shinned Hawk, except that its range extends only to southern Canada (e.g., Hoffman et al. 2002).

Ten radio-tracked migrants in the Appalachian Mountains of eastern Pennsylvania traveled on average 126 km day^{-1} (L. Goodrich unpubl. data). Some migrated exclusively along ridges, others migrated along ridges some of the time, but also soared across valleys in thermals. Individuals spent considerable time hunting and resting in forests, woodlots, and hedgerows.

Peak autumn migration occurs on average 1–2 weeks earlier in the interior west than in the east and migration tends to be more protracted in the east than in the west. Most migrants pass northern latitudes from early September through mid-October in the West, but migration extends through mid-November in the East (Bednarz et al. 1990, Hoffman and Smith 2003). At Veracruz, Mexico, most pass between mid-September and mid-November (Ruelas 2005).

In spring, most migrants pass Veracruz, Mexico, between early March and early May (Ruelas 2005), and the Sandia Mountains, New Mexico, between mid-March and early May (Hoffman and Smith 2003).

Highest average autumn counts occur along the Atlantic Coast occur at Cape May, New Jersey (4,162), and Kiptopeke, Virginia (1,920); along the Appalachian Mountains at Hawk Mountain (755) and Waggoner's Gap (750), Pennsylvania; around the Great Lakes at Erie Metropark, Michigan (722), and Hawk Cliff (525) and Holiday Beach (499), Ontario; around the Gulf Coast at Veracruz, Mexico (1,950), Smith Point, Texas (1,126), and the Florida Keys (545); in the interior west in the Goshute Mountains, Nevada (3,561), Grand Canyon, Arizona (2,035; two sites combined), and Manzano Mountains, New Mexico (1,263); and at Golden Gate, California (2,377).

Highest average spring counts occur in the east at Fort Smallwood, Maryland (504); Derby Hill (391) and Braddock Bay, New York (293); along the Gulf Coast at Bentsen Rio Grande, Texas (112); and in the west at the Sandia Mountains, New Mexico (715), and Dinosaur Ridge, Colorado (475).

Northern Goshawk (*Accipiter gentilis*)

Subspecies.—Two or three in North America, depending on authority: *atricapillus* is broadly distributed across the continent; *laingi* occurs on the Queen Charlotte Islands and Vancouver Island, British Columbia, and limited portions of coastal mainland Alaska; *apache* is variably recognized as occurring from southern Arizona south, locally through the mountains of northern and central Mexico. Six other subspecies occur in the Old World.

Range.—Central Alaska and north-central Yukon Territory east to Newfoundland, and south through the mountains of the western United States and central Mexico, and in the East to Minnesota, northern Wisconsin, central Michigan, Pennsylvania, northern New Jersey, and the Appalachian Mountains of West Virginia.

Maximum lifespan.—16 years, 4 months.

Breeding habitat.—Typically tracts of mature or old-growth conifer, mixed hardwood-conifer, birch, or aspen forest, or sometimes younger forest types but with a component of mature trees that afford high canopy coverage for nesting (Squires and Reynolds 1997). Appears to prefer nesting sites near forest openings or edges for foraging.

Migrant type.—Partial or *local*, often *irruptive* in northern portions of range. Makes short water crossings and displays altitudinal migration in some regions. A short- to moderate-distance migrant that is not known to flock on migration.

Migration ecology and behavior.—Northern populations appear generally more migratory than southern populations, but also periodically irrupt southward from northern latitudes in response to cyclical lows in populations of favored prey such as grouse and hares (Squires and Reynolds 1997). Irruptions may have occurred more regularly prior to the 1980s (Mueller et al. 2000). Eastern and midwestern autumn migration counts tend to increase following passage of cold fronts (Allen et al. 1996, Squires and Reynolds 1997); relationships with weather have not been formally evaluated in western North America.

Juveniles migrate south in autumn before second-year and older birds. Data from Wisconsin and eastern North America suggest that males precede females (Kerlinger 1989, Mueller et al. 2000). Banding data suggest that females precede males within age classes in the Goshute Mountains, Nevada (HWI unpubl. data). Adults return north in spring before juveniles and may winter closer to their breeding ranges; females may winter farther north than males (Kerlinger 1989).

Northern Goshawks display a variety of migration patterns. Individuals satellite-tracked from the Wasatch Mountains of northern Utah included permanent residents and short-distance, altitudinal migrants, as well as individuals that migrated latitudinally ≤200 km into southern Utah and Arizona (Sonsthagen et al. 2006). Others, primarily juvenile birds, tracked in Oregon, Washington, Nevada, Wyoming, and New Mexico, also showed various movements. All but two of more than 30 individuals tracked during a northern irruption remained within 150 km of the trapping site, which might be typical in many areas in North America. At Hawk Mountain, Pennsylvania, most of the flight occurs between mid-September and early December, with the peak in November (Bednarz et al. 1990). At the Goshute Mountains, Nevada, most birds head south earlier between late August and early November (Hoffman and Smith 2003).

Highest average autumn counts occur in the east at Observatoire d'oiseaux de Tadoussac, Québec (179), and at Waggoner's Gap (90) and Hawk Mountain (61), Pennsylvania; around the Great Lakes at Hawk Ridge, Minnesota (584), and Cedar Grove, Wisconsin (119); and in the west at the Goshute Mountains, Nevada (69), Mt. Lorette, Alberta (65), Bridger Mountains, Montana (33), and Chelan Ridge, Washington (28).

Spring flights are less well documented and, perhaps, more dispersed. Average counts exceeding 10 birds per spring include Whitefish Point, Michigan (124), Braddock Bay, New York (51), Bélvèdere Raoul-Roy, Parc National du Québec (51), Mt. Lorette, Alberta (33), Sandia Mountains, New Mexico (11), and Gunsight Mountain, Alaska (11).

Common Black-Hawk (*Buteogallus anthracinus*)

Subspecies.—At least two: *anthracinus*, from the southern United States south through Central America; *gundlachii*, on Cuba and Isla de la Juventud.

Range.—Limited distribution along river valleys from southwest Utah southeast through northwest, central, and southeast Arizona, and portions of central and southwestern New Mexico, south to northern South America. Limited breeding in southwest Texas (Schnell 1994).

Maximum lifespan.—13 years, 6 months.

Breeding habitat.—Most common in gallery forest along perennial streams with riffles and boulders for perching. Also in freshwater swamps, marshes, flooded forests in coastal plains, and mangroves, and along mountain streams. Nests in large trees in cottonwood-willow and mixed broadleaf forests (Schnell 1994).

Migrant type.—Partial. A short- to moderate-distance, soaring migrant in the northern part of its range, mainly sedentary in the tropics. Migrates alone or in small flocks.

Migration ecology and behavior.—Limited information. Regularly uses thermal updrafts for soaring on migration. One observation was recorded of a mated pair departing the breeding grounds together. Other limited data suggest that breeders may begin vacating breeding territories as early as late July but, apparently, migrating birds have been recorded through October; breeders begin returning to territories in early March, with adults preceding juveniles by as much as 2 months, and males may precede females (Schnell 1994).

Veracruz, Mexico, reports averages of five and one migrants in autumn and spring, respectively; however, migrants are difficult to distinguish from residents there, so true migrant numbers may be higher. One migrant or dispersing individual recorded in late September at Corpus Christi, Texas, since 1997; one in early April in the Sandia Mountains, New Mexico, since 1985 (HWI unpubl. data); and one, northbound in March, in the Marin Headlands, California (A. Fish pers. comm.).

Harris's Hawk (*Parabuteo unicinctus*)

Subspecies.—Two in North America: *superior* in California, Arizona, and Sonora and Sinaloa, Mexico; *harrisi* in Texas, eastern Mexico, and Central America. One other, *unicinctus*, in South America.

Range.—Parts of southeastern-most California, southern Arizona, and southwestern New Mexico, south through Baja California and along the Pacific slope of Mexico into Central America; southeastern New Mexico and southwestern and southern Texas, south along the Atlantic slope of Mexico to at least Veracruz; the Central Plateau of Mexico south to El Salvador; and farther south into South America where savanna and semi-open habitats occur (Bednarz 1995, Ferguson-Lees and Christie 2001).

Maximum lifespan.—14 years, 11 months.

Breeding habitat.—Semi-open desert scrub, savannas, grasslands, and wetlands. In Arizona, New Mexico, and Texas, Palo Verde-cactus habitats, riparian cottonwoods, and mesquite-live oak woodlands are used. In the Sonoran Desert, saguaro cactus (*Carnegiea gigantea*) often used as nesting substrate, but also nests in various trees and, increasingly, on utility structures in suburban areas. Access to water may be important (Bednarz 1995).

Migrant type.—Resident in North America; *partial* in South America.

Migration ecology and behavior.—No clear migratory tendencies documented in North America, but moderate-distance movements in South America (Kerlinger 1989, Bednarz 1995). Average autumn counts of 14 birds at Corpus Christi, Texas, and 11 in Veracruz, Mexico, suggest at least regional dispersal in North America. Spring counts in Veracruz average two birds.

Gray Hawk (*Buteo nitidus*)

The genus of this species was recently changed from *Asturina* to *Buteo*, based on new mitochondrial DNA analyses (Banks et al. 2006).

Subspecies.—One, *plagiata*, in North America from Texas, New Mexico, and Arizona south to northwestern Costa Rica. Three others in Central America and South America.

Range.—South-central Arizona through parts of southwestern New Mexico along the Gila and Mimbres rivers; southern Texas along the Rio Grande and west to Big Bend National Park and the Davis Mountains; Mexico except for the central highlands and south through Central America and into South America (Bibles et al. 2002).

Maximum lifespan.—Not known.

Breeding habitat.—Riparian areas dominated by cottonwoods, with mesquite woodland nearby; also thorn and thorn-scrub palm forest, coconut groves, and pine–oak forest, as well as broken forest and lowland forest edge and savannah in the southern part of its range. Typically nests in mesquite, hackberry, or oak trees (Bibles et al. 2002).

Migrant type.—Partial. A short- to moderate-distance, solitary migrant in the northern parts of its range; appears to be sedentary farther south.

Migration ecology and behavior.—Thermal soars during migration (Ferguson-Lees and Christie 2001). Not known to make long water crossings. Individuals from Arizona and northern Mexico migrate to southern Mexico, and birds from Texas may migrate into Mexico (Wheeler 2003b). Age classes appear to migrate simultaneously (Wheeler 2003b).

Counts in Veracruz, Mexico, average 524 in autumn and 10 in spring. Autumn migration occurs in September and October. In spring, adults return in March; juveniles in May (Ferguson-Lees and Christie 2001, Wheeler 2003b). One individual reported in the Marin Headlands, California in March 2005 (A. Fish pers. comm.).

Roadside Hawk (*Buteo magnirostris*)

Subspecies.—Four from Mexico to Central America: *griseocauda*, in Mexico except the Yucatan, south to northern Costa Rica; *conspectus*, in the Yucatan and Tabasco, Mexico and Belize; *gracilis*, Cozumel and Holbox islands off the Yucatan; *petulans*, from southwestern Costa Rica through Panama. Ten other subspecies occur on islands and in South America.

Range.—Northern Mexico, excluding the Sierra Madres, south through Central and South America to Uruguay and northeastern Argentina (Ferguson-Lees and Christie 2001).

Maximum lifespan.—Not known.

Breeding habitat.—Lowland and montane woods, wet and gallery forests, open woodlands and plantations, and scrub savanna. Often seen perching along forest edges (Ferguson-Lees and Christie 2001).

Migration type.—Largely sedentary throughout its range, but regularly disperses north into Texas and south into Argentina, and may be *nomadic* elsewhere (Ferguson-Lees and Christie 2001).

Migration ecology and behavior.—Unstudied. A single, possible migrant or dispersing individual was reported at Veracruz, Mexico, during autumn. Movements may be overlooked due to presence of local, sedentary birds.

Red-shouldered Hawk (*Buteo lineatus*)

Subspecies.—Five: *lineatus* is most widespread, from the northeastern United States and southeastern Canada, south to eastern Oklahoma, northern Arkansas, Tennessee, and the Carolinas; *alleni*, in the southeastern United States, except southern Florida, west to eastern Texas; *texanus*, in east-central Texas; *extimus*, in southern Florida; and *elegans*, from southwestern Oregon south through California to Baja California, Mexico.

Range.—Southern New Brunswick west across southern Ontario, south and west to the eastern edge of the Great Plains, and south and east to Florida, the Gulf Coast, and eastern Mexico. The western population breeds primarily west of the Sierra Nevada and Cascade Mountains from southwestern Oregon to northern Baja California (Crocoll 1994). Since 2001, several breeding records, presumably *B. l. elegans*, have been recorded east of the Sierra Nevada in western Nevada (E. Ammon, Great Basin Bird Observatory pers. comm.).

Maximum lifespan.—19 years, 11 months.

Breeding habitat.—Eastern birds occur in bottomland forest, riparian areas, and deciduous swamps with older trees, and, increasingly, residential areas. Western birds occur in riparian areas and oak woodlands, as well as eucalyptus groves and residential areas (Crocoll 1994).

Migrant type.—Partial. A medium-distance migrant known to make short water crossings. Migrates alone or in small groups.

Migration ecology and behavior.—Soars and flaps on migration (Crocoll 1994). Flies as high as 1,300 m, but often flies lower and flaps more than other buteos (Kerlinger 1989). Concentrates along *leading* and *diversion lines*, especially along coasts and shorelines. May migrate along river corridors. Migrates at speeds of 40–56 km h^{-1} (Broun and Goodwin

1943, Kerlinger 1989). Individuals in southern and western portions of the range have long been thought to be sedentary; however, autumn counts of several hundred birds suggest regular movements along the central coast of California. In autumn, juveniles migrate before adults.

At Hawk Mountain, Pennsylvania, most of the flight occurs between late September and late November, with a peak in late October (Bednarz et al. 1990). At Golden Gate Raptor Observatory in the Marin Headlands, California, most of the flight passes from early September to mid-November, and peaks in mid-September (A. Fish pers. comm.).

Highest average autumn counts occur in the east at Cape May, New Jersey (496), Waggoner's Gap, Pennsylvania (293), and Turkey Point Hawk Watch, Maryland (255); around the Great Lakes at Lake Erie Metropark, Michigan (970), and Hawk Cliff (811) and Holiday Beach (623), Ontario; around the Gulf Coast at Corpus Christi (55) and Smith Point (47), Texas; and in the west in the Marin Headlands, California (361).

Highest average spring counts occur in the east at Fort Smallwood, Maryland (210), and Tussey Mountain Hawkwatch (57) and Allegheny Front (53), Pennsylvania; and around the Great Lakes at Niagara Peninsula Hawkwatch, Ontario (554), and Braddock Bay (409) and Derby Hill (683), New York. Spring counts along the Gulf Coast range from two to seven birds per season (Table 2).

Broad-winged Hawk (*Buteo platypterus*)

Subspecies.—One, *platypterus*, in continental North America; five others on Caribbean islands.

Range.—Deciduous or mixed deciduous-coniferous forests from central Alberta east to New Brunswick and Cape Breton Island, Nova Scotia, and south through east-central Texas across to northern Florida. The species also exists at lower densities west through North Dakota and central Texas. Range expansion underway in western Alberta and British Columbia (Smith et al. 2001a).

Lifespan.—Maximum 16 years and 1 month.

Breeding habitat.—Continuous or very large, deciduous or mixed-deciduous forests with openings and nearby water sources (Goodrich et al. 1996). Some conifers are preferred. Highest nesting densities occur in spruce–hardwood forests in northern New England (Robbins et al. 1986, Titus et al. 1989). Often forages near small openings. No clear preference for nest-tree species (Goodrich et al. 1996). Historically, avoided developed areas, but nests near dwellings and forages along power-lines (Armstrong and Euler 1983).

Migrant type.—Complete. A long-distance, trans-equatorial, soaring migrant that travels in flocks of up to tens of thousands of birds and makes short water crossings.

Migration ecology and behavior.—Broad-front, thermal-soaring, flocking migrants that concentrate in loose corridors through some regions. Corridors can shift year to year due to weather and wind dynamics. Often travels in mixed-species flocks. Single, non-flocking migrants are rare in most regions, even at high latitudes (i.e., 12% of migrants sighted in central New York were alone; Goodrich et al. 1996, Kerlinger 1989), except at western watchsites where the species is comparatively rare and single birds are relatively common (HWI unpubl. data). Concentrates along coastlines and lake shores and, occasionally, along Appalachian ridges. Outbound migrants from across the continent converge along the Texas Gulf Coast and especially in Veracruz, Mexico, and then continue along the Mesoamerican corridor into northwestern South America (Goodrich et al. 1996).

In eastern North America, the species follows an elliptical migration pathway that is more eastern in autumn and western in spring, due to wind drift (Kerlinger 1989, Bildstein 2006). Some individuals attempt over-water passage into the West Indies, where they have been seen in Puerto Rico, Trinidad, and Tobago (Goodrich et al. 1996). In autumn, juveniles are more prone to wind drift and, as a result, appear along the Atlantic Coast in greater numbers than adults (Goodrich et al. 1996). Autumn counts in the Marin Headlands along the Pacific Coast of California also are among the highest in the west. Broad-winged Hawks migrate at higher altitudes than many other raptors, particularly at midday when thermal strength is greatest. Flight altitude in autumn averaged 855 m in one study in New England (Kerlinger 1989).

Little known about habitat use on migration, but suitable forests appear important for roosting. In Veracruz, Mexico, large numbers of birds roosted in forested slopes of canyons, and less often in mango plantations and rarely in open areas (E. Ruelas pers. comm.). Near Corpus Christi, Texas, thousands of migrants routinely roost communally within relatively large tracts of riparian, bottomland forest, such as are found near the watchsite there along the Nueces River (J. Simon pers. comm.)

Birds depart nesting areas in August and early September. In autumn, juveniles may migrate earlier than adults, although some follow adults when thermal-soaring (Maransky and Bildstein 2000). In spring, adults precede second-year birds. Migration timing not known to differ by sex. Most migrants pass Hawk Mountain, Pennsylvania, between late August and late September; the Goshute Mountains, Nevada, between mid-September and early October; the Marin Headlands, California, between mid-September and late October; and Veracruz, Mexico, between mid-September and mid-October, with peak activity in early October (Bednarz et al. 1990, Hoffman and Smith 2003, Ruelas 2005, A. Fish pers. comm.). More than 90% of all migrants that pass through Corpus Christi, Texas, do so during the last 2 weeks of September.

In spring, most migrants pass Veracruz, Mexico, between mid-March and early May (Ruelas 2005), the Sandia Mountains, New Mexico, between early March and early May (Hoffman and Smith 2003), and Hawk Mountain, Pennsylvania, in late April (McCarty et al. 1999).

Highest average autumn counts occur in the east at Quaker Ridge, Connecticut (8,666), Little Gap, Pennsylvania (7,955), and Rockfish Gap Hawk Watch, Virginia (7,156); around the Great Lakes at Southeastern Michigan Raptor Research–Point Mouillee State Game Area (79,012) and Lake Erie Metropark (76,036), Michigan, and Hawk Ridge, Minnesota (55,212); around the Gulf Coast at Veracruz, Mexico (1,904,261), and Corpus Christi, Texas (677,618); and in the west at Golden Gate, California (103), and Goshute Mountains, Nevada (77).

Highest average spring counts occur in the east at Fort Smallwood Park, Maryland (1,348), Hook Mountain, New York (1,323), and Rose Tree Park, Pennsylvania (1,346); around the Great Lakes at Braddock Bay (23,325) and Derby Hill (12,538), New York, and West Skyline Hawk Count, Minnesota (12,363); along the Gulf Coast in Veracruz, Mexico (31,798 at Veracruz River of Raptors sites and 84,948 at Tlacotalpan), and Bentsen Rio Grande, Texas (28,197); and in the west at Dinosaur Ridge, Colorado (54), and the Sandia Mountains, New Mexico (6). In Veracruz higher spring temperatures may disperse the migration over a broader area and result in much lower average counts than during autumn (Ruelas 2005).

Short-tailed Hawk (*Buteo brachyurus*)

Subspecies.—Two: *fuliginosus* in Florida and Central America; *brachyurus* in South America.

Range.—Peninsular Florida and possibly in the panhandle, and in Mexico from Tamaulipas south into Central America and South America, at less than 2,000 m elevation.

Maximum lifespan.—Not known.

Breeding habitat.—Dense, sometimes flooded, woodlands; closed canopy cypress swamps; outside of Florida, more open woodland, including thorn scrub and deciduous forest in agricultural areas (Miller and Meyer 2002).

Migrant type.—Partial. A short-distance, and possibly irruptive, largely solitary migrant (Kerlinger 1989). More migratory outside of the tropics. Migration observed in Mexico and Central America as far south as Costa Rica (Miller and Meyer 2002). Occasionally observed in coastal Texas during autumn (HWI unpubl. data).

Migration ecology and behavior.—Populations in northern Florida routinely migrate to areas south of Lake Okeechobee and into the Florida Keys (Miller and Meyer 2002). Migrants are also observed in Mexico and

Costa Rica, although data are scarce. Moves south in October and returns in February. In the Florida Keys, most southbound migrants are seen between mid-October and early November (Lott 2006).

Autumn counts average 29 birds at Curry Hammock State Park in the Florida Keys, and one at Veracruz, Mexico, although the latter count may be low as migrants are difficult to discern from residents (Ruelas 2005). Since 1997, nine migrating or dispersing individuals have been recorded at Corpus Christi, Texas (HWI unpubl. data). Spring counts average five birds at Tlacotalpan in Veracruz, Mexico.

Swainson's Hawk (*Buteo swainsoni*)

Subspecies.—Monotypic.

Range.—Patchily distributed in west-central Alaska, the Yukon Territory, and British Columbia; main distribution from southern Alberta across to southern Manitoba, south to western Minnesota, southwest Wisconsin, and northwest Illinois, and south through Washington and Oregon east of the Cascade Mountains, into central California, and throughout the Intermountain West and Great Basin, central and southern Rocky Mountains, and western plains states south to Texas and northern Mexico. Most of the population overwinters in Argentina, but a few individuals overwinter in south Florida (Browning 1974), and small numbers routinely winter in central California (Herzog 1996) and Costa Rica (K. Bildstein pers. obs.) and, most likely, elsewhere along the main migration corridor where appropriate habitat occurs. Recent satellite-tracking data suggest that individuals breeding in the Central Valley of California winter in Mexico and Colombia (California Department of Fish and Game 2000).

Maximum lifespan.—19 years, 7 months.

Breeding habitat.—Grasslands and shrub-steppe with scattered trees, large shrubs, or treed riparian areas for nesting. Often feeds in agricultural areas, especially improved pastures and hayfields. Nests on lone roadside trees, cottonwoods, and a variety of other species surrounding rural habitations, but more often in small, shrubby trees such as junipers in shrub-steppe or desert-plains landscapes (England et al. 1997).

Migrant type.—Complete. Long-distance, trans-equatorial, flocking, thermal-soaring migrants that make short water crossings and may travel across a broad front before converging along the coastal plains of south Texas and eastern Mexico and traveling south along the Mesoamerican corridor (England et al. 1997, Fuller et al. 1998).

Migration ecology and behavior.—Forms large flocks on migration, particularly in the tropics, and uses thermal-soaring more than ridge updrafts on migration. Along the Mesoamerican Land Corridor, flocks often exceed thousands of individuals and frequently include other species.

Traditional watchsites along *leading lines* and *diversion lines* in North America record relatively few Swainson's Hawks, likely due to the species' propensity for thermal soaring and traveling through grassland ecosystems. Sizeable counts at Hitchcock Nature Center, Iowa, in the Great Plains, other recent counts in valley locations such Borrego Valley, California (see Tables 1 and 2), as well as periodic passage under unusual wind conditions of thousands of migrants at sites such as the Manzano Mountains, New Mexico (HWI unpubl. data), corroborate this notion.

Swainson's Hawks gather in feeding groups in late August and early September and feed heavily on grasshoppers, often in agricultural areas, before migrating long distances to over-winter in Argentina. Birds appear to fast while traveling along the Mesoamerican Land Corridor (England et al. 1997).

South of Mexico, migrants variably travel along the Pacific and Atlantic slopes through Costa Rica and Panama, before entering Colombia where they then travel along the eastern foothills of the Andes through Bolivia and, eventually, into Argentina to over-winter (England et al. 1997, Fuller et al. 1998).

Most of the relatively modest flight passes the Goshute Mountains, Nevada, between late August and early October (Hoffman and Smith 2003). Much larger flights pass Corpus Christi, Texas (Smith et al. 2001b), and Veracruz, Mexico (Ruelas 2005), during a 3-week period in mid-October. The Florida Keys reports a modest passage between primarily late October and early November (Lott 2006).

In the spring, birds leave Argentina in mid-February, pass through Panama in March and early April, and pass through Veracruz, Mexico, between mid-March and late April (Ruelas 2005).

In autumn, the only counts in the East and Midwest that record more than a handful of migrants include an average of 84 birds in the Florida Keys (Lott 2006), and 1,985 at Hitchcock Nature Center, Iowa. In the west, highest counts occur at the Goshute Mountains, Nevada (358), Manzano Mountains, New Mexico (313; but 7,100 in 1993 and 4,600 in 2006), and Wellsville Mountains, Utah (118). Much higher concentrations occur in coastal Texas, with an average 6,036 at Corpus Christi, and especially along the Mesoamerican Land Corridor, with averages of 974,951 in Veracruz, Mexico, and 293,432 at Kekoldi, Costa Rica.

Only a few individuals are counted in spring at sites in the east and around the Great Lakes, and only modest average numbers are recorded in the Sandia Mountains, New Mexico (55), and at Dinosaur Ridge, Colorado (34). In contrast, Borrego Valley, California, reports a recent average of 2,921 birds in partial-season coverage; Corpus Christi, Texas, an average 2,010; and Veracruz River of Raptors, Mexico an average 34,537.

White-tailed Hawk (*Buteo albicaudatus*)

Subspecies.—One in North America, *hypospodius*, from southeast Texas through Mexico and Central America; two others in South America.

Range.—Southeast Texas and south along the Pacific and Gulf coasts through Mexico and Central America at <1,600 m elevation.

Maximum lifespan.—Not known.

Breeding habitat.—Humid to arid, open or semi-open grasslands, prairies, savannas, and mesquite shrublands. Usually nests on low (≤3 m) shrubs and succulent plants, but sometimes in taller, scrubby trees (Farquhar 1992).

Migrant type.—Largely sedentary but some evidence of *partial* and possibly *irruptive* tendencies (Farquhar 1992, Wheeler 2003b, Bildstein 2006).

Migration ecology and behavior.—Breeding adults are believed to be largely sedentary throughout most of the species' range, but may disperse during the nonbreeding season to forage in burned and plowed fields (Wheeler 2003b). Juveniles and subadults appear to disperse more regularly and are semi-nomadic during autumn and winter. Apparent southbound migrants are seen in small numbers in coastal Texas in autumn (Smith et al. 2001b). Unconfirmed reports suggest southbound flocks in Santa Cruz, Bolivia, in autumn (Bildstein 2006).

Autumn counts of migrants in coastal Texas average 11 birds at Smith Point and 9 at Corpus Christi.

Zone-tailed Hawk (*Buteo albonotatus*)

Subspecies.—Monotypic.

Range.—Arizona as far north as the Grand Canyon, northern New Mexico, possibly southwestern California, Baja California and interior northern Mexico, south along both the Pacific and Atlantic slopes through Central America. In South America from Trinidad and Colombia east of Andes, south to Bolivia, Paraguay, Ecuador, and Peru. Relatively uncommon and locally distributed throughout its range. Vagrants northeast to Nova Scotia.

Maximum lifespan.—Not known.

Breeding habitat.—Riparian forest and woodlands; desert uplands and forested canyons; and mixed-conifer, cottonwood-willow, pine, and scrub forests (Johnson et al. 2000).

Migrant type.—*Partial.* Moderate-distance migrant that makes short water crossings. Migrates alone, sometimes in small groups.

Migration ecology and behavior.—Physical appearance and flight behavior similar to the Turkey Vulture, which it often travels with and mimics to approach prey (Johnson et al. 2000, Wheeler 2003b). The similarity with Turkey Vultures makes detection and identification at watchsites difficult, particularly at times when large numbers of the latter are migrating.

Northern populations appear to migrate regularly, whereas populations south of central Mexico appear largely sedentary, except for possible altitudinal movements (Johnson et al. 2000). Autumn movements occur between late August and mid-November. Families in the Grand Canyon, Arizona, typically leave the area by mid-September, and most migrants pass Corpus Christi, Texas, between mid-September and mid-October (HWI unpubl. data). Spring flights occur between mid-February and early May. Earliest return dates to Arizona breeding areas are in mid-March (Johnson et al. 2000). Passage of small numbers in the Sandia Mountains, destined for the northernmost breeding area for the species in New Mexico, occurs between late March and early May (HWI unpubl. data). No evidence of differential movement by age or sex (Wheeler 2003b).

The breeding distribution of this species lies predominantly south of most long-term watchsites in North America. That said, in autumn, 1–3 migrants are recorded most years in the Manzano Mountains, New Mexico; departures of local breeding birds and their offspring are recorded in the Grand Canyon, Arizona; 2–10 migrants are recorded each year at Corpus Christi, Texas; and counts average 189 in Veracruz, Mexico. Similarly, spring counts average 17 at Veracruz River of Raptors, and 8 at Tlacotalpan in Veracruz, Mexico, and 1–10 at Sandia Mountains, New Mexico.

Red-tailed Hawk (*Buteo jamaicensis*)

Subspecies.—Twelve to 14 recognized in North America and Central America, depending on the authority. In North America, *borealis*, throughout eastern Canada and the United States west to the Rocky Mountains; *calurus*, throughout most of western North America from southern Alaska to Baja California and parts of northern Mexico, east to central Manitoba in Canada and through the Rocky Mountains in the United States; *harlani*, in mainland Alaska, the Yukon Territory, and far northern British Columbia; *alascensis*, on the islands and along the adjacent coastal mainland areas of southeastern Alaska and British Columbia; *fuertesi*, in southeastern Arizona, southern New Mexico, central and southwestern Texas, and northern Mexico; and sometimes recognized *krideri*, in the Great Plains region.

Range.—Ubiquitous across Canada and the United States below treeline, south into northern and central Mexico, high-elevation areas in Central America as far as northern Nicaragua, and the West Indies.

Maximum lifespan.—28 years, 10 months.

Breeding habitat.—Generalist; open, semi-open, and forested natural and human-dominated landscapes. Nests in a variety of moderate-to-tall trees, cliffs, powerline structures, and, occasionally, buildings. Generally requires elevated perches for hunting.

Migrant type.—Partial. Short- to moderate-distance, soaring migrant that makes water crossings of up to 25 km and may display a *leap-frog migration* in some regions. Not a regular trans-equatorial migrant, but small numbers are recorded each autumn in southeastern Costa Rica, Panama, and Colombia (Ferguson-Lees and Christie 2001, Castaño R. and Colorado Z. 2002, P. Porras pers. comm.). Generally migrates alone or in small groups, but sometimes in flocks of up to 50 birds.

Migration ecology and behavior.—Northernmost populations migrate earlier than more southern populations, and may winter farther south; however, recent satellite tracking of mainly adults in western North America does not this show this pattern. Breeding adults may be largely sedentary at southern latitudes, but southern juveniles may disperse long distances north before returning south (Bloom 1985). Migratory individuals remain absent from breeding areas for 3–5 months (Preston and Beane 1993) and, in the west, satellite tracking indicates that adults show high fidelity to their summer and winter ranges and to migration routes (Fig. 4; HWI unpubl. data).

Both slope soars and thermal soars on migration, the latter occurring more often in early autumn than later on (Maransky et al. 1997). Kerlinger (1989) reported mean air and ground speeds of 48 and 56 km h^{-1}. The average altitude of migrants has been reported at 839 m (Kerlinger et al. 1985).

Juveniles precede adults in autumn (Fig. 5); adults precede second-year birds in spring (Wheeler 2003a). Juveniles tend to concentrate more along coastlines than adults (Kerlinger 1989), and adults may over-winter closer to the breeding grounds than juveniles (Preston and Beane 1993).

Timing and rate of migration are influenced by weather, particularly snow cover, and food availability. High prey availability may delay or shorten migratory movements (Craighead and Craighead 1956). In autumn, at Hawk Mountain, Pennsylvania, higher counts occur following passage of cold fronts (Allen et al. 1996). On the Pacific Coast, higher counts occur on warm, fog-free days with rising barometric pressure (Hall et al. 1992).

Red-tailed Hawks feed regularly on migration, particularly early and late in the day. More than 20% of migrants seen at Hawk Mountain, Pennsylvania, had distended crops, juveniles more frequently than adults (HMS unpubl. data).

In eastern North America, most of the flight passes between early October and early December, peaking in early November. In contrast, at sites in the inland west, such as the Goshute Mountains, Nevada, most of the flight occurs from early September through late October (Hoffman et al. 2003). The flight along the Pacific Coast of California extends from September through early December (A. Fish pers. comm.).

In the east, higher numbers are reported inland than on the coast (Table 2). For example, the species makes up 18% and 4% of the overall 1976–2004 flights at Hawk Mountain, Pennsylvania, and Cape May, New Jersey, respectively.

Highest average autumn counts occur in the east at Waggoner's Gap (4,116) and Hawk Mountain (3,330), Pennsylvania, and Tadoussac, Québec (3,083); around the Great Lakes at Hawk Ridge, Minnesota (8,934), Lake Erie Metropark, Michigan (8,125), and Hawk Cliff, Ontario (4,924); and in the west at Golden Gate, California (9,340), Goshutes Mountains, Nevada (3,660), and Grand Canyon, Arizona (Lipan Point and Yaki Point; 2,342). Averages of <200 birds per autumn are counted at Gulf Coast sites in Texas and Veracruz, Mexico.

Highest average spring counts occur in the east at Tussey Mountain (581) and Allegheny Front (443), Pennsylvania, and Fort Smallwood, Maryland (345); around the Great Lakes at West Skyline Hawk Count, Minnesota (5,343), Derby Hill, New York (5,086), and Belvedere Raoul-Roy, Québec (3,019); and in the west at Jordanelle Reservoir, Utah (1,029), Dinosaur Ridge, Colorado (982), and Gunsight Mountain, Alaska (551).

Ferruginous Hawk (*Buteo regalis*)

Subspecies.—Monotypic.

Range.—Southern Canada east of the Rocky Mountains to the Great Plains, south to northern Arizona and New Mexico, including portions of southern British Colombia, Alberta, Saskatchewan, and Manitoba, south through North Dakota, South Dakota to the Texas Panhandle and northern New Mexico.

Maximum lifespan.—17 years, 11 months.

Breeding habitat.—Open grassland, shrubsteppe, desert shrublands, and sparse pinyon-juniper woodlands. Nests on cliffs, elevated knolls, isolated low trees, stout shrubs, haystacks, small rock piles, on the ground, artificial nest structures, and a variety of other manmade structures if left undisturbed (Bechard and Schmutz 1995).

Migrant type.—Partial. A medium-distance migrant that displays complex, regional movements including loop migration (Kerlinger 1989, Bechard and Schmutz 1995, Watson and Banasch 2005). Migrates alone and in small groups.

Migration ecology and behavior.—Northern populations more migratory than those to the south. The species does not appear to concentrate along *leading lines* or *diversion lines*. In autumn, adults migrate earlier than juveniles (Bechard and Schmutz 1995).

Autumn migration begins in August and September. Most migrants pass the Goshute Mountains, Nevada, between late August and late October (Hoffman and Smith 2003). In spring, individuals return in late March or early April. Most pass the Sandia Mountains, New Mexico, between late February and late April (Hoffman and Smith 2003).

Migrants from Alberta move south and east to Montana and North Dakota and then south, following grassland habitats to winter ranges farther south. In the Great Plains, birds move east of the Continental Divide and overwinter in Texas and Mexico. Satellite-tracked birds from Alberta, Saskatchewan, Wyoming, and Colorado remained east of the Continental Divide year-round, moving north-south with the seasons along the edge of the Great Plains, and, in some cases, flying as far south as northeastern Mexico (Watson and Banasch 2005). In contrast, birds tracked from Great Basin areas in Utah, Arizona, and Nevada demonstrated complex movement patterns while remaining in the Intermountain West, and moving as far south as north-central Mexico. An even more extensive tracking dataset from the northern Great Basin of southeastern Washington indicates that some individuals make extensive loop migrations out onto the western Great Plains and through the Great Basin or Central Valley of California. In general, adults showed more directional movement, whereas juveniles tended to disperse.

The only autumn counts on the continent that record long-term averages of more than 10 migrants per season occur at Golden Gate, California (average of 23), Goshute Mountains, Nevada (16), Manzano Mountains, New Mexico (13), Grand Canyon, Arizona (Lipan Point and Yaki Point; 11). Similarly, the only spring watchsites that record long-term averages of more than 10 migrants per season are Dinosaur Ridge, Colorado (74) and the Sandia Mountains, New Mexico (12).

Rough-legged Hawk (*Buteo lagopus*)

Subspecies.—One, *sanctijohannis*, in North America; two others globally.

Range.—Throughout northern Canadian arctic islands and coastal areas of Baffin Island; northern Alaska as far west as the Seward Peninsula, the lower Yukon River, and Aleutian Islands, and south to the Brooks Range in central Alaska; east through the Northwest Territories, Nunavut, northern Manitoba, northern Ontario, along Hudson Bay, and in northern Québec south to 52°, and along the northern shore of the Gulf of Saint Lawrence (Bechard and Swem 2002).

Maximum lifespan.—17 years, 9 months.

Breeding habitat.—Open areas in high sub-arctic and arctic regions; also boreal forest, and low boreal forest-tundra ecotones, and treeless tundra and alpine areas. Nests on cliffs and elevated bluffs. Uses forested tundra and taiga if prey are numerous. Also hunts in bogs or clearings (Bechard and Swem 2002).

Migrant type.—Complete. A medium-distance migrant that makes intermediate-distance water crossings. Sometimes seen in small groups on migration; roosts communally during winter.

Migration ecology and behavior.—Soars on deflection updrafts and thermals on migration. Crosses water barriers ≤100 km in Europe, although often avoids water crossings in North America (e.g., 31% avoided a 24-km crossing in Whitefish Point, Michigan; Bechard and Swem 2002). Some individuals winter as far south as the southern United States, but abundance varies among years, apparently dependent on snow cover and its affect on food availability (Bechard and Swem 2002).

Often seen hunting on migration, particularly early and late in the day. Flight altitude can be low, although some individuals fly at the limit of aided vision (Bechard and Swem 2002). Radio-tagged birds traveled more than 200 km during 2 days. Tends to migrate after cold fronts in autumn. Little is known about spring migration (Bechard and Swem 2002).

A late-season autumn migrant. Departs breeding grounds in late August or early September, with latest reported departure date of 29 September (Bechard and Swem 2002). Lemming abundance and snow affect timing of departure. Males migrate farther than females; juveniles farther than adults (Olson and Arsenault 2000, Bechard and Swem 2002). Juveniles are believed to migrate south before adults, and among adults, females precede males, although observations in Wisconsin show no age difference (Mueller et al. 2000). Some individuals may still be migrating in December and January.

Probably a broad-front migrant that does not concentrate as regularly along ridges as many other migrants, but does concentrate along some rivers and shorelines of the Great Lakes. The Tanana and Matanuska river valleys in Alaska, river valleys in British Columbia, and the eastern slope of the Rocky Mountains appear to be important autumn routes in the west (Bechard and Swem 2002). The Connecticut River valley is a notable migration route in spring. In the east, numbers are highest at more northerly sites and the primary winter range lies north of the mid-Atlantic region, keeping counts lower at sites from Pennsylvania south (Table 2).

In autumn, migration peaks in Alaska from late September to early October. At Windy Point, Alberta, the median passage date is 21 October (Bechard and Swem 2002). First migrants are usually observed in the northern United States in late September (Wheeler 2003b). At Hawk Ridge, Minnesota, most of the flight occurs between early September and early December, with a peak in late October. At Hawk Mountain, Pennsylvania, most of the flight occurs between mid-October and mid-December, but counts are low. Individuals arrive in the Great Plains of Colorado in mid-October, with females arriving before males (Wheeler 2003b). In the west, Rough-legged Hawks are rarely observed at most watchsites before mid-October.

In spring, birds leave wintering areas as early as February and as late as early May (Bechard and Swem 2002). In the Great Lakes, spring flights peak in early April. Most arrive on the breeding grounds in late April and May, although some may not return until June.

Highest average autumn counts occur at northern watchsites such as Hawk Ridge, Minnesota (487), Tadoussac, Québec (236), Thunder Cape Bird Observatory, Ontario (136), Mt. Lorette, Alberta (64), Bridger Mountains, Montana (36), and Chelan Ridge, Washington (28). Similarly, the highest average spring counts occur at sites such as Whitefish Point, Michigan (859), Derby Hill, New York (346), Braddock Bay, New York (340), and Gunsight Mountain, Alaska (302).

Golden Eagle (*Aquila chrysaetos*)

Subspecies.—One, *canadensis*, in North America; four others globally.

Range.—Predominantly western North America from Alaska south to central Mexico, with small, isolated populations in northeastern North America.

Maximum lifespan.—28 years, 3 months. Six percent are estimated to live more than 13 years (Kochert et al. 2002).

Breeding habitat.—Open to semi-open habitats including tundra, shrublands, grasslands, desert canyonlands, shrubsteppe, open woodlands and coniferous forest, farmlands, and riparian habitats in the Great Plains (Kochert et al. 2002). In the east, may nest near burns, marshes, bogs, and along cliffs above rivers. In the west, from lowland deserts and canyonlands to high mountain conifer forest and subalpine habitats. In Alaska, in mountainous terrain near or above timberline, and in cliffs along rivers, lakes, and seas.

Migrant type.—Partial. A short- to long-distance migrant that makes moderate water crossings of ≤50 km. An obligate soaring migrant that depends on thermals or deflection updrafts during migration. Breeding adults may be largely sedentary at lower latitudes, but mountain breeders may undertake altitudinal migrations depending on winter severity and prey availability. Occasionally migrates in small groups; no evidence of family members migrating together (Kochert et al. 2002).

Migration ecology and behavior.—Observed more at inland watchsites than along coasts. Northern populations are more migratory than those to the south, and juveniles tend to migrate or disperse broadly regardless of latitude (Kochert et al. 2002, Wheeler 2003a). Concentrates along *leading lines* and *diversion lines*, with the Appalachian Mountains in the east and the Rocky Mountains in the west serving as particularly important migration corridors. In the east, autumn migrants appear to follow western ridges of the central Appalachians to a greater degree than eastern ridges, and also appear to use the Susquehanna River as a travel corridor from the northern Appalachians south across Pennsylvania. In this region, the species also exhibits an elliptical (or loop) migration that is more easterly in autumn and westerly in spring, most likely reflecting the effects of prevailing winds (Bildstein 2006).

Satellite-tracked juveniles from central Alaska (McIntyre 2005, McIntyre et al. 2006) and other young birds satellite tracked from migration sites in Oregon, Washington, Nevada, Wyoming, and New Mexico (HWI unpubl. data) demonstrate that northern individuals travel along a number of pathways to winter ranges from southern Canada south through the Rocky Mountains, western plains, and into Mexico (Fig. 4). Southeastern New Mexico and west Texas appear to be an important wintering area for many northern eagles. Satellite-tracked juveniles from the Goshute Mountains, Nevada, remained within the Great Basin and Intermountain West, whereas many of those tracked from the Manzano Mountains, New Mexico, in the southern Rocky Mountains were longer-distance migrants. Some juveniles tracked in the west for several years have shown significant variation in use of over-winter and breeding ranges, with some sites thousands of kilometers apart in different years. Given small numbers of satellite-tracked birds, this behavior probably is more common than previously thought.

Outbound migrants at Hawk Mountain, Pennsylvania, travel at up to 51 km h^{-1} (Broun and Goodwin 1943), although average rates are likely lower. Individuals satellite-tracked from Hudson Bay migrated an average of 65 km day^{-1} in autumn and 68 km day^{-1} in spring (Brodeur et al. 1996). Juveniles tracked from Denali National Park, Alaska, migrated for 28–58 days before arriving on winter ranges from southern Alberta to New Mexico. Second-year birds arrived slightly earlier than juveniles (Kochert et al. 2002). In the East, satellite-tracked individuals from northern Québec migrated for 26–40 days before arriving on wintering areas in Maryland, West Virginia, Alabama, and Pennsylvania (Brodeur et al. 1996). One adult female took 2.5 months to travel roughly 6,500 km from the Lisburne Peninsula in northwestern Alaska to south of Puerto Vallarta in southwestern Mexico (HWI upubl. data).

In autumn at Hawk Mountain, passage rates were higher 1 to 2 days after frontal passage (Allen et al. 1996), and migration at Glacier National Park, Montana, was associated with increasing temperature and rising barometric pressure (Yates et al. 2001). Migrants stop over, presumably to feed and rest, but rarely for more than a 1 to 2 days (Brodeur et al. 1996).

Adults precede juveniles in spring; second-year birds precede adults in autumn (Kochert et al. 2002). Satellite-tracked juveniles from Denali National Park, Alaska, departed between mid-September and early October, whereas an adult from Québec remained until 30 October (Kochert et al. 2002). Most of the flight occurs between mid-September and early December at Hawk Mountain, Pennsylvania, peaking in early November (Bednarz et al. 1990). Movements of young birds may begin as early as late August at western sites such the Goshute Mountains, Nevada, and Bridger Mountains, Montana, but most migration is after mid-September; extended counts at Mt. Lorette, Alberta, confirm continued passage through November (Omland and Hoffman 1996, Hoffman and Smith 2003, Sherrington 2003).

In spring, eastern adults depart wintering areas in early to late March and arrive on the breeding grounds between late March and May (Brodeur et al. 1996). Satellite-tracked juveniles from Alaska departed between early April and early May and traveled for 22–47 days in returning to summer ranges near their natal areas. Most of the flight at the Sandia Mountains, New Mexico, occurs from late February through April, peaking in late March (Hoffman and Smith 2003).

Highest average autumn counts occur at inland sites in the east, including Waggoner's Gap (199) and Allegheny Front (199), Pennsylvania, Franklin Mountain, New York (134), and Hawk Mountain, Pennsylvania (112). Counts on the Atlantic Coast are much lower (e.g., 10 per autumn at Cape May Point, New Jersey). Highest autumn counts around the Great Lakes occur at Hawk Ridge, Minnesota (136), and Lake Erie Metropark, Michigan (106). By far the largest counts on the continent occur along the northeastern Rocky Mountains at Mt. Lorette, Alberta (3,897) and the Bridger Mountains, Montana (1,424), with counts quickly falling off farther south (e.g., 256 in the Goshute Mountains, Nevada, and only 118 in the Manzano Mountains, New Mexico).

Highest average spring counts occur in the east at Tussey Mountain, Pennsylvania (172), and Allegheny Front, Pennsylvania (63); around the Great Lakes at the West Skyline Hawk Count, Minnesota (63), Derby Hill, New York (63), and Eagle Crossing, Québec (48); and in the west at Mt. Lorette, Alberta (3,304), Gunsight Mountain, Alaska (278), and the Sandia Mountains, New Mexico (365).

Crested Caracara (*Caracara cheriway*)

Subspecies.—Two in North America: *audubonii* in Florida, Texas, Arizona, and south through northern Central America; and *pallidus* on Tres Marias Island off Mexico.

Range.—Fragmented distribution from Baja California, southeast Texas, and southern Arizona south through Central and South America and on nearby islands, with isolated populations in Florida, Cuba, and the Isla de la Juventud (Morrison 1996). A rare breeder in Louisiana and northern Oklahoma.

Maximum lifespan.—17 years, 7 months.

Breeding habitat.—Open or semi-open, mesic to arid grassland, prairie, savanna, pampas, rangeland, brushlands, mesquite woodlands, and deserts. Patches of trees, scattered trees, poles, and fences interspersed with open grassland with an open view are favored as perches. Also occurs in grassy areas interspersed with freshwater marshes (Morrison 1996).

Migrant type.—Local. Sometimes nomadic; juveniles often disperse. A regular influx of juveniles into south Texas in winter suggests migration (Morrison 1996).

Migration ecology and behavior.—Little studied. Veracruz, Mexico, and Texas Gulf Coast watchsites report small numbers as possible migrants, with the highest average autumn counts of 10–11 birds at Corpus Christi and Smith Point, Texas, and an average spring count of 3 birds at Bentsen Rio Grande, Texas. Three possible migrants were seen at La Gran Piedra watchsite in southeastern Cuba in autumn 2001 (Rodriguez et al. 2003). Three individuals were sighted at Golden Gate, California, in 2005–2006 (A. Fish pers. comm.). The species also has been seen with increased frequency along the Pacific Coast to British Columbia, as well as in New Jersey, Massachusetts, and Ontario, in the last 10 years (R. Veit pers. comm.)

American Kestrel (*Falco sparverius*)

Subspecies.—Three subspecies in North America: *sparverius* across most of continental North America; *paulus* in eastern Texas and parts of Louisiana, Mississippi, Alabama, Georgia, South Carolina, and Florida; and *peninsularis* in southern Baja California and western Mexico. Fourteen others occur from southern Mexico into South America.

Range.—Central Alaska across southern Canada, south throughout the United States, Mexico, the Caribbean, Central America, and South America south to Tierra del Fuego; absent from the Amazon and the Atlantic Forest of Brazil.

Maximum lifespan.—14 years, 8 months.

Breeding habitat.—Open and semi-open habitats, including various woodlands, cultivated farmland, grasslands, savannas, deserts, and marshes. Requires perches for hunting and cavities for nesting (Smallwood and Bird 2002). Uses artificial nest boxes and routinely hunts from telephone and power lines; also hover hunts.

Migrant type.—Partial. Moderate-distance migrant that will make short water crossings. Migrates alone, also in small groups.

Migration ecology and behavior.—Northern populations are highly migratory, whereas southern populations often are sedentary (Smallwood and Bird 2002). Concentrates along *leading lines* and *diversion lines*, particularly along coastlines in some areas, but relatively uncommon as a migrant along the Pacific Coast compared with inland western sites, possibly due to most individuals on the Pacific Coast being largely sedentary. Juveniles may be more migratory than adults. The species displays *leap-frog migration* and *differential migration* by age and sex. Band returns associated with migration projects in the Goshute Mountains, Nevada, and Manzano Mountains, New Mexico, show a range of recovery sites from Alaska and the Yukon Territory to southern Mexico (Hoffman et al. 2002). Color-banding in central Gulf Coast Florida indicates considerable winter-site fidelity, at least among females, there (K. Bildstein pers. comm.).

In autumn at Hawk Mountain, Pennsylvania, the largest flights usually occur the day of and the day after frontal passage (Allen et al. 1996).

Routinely feeds on migration and often can be seen taking insects on the wing (Smallwood and Bird 2002).

On average, females precede males by 11 days during autumn migration at Hawk Mountain, Pennsylvania (Stotz and Goodrich 1989), and by 6 days in the Goshute Mountains, Nevada (HWI unpubl. data). Trapping at Cedar Grove, Wisconsin, further indicates that juveniles precede adults within sexes and that females precede males within age classes (Mueller et al. 2000). In spring, some data suggest that males precede females (Kerlinger 1989); however, no significant difference in median passage dates is evident in the Sandia Mountains, New Mexico, where females actually average 1 day earlier than males (HWI unpubl. data).

Autumn migration timing appears to be similar across the continent. Departure of adults may be delayed by flight-feather molt (Smallwood and Bird 2002). Most of the flight occurs between mid-August and late October at Hawk Mountain, Pennsylvania (Bednarz et al. 1990); in October in the Florida Keys (Lott 2006); between mid-September and late November in Veracruz, Mexico (Ruelas 2005); and between late August and mid-October in the Goshute Mountains, Nevada (Hoffman and Smith 2003).

In spring, migration peaks in mid-April in the east (McCarty et al. 1999); in the west most of the flight passes the Sandia Mountains, New Mexico, and Veracruz, Mexico, between mid-March and late April (Hoffman and Smith 2003, Ruelas 2005).

Highest average autumn counts occur in the east at Cape May, New Jersey (6,563), Kiptopeke, Virginia (3,788), and the Florida Keys (2,800); around the Great Lakes at Hawk Cliff (3,918) and Holiday Beach (2,196), Ontario, and Hawk Ridge, Minnesota (2,138); along the western Gulf Coast at Veracruz, Mexico (3,551), and Smith Point, Texas (1,341); and in the west at the Goshute Mountains, Nevada (2,424), Grand Canyon, Arizona (Lipan Point and Yaki Point; 1,906), and Boise Ridge, Idaho (1,233).

Highest average spring counts occur in the east at Fort Smallwood, Maryland (544), Pilgrim Heights, Massachusetts (222), and Cape Henlopen, Delaware (206); around the Great Lakes at Whitefish Point, Michigan (426), and Ripley (277) and Braddock Bay (277), New York; along the Gulf Coast in Veracruz (129 at Tlacotalpan, 70 at Veracruz River of Raptors sites) and at Bentsen Rio Grande, Texas (35); and in the west at Dinosaur Ridge, Colorado (712), and the Sandia Mountains, New Mexico (234).

Aplomado Falcon (*Falco femoralis*)

Subspecies.—One, *septentrionalis*, from the southwestern United States south through Mexico and Nicaragua; two others farther south in Central America and South America.

Range.—Southernmost New Mexico and Texas, central and eastern Mexico, south through coastal savanna and disturbed habitats on both coasts through Central America, and into lowland tropical savannah areas throughout much of South America (Keddy-Hector 2000). Uncommon in North America, with recolonization in the southern United States currently aided by captive propagation and release.

Maximum lifespan.—6 years, 7 months.

Breeding habitat.—Coastal prairie, desert grassland, mesquite woodland, and oak and riparian forest interspersed within desert grasslands; also coastal savanna and marshlands, cleared pastureland, and farmland in Mexico; and open floodplains, dense upland forest bordering agricultural fields, tidal flats and beaches, dry tropical woodlands, coastal shrublands, and lowland tropical savanna in South America (Keddy-Hector 2000).

Migrant type.—Partial. Sedentary in many areas, but altitudinal migrant in some. Regular winter visitors in western Mexico may represent a limited migration from northern populations. Makes short water crossings. Follows insect swarms; not known to flock on migration.

Migration ecology and behavior.—May disperse or use different areas within Mexico outside of the breeding season, but migration not observed (Keddy-Hector 2000). Four so-called "dispersing" individuals recorded since 1997 during autumn counts at Corpus Christi, Texas, and one bird recorded since 1985 in spring counts in the Sandia Mountains, New Mexico (HWI unpubl. data.). Reportedly migrates from the Andes to the coast in Peru and Chile; appears to be a partial latitudinal migrant in Patagonia (Ferguson-Lees and Christie 2001). Flocks in Brazil may indicate nomadic movements by juveniles.

Merlin (*Falco columbarius*)

Subspecies.—Three in North America: *columbarius* from Alaska east across Canada and south into forested regions of the northern continental United States; *richardsoni* in the northern Great Plains of southern Alberta, Saskatchewan, Manitoba, Montana, and the Dakotas; and *suckleyi* in the Pacific Northwest from southeast Alaska to northwestern Washington. Six others globally.

Range.—Breeds throughout most of Alaska and Canada; in northern fringe areas of the northeastern and midwestern United States; in northern

Great Plains states to northwest Nebraska; and in mountains in western Oregon and Washington, northern Idaho, northern Wyoming, and most of Montana. Expanding south in the northeastern United States, particularly in suburban and urban areas.

Maximum lifespan.—11 years, 11 months.

Breeding habitat.—Open to semi-open habitats with scattered woodlands or forest patches for nesting and open country for hunting. In humid boreal forests and taiga of Alaska and northern Canada; in humid rain forests of the Pacific Northwest; in conifer forests of the northern United States; and in prairie parklands, scattered woodlots, and riparian areas in the Great Plains. Also found on islands in large lakes and, increasingly, in suburban and urban areas in parks, cemeteries, and school yards where open habitat is available for hunting. Often nests in old corvid nests in trees, but also nests on the ground in some areas, possibly an adaptation for exploiting boreal habitats that lack trees (Sodhi et al. 1993).

Migrant type.—Partial. A moderate- to long-distance migrant that makes long water crossings and sometimes displays altitudinal migration. Migrates alone; also in small groups.

Migration ecology and behavior.—Generally uses powered flight on migration, especially on overcast days, but sometimes soars. Often hunts in the morning prior to migrating (Sodhi et al. 1993). Greatest concentrations occur along coasts.

Different subspecies show different migration patterns (Sodhi et al. 1993). Coastal Black Merlins (*suckleyi*) are largely sedentary, but northern populations may move south relatively short distances, with scattered occurrences at migration sites in at least California, Oregon, Washington, and Nevada (HWI unpubl. data, A. Fish pers. comm.). Some Prairie Merlins (*richardsoni*), especially those occupying urban areas, are sedentary, but most migrate moderate distances to winter in the south-central United States and northern Mexico, with scattered individuals encountered at migration sites as far west as coastal California. In comparison, the relatively widespread Taiga Merlin (*columbarius*) is highly migratory, with individuals wintering along the Pacific Coast, in the southern United States, and south into Central and northernmost South America.

Birds from west-central Canada may migrate along the eastern Rocky Mountains (Sodhi et al. 1993). In the east, birds move primarily down the coast, with many making regular water crossings. Limited returns from birds banded in the Florida Keys indicate longitudinal origins from at least the Great Lakes to the Atlantic Coast (HWI unpubl. data).

Juveniles appear to migrate before adults; females precede males in autumn; and males precede females in spring (Kerlinger 1989, Mueller et al. 2000, Wheeler 2003b).

Individuals may begin leaving breeding grounds in early August. Aside from slight latitudinal differences, both autumn and spring migration timing appear similar across the continent. The majority of most autumn flights occurs between early to mid-September and early to mid-November, and the majority of most spring flights occurs between early March and early to mid-May (Bednarz et al. 1990, McCarty et al. 1999, Hoffman and Smith 2003, Ruelas 2005, Lott 2006, A. Fish pers. comm.).

Highest average autumn counts occur in the east at Cape May, New Jersey (1,805), Kiptopeke, Virginia (1,353), and Fire Island, New York (1,109); around the Great Lakes at Illinois Beach State Park, Illinois (305), and Concordia (279) and Cedar Grove (248), Wisconsin; around the Gulf Coast at the Florida Keys (525), Veracruz, Mexico (150), and Smith Point, Texas (58); and in the west at Golden Gate, California (157), Bonney Butte, Oregon (67), and the Goshute Mountains, Nevada (53).

Highest average spring counts occur in the east at Cape Henlopen, Delaware (121), Fort Smallwood, Maryland (67), and Pilgrim Heights, Massachusetts (67); around the Great Lakes at Whitefish Point, Michigan (43), and Derby Hill (31) and Braddock Bay (19), New York; along the western Gulf Coast at Tlacotalpan, Mexico (10); and in the west at Dinosaur Ridge, Colorado (17), Gunsight Mountain, Alaska (15), and the Sandia Mountains, New Mexico (10).

Prairie Falcon (*Falco mexicanus*)

Subspecies.—Monotypic.

Range.—Western North America from northern British Columbia, southern Alberta, and southern Saskatchewan, south into California, throughout the Intermountain West, Great Basin, Arizona and New Mexico, and on into north-central Mexico to Chihuahua, Coahuila, and San Luis Potosi. Also south and east to the badlands of South Dakota, western Nebraska, eastern Colorado, Okalahoma, and western Texas.

Maximum lifespan.—17 years, 3 months.

Breeding habitat.—Open habitats including arid plains, shrubsteppe, desert, grasslands, mixed shrublands, alpine tundra, meadows, and chaparral, where cliffs, bluffs, and rocky outcrops provide nest sites (Steenhof 1998).

Migrant type.—Partial. A moderate-distance migrant not known to make water crossings or migrate in flocks. Does not appear to follow *leading lines* or *diversion lines* to any extent (Steenhof 1998). Some western populations undertake lengthy loop migrations among three distinct seasonal ranges (Steenhof et al. 2005).

Migration ecology and behavior.—Some individuals over-winter near nesting areas, whereas others make lengthy migrations. Juveniles leave the breeding grounds before adults and may return later in spring (Steenhof

1998). Adult males precede adult females in spring. Migration speed may be more rapid in spring than autumn (Schmutz et al. 1991). May migrate in advance of storms.

Forty adult females satellite-tracked from the Snake River Canyon in southwest Idaho moved northeast across the Continental Divide to spend late summer on the prairies of eastern Montana, Alberta, Saskatchewan, and South and North Dakota (Steenhof et al. 2005). After 1 to 4 months, some returned to southwest Idaho for the winter, but others headed southeast to the southern Great Plains and Texas panhandle for the winter, returning to Idaho in the spring by various direct routes, depending on the winter location, and completing broad looping migration patterns. Snake River Prairie Falcons appear to have three seasonal-use areas: a spring nesting area, a post-nesting summer range, and an over-wintering range (Steenhof et al. 2005).

Other data indicate that Canadian breeders typically travel along two flight-lines, one on either side of 111°W longitude. East of this line, individuals tend to move east to Saskatchewan and south to the Great Plains; west of the line, birds move southwest, west of the Rocky Mountains (Schmutz et al. 1991).

Migrants appear to feed during migration, and movement to post-nesting areas appears driven by availability of key prey species, such as Richardson's ground squirrel (*Spermophilus richardsoni*) and Horned Larks (*Eremophila alpestris*) (Steenhof 1998). Large numbers of Prairie Falcons from both the United States and Canada appear to feed on Horned Larks throughout the Great Plains from November through February (Steenhof 1998). Immature birds may concentrate in winter in some regions; for example, 64% of birds trapped in north-central Utah were juveniles (Steenhof 1998).

Juvenile and adult birds generally depart both Idaho and Utah (HWI unpubl. data) breeding areas in June and July. Prairie Falcons show a relatively protracted migration in the Goshute Mountains, Nevada, extending from mid-August at least through late October. Birds generally arrive on wintering grounds in northern Colorado and southern Wyoming in November. In contrast, most of the flight at Golden Gate, California, occurs during a relatively brief period from late August through mid-September.

In spring, individuals depart wintering grounds in Colorado and Wyoming in March (Steenhof 1998). As in autumn in the Goshutes, spring migration in the Sandia Mountains, New Mexico, is protracted, occurring from at least late February through early May (HWI unpubl. data).

Highest average counts occur in the west at the Goshute Mountains, Nevada (30), Manzano Mountains, New Mexico (23), and Wellsville Mountains, Utah (18). Highest average spring counts occur at the Sandia Mountains, New Mexico (25), and Dinosaur Ridge, Colorado (23). Most other autumn and spring sites in the west, Iowa, and Texas, record fewer than 10 migrants per season.

Gyrfalcon (*Falco rusticolus*)

Subspecies.—Monotypic.

Range.—Found from 60° to 79° north in Alaska, and to 82° north on the northern coast, the western Aleutians, Cook's Inlet, and southeastern Alaska, and in northern British Columbia, the southeastern Northwest Territory, northern Québec, Labrador, coastal Greenland; also in northern Europe and Asia.

Maximum lifespan.—13 years, 6 months.

Breeding habitat.—Arctic and alpine tundra along rivers and coastlines; tundra-boreal forest ecotones; small spruce stands along drainages; and beach and dune habitats; rocky seacoasts, and island and rocky outcrops near coasts; river bluffs above drainages through foothills in tundra or edge of taiga; and mountains above the tree-line (Clum and Cade 1994).

Migrant type.—Partial. A moderate- to long-distance migrant that makes long water crossings. A solitary migrant.

Migration ecology and behavior.—Adults may stay at or near nesting territories; juveniles usually migrate. Adults winter farther north than immatures and often winter near prey concentrations (Clum and Cade 1994). Montane and inland birds are more likely to migrate than coastal populations. Timing of adult and juvenile movements appears similar. Females, particularly juveniles, may be more prone to migrate than males (Wheeler 2003a, b). Mated pairs sometimes overwinter together south of their breeding grounds (Wheeler 2003a). Males precede females in spring return flights.

In North America, movements begin in late August and September, with birds arriving on winter ranges from October through November. In eastern Canada, migrants move along and across the Labrador coast, Gulf of St. Lawrence, Hudson Bay, and through interior Labrador. In central and western Canada, birds sometimes move west or east before heading south. In Alaska, birds move along the Kenai Peninsula and Cold Bay. Two satellite-tracked individuals from Alaska wintered in Russia.

Gyrfalcons are seen only occasionally at most watchsites, primarily because of their northern distribution and late-season movements. No watchsite in North America averages more than a few birds per season; the most active being Mt. Lorette, Alberta, with an average four birds in autumn (Table 2).

Peregrine Falcon (*Falco peregrinus*)

Subspecies.—Three in North America: *anatum* in most of North America; *pealei* on coastal islands in the Pacific Northwest; *tundrius* in arctic of Alaska, Canada, and Greenland. The *anatum* subspecies was extirpated east of the Mississippi River in the early 1960s, with current populations there formed from mixes of captive stock of several subspecies (White et al. 2002; Wheeler 2003a, b). Thirteen others globally.

Range.—Aleutian Islands east and north along coastal, western Alaska to the north slope of the Yukon Territory and across Canada to Québec; and locally throughout much of the continental United States, including urban areas as a result of captive releases, as well as in Baja California and the Sierra Madre ranges of Mexico.

Maximum lifespan.—19 years, 3 months.

Breeding habitat.—Tundra, along lakes, rivers, and sea coasts; semi-open montane areas with rocky cliffs, outcrops, and canyons; coastal and interior areas near lakes or rivers; islands with rugged wooded coasts and high cliffs; and desert and arid canyon regions in the west (e.g., the Grand Canyon). Also now found in urban areas. Nests on cliffs, in cavities within large trees, sometimes on the ground at northern latitudes, and, in urban areas, on buildings, towers, smoke stacks, and bridges (White et al. 2002).

Migrant type.—Partial. A long-distance, trans-equatorial, migrant that undertakes long water crossings. A *leap-frog* migrant. Travels alone, but also in small groups of up to 10–15 birds in the Florida Keys (C. Lott pers. comm.), and in groups of at least 20 birds at Kekoldi, Costa Rica (K. Bildstein pers. comm).

Migration ecology and behavior.—Undertakes some of the longest migrations of any raptor. Often follows defined routes based on prey availability. Northern birds winter as far south as Argentina and Chile (White et al. 2002). In North America, southern breeders appear to move shorter distances. Some individuals are sedentary, particularly in urban areas and in the subtropics.

Peregrines concentrate along *leading lines* and *diversion lines*, particularly in autumn. Birds hunt on migration regularly and may stop over for up to 8 days. Autumn migrants stage at sites such as Assateague Island, Maryland–Virginia, and Padre Island, Texas.

Adults may precede juveniles in autumn at some locations (Mueller et al. 2000). Adults precede second-year birds in spring.

Migrates at flight altitudes of ≤900 m (Kerlinger 1989). Movements occur primarily from morning through late afternoon (White et al. 2002). Forty individuals of the *tundrius* subspecies satellite-tracked from several sites in North America flew an average of 172 km day^{-1} southbound, and migrated an average distance of 8,624 km (Fuller et al. 1998). Average northbound rates were 198 km day^{-1} for distances of up to 8,247 km (Fuller et al. 1998). In another study, individuals wintering in northeastern Mexico flew an average of 172 km day^{-1} northward in spring and averaged 142 km day^{-1} southbound in autumn (n = 13) (McGrady et al.

2002). Longer daily flights occurred regularly in both studies. Average ground speed during flapping flight of satellite-tagged birds was 49 km h^{-1}, with an overall average flight speed of 33 km h^{-1} (White et al. 2002). One bird satellite-tracked from Greenland bird flew 560 km at an average rate of 64 km h^{-1} from Chicago, Illinois, to central Tennessee in 1 day (Cochran 1975). Migration journeys lasted an average of 40 days (McGrady et al. 2002).

Migration strategies include a combination of both broad front and narrow-front, corridor migration that has been called a "sieve" pattern (Fuller et al. 1998, McGrady et al. 2002, White et al. 2002). Satellite-tagged *tundrius* birds followed a *broad front* south across North America from nesting areas, before converging along the Gulf Coast. Migrants focused in three distinct pathways into Central America and South America. One route traversed Florida south to its southern tip and then across the Gulf of Mexico to Yucatan Peninsula in Mexico. A second crossed the Gulf of Mexico from Texas, Louisiana, or Alabama to the Yucatan. And a third moved overland along Mesoamerican Land Corridor (Fuller et al. 1998). In autumn, Greenland birds move west to Canada and then south along the Atlantic Coast, with some passing through the Florida Keys, the Caribbean Basin, and, eventually, Central America and South America (White et al. 2002). One individual satellite-tracked from Nunavut, Canada, flew south along the western shoreline of Hudson Bay to Churchill, Manitoba, then south through the midwestern United States to coastal Louisiana, and then across the Gulf of Mexico to the Yucatan (Henny et al. 1996).

In autumn, most of the flight passes Hawk Mountain, Pennsylvania, between late August and mid-November, with a sharp peak in early October (Bednarz et al. 1990). In the Florida Keys, most birds pass between late September and mid-October (Lott 2006). In Veracruz, Mexico, most movement occurs from early September to mid-November (Ruelas 2005). In the Goshute Mountains, Nevada, flights occur from late August to late October (Hoffman and Smith 2003).

In spring, most of the flight passes Veracruz, Mexico between mid-March and mid-May (Ruelas 2005). Satellite-tracked birds from Tamaulipas, Mexico, left from late April through late May, and some did not arrive on breeding grounds until June (McGrady et al. 2002). Central Alberta birds migrated north between late April and early June, with adults preceding juveniles by 1 week (White et al. 2002).

Highest average autumn counts occur in the east at Cape May, New Jersey (1,051), Kiptopeke, Virginia (628), and Fire Island, New York (107); around the Great Lakes at Illinois Beach State Park, Illinois (104), Hawk Cliff, Ontario (101), and Hawk Ridge, Minnesota (69); around the Gulf Coast in the Florida Keys (1,827) and at Veracruz, Mexico (658); and in the west at Golden Gate, California (149), Manzano Mountains, New Mexico (80), and Goshute Mountains, Nevada (19). Farther south, an average 1,696 falcons are counted at the Kekoldi, Costa Rica, watchsite each autumn.

Highest average spring counts are comparatively small everywhere, with few sites recording more than 10 migrants per season. Exceptions include averages of 18 birds at Whitefish Point, Michigan, and Braddock Bay, New York, 99 at Tlacotalpan in Veracruz, Mexico, 65 in the Sandia Mountains, New Mexico, and 20 at Dinosaur Ridge, Colorado.

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3

Long-Term Monitoring: The Raptor Population Index in Principle

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Abstract.—We present a short history of hawkwatching and the use of migration counts to monitor raptor populations in North America. We argue the need to continue monitoring hawks during their migrations as a component of a comprehensive monitoring and conservation program for North American landbirds. We also discuss some of the concepts, principles, and assumptions required for the proper analysis and interpretation of population-trend data. Since the first analyses of migration counts at the end of the 1960s, most researchers have used annual indexes of effort-adjusted counts to calculate long-term population trends using regression models. In this chapter, we advocate use of regression models designed to accommodate the non-normal distribution of counts of birds and to correct for effects of potentially confounding variables and missing data on long-term population trends. Most analyses of population trends derive from counts taken at a single site. We briefly discuss pooling of trends and interpretation of results from multiple watchsites and argue for continued improvement and standardization of methods. We also describe the development of hawkcount.org and the Raptor Population Index (RPI), and their roles in monitoring populations of North America's migratory raptors.

Counting Migrating Raptors

The modern era of hawkwatching began in 1934 when the first full-season counts were conducted at Hawk Mountain, Pennsylvania. Counts have continued there annually each autumn since, except during the war years of 1943–1945 (Bildstein 1998, Zalles and Bildstein 2000).

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Observations and trapping began at Cedar Grove, Wisconsin, in 1936, but consistent estimation of daily numbers, which were made ancillary to trapping, was only started in 1950, and records for that first year have been lost (Mueller et al. 2001). Sporadic counts were conducted at Cape May Point, New Jersey since 1931, but regular daily monitoring began there only in 1976 (Zalles and Bildstein 2000).

According to Robbins (1975), regular hawk counts occurred during the 1950s and 1960s at several sites in Massachusetts, New Jersey, New York, Pennsylvania, West Virginia, Virginia, Minnesota, and Ontario. A review of the listings for North and Central America in the Raptor Watch directory (Zalles and Bildstein 2000) shows that among sites with regular monitoring (≥20 days per year), which were still in operation in 1998, only 10% (9 of 92) began observations before 1970. A large expansion in watchsite activity occurred after 1970 (i.e., 22%, 31%, and 37% of 92 sites started regular counts in the 1970s, 1980s, and 1990s, respectively).

Increased interest in seeing, counting, and studying hawks during migration led to the formation of the Hawk Migration Association of North America (HMANA) in 1974 (Harwood 1975, Roberts 2001). HMANA designed and promoted standard protocols for counting and recording migrating hawks, published seasonal records, and undertook to store the data in a central archive for future use (Harwood 1975). This led to the founding of additional organized watchsites that fed data into the system in the following decades.

Before the 1980s, monitoring hawk migration was primarily an eastern phenomenon, but this changed with the formation of the Golden Gate Raptor Observatory, which started regular monitoring in 1982, and the establishment of several watchsites on western mountains from 1977 to 1992 (Hoffman and Smith 2003), and, thereafter, along the Gulf of Mexico. The latter developments resulted from the initiative and foresight of Stephen Hoffman and the organization that later became HawkWatch International (HWI). Hoffman and HWI have had a major impact on hawkwatching in western North America and along the coasts of the Gulf of Mexico; without their work, the continent-wide perspective of this volume would have been impossible. Currently, HWI coordinates, directly or in partnership with others, 10 watchsites in western states, 2 on the Gulf coast of Texas, 1 on the Florida Keys, and 1 at Veracruz, Mexico, the latter in partnership with Hawk Mountain Sanctuary and Pronatura Veracruz (J. Smith pers. comm.).

Hawk counting has many objectives and motivations, including recreation, conservation, and even fund-raising, as well as education and research. Nevertheless, an underlying theme throughout the literature is that hawk counts can and should be used to monitor the status and health of populations. Despite this, widespread and comprehensive use of hawk counts for monitoring has developed slowly.

A Brief History of Monitoring Population Change

Spofford (1969) and Nagy (1977) were among the first to use hawk-migration counts explicitly to track population change. Both used 5-year moving averages of counts at Hawk Mountain to plot population trajectories over 32 and 40 years, respectively. Hackman and Henny (1971) compared numbers of hawks seen per hour over three months to assess population changes between 1951–1954 and 1958–1961. Robbins (1975) presented trend graphs for Sharp-shinned Hawks (*Accipiter striatus*), Cooper's Hawks (*A. cooperii*), Red-tailed Hawks (*Buteo jamaicensis*), and Peregrine Falcons (*Falco peregrinus*) from counts at Cape May Point, New Jersey; Hawk Mountain Sanctuary, Pennsylvania; White Marsh, Maryland; and Hawk Ridge, Duluth, Minnesota. Counts were first adjusted for daily or hourly effort and then analyzed by linear regression.

Several analyses have been conducted on the long data sets from Cedar Grove Ornithological Station, Wisconsin, and Hawk Mountain Sanctuary, Pennsylvania. Mueller and Berger (1967) and Mueller et al. (1977) examined the irruptive migratory behavior of Northern Goshawks (*A. gentilis*) at Cedar Grove by comparing numbers counted in different years with an "expected" number for the dates of observation each year. Mueller et al. (1988) used counts from 1936 to 1985 to show that Peregrine Falcons migrating past Cedar Grove in fall "*declined from the 1950s to an extreme low in the early and mid-1970s and then showed a remarkable recovery in the 1980s*" (Mueller et al. 1988:504). A more recent paper graphed birds per day, 5-year moving averages, and linear regression trends for selected periods for 15 species at Cedar Grove from 1936 to 1999 (Mueller et al. 2001). Bednarz et al. (1990) presented a comprehensive analysis of Hawk Mountain counts for 1934–1986. They determined annual indexes of abundance of migrating hawks, expressed as birds per 10 hours of observation within a predetermined range of dates, for each of 14 species, and calculated linear regression trends for three periods: pre-DDT (1934–1942), DDT (1946–1972), and post-DDT (1973–1986).

There have been few multisite analyses of population trends. Titus and Fuller (1990) used linear regression to estimate trends (mean annual percent increase or decrease) of season-long total counts for 14 species at six eastern watchsites. They also estimated an overall trend using the route-regression method, weighting the site trends by the number of years of counts and the average number of hawks of each species recorded at each site. Weighting by the average size of the flight at each site assumes that the proportion of the monitored population sampled at each site is constant across sites, an assumption that is not likely to be true (Dunn and Hussell 1995). Hoffman and Smith (2003) provided the first multisite analysis from the western United States, involving 15 species migrating past six watchsites in the Intermountain and Rocky Mountain regions. They estimated linear and quadratic trajectories for annual passage rates during standardized migration periods.

The Need for Migration Monitoring

Accurate knowledge of population status and change is fundamental to species conservation if scarce resources are to be allocated wisely. Most agree that knowledge of the conservation status of most species of North American raptors is inadequate. The premier scheme for monitoring population change in North American birds is the Breeding Bird Survey (BBS; Robbins et al. 1986, Sauer et al. 2002). The BBS roadside survey method is unsatisfactory for monitoring population changes in most raptors, because of their low densities, and because the survey is conducted in June when most birds of prey are difficult to detect. For 10 raptor species monitored at Cape May, New Jersey, and Hawk Mountain, Pennsylvania, except for American Kestrels (*F. sparverius*) and Red-tailed Hawk, confidence intervals of trends derived from migration counts were much narrower than those estimated from regional BBSs, presumably because of low densities or low detection rates (or both) for the other species on the survey routes (Farmer et al. 2007). Furthermore, landscape-level nesting studies often are logistically difficult and prohibitively expensive (Bednarz and Kerlinger 1989, Dunn and Hussell 1995). Christmas Bird Counts (CBC) hold promise for monitoring raptors that winter mainly in North America (National Audubon Society 2002, Sauer et al. 2004) but are not suitable for those that winter farther south.

Migrating raptors concentrate at many watchsites throughout North and Central America and are counted in large numbers (Zalles and Bildstein 2000). Many researchers have concluded that counting migratory raptors at these concentration points is an efficient method for monitoring regional population trends of multiple species (Bednarz et al. 1990, Bildstein et al. 1995, Dunn and Hussell 1995, Dixon et al. 1998, Smith and Hoffman 2000, Zalles and Bildstein 2000, Hoffman and Smith 2003). This view was recently endorsed by The Partners in Flight North American Landbird Conservation Plan (Rich et al. 2004), whose recommendations included "*continue improvement of migration monitoring to meet information needs of many raptors…that are largely inaccessible for monitoring both in the breeding or wintering seasons*" and "*…research is needed on best analysis methods and precision estimation, and annual analysis and reporting should be instituted*" (Rich et al. 2004:29, 30).

Methodological research is ongoing (e.g., Farmer et al. 2007), and the advantages and limitations of migration monitoring are well understood, as is the research and institutional support needed to improve the conservation relevance of migration monitoring (e.g., Hussell 1981, Dunn and Hussell 1995, Dunn 2005). No monitoring method provides absolutely reliable results, and migration monitoring is no exception to this rule. But if properly analyzed, counts of migrating raptors can help to provide information relevant to determining the conservation status of migratory raptors.

A recent assessment concluded that 14 species of North American raptors are inadequately monitored, either because the precision of existing trends is unknown or low, or because more than one-third of the Canadian and United States breeding range is not covered by a breeding season survey (Dunn et al. 2005). To address these deficiencies, Rich et al. (2004) recommended an integrated approach, including expanded BBS coverage, additional breeding-season surveys, improved CBC analyses, and migration monitoring. Breeding-season surveys are always the first choice for improvement of continental monitoring, even if difficult or expensive to implement. However, most North American raptor species are partial or complete migrants, and migration monitoring can be an effective component of integrated population monitoring and was recommended for 13 of those 14 species (Table 1). Migration monitoring was recommended as a component of integrated monitoring for five other species. Two additional species were counted at many watchsites, but were judged to be well monitored by other methods.

Monitoring Migrants at a Single Site

Concepts

Many extrinsic (e.g., day length, weather) and intrinsic (e.g., observer number or experience) factors other than population levels influence numbers of migrants counted on any day. Intrinsic factors can be controlled or mitigated by adopting standardized observation procedures. Extrinsic factors can be addressed by using appropriate analysis methods (Hussell 1981).

The importance of observation consistency was recognized at the time of the formation of HMANA. The essential need was spelled out by Robbins (1975):

> *"If hawk counts are to be used for monitoring population changes, we must become interested in the standardization of observation and reporting procedures and in the consistency of the counts from year-to-year. …it is of the utmost importance that we learn how we can get the most consistent counts from year to year"* Robbins (1975:31, 37).

Table 1. Monitoring needs of migratory raptors (from Appendix 1 in Dunn et al. 2005).

Species	Monitoring-needs status[a]	Migration-monitoring recommendations[b]
Turkey Vulture (*Cathartes aura*)	–	0
Osprey (*Pandion haliaetus*)	2, 3	+ +
Swallow-tailed Kite (*Elanoides forficatus*)	2, 4	+ +
Mississippi Kite (*Ictinia mississippiensis*)	2	+ +
Bald Eagle (*Haliaeetus leucocephalus*)	3	+ +
Northern Harrier (*Circus cyaneus*)	3	+ +
Sharp-shinned Hawk (*Accipiter striatus*)	3	+ +
Cooper's Hawk (*A. cooperii*)	2	+ +
Northern Goshawk (*A. gentilis*)	2, 3	+ +
Red-shouldered Hawk (*Buteo lineatus*)	–	+
Broad-winged Hawk (*B. platypterus*)	–	+
Swainson's Hawk (*B. swainsoni*)	2	+ +
Red-tailed Hawk (*B. jamaicensis*)	–	0
Ferruginous Hawk (*B. regalis*)	–	+
Rough-legged Hawk (*B. lagopus*)	2, 3	+ +
Golden Eagle (*Aquila chrysaetos*)	3	+ +
American Kestrel (*Falco sparverius*)	–	+
Merlin (*F. columbarius*)	2, 3	+
Peregrine Falcon (*F. peregrinus*)	2, 3	+ +
Prairie Falcon (*F. mexicanus*)	2	+ +

[a] Continental monitoring need status: – = adequately monitored by other methods (usually BBS); 2 = trend information available from existing survey, but trend precision is low; 3 = one-third or more of Canadian and U.S. breeding range is not covered by a breeding season survey (i.e., much of the range north of BBS coverage); 4 = two-thirds or more of Western Hemisphere breeding range is south of the United States.

[b] Migration monitoring recommendation: 0 = not needed, adequately monitored by other surveys; + + = recommended, next to preferred option of breeding season survey; + = recommended, as third option.

HMANA took that advice to heart by providing standard protocols and reporting forms (Harwood 1975) that are essentially unchanged today. Although "consistency" is sometimes interpreted as striving to be as accurate as possible on each and every day by recruiting one or more highly skilled birders to detect and count as many hawks as possible, it really means striving for a consistent level of expertise and effort over the long term, so that *the average proportion of hawks that are missed by the counters remains relatively constant from year to year*, even if not from day to day.

Extracting the Population Signal: The Annual Abundance Index

Recognition that daily migration counts are skewed means that the median and geometric mean of the counts (or daily passage rates) are better indicators of annual abundance than the mean or sum (Dunn and Hussell 1995, Chapter 4). Compared with average or total passage rates, the geometric mean and median are less sensitive to unusually high counts and are better indicators of the shifts in the entire distribution of the counts, shifts that are expected to occur when the size of the sampled population changes. Moreover, for abundant species, we can assume a log-normal distribution of counts and safely use ordinary multiple regression methods to model the effects of other variables (e.g., date, weather, and year) on the log-transformed daily counts. Because the years are treated as categorical factors and date and weather variables are continuous independent variables, the model is best described as an analysis of covariance. This approach allows us to extract annual abundance indexes from the regression results that are "corrected" for the effects of date and extrinsic variables. Such methods have been developed and used for calculating annual indexes for songbird migrants (Hussell 1981, Hussell et al. 1992, Dunn and Hussell 1995, Dunn et al. 1997, Francis and Hussell 1998) but, prior to this work, have been little used to analyze hawk counts (for exceptions, see Hussell 1985, Hussell and Brown 1992, Farmer et al. 2007).

Trends

Once annual indexes are calculated, we need to estimate the magnitude of the trend and determine whether it is statistically significant. Several methods are available to model the pattern of change over time, or population trajectory. A trend is defined as the geometric mean rate of population change over the time period of interest (Link and Sauer 1997, 1998), which can be expressed as percentage change per year. If the trend is linear, the geometric mean rate of change can be estimated by fitting a linear regression to the logarithm of the annual index.

Most authors have analyzed trends using linear regression (e.g., Bednarz et al. 1990, Mueller et al. 2001, Hoffman and Smith 2003). Time series of animal abundance often follow a nonlinear pattern. If so, linear regression may provide a poor fit to the trajectory and misrepresent the rate and even the direction of change. Nonlinear trajectories can often be modeled better with polynomial regressions. Hussell and Brown (1992) introduced a method for estimating and testing the significance of a trend between two preselected years on a polynomial curve (see also Francis and Hussell 1998 and Farmer et al. 2007).

Combining Trends from Multiple Sites

Sites that are close together along a transect, approximately perpendicular to the principal axis of migration in the region, but not so close as to observe the same birds, probably sample the same monitored population (*sensu* Dunn and Hussell 1995), and we can calculate pooled annual indexes for the sites and use those indexes to estimate trends in the same way as for single sites, see Tadoussac, Québec (Chapter 5), the Grand Canyon, Arizona (Chapter 6), and Veracruz, Mexico (Chapter 7) for details.

Counts from a series of sites along a transect provide us with independent samples from the monitored population and their use should increase the precision of the estimates of annual indexes and the power of the method to detect trends. In the absence of a pooled trend estimate, mapping of single-site trends provides a useful qualitative picture of continental trends that can contribute valuable perspectives to conservation assessments (Chapter 9). Refinement of knowledge of migration flyways and catchment areas will increase the usefulness of these results.

Hawkcount.org and the Raptor Population Index (RPI)

The executive committee of HMANA was charged with several responsibilities. The first three of those dealt with housekeeping; the fourth outlined some immediate objectives for the new association:

> "*Prepare a standard daily reporting form, to be used by all participating hawkwatchers, spring and fall. These report forms, filled out, would be sent from the lookouts to the appropriate regional representatives/editors who would then prepare seasonal reports on the raptor migration through their respective regions… All daily report forms would ultimately be collected and filed in one place—a clearing house—as a service to researchers into the phenomena of hawk migration. An effort would be made to raise sufficient funding… to permit the association itself to sponsor a computer assisted pilot study of migration over a five-year period*" (Harwood 1975:157).

All except the last of these objectives was realized within 25 years. The initial version of the reporting form was published along with those objectives (Harwood 1975). Regions were formed and seasonal reports were published, initially in a newsletter and later in *Hawk Migration Studies*. Daily report forms were archived, initially at Muhlenberg College, Allentown, Pennsylvania, and now at Hawk Mountain Sanctuary. By January 2000, the archive contained information from 1,740 sites in the United States and 148 in Canada, but only 4% had ≥10 years of counts (McCarty et al. 2000).

Although there was some use of computers for limited studies (e.g., Titus and Fuller 1990), the original vision of HMANA itself undertaking comprehensive computer-assisted analyses never came about. By

2000, HMANA realized that "electronic" was the way to go and that a professional staff was needed (Hoffman 2000, Moulton 2000). In 2001, HMANA announced "Raptors Online" (Moulton 2001), which was further elaborated the following year with the introduction of HMANA's hawkcount.org online data entry and database system (Moulton and Weber 2002). Developing the vision and making plans to hire staff proved to be easier than raising the necessary funds. Consequently, the development of HMANA's hawkcount.org database was done entirely by a volunteer, Jason Sodergren, who adapted a system used at Holiday Beach Migration Observatory (Moulton and Weber 2002, Chapter 10).

The objectives of hawkcount.org conformed exactly to HMANA's original objectives: to collect hawk count data, store it in a secure archive, and make it available for study to qualified researchers. In 2002, HMANA began to consider a proposal for a comprehensive program to use the data for long-term population monitoring: the RPI program (Moulton and Weber 2002). During this time, Hawk Mountain Sanctuary also decided to pursue a continental strategy for monitoring North America's raptors. Discussions in 2003 led to the formation of a partnership among HMANA, Hawk Mountain Sanctuary, and HawkWatch International whose goal was to "*jointly develop a Raptor Population Index program…to determine annual population indices and trends of hawks counted during spring and fall migrations at sites throughout the United States, Canada and Central America*" and its specific objectives were "*to (1) produce scientifically defensible indices of annual abundance and trends for each species of migratory raptor, from as many count sites as possible; and (2) make those results available widely, i.e. to participating count sites, the scientific community, conservation agencies and the public*" (McLeod 2004).

In June 2004, Hawk Mountain Sanctuary was awarded a 2:1 challenge grant from the National Fish and Wildlife Foundation to support a three-year project to develop RPI, which was launched on 1 January 2005 (Goodrich 2005). Professional staff at the partner organizations and their advisors have been working diligently to bring RPI to fruition since then (Ruelas 2005, 2006a, b).

We believe that RPI ushers in a new era of focused and productive hawk watching, as well as a significant advance in monitoring to support conservation of migratory raptors in the Western Hemisphere. *State of North America's Birds of Prey* summarizes much of what has been accomplished in the past three years and points a way to the future.

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4

The Raptor Population Index in Practice

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Abstract.—This chapter describes the methods by which hawk migration count data are collected, stored, and converted into annual indexes and trends, as well as how they contribute to conservation assessments and actions. We describe the methods used to derive the results in several other chapters of this book and the methodological framework within which the Raptor Population Index (RPI) is expected to operate in the future.

Introduction

The goal of the Raptor Population Index (RPI) is to use migration counts to help monitor populations of migratory raptors in North America. Key to realizing this goal is developing a means of using migration counts to estimate temporal trends in populations by calculating trends in appropriately adjusted migration counts. Raptor migration count trends are based on daily migration counts, defined as a tally of birds during spring or autumn migration (Dunn and Hussell 1995). Consistent, standardized collection of count data and recording of counts and covariates, preferably on an hourly basis, is a prerequisite for the analysis (see Hussell and Ralph 2005, Farmer et al. 2007, Chapter 3).

The RPI program is a "citizen-science" project in the sense that many of the data are collected by a large corps of expert volunteers (as well as independent technicians and scientists) under the general direction of a

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small professional staff. In the best tradition of citizen-science projects, such as the North American Breeding Bird Survey (Robbins et al. 1986), the protocols for collecting data are set by the professional staff, and data are fed to them for analysis, interpretation, and publication.

RPI is a network composed of many individual hawk counters and independent count sites. Counts at most of the major long-term sites have institutional sponsorship, either from organizations formed solely for that purpose, or as components of the programs of organizations with wider interests. For example, the spring migration count at Grimsby, Ontario, is the principal activity of the Niagara Peninsula Hawk Watch (www.hwcn.org/link/niaghawk), which was formed to operate the count; the autumn count at Cape May Point, New Jersey, is operated by Cape May Bird Observatory, a branch of New Jersey Audubon (www.njaudubon.org/Centers/CMBO); and counts at Hawk Mountain, Pennsylvania, are operated by Hawk Mountain Sanctuary Association (www.hawkmountain.org), which originally was formed to manage the sanctuary and protect birds of prey from shooting at the site. Fourteen count sites in the western United States and along coastal areas of the Gulf of Mexico are operated by HawkWatch International, either directly or in partnership with other organizations (see Chapter 8).

Unlike most citizen-science projects, RPI is not directed by a single organization but rather is the responsibility of a partnership of three organizations: Hawk Mountain Sanctuary Association (HMS), HawkWatch International (HWI), and the Hawk Migration Association of North America (HMANA). The program is guided by a management committee, consisting of representatives of the three partners, and is advised by an external science-advisory committee. The partnership aims to build on the strengths of each of the partners to achieve its goal of contributing to the conservation of migratory raptors by using counts of migrating raptors from a continent-wide network of watchsites to provide timely and scientifically defensible assessments of population status and trends of these important biological indicators of environmental health.

HMANA is the primary contact with multiple independent hawk counts and counters. It also maintains the database and provides feedback to count sites. HMS analyzes, interprets, and summarizes the data for publication. HWI contributes data from its network of western and Gulf Coast sites, and interprets and summarizes the data for publication. All three partners are responsible for various aspects of providing input to conservation policies and actions by bringing RPI results and conservation assessments to the attention of resource-management and conservation agencies and organizations.

Below, we describe the methods by which hawk migration count data are collected, stored, and converted into annual indexes and trends, as well as how they contribute to conservation assessments and actions. We also describe, in general terms, the methods used to derive the results in several other chapters in this work and the methodological framework within which RPI is expected to operate in the future.

Data Collection

Approximately 10% of existing watchsites started regular daily counts before 1970 (see Chapter 8). Most new and existing watchsites have followed field protocols and recording procedures first recommended by HMANA in 1975, and revised in 1979 and 1986 (Harwood 1975; Hawk Migration Association of North America 2008a, 2008b). Most regularly operated sites have their own protocols that deal with site-specific concerns (e.g., Barber et al. 2001, Holiday Beach Migration Observatory 2002, Kunkle 2002, Vekasy and Smith 2002). The primary objective of the protocols is to achieve consistency in counting methods from day to day and from year to year (Robbins 1975).

The standard HMANA data-collection protocol requires reporting of separate tallies of each species for each hour of the day (local standard time), together with counts of various unidentified hawks (e.g., unidentified *Accipiter*, *Buteo*, etc.), a record of the number of contributing observers, and descriptions of predominant flight altitude and direction. Several weather variables are also recorded, including visibility, air temperature, wind speed, wind direction, cloud cover (percentage), and precipitation (Hawk Migration Association of North America 2008a).

Data Reporting and Storage

Before 2002, almost all hawk counts were reported on the standard report forms (see Chapter 3) that were sent to the regional editors of HMANA's journal, *Hawk Migration Studies*, for use in regional reports in that journal. Regional editors then forwarded the data sheets to HMANA's archive, initially at Muhlenberg College in Allentown, Pennsylvania, and thereafter at Hawk Mountain Sanctuary.

In 2002, HMANA created HawkCount.org, an online data-entry and database system (Moulton and Weber 2001). HawkCount.org allows hawkwatchers to enter their counts and other data online on an hourly or daily basis for storage in HawkCount's electronic database. By January 2007, 185 sites had registered on HawkCount and 171 of these had entered at least one daily count report. More importantly, 21 sites had entered 10 to 55 years of data, and a total of 35 sites had entered more than 5 years, either in daily or hourly format (J. Sodergren pers. comm.). Clearly, there are numerous historical data remaining to be entered, but the electronic database is rapidly becoming a valuable resource for monitoring purposes.

Data entered into HawkCount are exported for analysis. As suitable data sets become available with at least 10 years of regular counts, they are analyzed by the RPI North American Monitoring Coordinator at HMS, who calculates annual indexes and trends as described below. The data for many of the analyses described in this work, however, were not yet available in HawkCount and were obtained directly from the watchsites or otherwise, either in electronic files or on paper forms that were then entered into electronic files from the paper archives. Following compilation at HMS or HWI, counts were loaded into HawkCount for secure storage and future updating and use.

Annual Abundance Indexes

Daily migration counts are influenced by variables such as date and weather, and as a result, 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 unduly influenced by the size of the large counts in each year. However, year-to-year population change is expected to affect all daily counts in the same way (not only the large counts). Therefore, the median of the daily counts is a more useful annual index of population change than the mean or sum, because the median is more sensitive to shifts in the distribution of all of the counts and less sensitive to the sizes of the large counts.

Our analysis takes advantage of the rationale behind the use of the median while using a regression analysis to compensate for the effects of missing data and additional factors such as date and weather. A key component is that the daily counts are log transformed prior to calculation of an annual index.

Hawk counts.—We used hourly counts of visible migrating raptors during autumn migration to develop population indexes. Total hours of observation varied from day to day and among years at each watchsite, so we standardized the count day at each watchsite. For each species, we identified a daily passage window during which the middle 95% of individuals was counted. We excluded from analyses any raptors counted outside of the standard daily period at each watchsite. For days with incomplete coverage during the standard period, we estimated the daily count as $N = C \times H/h$, where C was the count during the standard hours, h was the number of hours of observation, and H was the number of hours in the standard period.

We chose a seasonal passage window for each species that included days when the middle 95% of the individuals of that species was counted across all years. Increases in the number of count days across years can increase the frequency of low counts, producing spurious trends in passage rates (Titus et al. 1989). Using a 95% seasonal passage window reduces the effect of changes in coverage. It also eliminates many days with zero counts at both ends of the season, which might otherwise contribute to unacceptable distributions of residuals in regression analyses.

Weather.—Wind speed and wind direction are believed to be the weather variables most directly affecting the concentration of raptors near watchsites (Mueller and Berger 1961, Haugh 1972, Richardson 1978, Newton 1979, Kerlinger 1989). That said recent work suggests that compensating for weather is not important for trend estimation at most watchsites over the periods considered in this volume (Allen et al. 1996, Farmer et al. 2007). Hourly surface data from observation stations near many watchsites in the United States are available from the National Climatic Data Center (www.ncdc.noaa.gov/oa/ncdc.html). Alternatively, most hawkwatchers record hourly weather observations coinciding with their raptor counts. These observations can be used as covariates in an analysis. Index calculation for RPI currently uses a date-adjusted index for all watchsites; however, wind direction and speed covariates have also been tested in indexes for all sites. We derived wind variables—E (east), SE (southeast), S (south), and SW (southwest)—from vector addition of wind speeds and directions at 0700, 1000, and 1300 hours. We calculated vectors so that positive and negative values of E represented east and west winds, respectively, positive and negative values of SE represented southeast and northwest winds, etc. (Hussell 1981). We also used second-order wind variables, enabling us to model curvilinear effects of wind speed and direction (Francis and Hussell 1998).

Migration count index.—We used multiple regression to derive geometric-mean population indexes that allowed compensation for missing days and, in some cases, weather covariates (e.g., wind speed and direction). The basic methods are described in Hussell (1981), Francis and Hussell (1998), and Farmer et al. (2007). In our description, "count" always means the daily number of hawks counted or estimated within the daily and seasonal windows. Adding wind variables in some analyses led to smaller sample sizes because we excluded days for which wind data were missing. In addition, our analysis included a regression to eliminate days at the start and end of the seasons that would result in poor distribution of residuals.

For each watchsite, the indexes we calculated were date-adjusted estimated geometric-mean daily counts ("date-adjusted" hereafter) or date-adjusted estimated geometric-mean daily counts with wind covariates ("date-wind-adjusted"). These indexes were estimates of the annual mean daily counts, derived from regression estimates of the "geometric mean" daily count, adjusted for covariates. The full regression model with all covariates was

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

where N_{ij} was the number of one species counted (or estimated) during the standard hours on day i in year j; Y_j was a series of J dummy variables which were set equal to one when year $= j$ and were 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 were first through fourth order terms in date; W_{lij} was the value of weather variable l on day i in year j; a_0 was the intercept estimated by the regression; a_j, b_k, and c_{jk} were 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 was a one-way ANCOVA, with year terms as factors and all other independent variables as covariates. Regression analyses were weighted in proportion to the number of hours of observation on each day, h_{ij}. The method of deriving geometric-mean indexes was similar to those used previously (Hussell 1981, Francis and Hussell 1998), except that each index was expressed as the estimated mean count per day (Farmer et al. 2007), instead of as the estimated mean count on a "typical" day (derived from the adjusted mean for year in the transformed scale). The latter change makes no difference to the estimated trends calculated from the indexes.

Date-adjusted and date-wind-adjusted indexes were derived from each time series of migration counts. In most cases, the date-adjusted index performed best, according to the criteria described by Farmer et al. (2007).

The date-adjusted index was estimated from the regression model including year and date terms only:

$$\ln(N_{ij}+1) = a_0 + \sum_{j=1}^{J} a_j Y_j + \sum_{k=1}^{4} b_k i^k + e_{ij} \quad (2)$$

This index was designed to eliminate bias introduced by days when data were not collected. The estimated geometric-mean count (back-transformed) for each day in each year was then 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:

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

Three watchsites (Grand Canyon, Arizona; Tadoussac, Québec; and Veracruz, Mexico) had survey lines composed of two sites where counts were usually conducted simultaneously and generated counts that were assumed to be independent samples of the same flow of migrants. The model for these watchsites was

$$\ln(N_{hij}+1)=a_0+\sum_{j=1}^{J}a_jY_j+\sum_{k=1}^{4}b_ki^k+dS+e_{hij} \tag{4}$$

where N_{hij} was the number of one species counted (or estimated) during the standard hours at subsite h, on day i, in year j; S was a dummy variable whose value was set equal to 0 and 1 for observations from subsites 1 and 2, respectively; d was a coefficient estimated by the regression; e_{hij} represented unexplained variation; and all other variables and coefficients were as defined for equation (1). Therefore, for each species, this model assumed equal year effects across all sites and dates, equal date effects across all years and both sites, and equal site effects across all years and dates, all of which were additive in the transformed scale (and approximately multiplicative in the original scale). For each site, this assumption was tested by looking for year * site interactions.

The date-adjusted index was calculated in the same way as before (equation 3), except that the estimated geometric-mean count (back-transformed) for each day in each year was first adjusted to estimate the count at a hypothetical "average" site by setting S equal to its weighted-average value in the entire data set.

The date-wind-adjusted index was derived in the same manner as the date-adjusted index, with the addition of 12 variables incorporating wind speed and direction (E, SE, S, SW, $E^2 \ldots SW^3$, represented by

$$\sum_{l=1}^{L}d_lW_{lij}$$

in the regression model). However, for this index the estimated geometric-mean count (back-transformed) for each day in each year was calculated assuming that the value of each wind variable on all days in all years was equal to the mean value of that variable in the data.

Trend Analysis

Trends in annual indexes were estimated as the geometric-mean rate of change over a specified interval for each site (Link and Sauer 1997). Preliminary examination of index-by-year plots suggested that most species did not follow log-linear trajectories. We analyzed trajectories by fitting a polynomial regression to the time series of log $(\text{index})_j$ values. To reduce correlations among the polynomial terms, each regression was centered at the midpoint year in the series.

A best-fitting polynomial model was identified for each species using a three-step process. To avoid overfit, the number of possible models was limited to the set for which the number of regression coefficients was ≤ $n/5$, where n was the number of years in the regression (Tabachnick and Fidell 1989). Positive and negative autocorrelation of residuals indicate poor fit and overfit, respectively, so we identified a subset of candidate models for which autocorrelation of residuals was minimized ($-0.20 \leq a \leq 0.20$). A best-fit model was then chosen from this subset by selecting the single model that minimized Akaike's Information Criterion (AIC_c), corrected for sample size (Burnham and Anderson 2002), retaining all lower-order terms in the model. The information-theoretic approach to model selection typically identifies more than one model as approximately equally likely given the data ($\Delta AIC \leq 2.0$), so other models in each candidate set may also provide reasonable estimates of trend.

Trend estimates and their significance were derived by reparameterizing the year terms (Francis and Hussell 1998). This method takes into account the trend within the set of years being compared and uses the variance around the entire trajectory. It provides greater statistical power for the detection of trends than linear regressions that do not truly fit the trajectory of the index. The reparameterization transformed year terms so that the first-order term estimated the rate of change between the two sets of years and therefore was equivalent to the slope of a log-linear regression. To reduce the potential effect of extreme trajectories at the ends of the polynomial model, we compared mean indexes for the three-year periods at either end of the period of interest (e.g., 1974–1976 and 2002–2004). These estimates of the mean were influenced by the observed index in all years, thereby accounting for any trend within the averaged years (Francis and Hussell 1998). Similarly, tests of trend significance were based on the mean-squared deviation from the regression curve of all index values, not just those in the averaged years.

Interpretation of Abundance Indexes and Trends

One objective of the RPI is to provide information relevant to assessing the conservation status of migratory raptors. Species conservation status reports in this volume (Chapter 9) and elsewhere (e.g., www.hawkmountain.org/index.php?pr=raptor_life_history) show how RPI provides input to an integrated approach to assessing the status of North American migratory raptors.

It is not possible to combine data from multiple watchsites to derive a valid composite population trend for the entire continental population of any species (Dunn and Hussell 1995); however, graphic examination of consistencies and inconsistencies in estimated trends across the continent may demonstrate an overall pattern of regional and continental change or stability. For example, our analysis showed widespread declines in

American Kestrels (*Falco sparverius*) at most watchsites between 1994 and 2004 in eastern North America, and between 1995 and 2005 in western North America (Fig. 18 in Chapter 9), whereas relatively stable trends were shown for several other species. On the other hand, several species, including Bald Eagle (*Haliaeetus leucocephalus*), Cooper's Hawk (*Accipiter cooperii*), Merlin (*F. columbarius*), and Peregrine Falcon (*F. peregrinus*), increased rapidly at most sites in eastern North America following bans on DDT in 1971–1972 (Chapter 5) and have apparently recovered from earlier declines (Bednarz et al. 1990). Overall, our results, when considered in conjunction with information 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 is limited by a lack of knowledge of population size, as well as or the breeding and wintering ranges of the populations monitored (Chapter 2). Analyses of band encounters, ratios of stable isotopes in feathers, and tracking of individual birds by satellite have all 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 research specifically aimed at delineating regional populations, identifying their flyways, and establishing connectivity between breeding and wintering ranges will greatly increase the value of migration-trend estimates.

The Partners in Flight *North American Landbird Conservation Plan* (Rich et al. 2004) uses six vulnerability criteria for assessing the status of populations: (1) population size, (2) breeding distribution, (3) nonbreeding distribution, (4) threats to breeding, (5) threats to nonbreeding, and (6) population trend. In the latter category, species declining 50% or more over a 30-year period were considered most vulnerable, whereas species with increasing trends were considered least vulnerable.

Butcher et al. (1993) suggested that 80% power to detect a 50% decline in 20 years is a reasonable target for a trend-monitoring program. This target was evaluated and extended by Bart et al. (2004), who proposed a standard for considering landbird populations to be adequately monitored: 80% power to detect a 50% decline occurring within 20 years, using a two-tailed test and a significance level of 0.10, and incorporating effects of potential bias, and coverage of at least two-thirds of the target region. Those authors also recommended that the standard should be achieved for species' entire ranges or for any area one-third the size of the temperate portions of Canada and the United States, whichever is smaller. Exactly how these standards can be applied to or adapted for migration monitoring remains to be seen. An obvious first step is to determine whether the trend standard can be met for each species at individual watchsites. For example, Farmer et al. (Chapter 5) estimate a linear, 28-year decline of 4.5% per year ($P \leq 0.01$) in the index for American Kestrels at Cape May. This translates to a 50% decline over 15.4 years, or a 59% decline from the initial population over 20 years. Farmer et al. (Chapter 5) also report a 1.6% per year ($P \leq 0.01$) decline in counts of American Kestrels at Hawk Mountain Sanctuary, during a 30-year period (27% decline in 20 years), which suggests that the power of migration monitoring to detect trends at sites with low count variance can easily exceed the Bart et al. (2004) goal. Determinations of this sort should be followed by identifying regional populations and their flyways, grouping sites within the same flyway, and determining the ability of the grouped sites to meet the standard.

As is recognized by the Partners in Flight criteria summarized above (Rich et al. 2004), population trends are not the only important criterion to consider in a conservation assessment. Viewing recent trends in the context of the historical record also adds a useful perspective. A recent sharp decline may not be a cause for concern if the population remains above historical levels or if similar declines in the past have been followed by recovery. Therefore, we suggest that it is important to consider the following questions in future RPI analyses:

- What is the estimated recent rate of change in the annual indexes, and is the change statistically significant? We define "recent" as the past 10 years.
- Are recent population levels significantly higher or lower than in the past? We suggest comparing average levels in the past 10 years with those in at least the preceding 30 years (or from the start of observations, if less than 30 years).
- Are current population levels significantly lower (or higher) than they were at any time in the historical record? We suggest comparison of the most recent five-year period with all preceding half-decade periods (e.g., 1990–1994, 1995–1999, etc).

Significant recent declines to population levels below the long-term average, and especially to five-year averages lower than ever recorded previously, would be a cause for concern and action.

Each of these questions is easily answered using the methods described in this paper for single watchsites with at least 15 years of counts. As more data accumulate at more sites, the usefulness of these data to provide answers at a broad geographical scale will increase.

In the past, questions like these were addressed less formally to describe declines in migrating raptors, usually long after the existence and nature of the threat had been identified from other information (Spofford 1969, Nagy 1977, Mueller et al. 1988, Bednarz et al. 1990). The conceptual framework and the means provided by RPI now allow us to use counts of migrating raptors to serve as a timely early-warning system of population declines, and we should do so.

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5

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

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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

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

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).

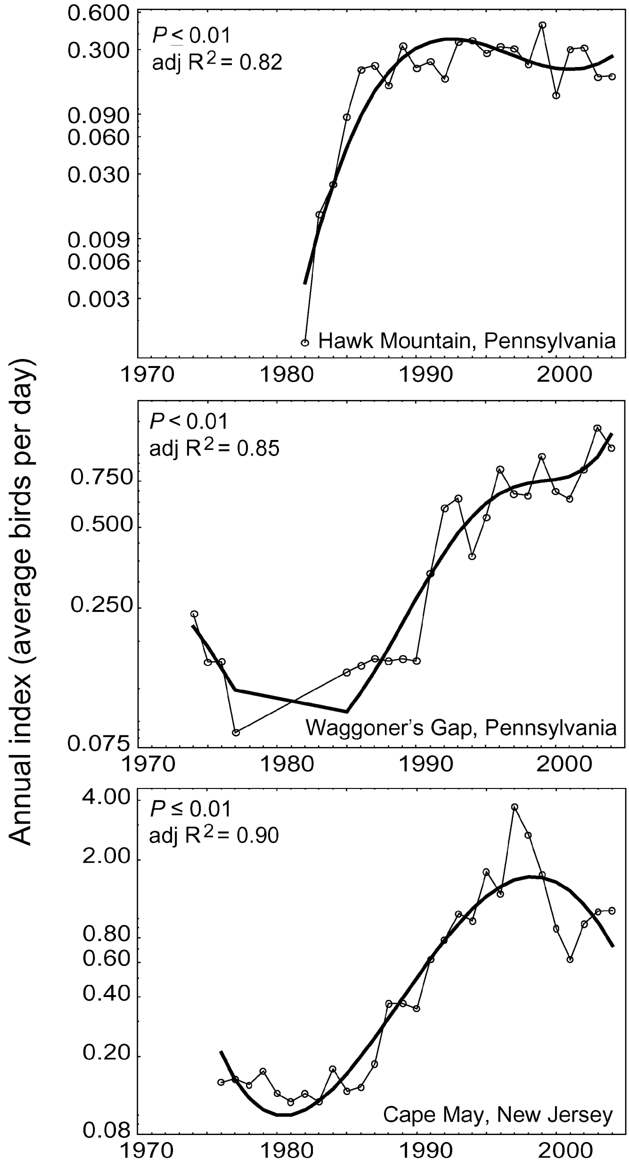

Fig. 2. Population indexes and trajectories for Black Vultures (*Coragyps atratus*) at three watchsites in northeastern North America. Index values are represented by open circles connected by thin lines to highlight patterns of interannual variation. Thick solid ($P \leq 0.10$) or dashed ($P > 0.10$)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

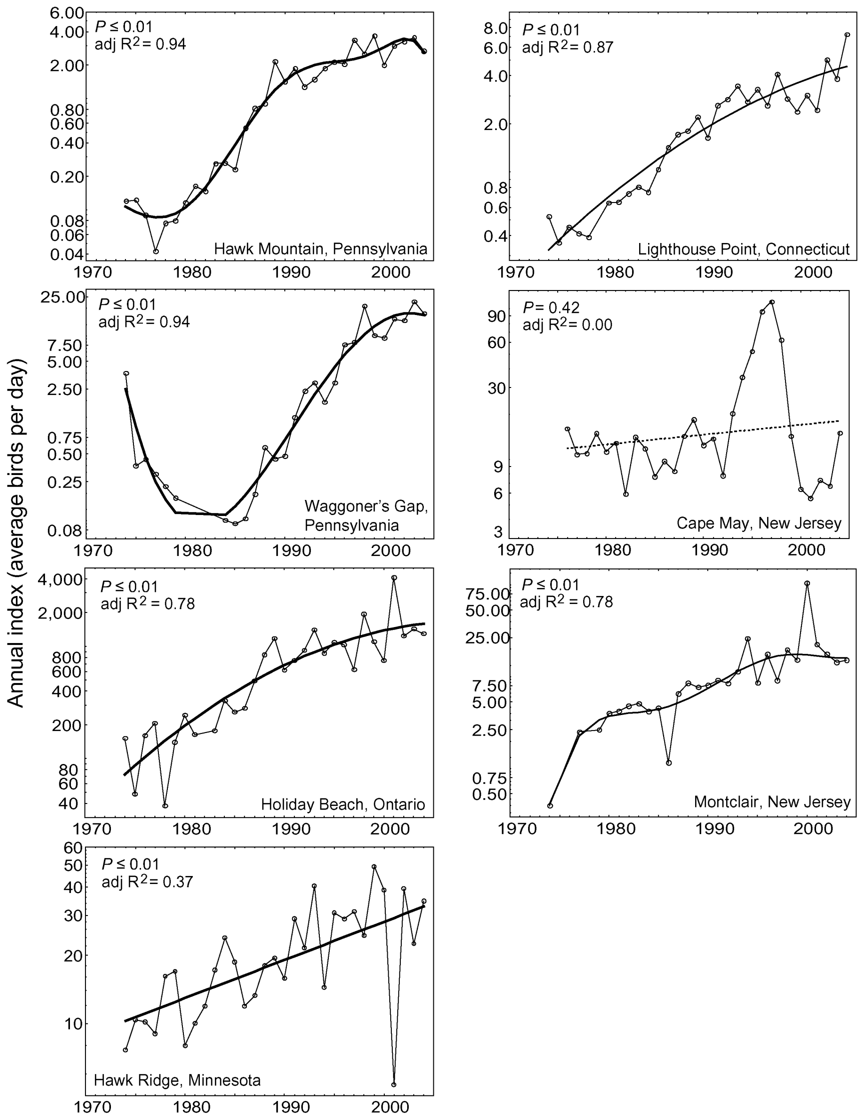

Fig. 3. Population indexes and trajectories for Turkey Vultures (*Cathartes aura*) at seven watchsites in northeastern North America. Index values are represented by open circles connected by thin lines to highlight patterns of interannual variation. Thick solid ($P \leq 0.10$) or dashed ($P > 0.10$)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

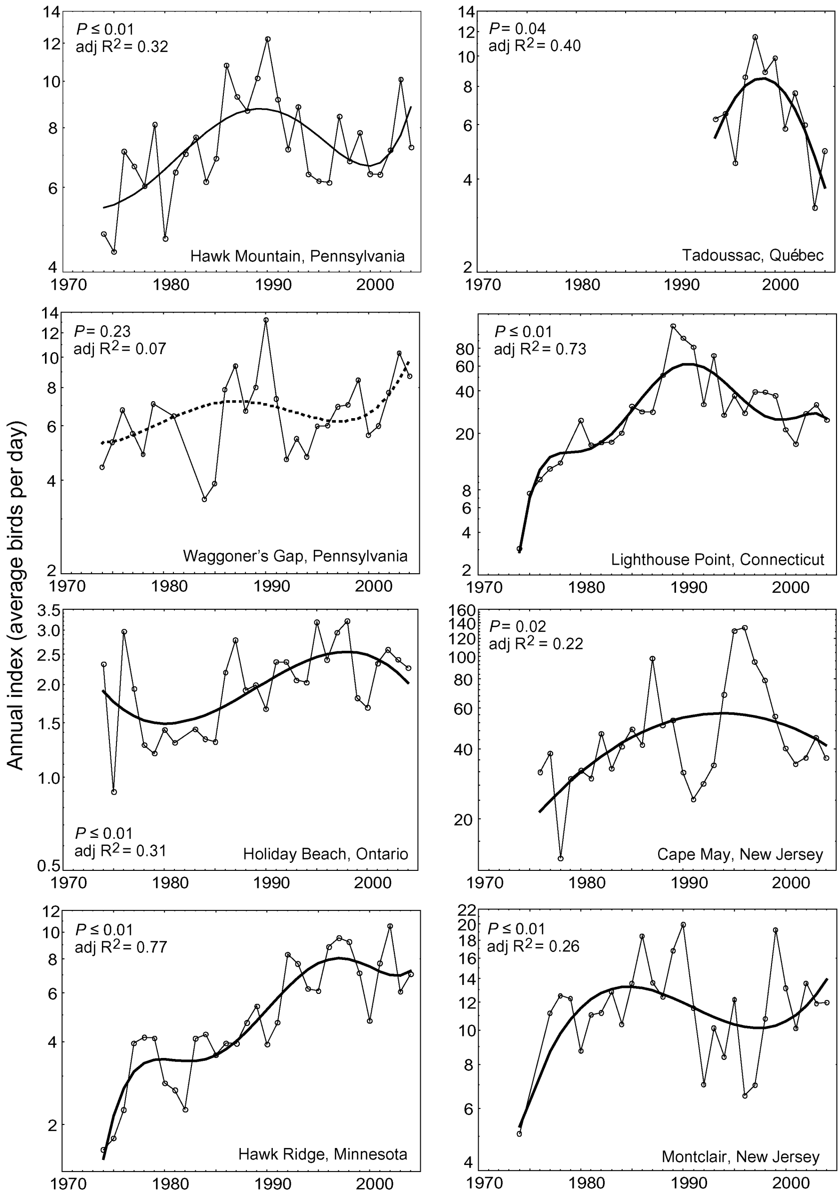

Fig. 4. Population indexes and trajectories for Ospreys (*Pandion haliaetus*) at eight watchsites in northeastern North America. Index values are represented by open circles connected by thin lines to highlight patterns of interannual variation. Thick solid ($P \leq 0.10$) or dashed ($P > 0.10$) lines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

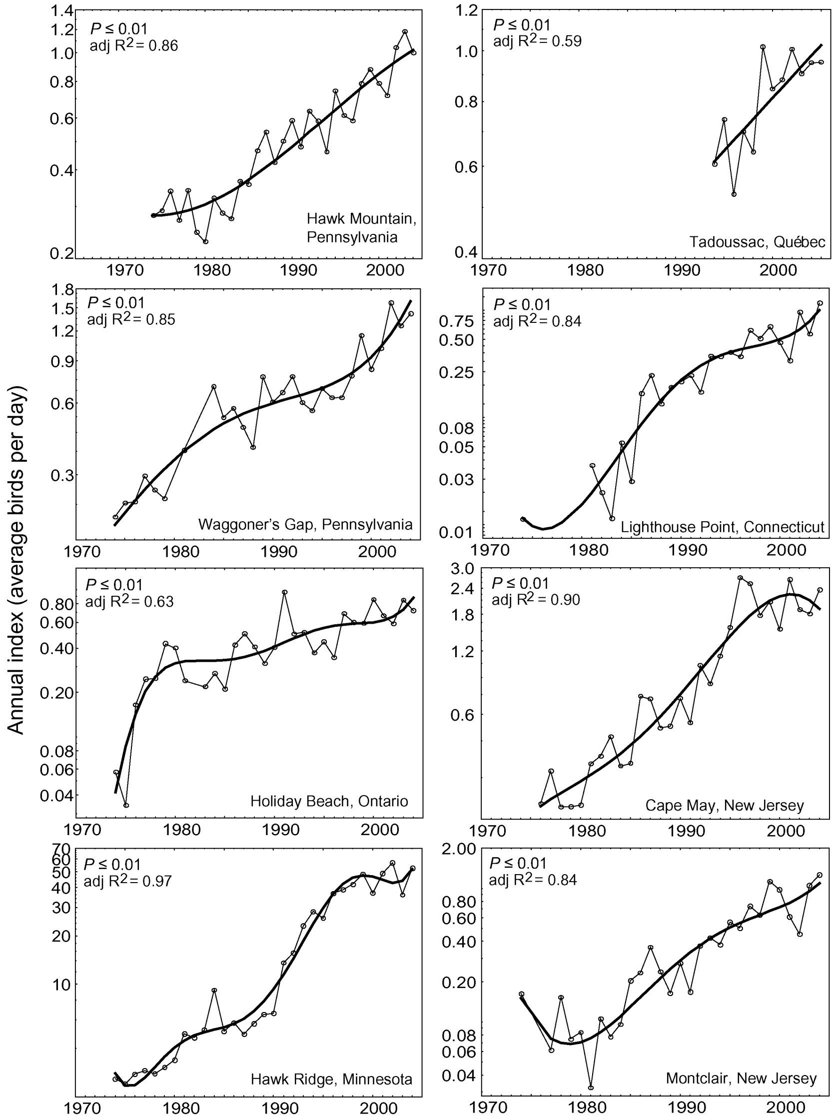

Fig. 5. Population indexes and trajectories for Bald Eagles (*Haliaeetus leucocephalus*) at eight watchsites in northeastern North America. Index values are represented by open circles connected by thin lines to highlight patterns of inter-annual variation. Thick solid ($P \leq 0.10$) or dashed ($P >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

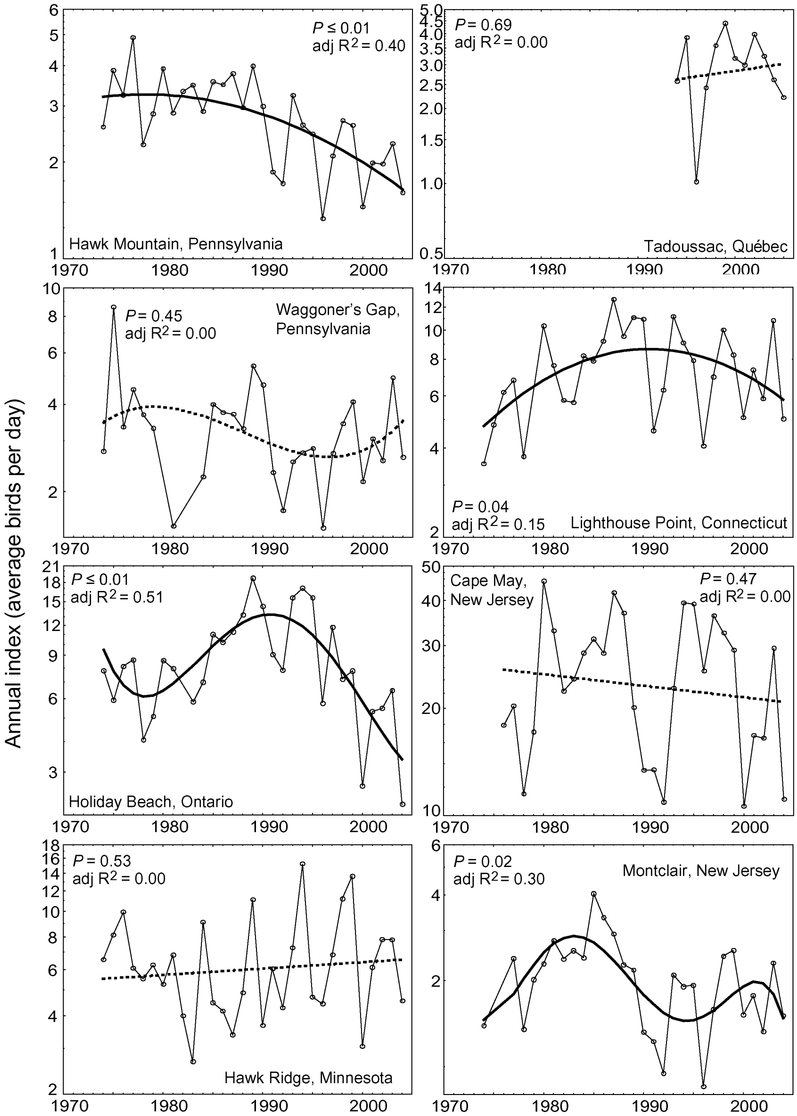

Fig. 6. Population indexes and trajectories for Northern Harriers (*Circus cyaneus*) at eight watchsites in northeastern North America. Index values are represented by open circles connected by thin lines to highlight patterns of interannual variation. Thick solid ($P \leq 0.10$) or dashed ($P > 0.10$)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

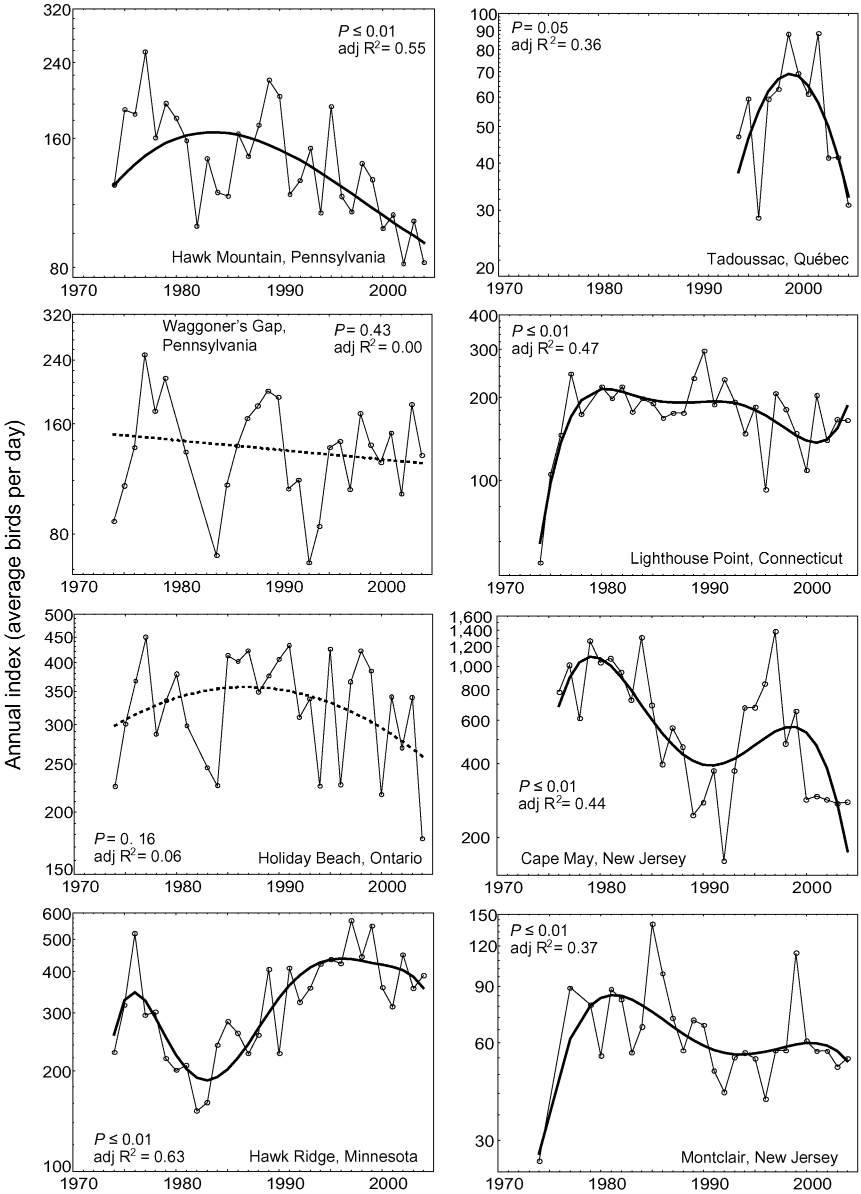

Fig. 7. Population indexes and trajectories for Sharp-shinned Hawks (*Accipiter striatus*) at eight watchsites in northeastern North America. Index values are represented by open circles connected by thin lines to highlight patterns of interannual variation. Thick solid ($P \leq 0.10$) or dashed ($P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

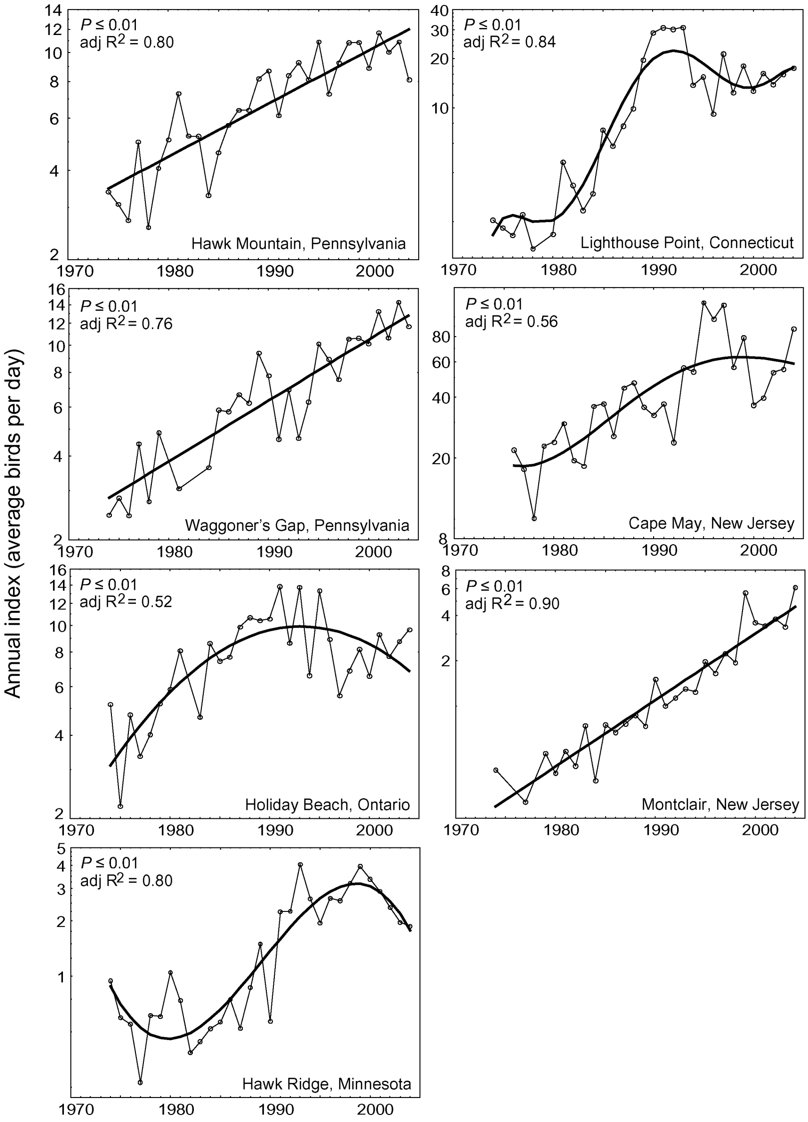

Fig. 8. Population indexes and trajectories for Cooper's Hawks (*Accipiter cooperii*) at seven watchsites in northeastern North America. Index values are represented by open circles connected by thin lines to highlight patterns of inter-annual variation. Thick solid ($P \leq 0.10$) or dashed ($P > 0.10$)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

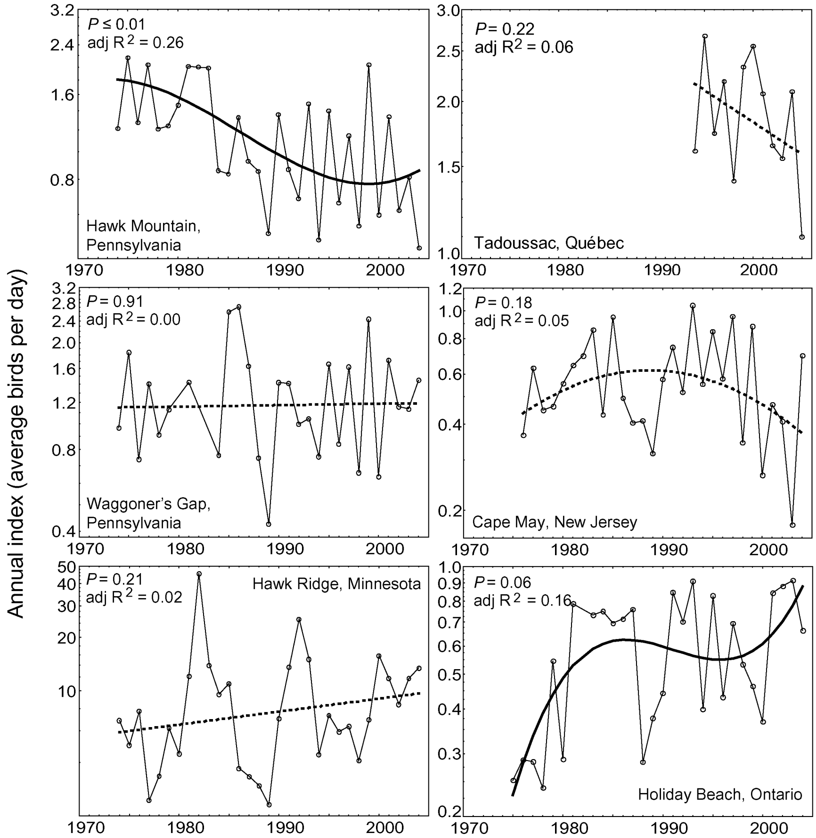

Fig. 9. Population indexes and trajectories for Northern Goshawks (*Accipiter gentilis*) at six watchsites in northeastern North America. Index values are represented by open circles connected by thin lines to highlight patterns of interannual variation. Thick solid ($P \leq 0.10$) or dashed ($P > 0.10$) 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

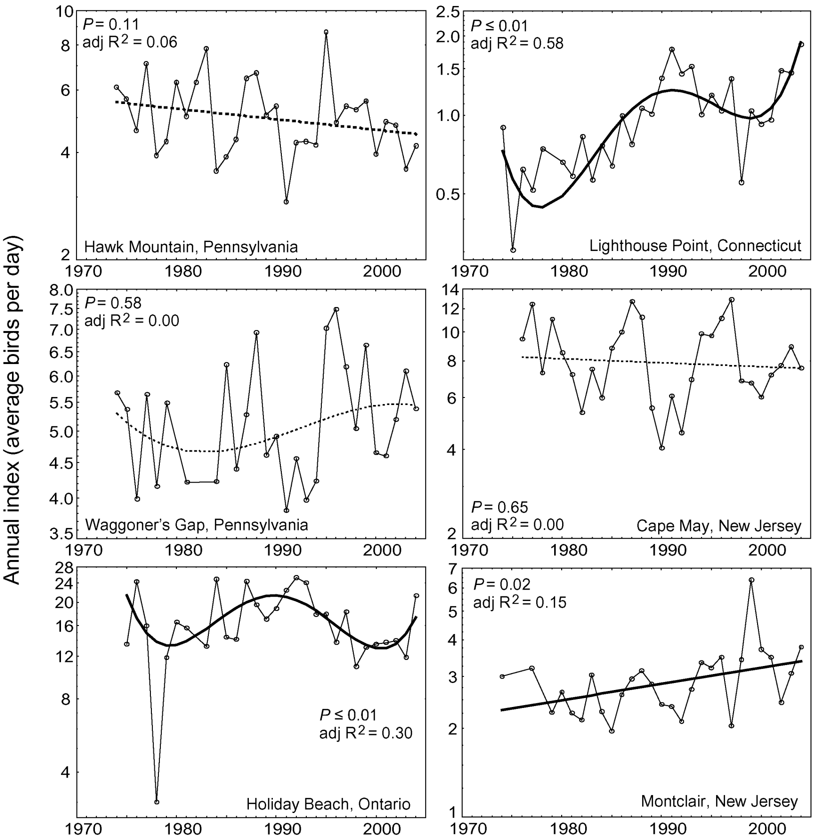

Fig. 10. Population indexes and trajectories for Red-shouldered Hawks (*Buteo lineatus*) at six watchsites in northeastern North America. Index values are represented by open circles connected by thin lines to highlight patterns of interannual variation. Thick solid ($P \le 0.10$) or dashed ($P > 0.10$)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

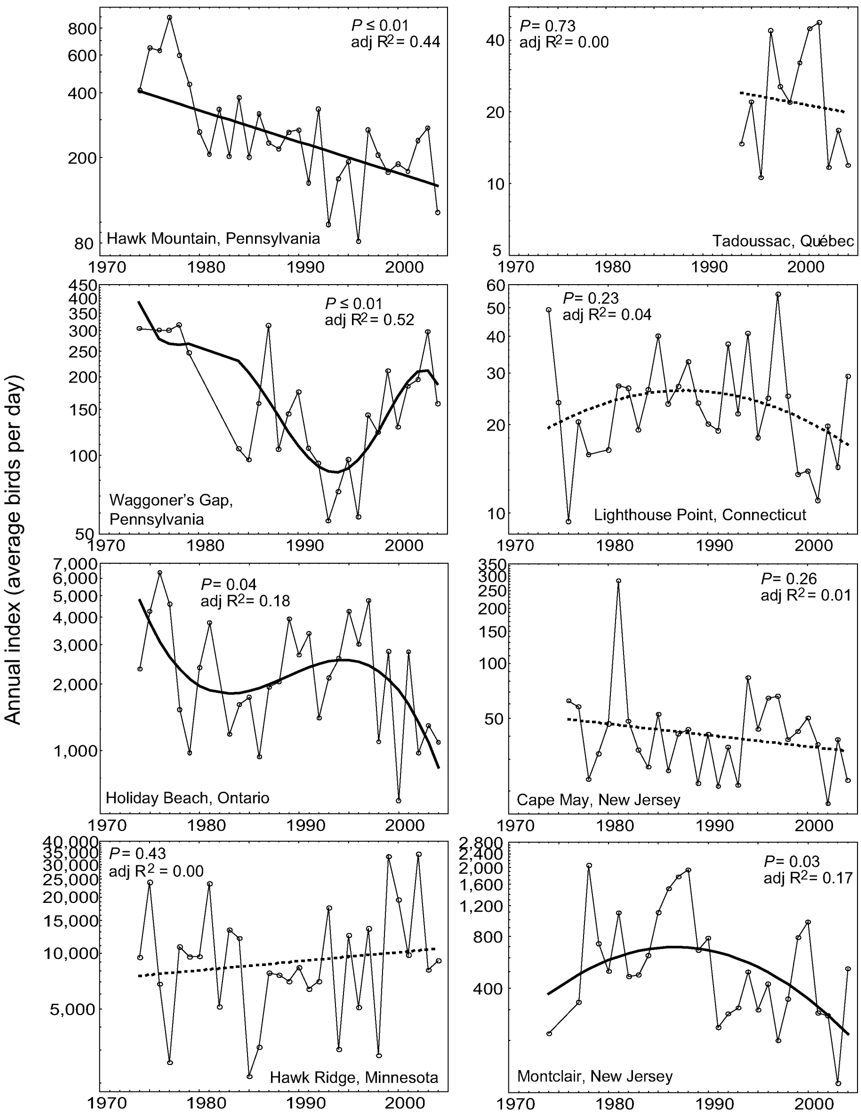

Fig. 11. Population indexes and trajectories for Broad-winged Hawks (*Buteo platypterus*) at eight watchsites in northeastern North America. Index values are represented by open circles connected by thin lines to highlight patterns of inter-annual variation. Thick solid ($P \leq 0.10$) or dashed ($P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

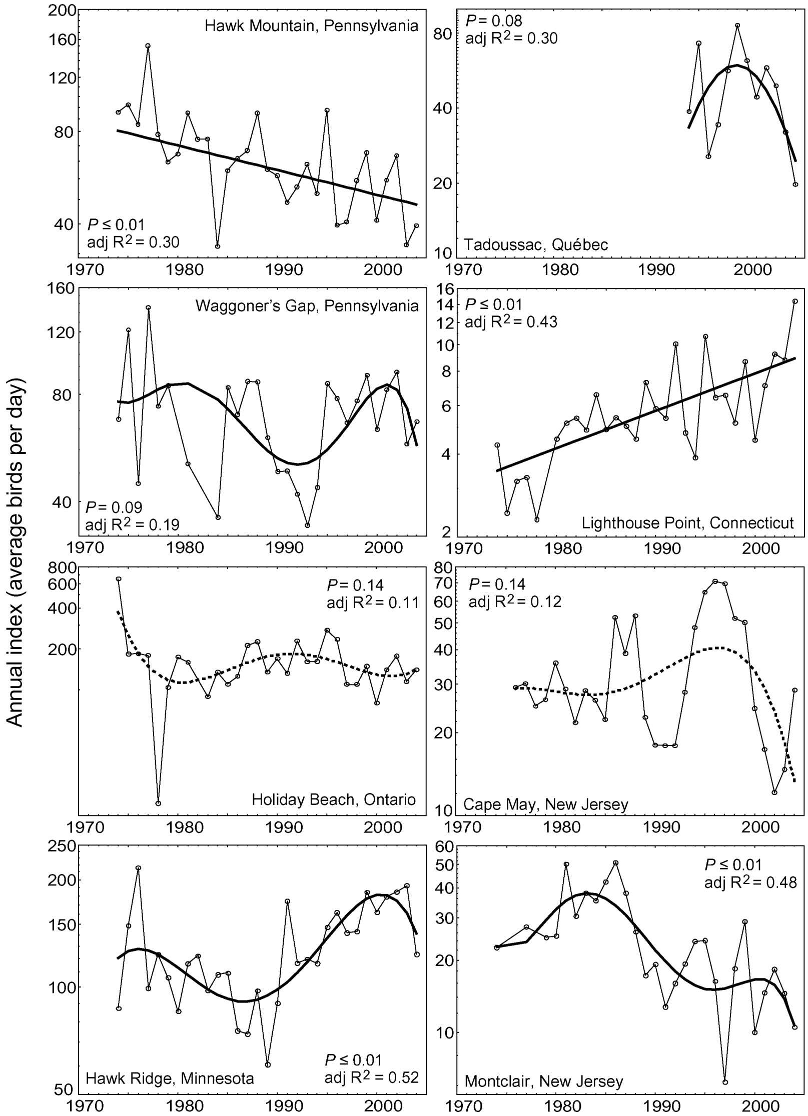

Fig. 12. Population indexes and trajectories for Red-tailed Hawks (*Buteo jamaicensis*) at eight watchsites in northeastern North America. Index values are represented by open circles connected by thin lines to highlight patterns of inter-annual variation. Thick solid ($P \leq 0.10$) or dashed ($P >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

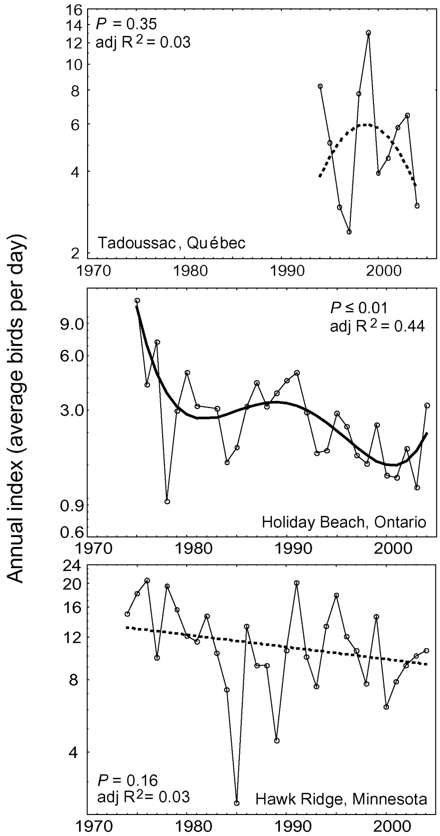

Fig. 13. Population indexes and trajectories for Rough-legged Hawks (*Buteo lagopus*) at three watchsites in northeastern North America. Index values are represented by open circles connected by thin lines to highlight patterns of interannual variation. Thick solid ($P \leq 0.10$) or dashed ($P > 0.10$) 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

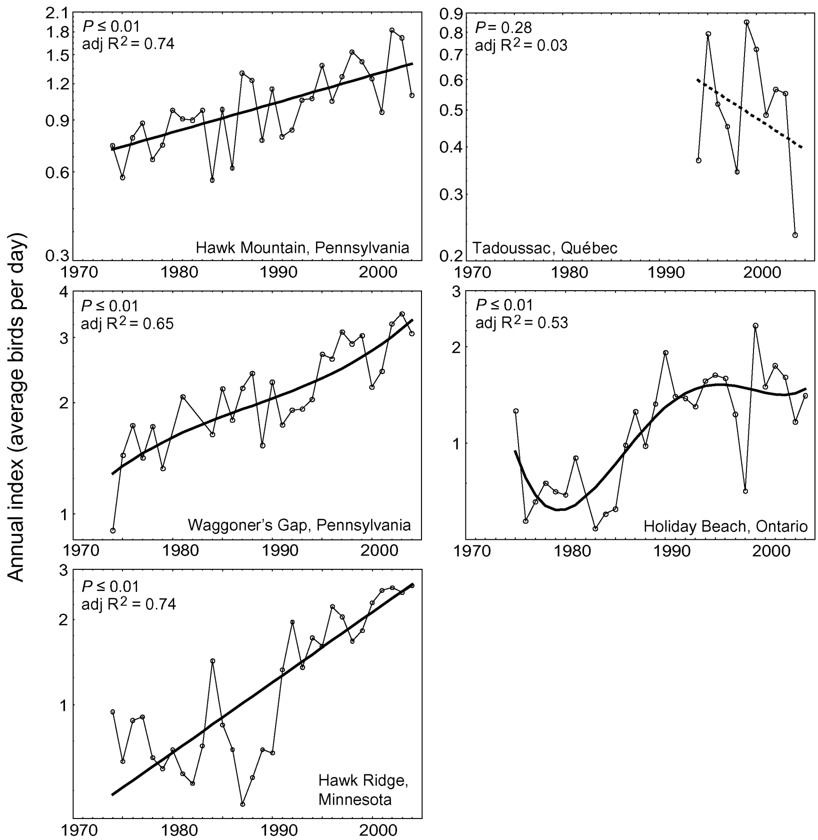

Fig. 14. Population indexes and trajectories for Golden Eagles (*Aquila chrysaetos*) at five watchsites in northeastern North America. Index values are represented by open circles connected by thin lines to highlight patterns of interannual variation. Thick solid ($P \leq 0.10$) or dashed ($P > 0.10$)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

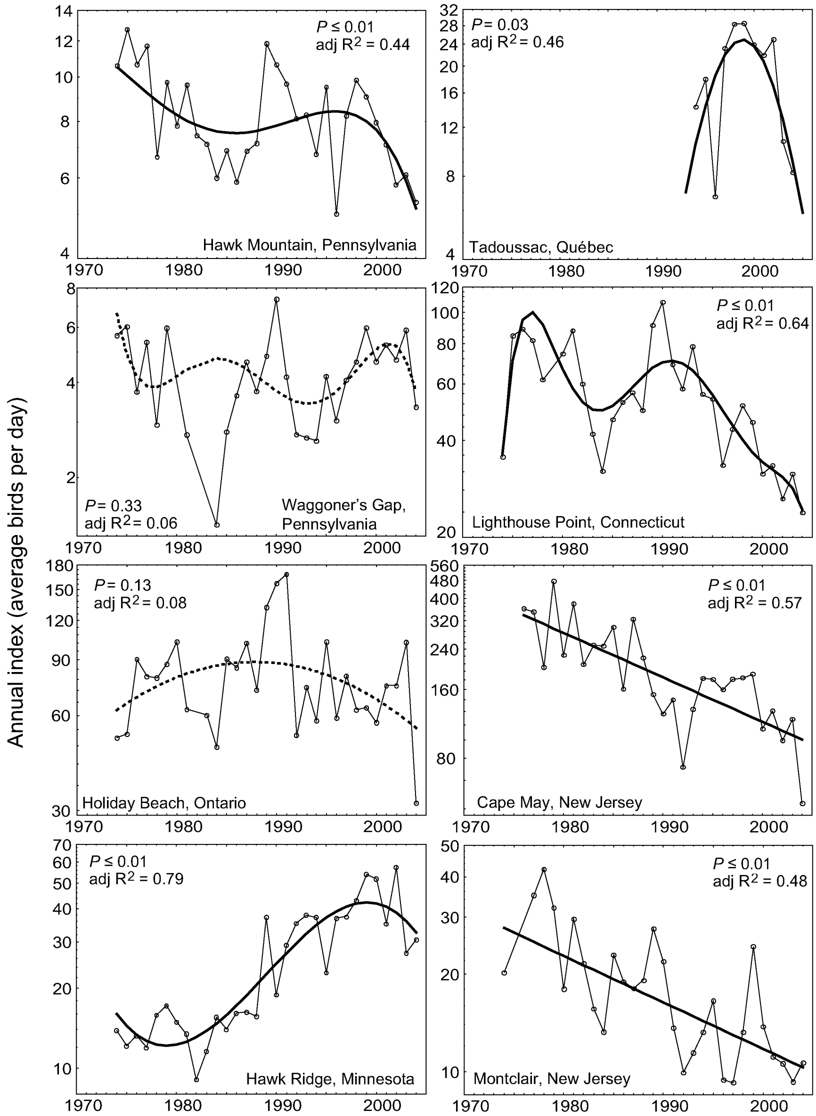

Fig. 15. Population indexes and trajectories for American Kestrels (*Falco sparverius*) at eight watchsites in northeastern North America. Index values are represented by open circles connected by thin lines to highlight patterns of inter-annual variation. Thick solid ($P \leq 0.10$) or dashed ($P >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

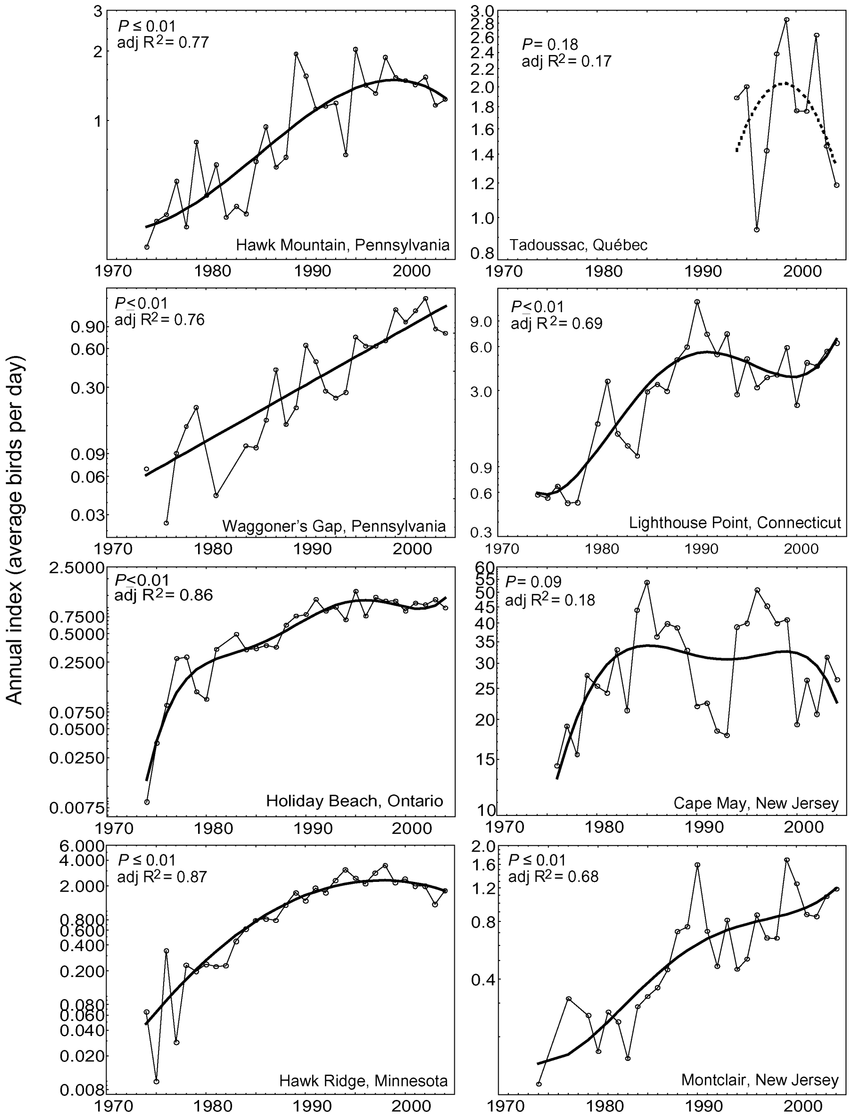

Fig. 16. Population indexes and trajectories for Merlins (*Falco columbarius*) at eight watchsites in northeastern North America. Index values are represented by open circles connected by thin lines to highlight patterns of interannual variation. Thick solid ($P \leq 0.10$) or dashed ($P > 0.10$) lines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

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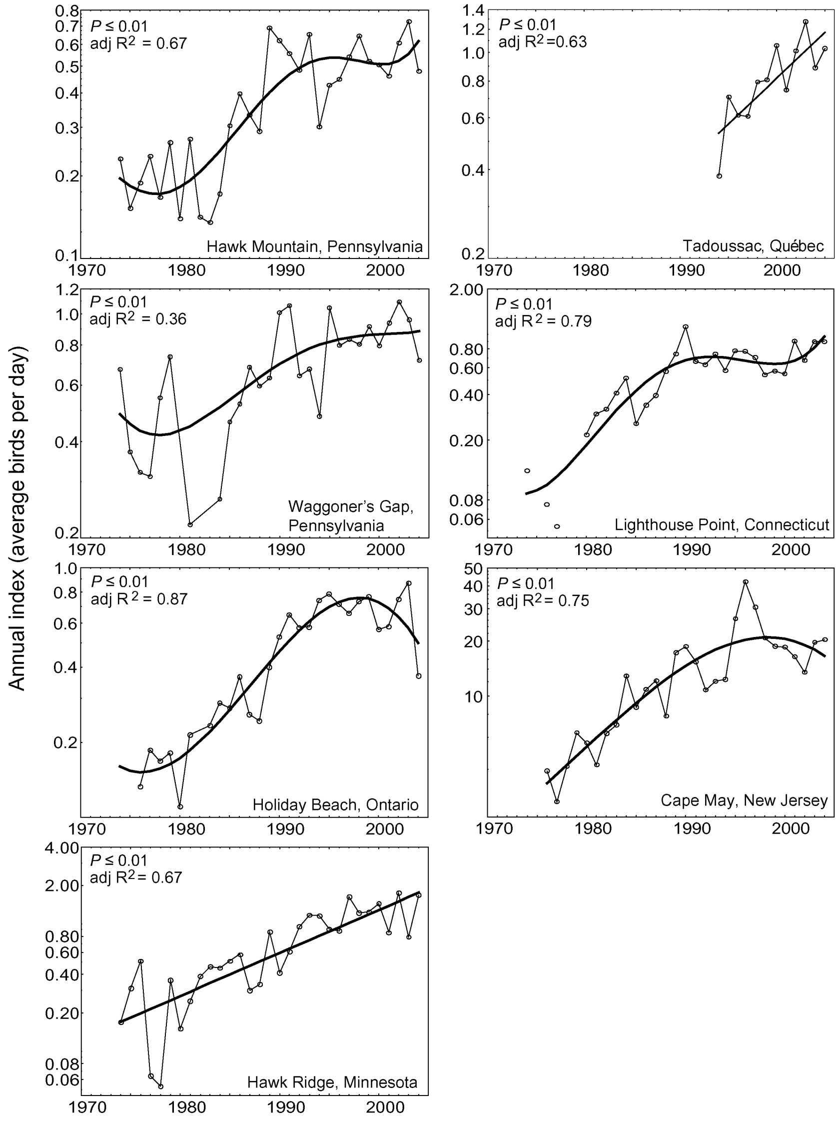

Fig. 17. Population indexes and trajectories for Peregrine Falcons (*Falco peregrinus*) at seven watchsites in northeastern North America. Index values are represented by open circles connected by thin lines to highlight patterns of inter-annual variation. Thick solid ($P \leq 0.10$) or dashed ($P >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

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6

Trends in Autumn Counts of Migratory Raptors in Western North America

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Abstract.—We analyzed counts from 10 watchsites in western North America. Average counts at watchsites ranged from 2,000 to 15,000 migrants each autumn, with as many as 21 species represented. Five species consistently made up 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%, Golden Eagle (*Aquila chrysaetos*), 9–14%, and American Kestrel (*Falco sparverius*), 8–13%. We estimated geometric-mean rates of change in annual count indexes for 16 species. Turkey Vultures (*Cathartes aura*) increased significantly ($P \leq 0.10$) at three sites. Swainson's Hawks (*B. swainsoni*), Merlins (*F. columbarius*), and Peregrine Falcons (*F. peregrinus*) increased significantly at some but not all sites. Northern Goshawks (*A. gentilis*) and Northern Harriers (*Circus cyaneus*) declined significantly at two sites, and Golden Eagles declined significantly at five sites. Ospreys (*Pandion haliaetus*), Sharp-shinned Hawks, Cooper's Hawks, Broad-winged

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Hawks (*B. platypterus*), Red-tailed Hawks, American Kestrels, and Prairie Falcons (*F. mexicanus*) declined significantly at one or more sites. Bald Eagles (*Haliaeetus leucocephalus*; analyzed at three sites) and Rough-legged Hawks (*B. lagopus*; analyzed at two sites) showed no significant trends. For many species, trends were related to regional variation in precipitation and drought, especially in the Great Basin–Intermountain region since the late 1980s.

Introduction

Each autumn, more than 20 species of diurnal raptors migrate through western North America (Zalles and Bildstein 2000) where numbers of migrants are monitored at a network of traditional watchsites (e.g., Smith et al. 2001, Hoffman and Smith 2003, Sherrington 2003). We estimated trends for 16 species of migrating diurnal raptors across periods of various lengths between 1983 and 2005 at 10 watchsites along three major regional migration corridors in the region (*sensu* Hoffman et al. 2002; see Chapter 2). The Chelan Ridge Raptor Migration Project in the Cascade Mountains of Washington and Bonney Butte Raptor Migration Project in the Cascades of Oregon are in the Pacific Coast Corridor (Fig. 1). Boise Ridge in the Boise Mountains of western Idaho, the Goshute Mountains Raptor Migration Project in northeastern Nevada, and two sites, Lipan Point and Yaki Point, at the Grand Canyon in Arizona, are in the Intermountain Corridor. The Bridger Mountains Raptor Migration Project in Montana, the Wellsville Mountains Raptor Migration Project in Utah, the Manzano Mountains Raptor Migration Project in New Mexico, and Mt. Lorette in Alberta, are in the Rocky Mountain corridor (see Chapter 8 for details).

Annual mean counts ranged from 2,000 to 15,000 migrants per site. The analyses we present incorporate an additional four years of data for five watchsites reported in Hoffman and Smith (2003) together with data from five other sites.

Methods

Data Collection

Hourly counts were used to estimate trends. Site coverage ranged from 8 to 23 years (Table 1). Almost all counts were conducted annually throughout most of autumn migration, except during inclement weather. At all watchsites, trained observers used 7–10× binoculars to detect and identify migrating raptors. Spotting scopes sometimes were used to identify, but not to detect, raptors.

Most counts were conducted at a single traditional watchsite by two trained observers who worked throughout the season, with count teams varying across years. Most counters followed standardized count and data-recording protocols (cf. Hoffman and Smith 2003). All sites except those

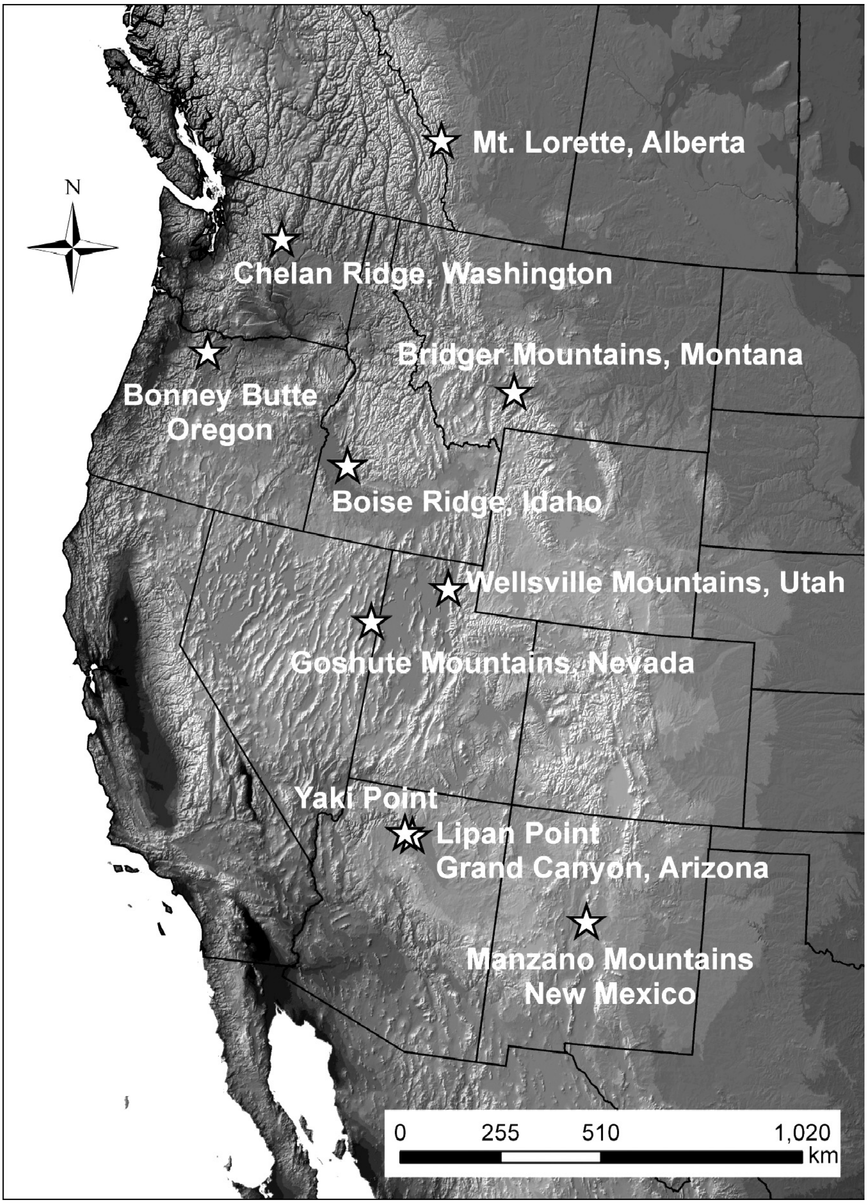

Fig. 1. Raptor-migration watchsites in western North America.

Table 1. Details of watchsites included in this analysis.

Location	Latitude	Longitude	Elevation (m)	Count years	Count season	Mean (range) days season^{-1}	Mean ± SD (h day^{-1})	Standardized daily window (n h)
Chelan Ridge, Washington [a]	48°01′13″N	120°05′38″W	1,729	1998–2005	24 Aug. to 27 Oct.	60 (53–67)	8.0 ± 2.3	0700–1700 (10)
Bonney Butte, Oregon [b]	45°15′47″N	121°35′31″W	1,754	1994–2005	27 Aug. to 31 Oct.	50 (38–59)	7.1 ± 2.0	0800–1700 (9)
Boise Ridge, Idaho [c]	43°36′19″N	116°03′37″W	1,799	1995–2005	25 Aug. to 31 Oct.	64 (59–68)	7.2 ± 1.6	0900–1800 (9)
Goshute Mountains, Nevada [d]	40°25′25″N	114°16′17″W	2,740	1983–2005	15 Aug. to 5 Nov.	78 (66–85)	8.6 ± 1.8	0700–1800 (11)
Lipan Point, Grand Canyon, Arizona [e]	36°01′59″N	111°51′12″W	2,125	1991–2005	27 Aug. to 5 Nov.	67 (57–71)	7.7 ± 1.4	0800–1700 (9)
Yaki Point, Grand Canyon, Arizona [e]	36°03′31″N	112°05′02″W	2,025	1997–2005	27 Aug. to 5 Nov.	69 (66–71)	7.8 ± 1.5	0800–1700 (9)
Mt. Lorette, Alberta [f]	50°52′36″N	115°09′25″W	1,440	1993–2005	late Aug. to late Nov.	86 (69–101)	9.9 ± 1.9	0700–1900 (12)
Bridger Mountains, Montana [g]	45°49′01″N	110°55′47″W	2,610	1992–2005	27 Aug. to 31 Oct.	51 (39–64)	6.5 ± 1.7	0800–1700 (9)
Wellsville Mountains, Utah [h]	41°41′18″N	112°02′54″W	2,617	1987–2004	late Aug. to 31 Oct.	54 (43–65)	7.1 ± 1.5	0900–1800 (9)
Manzano Mountains, New Mexico [i]	34°42′15″N	106°24′40″W	2,805	1985–2005	27 Aug. to 5 Nov.	64 (50–70)	7.9 ± 1.8	0800–1800 (10)

[a] Two full-time counters. Count period of 27 August to 31 October for 1998–2000, shifted earlier after that to account for early snowfall.

[b] Two full-time counters. Before 1999, start dates of 1–4 September and end dates of 25 October to 3 November.

[c] Two full-time counters.

[d] Single, full-time counter, 1983–1986; a second full-time counter during peak month, 1987–1989; two full-time counters, 1990–2005.

[e] Two observation points, one at each end of a 30-km, east–west transect. Two full-time counters per observation point; four counters rotate duties between points. Before 1996, start dates of 31 August to 8 September at Lipan Point.

[f] Rotating teams of one to four counters. Start dates of 27 August to 2 September, except for four years when start dates were 8–17 September. End dates of 29 November to 6 December, except for three years when end dates were 22 November, 12 December, and 17 December.

[g] Start dates of 1–13 September for 1992–1996. End date of 3 November in 1995.

[h] No counts conducted in 2002 or 2005. Single full-time counter, 1987–1991; two full-time counters, 1992–2004. Start dates of 3–7 September and end date of 20 October for 1987–1989; start dates of 22–28 August and end dates of 24–31 October for 1990–2004.

[i] Single full-time counter, 1985–1987; second full-time counter during peak 75% of the season, 1988–1989; two full-time counters,1990–2005. Start date of 27 August since 1995, 23 August to 6 September before then. End date of 5 November since 1991, 30 October to 8 November before then.

in the Grand Canyon and at Mt. Lorette were on north–south oriented ridgetops (elevations from 1,700 to 2,900 m above sea level). Migrants were counted as they crossed an east–west axis passing through the site.

Migrants cross the Grand Canyon along a *broad front*, descending into the canyon as they cross, before rising on thermals at the south rim. The use of a two-count transect (sites 30 km apart) at the Grand Canyon affords better sampling of this broad-frontal movement, which is subject to longitudinal shifting depending on the weather (cf. Ruelas 2005).

Ridgetop monitoring is impractical in western Alberta because of the stature of the Rocky Mountains and the region's climate. Thus, the Mt. Lorette count site is at a relatively low site in the Kananaskis Valley. Although data were recorded for many species at the site, we analyzed data only for Golden Eagles (*Aquila chrysaetos*), which is by far the most abundant migrant at the site.

Table 1 and Chapter 8 provide additional information for each site.

Trend Analysis

With one exception, our methods follow those in Chapter 5 (see also Chapter 4 and Farmer et al. 2007). We combined counts from the two Grand Canyon sites during the nine years that both sites were active and derived integrated annual count indexes for them following the methods of Hussell (1981) and Francis and Hussell (1998). Below, we present trends for the full 15-year Lipan Point data set as well as for the 9-year, two-site data set.

Besides estimating trends for all species–watchsite combinations, we also estimated trends before 1998 and after 1997. All sites were included in post-1997 analyses. Sites initiated on or before 1993 were included in pre-1998 analyses. We selected these periods for analyses because 1998 concluded a five-year period of high-moisture levels throughout much of the interior West associated with a strong *El Nino* that was followed by a lengthy period of severe and widespread drought (NOAA 2006; see also Hoffman and Smith 2003).

Results and Discussion

Sharp-shinned Hawks (*Accipiter striatus*; 25–30% of the annual total), Cooper's Hawks (*A. cooperii*; 15–22%), Red-tailed Hawks (*Buteo jamaicensis*; 13–20%), Golden Eagles (9–14%), and American Kestrels (*Falco sparverius*; 8–13%) (Table 2) were the most numerous migrants. The Northern Harrier (*Circus cyaneus*) was the only other migrant seen in sufficient numbers to be included in the analysis at all sites excluding Mt. Lorette. We were able to calculate trends at only one or two sites for Broad-winged Hawks (*B. platypterus*), Rough-legged Hawks (*B. lagopus*), and

Table 2. Average annual autumn migration counts (CV in parentheses) for 17 species of raptors at western watchsites in three migration corridors. (Counts of Ferruginous Hawks are included in this table, but were too low to permit trend analyses at any watchsite.)

	Rocky Mountain			
Species	Mount Lorette, Alberta (1993–2005)	Bridger Mountains, Montana (1992–2005)	Wellsville Mountains, Utah (1987–2005)	Manzano Mountains, New Mexico (1983–2005)
Turkey Vulture (*Cathartes aura*)	<1	<1	21 (65)	394 (62)
Osprey (*Pandion haliaetus*)	9 (60)	6 (77)	25 (45)	30 (59)
Bald Eagle (*Haliaeetus leucocephalus*)	383 (27)	82 (30)	4 (90)	3 (78)
Northern Harrier (*Circus cyaneus*)	21 (48)	49 (111)	277 (40)	58 (44)
Sharp-shinned Hawk (*Accipiter striatus*)	212 (28)	340 (35)	855 (20)	1,482 (30)
Cooper's Hawk (*A. cooperii*)	42 (19)	168 (47)	525 (31)	1,024 (36)
Northern Goshawk (*A. gentilis*)	58 (75)	35 (67)	24 (58)	16 (59)
Broad-winged Hawk (*Buteo platypterus*)	12 (72)	9 (106)	4 (90)	7 (65)
Swainson's Hawk (*B. swainsoni*)	1 (88)	2 (128)	142 (109)	553 (284)
Red-tailed Hawk (*B. jamaicensis*)	70 (45)	107 (51)	576 (45)	656 (27)
Ferruginous Hawk (*B. regalis*)	<1	2 (87)	10 (63)	13 (41)
Rough-legged Hawk (*B. lagopus*)	64 (25)	35 (59)	2 (87)	<1
Golden Eagle (*Aquila chrysaetos*)	3,897 (11)	1,463 (17)	182 (47)	117 (28)
American Kestrel (*Falco sparverius*)	9 (64)	76 (56)	812 (29)	562 (27)
Merlin (*F. columbarius*)	14 (42)	9 (62)	11 (51)	25 (57)
Peregrine Falcon (*F. peregrinus*)	6 (59)	8 (61)	9 (68)	49 (76)
Prairie Falcon (*F. mexicanus*)	3 (63)	13 (31)	16 (44)	20 (57)
Total raptors	4,804	2,112	3,602	5,208

Table 2. Continued.

Species	Intermountain			
	Boise Ridge, Idaho (1993–2005)	Goshute Mountains, Nevada (1983–2005)	Lipan Point, Arizona (1991–2005)	Grand Canyon combined, Arizona (1997–2005)
Turkey Vulture (*Cathartes aura*)	1,010 (51)	320 (51)	–[a]	–[a]
Osprey (*Pandion haliaetus*)	60 (32)	86 (48)	74 (32)	119 (24)
Bald Eagle (*Haliaeetus leucocephalus*)	6 (64)	13 (52)	19 (61)	35 (41)
Northern Harrier (*Circus cyaneus*)	231 (40)	170 (43)	80 (43)	108 (36)
Sharp-shinned Hawk (*Accipiter striatus*)	1,175 (30)	4,534 (44)	1,420 (29)	2,395 (18)
Cooper's Hawk (*A. cooperii*)	797 (44)	3,155 (46)	1,059 (39)	2,016 (34)
Northern Goshawk (*A. gentilis*)	41 (45)	103 (57)	9 (123)	10 (56)
Broad-winged Hawk (*Buteo platypterus*)	18 (51)	45 (80)	10 (104)	25 (53)
Swainson's Hawk (*B. swainsoni*)	65 (57)	222 (90)	42 (66)	91 (80)
Red-tailed Hawk (*B. jamaicensis*)	1,010 (29)	3,002 (31)	1,624 (37)	2,328 (19)
Ferruginous Hawk (*B. regalis*)	<1	16 (42)	6 (63)	11 (47)
Rough-legged Hawk (*B. lagopus*)	5 (59)	14 (78)	<1	<1
Golden Eagle (*Aquila chrysaetos*)	52 (22)	254 (26)	26 (64)	27 (63)
American Kestrel (*Falco sparverius*)	1,144 (20)	1,870 (46)	1,076 (23)	1,735 (21)
Merlin (*F. columbarius*)	31 (48)	38 (64)	11 (49)	22 (39)
Peregrine Falcon (*F. peregrinus*)	8 (80)	10 (84)	8 (42)	16 (38)
Prairie Falcon (*F. mexicanus*)	9 (39)	26 (55)	5 (55)	10 (26)
Total raptors	5,987	14,430	5,891	10,076

Table 2. Continued.

Species	Pacific Coast: Chelan Ridge, Washington (1998–2005)	Pacific Coast: Bonney Butte, Oregon (1994–2005)
Turkey Vulture (*Cathartes aura*)	31 (46)	302 (44)
Osprey (*Pandion haliaetus*)	42 (39)	66 (31)
Bald Eagle (*Haliaeetus leucocephalus*)	5 (92)	47 (25)
Northern Harrier (*Circus cyaneus*)	113 (36)	30 (46)
Sharp-shinned Hawk (*Accipiter striatus*)	796 (30)	1,119 (32)
Cooper's Hawk (*A. cooperii*)	212 (17)	341 (27)
Northern Goshawk (*A. gentilis*)	28 (47)	26 (41)
Broad-winged Hawk (*Buteo platypterus*)	5 (41)	8 (252)
Swainson's Hawk (*B. swainsoni*)	7 (88)	1 (136)
Red-tailed Hawk (*B. jamaicensis*)	302 (30)	607 (24)
Ferruginous Hawk (*B. regalis*)	<1	<1
Rough-legged Hawk (*B. lagopus*)	28 (59)	13 (59)
Golden Eagle (*Aquila chrysaetos*)	127 (27)	95 (35)
American Kestrel (*Falco sparverius*)	66 (40)	22 (33)
Merlin (*F. columbarius*)	38 (31)	67 (39)
Peregrine Falcon (*F. peregrinus*)	6 (72)	7 (77)
Prairie Falcon (*F. mexicanus*)	8 (65)	5 (67)
Total raptors	2,134	2,898

[a] Tallying of vultures ceased at these sites in 2001 because of difficulties in distinguishing migrants from residents.

Peregrine Falcons (*F. peregrinus*). We were able to calculate trends for at least three sites as well as for at least one site in each of the three corrdiors, for all other species except Swainson's Hawks (*B. swainsoni*), which were too uncommon for such analyses in the Pacific Northwest. Ferruginous Hawks (*B. regalis*) occurred in numbers too low to support analyses at any watchsite (but see Hoffman and Smith 2003).

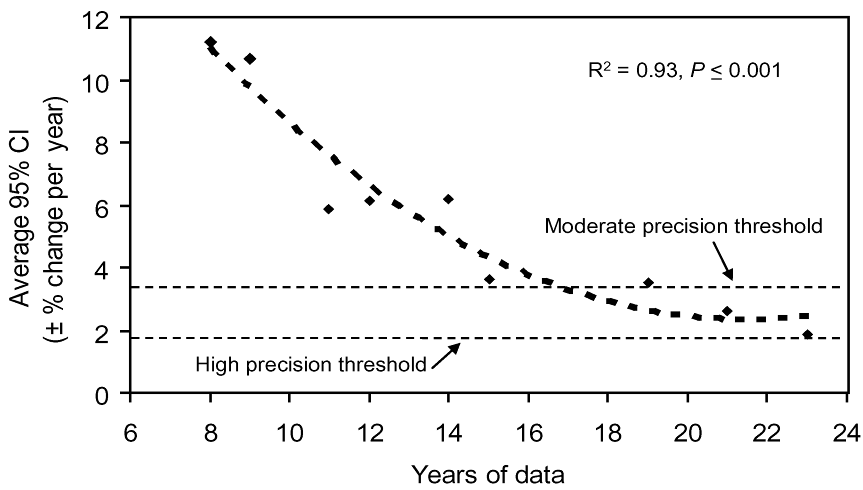

Fig. 2. Relationship between years of data collection and average 95% confidence intervals (CI) for species trend estimates. See Chapter 5 for explanation of moderate- and high-precision thresholds.

On average, confidence intervals (CI) for trend estimates decreased substantially as years of coverage increased (Fig. 2), particularly during the first 15 years of coverage. Thirty-six of 75 (48%) long-term trend estimates were of high or moderate precision. Low precision occurred primarily in data sets shorter than 15 years (Tables 3–5). Figure 2 suggests that confidence intervals of ±10% per year or less with 10–15 years of data yield at least moderate precision with 20–25 years of data. These results indicate the value of continued monitoring for long periods, as well as the value of comparing the results of short-term and long-term data sets.

We report annual percentage rates of change for each watchsite in Tables 3–5, and annual indexes and fitted trajectories for each species at each watchsite in Figures 4–19.

Regional Patterns and Trends

Long-term patterns.—Numbers of Turkey Vultures (*Cathartes aura*), Ospreys (*Pandion haliaetus*), Swainson's Hawks, Red-tailed Hawks, Merlins (*F. columbarius*), and Peregrine Falcons increased in the Goshutes, Manzanos, and Wellsvilles (Table 3 and Figs. 4–19). Long-term trend estimates for these species were significant in the Goshutes, both significant and nonsignificant in the Manzanos, and nonsignificant in the Wellsvilles. Broad-winged Hawks also increased significantly in the Goshutes, one of only two sites analyzed for this species. Northern Goshawks (*A. gentilis*),

Table 3. Trends (mean percentage of change per year ± 95% CI[a]) in autumn migration counts of 16 species of raptors at western watchsites in three migration corridors.

	Rocky Mountain			
Species	Mount Lorette, Alberta (1993–2005)	Bridger Mountains, Montana (1992–2005)	Wellsville Mountains, Utah (1987–2004)	Manzano Mountains, New Mexico (1985–2005)
Turkey Vulture	–	–	0.3 ± 3.5	2.3 ± 3.8
Osprey	–	–	0.7 ± 2.7	3.8 ± 2.2*
Bald Eagle	–	0.4 ± 3.6	–	–
Northern Harrier	–	–2.4 ± 9.9	0.3 ± 3.9	–1.3 ± 2.2
Sharp-shinned Hawk	–	–1.1 ± 4.6	–1.7 ± 2.0†	2.2 ± 2.0‡
Cooper's Hawk	–	–4.4 ± 4.9†	–1.7 ± 2.7	4.5 ± 1.9*
Northern Goshawk	–	–4.6 ± 9.0	–0.2 ± 3.6	–
Broad-winged Hawk	–	–	–	–
Swainson's Hawk	–	–	2.0 ± 6.1	3.9 ± 6.1
Red-tailed Hawk	–	–1.7 ± 6.3	1.5 ± 4.1	2.1 ± 1.6‡
Rough-legged Hawk	–	–1.1 ± 7.4	–	–
Golden Eagle	–2.2 ± 2.5†	–2.3 ± 2.8†	0.6 ± 3.6	–1.9 ± 1.6‡
American Kestrel	–	–4.2 ± 7.3	–3.6 ± 2.8†	0.1 ± 1.6
Merlin	–	–	–	5.6 ± 2.9*
Peregrine Falcon	–	–	–	9.6 ± 2.9*
Prairie Falcon	–	–	–	2.0 ± 2.6

	Intermountain			
Species	Boise Ridge, Idaho (1995–2005)	Goshute Mountains, Nevada (1983–2005)	Lipan Point, Arizona (1991–2005)	Grand Canyon combined, Arizona (1997–2005)
Turkey Vulture	18.3 ± 2.6*	4.3 ± 1.6*	–	–
Osprey	4.4 ± 5.0†	4.4 ± 1.3*	0.3 ± 2.5	–4.4 ± 5.6†
Bald Eagle	–	–	–	–1.2 ± 9.6
Northern Harrier	0.3 ± 6.7	0.4 ± 1.7	–5.3 ± 4.0‡	–10.6 ± 7.8‡
Sharp-shinned Hawk	0.7 ± 6.1	1.7 ± 1.8†	–3.4 ± 3.1‡	–5.6 ± 7.7§
Cooper's Hawk	2.1 ± 6.5	1.6 ± 1.6†	–8.7 ± 2.8*	–16.0 ± 8.3*
Northern Goshawk	–3.9 ± 8.7	–4.7 ± 2.9*	–	–
Broad-winged Hawk	–	6.8 ± 2.4*	–	–11.9 ± 9.4‡
Swainson's Hawk	–2.3 ± 10.2	5.4 ± 2.1*	5.5 ± 3.9*	8.7 ± 15.5§
Red-tailed Hawk	7.3 ± 3.7*	2.0 ± 1.5‡	–6.0 ± 4.2*	–6.2 ± 11.4§
Rough-legged Hawk	–	–	–	–
Golden Eagle	1.2 ± 4.2	–2.4 ± 1.3*	–10.0 ± 5.8*	–11.6 ± 17.8§
American Kestrel	–1.9 ± 4.3	3.4 ± 1.5*	–4.1 ± 2.5*	–2.8 ± 9.8
Merlin	6.3 ± 6.7†	9.1 ± 2.5*	–	–5.7 ± 14.3§
Peregrine Falcon	–	–	–	–
Prairie Falcon	–	–2.1 ± 2.3‡	–	–

Table 3. Continued.

	Pacific Coast	
Species	Chelan Ridge, Washington (1998–2005)	Bonney Butte, Oregon (1995–2005)
Turkey Vulture	5.0 ± 13.0	5.5 ± 6.7†
Osprey	–6.0 ± 13.8	2.2 ± 4.1
Bald Eagle	–	2.0 ± 3.0
Northern Harrier	–10.1 ± 11.6†	–3.3 ± 8.9
Sharp-shinned Hawk	–12.8 ± 9.7‡	–0.1 ± 6.1
Cooper's Hawk	–6.3 ± 7.3†	–0.9 ± 6.0
Northern Goshawk	–12.9 ± 14.8†	–2.3 ± 8.7
Broad-winged Hawk	–	–
Swainson's Hawk	–	–
Red-tailed Hawk	–5.0 ± 10.5	–1.7 ± 6.8
Rough-legged Hawk	–2.2 ± 10.5	–
Golden Eagle	4.5 ± 8.3	–3.8 ± 5.5
American Kestrel	–11.7 ± 13.5†	–7.9 ± 3.7*
Merlin	–0.4 ± 10.3	2.1 ± 8.1
Peregrine Falcon	–	–
Prairie Falcon	–	–

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

Golden Eagles, and Prairie Falcons (*F. mexicanus*) declined significantly at one or more of the sites and did not increase significantly at any site. Sharp-shinned Hawks, Cooper's Hawks, and American Kestrels showed a mix of significant increases and decreases at the three sites. Northern Harriers showed no significant trends at the three sites.

Pacific Coast Migration Corridor.—Bonney Butte and Chelan Ridge, which lie within the Pacific Coast corridor, monitor a relatively distinct collection of migrants for most species (Hoffman et al. 2002; Chapter 2). Although the drought that began in the interior West in the late 1990s (e.g., Fig. 3) extended into many areas along the eastern Cascades, moisture generally remained more favorable in the Pacific Northwest (NOAA 2006). Thus, one might expect common patterns at these two sites as well as significant differences between them and sites farther east. Indeed, trends for the two sites were similar for many species, with six species declining at both and similar increases at both for Turkey Vultures (Table 3 and Figs. 4–19). American Kestrels declined significantly at Bonney Butte, whereas Northern Harriers, all three accipiters, and American Kestrels, declined significantly at Chelan Ridge. Variation in all-species counts was positively correlated from 1998 to 2000, but negatively correlated thereafter. Although band encounters and satellite tracking clearly link the two sites

Table 4. Trends (mean percentage of change per year ± 95% CI[a]) in autumn migration counts of 16 species of raptors at western watchsites in two migration corridors before 1998.

	Rocky Mountain			Intermountain	
	Bridger Mountains, Montana (1992–1997)	Wellsville Mountains, Utah (1987–1997)	Manzano Mountains, New Mexico (1985–1997)	Goshute Mountains, Nevada (1983–1997)	Lipan Point, Arizona (1992–1997)
Turkey Vulture	–	0.3 ± 3.5	10.4 ± 5.9*	6.2 ± 2.6*	–
Osprey	–	7.6 ± 4.8*	6.8 ± 3.8*	8.1 ± 2.0*	10.9 ± 5.8*
Bald Eagle	0.4 ± 3.6	–	–	–	–
Northern Harrier	–2.4 ± 9.9	0.3 ± 3.9	3.0 ± 3.8§	5.5 ± 2.5*	–5.3 ± 4.0‡
Sharp-shinned Hawk	5.9 ± 11.3§	0.8 ± 3.6	2.2 ± 2.0‡	7.0 ± 3.0*	–3.4 ± 3.1‡
Cooper's Hawk	9.0 ± 15.5§	6.4 ± 4.9‡	4.5 ± 1.9*	7.4 ± 2.6*	2.2 ± 6.5§
Northern Goshawk	–4.6 ± 9.0§	–0.2 ± 3.6	–	3.0 ± 4.0§	–
Broad-winged Hawk	–	–	–	10.6 ± 4.0*	–
Swainson's Hawk	–	11.6 ± 11.1‡	13.7 ± 10.2*	5.4 ± 2.1*	5.5 ± 3.9*
Red-tailed Hawk	–2.2 ± 6.3	6.4 ± 7.4†	2.1 ± 1.6‡	2.0 ± 1.5*	3.6 ± 9.8§
Rough-legged Hawk	–1.1 ± 7.4	–	–	–	–
Golden Eagle	–7.1 ± 6.8‡	3.6 ± 7.1§	1.2 ± 2.6	1.3 ± 1.9§	–10.0 ± 5.8*
American Kestrel	8.7 ± 18.2§	0.8 ± 5.0	0.1 ± 1.6	9.6 ± 2.3*	–4.1 ± 2.5*
Merlin	–	–	10.1 ± 5.0*	20.1 ± 4.1*	–
Peregrine Falcon	–	–	14.4 ± 4.8*	–	–
Prairie Falcon	–	–	6.1 ± 4.0*	6.3 ± 3.2*	–

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

Table 5. Trends (mean percentage of change per year ± 95% CI[a]) in autumn migration counts of 16 species of raptors at 10 western watchsites in three migration corridors during the drought years of 1998–2005.

	Rocky Mountain			
	Mount Lorette, Alberta	Bridger Mountains, Montana	Wellsville Mountains, Utah	Manzano Mountains, New Mexico
Turkey Vulture	–	–	0.3 ± 3.5	–12.9 ± 12.0†
Osprey	–	–	–10.0 ± 6.7‡	–1.1 ± 5.7
Bald Eagle	–	0.4 ± 3.6	–	–
Northern Harrier	–	–2.4 ± 9.9	0.3 ± 3.9	–8.2 ± 5.8‡
Sharp-shinned Hawk	–	–6.3 ± 8.8§	–5.7 ± 5.2†	2.2 ± 2.0†
Cooper's Hawk	–	–5.6 ± 9.9§	–14.3 ± 7.0‡	4.5 ± 1.9‡
Northern Goshawk	–	–4.6 ± 9.0§	–0.2 ± 3.6	–
Broad-winged Hawk	–	–	–	–
Swainson's Hawk	–	–	–13.1 ± 14.9†	–7.3 ± 20.1§
Red-tailed Hawk	–	–2.2 ± 6.3	–6.1 ± 10.3§	2.1 ± 1.6†
Rough-legged Hawk	–	–1.1 ± 7.4	–	–
Golden Eagle	–2.2 ± 2.5§	1.3 ± 5.5	–5.3 ± 11.0§	–9.6 ± 5.0*
American Kestrel	–	–13.8 ± 13.9†	–10.5 ± 7.0‡	0.1 ± 1.6
Merlin	–	–	–	–1.7 ± 7.4
Peregrine Falcon	–	–	–	–2.1 ± 8.8
Prairie Falcon	–	–	–	–9.1 ± 8.1†
	Intermountain			
	Boise Ridge, Idaho	Goshute Mountains, Nevada	Lipan Point, Arizona	Grand Canyon combined, Arizona
Turkey Vulture	18.3 ± 2.6*	2.3 ± 3.0	–	–
Osprey	4.4 ± 5.0†	–2.3 ± 3.4§	–9.0 ± 5.0‡	–4.4 ± 5.6†
Bald Eagle	–	–	–	–1.2 ± 9.6
Northern Harrier	0.3 ± 6.7	–10.6 ± 6.2‡	–5.3 ± 4.0†	–10.6 ± 7.8‡
Sharp-shinned Hawk	0.7 ± 6.1	–8.3 ± 4.7*	–3.4 ± 3.1†	–5.6 ± 7.7§
Cooper's Hawk	2.1 ± 6.5§	–9.3 ± 4.5‡	–18.2 ± 5.8‡	–16.0 ± 8.3*
Northern Goshawk	–3.9 ± 8.7§	–13.9 ± 10.5‡	–	–
Broad-winged Hawk	–	–0.4 ± 6.5	–	–11.9 ± 9.4‡
Swainson's Hawk	–2.3 ± 10.2	5.4 ± 2.1‡	5.5 ± 3.9‡	8.7 ± 15.5§
Red-tailed Hawk	7.3 ± 3.7*	2.0 ± 1.5†	–14.3 ± 8.7‡	–6.2 ± 11.4§
Rough-legged Hawk	–	–	–	–
Golden Eagle	1.2 ± 4.2	–12.6 ± 4.7‡	–10.0 ± 5.8‡	–11.6 ± 17.8§
American Kestrel	–1.9 ± 4.3§	–8.2 ± 4.1‡	–4.1 ± 2.5‡	–2.8 ± 9.8
Merlin	6.3 ± 6.7†	–11.6 ± 6.4‡	–	–5.7 ± 14.3§
Peregrine Falcon	–	–	–	–
Prairie Falcon	–	–17.1 ± 7.7‡	–	–

Table 5. Continued.

	Pacific Coast	
	Chelan Ridge, Washington	Bonney Butte, Oregon
Turkey Vulture	5.0 ± 13.0[§]	5.5 ± 6.7[†]
Osprey	–6.0 ± 13.8[§]	2.2 ± 4.1[§]
Bald Eagle	–	2.0 ± 3.0[§]
Northern Harrier	–10.1 ± 11.6[†]	–3.3 ± 8.9[§]
Sharp-shinned Hawk	–12.8 ± 9.7[‡]	–0.1 ± 6.1
Cooper's Hawk	–6.3 ± 7.2[†]	–0.9 ± 6.0
Northern Goshawk	–12.9 ± 14.8[†]	–2.3 ± 8.8
Broad-winged Hawk	–	–
Swainson's Hawk	–	–
Red-tailed Hawk	–5.0 ± 10.5[§]	–1.7 ± 6.8
Rough-legged Hawk	–2.2 ± 10.5	–
Golden Eagle	4.5 ± 8.3[§]	–3.8 ± 5.5[§]
American Kestrel	–11.7 ± 13.5[†]	–7.9 ± 3.7[‡]
Merlin	–0.4 ± 10.3	2.1 ± 8.1
Peregrine Falcon	–	–
Prairie Falcon	–	–

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

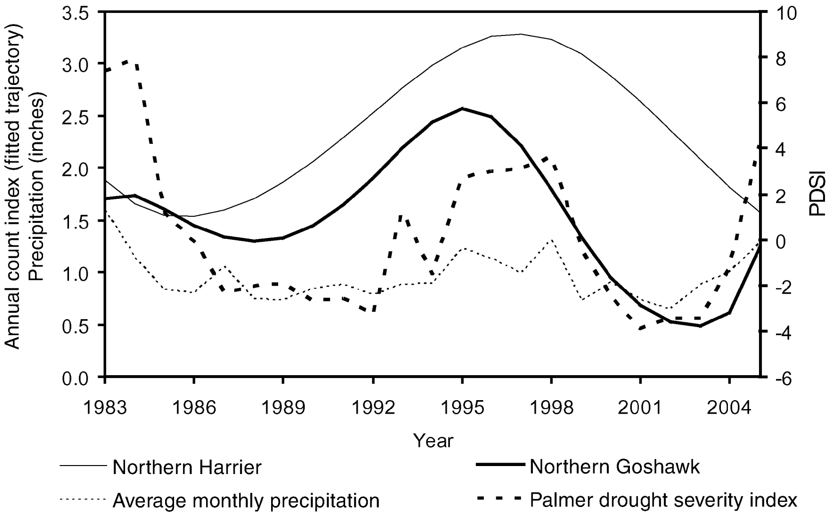

Fig. 3. Fitted trajectories of annual count indexes for selected species of migrating raptors in the Goshute Mountains, Nevada in relation to annual variation in regional drought severity and precipitation levels in the northern Great Basin since the 1980s (NOAA 2006; data represent the Nevada Division 2 geographic realm).

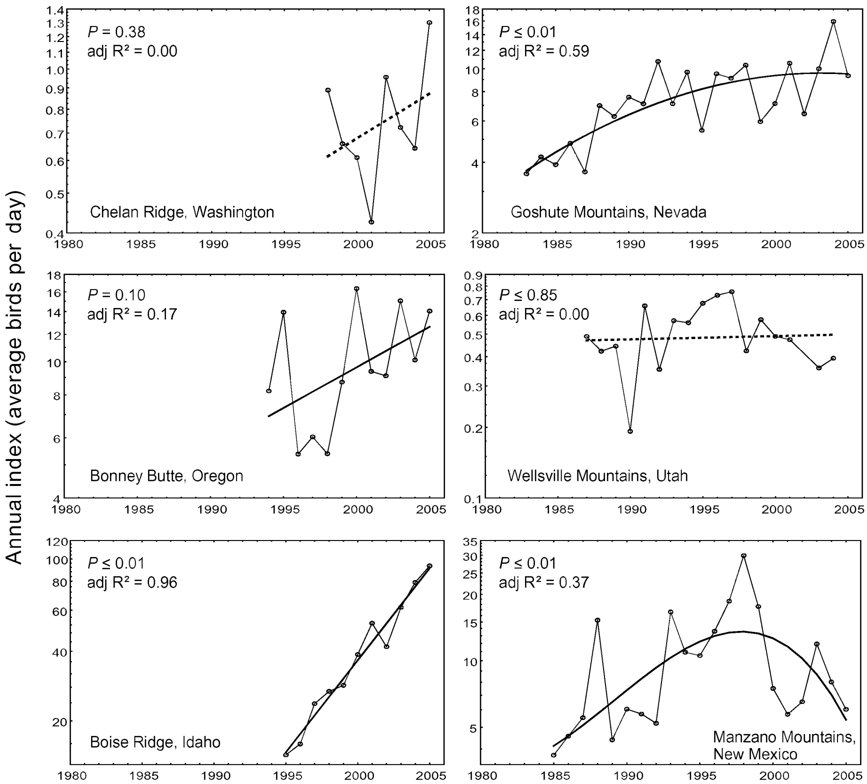

Fig. 4. Trends in annual count indexes of Turkey Vultures (*Cathartes aura*) at western migration sites since the early 1980s. Solid lines illustrate significant ($P \leq 0.10$) regression models; dashed lines illustrate nonsignificant ($P > 0.10$) best-fit models.

for some species (HawkWatch International [HWI] unpubl. data), the two appear to draw migrants of many species from different ranges. For many species, trends at Bonney Butte are more similar to those at Boise Ridge than to those at Chelan Ridge (Figs. 4–19). In particular, counts at both Bonney Butte and Boise Ridge remained high during the recent drought, whereas counts declined at Chelan Ridge and the Goshutes, which suggests that some intermountain migrants began flying southwest across Oregon and then down the Sierra Nevada–Cascade range at the onset of drought in the northern Great Basin.

Intermountain Migration Corridor.—At the Goshutes, the common pattern of change included low to moderate counts in the early 1980s, increases through about 1998, and stable or declining counts thereafter (Tables 4–5 and Figs. 4–19). Other watchsites in the corridor showed

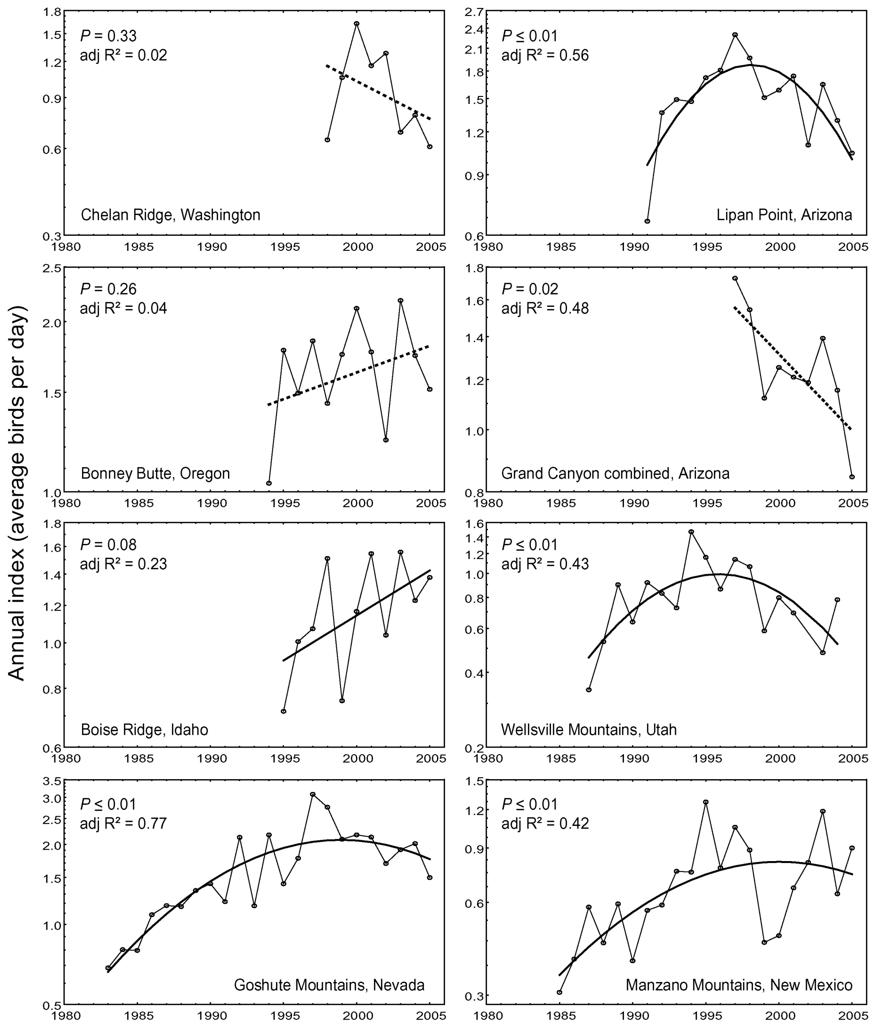

Fig. 5. Trends in annual count indexes of Ospreys (*Pandion haliaetus*) at western migration sites since the early 1980s. Solid lines illustrate significant ($P \leq 0.10$) regression models; dashed lines illustrate nonsignificant ($P > 0.10$) best-fit models.

similar patterns, which, since the early 1990s, parallel variation in drought severity in the region (e.g., see Fig. 3).

Rocky Mountain Migration Corridor.—For many species, patterns at the Manzanos and Wellsvilles were similar to those at the Goshutes (Figs. 4–19). That said, numbers of Sharp-shinned Hawks, Cooper's Hawks, American Kestrels, and Merlins decreased after the late 1990s in

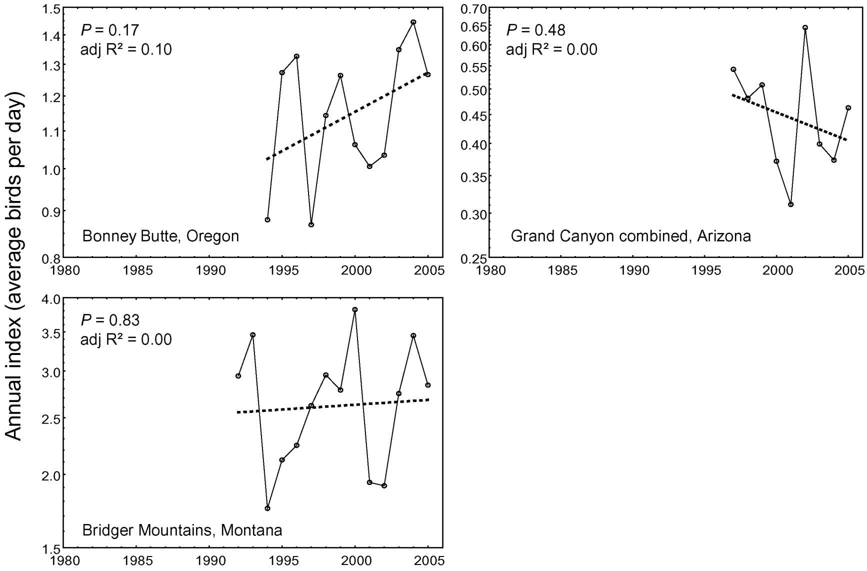

Fig. 6. Trends in annual count indexes of Bald Eagles (*Haliaeetus leucocephalus*) at western migration sites since the early 1980s. Dashed lines illustrate nonsignificant ($P > 0.10$) best-fit models.

the Goshutes and Wellsvilles, but were stable or increasing at the same time in the Manzanos (Figs. 8, 9, 16, and 17). Counts of Turkey Vultures remained relatively stable in the Goshutes, but declined significantly in the Manzanos and nonsignificantly in the Wellsvilles after 1997 (Fig. 4). Prairie Falcons declined significantly in the Goshutes and increased nonsignificantly in the Manzanos (Fig. 19). Other watchsites that began in the 1990s, including the Bridger Mountains and Mt. Lorette (Golden Eagles), showed patterns similar to those seen in the Wellsvilles and Manzanos.

Effects of drought.—There were 19 exchanges of banded accipiters between Boise Ridge and the Goshutes since 1995, and Red-tailed Hawks satellite tracked from the Goshutes passed through western Idaho (see Chapter 2). Nevertheless, the distribution of Boise Ridge band returns is decidedly more southwesterly (i.e., leading to primary winter ranges in southern California and northwestern Mexico; Idaho Bird Observatory [IBO] unpubl. data) than is that for the Goshutes (i.e., primary winter ranges from northwest to southwest Mexico; Hoffman et al. 2002). Moreover, 73% (n = 14) of Boise Ridge winter band returns from outside of Idaho since the drought began came from the west coast (Washington

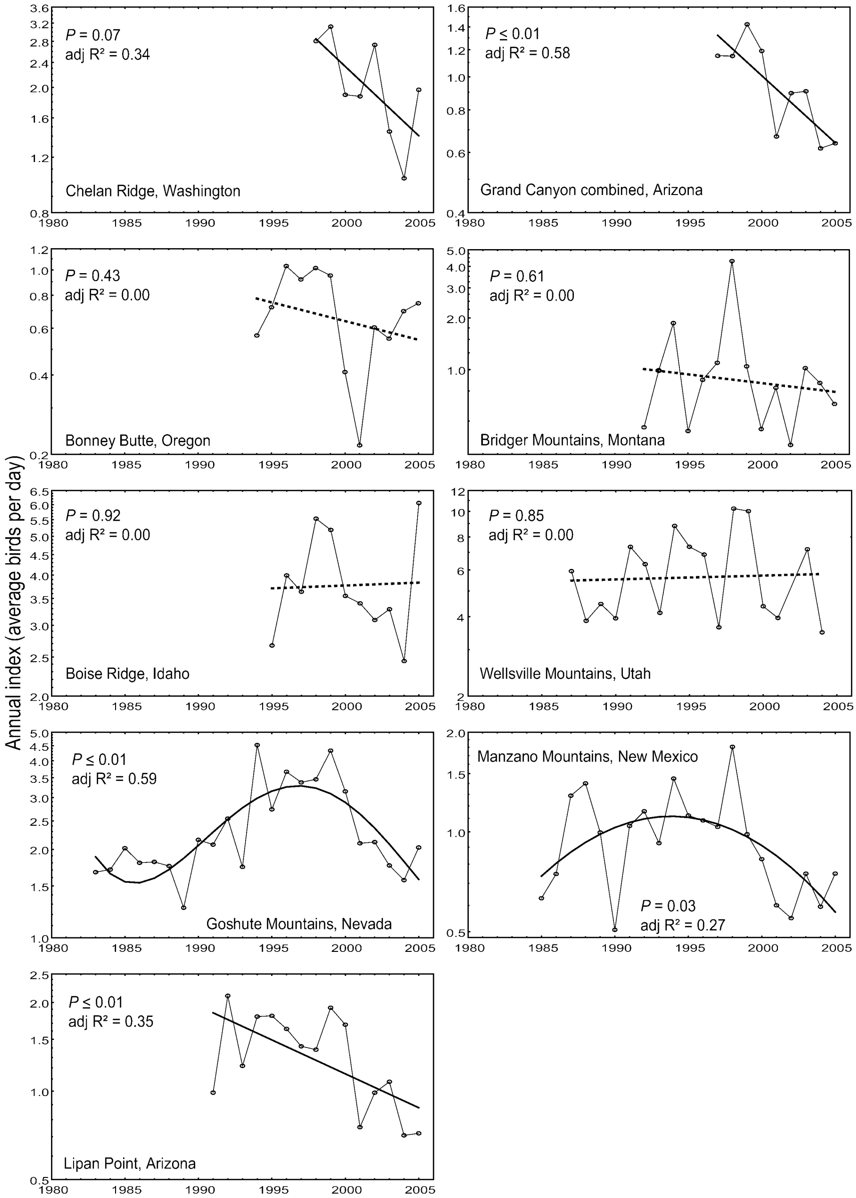

Fig. 7. Trends in annual count indexes of Northern Harriers (*Circus cyaneus*) at western migration sites since the early 1980s. Solid lines illustrate significant ($P \leq 0.10$) regression models; dashed lines illustrate nonsignificant ($P > 0.10$) best-fit models.

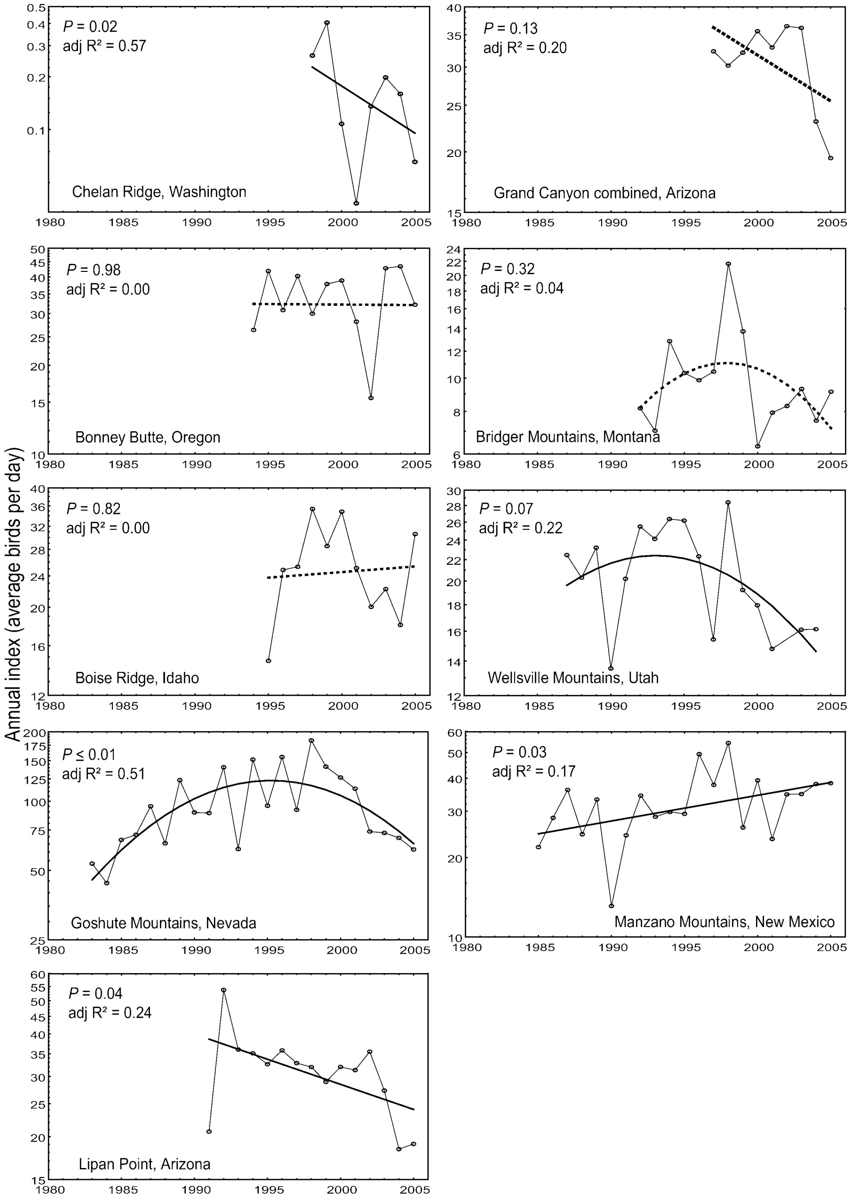

Fig. 8. Trends in annual count indexes of Sharp-shinned Hawks (*Accipiter striatus*) at western migration sites since the early 1980s. Solid lines illustrate significant ($P \leq 0.10$) regression models; dashed lines illustrate nonsignificant ($P > 0.10$) best-fit models.

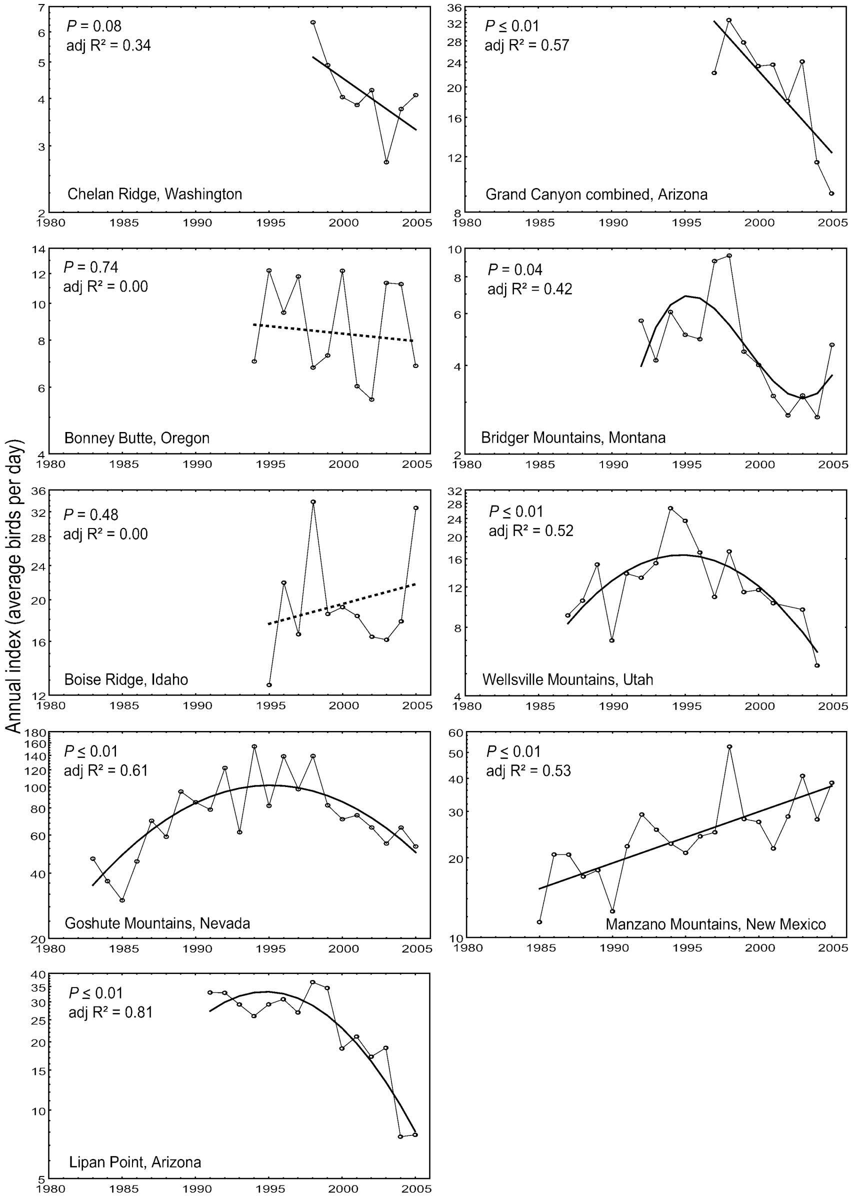

Fig. 9. Trends in annual count indexes of Cooper's Hawks (*Accipiter cooperii*) at western migration sites since the early 1980s. Solid lines illustrate significant ($P \leq 0.10$) regression models; dashed lines illustrate nonsignificant ($P > 0.10$) best-fit models.

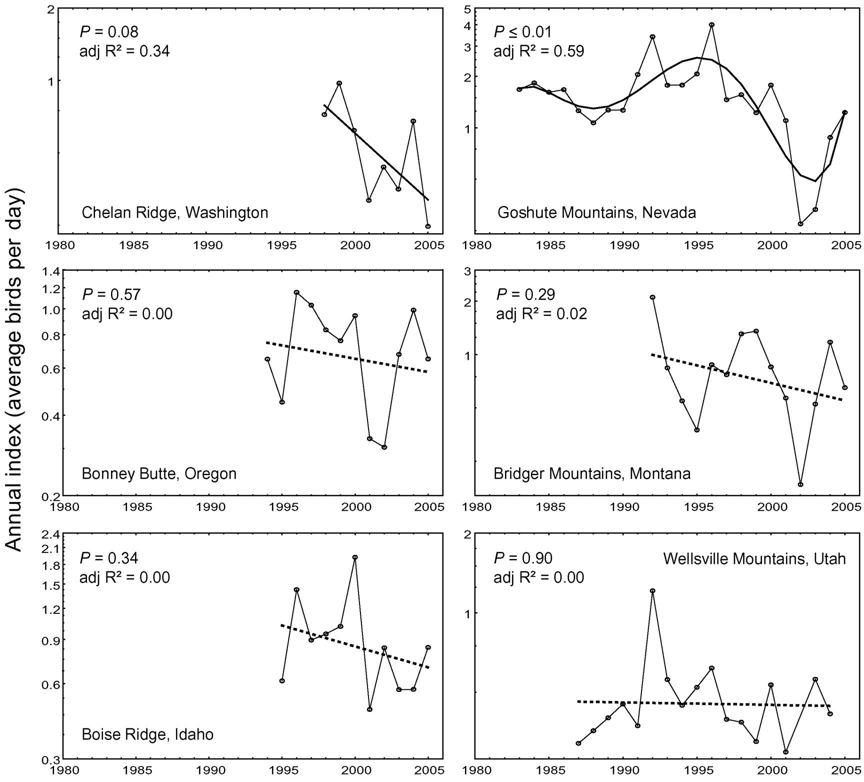

Fig. 10. Trends in annual count indexes of Northern Goshawks (*Accipiter gentilis*) at western migration sites since the early 1980s. Solid lines illustrate significant ($P \leq 0.10$) regression models; dashed lines illustrate nonsignificant ($P > 0.10$) best-fit models.

to Baja California), whereas only 38% ($n = 9$) of predrought returns came from this region. This suggests that Idaho migrants may have diverted west during the drought, presumably along other pathways to the Sierra–Cascade range.

The evidence above suggests that the relatively wet *El Nino* years of the early 1980s and early- to mid-1990s, interspersed with multiyear droughts in the late 1980s and, especially, since 1999, influenced the long-term patterns of migration across much of the interior West. The strongest correlations between regional moisture patterns and migration occurred in the central Intermountain corridor within the xeric Great Basin (e.g., see Fig. 3), in the Wellsville Mountains along the eastern edge of the Great Basin, and in the rain-shadow of the northeastern Cascade Mountains of Washington at the western edge of the Columbia Basin.

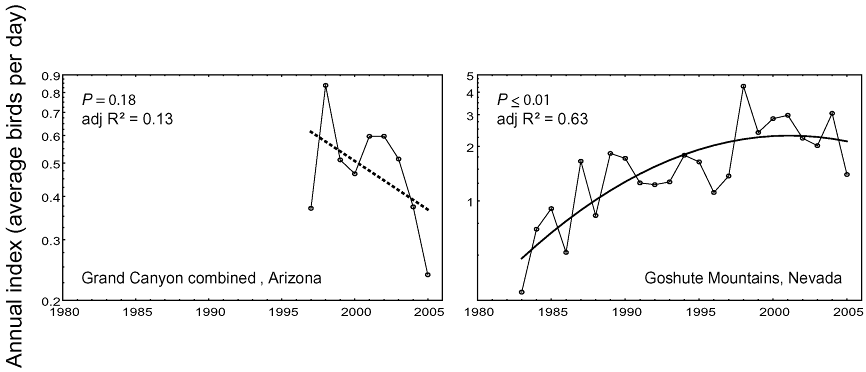

Fig. 11. Trends in annual count indexes of Broad-winged Hawks (*Buteo platypterus*) at western migration sites since the early 1980s. Solid lines illustrate significant ($P \leq 0.10$) regression models; dashed lines illustrate nonsignificant ($P >$ 0.10) best-fit models.

Apparent declines since 1998 often were less pronounced or less prolonged at the Manzanos in the southern Rocky Mountains compared with those at the Goshutes in northern Nevada (e.g., compare patterns for Sharp-shinned Hawks and Cooper's Hawks; Figs. 8 and 9). This suggests either that Rocky Mountain populations of several species were relatively unaffected by the drought, or that there was a shift in migration away from the Great Basin that augmented counts in central and southern Rocky Mountain, masking any declines. Finally, certain species, including Turkey Vulture, were less affected by regional moisture patterns than were others, including Ospreys, Northern Harriers, Sharp-shinned Hawks, and Cooper's Hawks.

Species Trends

Turkey Vulture.—We calculated trends for this species at six watchsites (Tables 3–5). Numbers increased either significantly or not significantly at all six sites (Tables 3–5).

Osprey.—We calculated trends for this species at eight watchsites (Tables 3–5). Overall, numbers followed the drought pattern mentioned above (Fig. 5). Long-term increases occurred at the Goshutes and the Manzanos (Tables 3–5). After 1997, numbers declined significantly at both the Wellsvilles and the combined Grand Canyon sites (Table 5).

Bald Eagle.—We calculated trends for Bald Eagles (*Haliaeetus leucocephalus*) at three watchsites (Bonney Butte, Bridger Mountains, and combined Grand Canyon) (Tables 3–5). No significant trends were detected (Tables 2–5 and Fig. 6). Late-season snowfall limits full-season mountaintop counts of this species (cf. Buehler 2000).

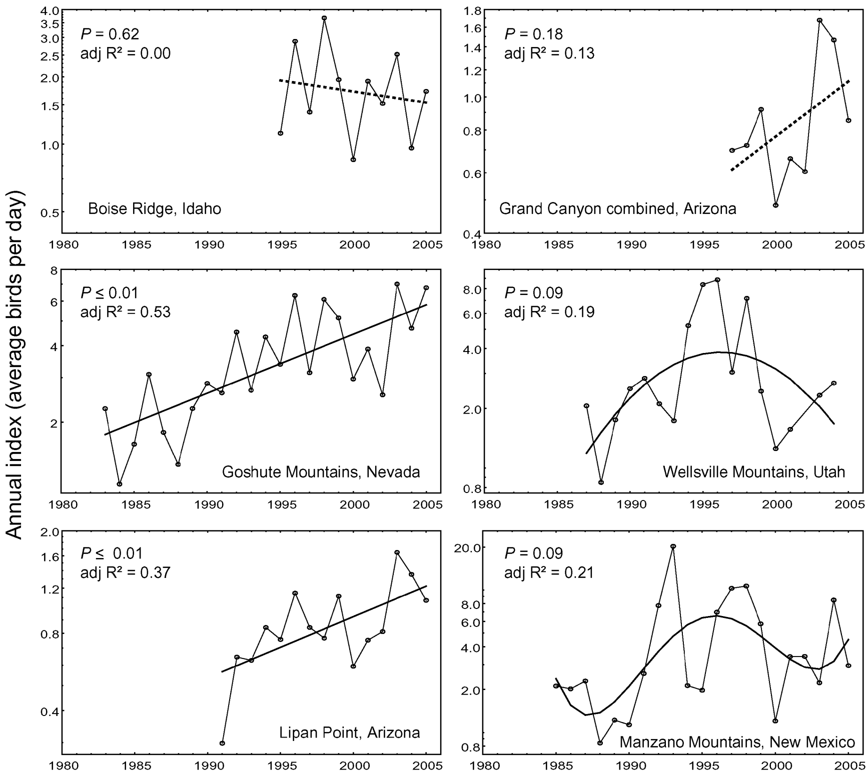

Fig. 12. Trends in annual count indexes of Swainson's Hawks (*Buteo swainsoni*) at western migration sites since the early 1980s. Solid lines illustrate significant ($P \leq 0.10$) regression models; dashed lines illustrate nonsignificant ($P > 0.10$) best-fit models.

Northern Harrier.—We calculated trends for this species at eight watchsites (Tables 3–5). Numbers at the Goshutes and Manzanos followed the drought pattern of increases before 1998 and declines thereafter, with no long-term trends (Fig. 7). No long-term trend occurred at the Wellsvilles, where there was a somewhat cyclical pattern of abrupt increases every three to four years followed by two to three years of gradual decline. After 1998, harriers declined significantly at five sites (Table 5).

Sharp-shinned Hawk.—We calculated trends for this species at nine watchsites (Tables 3–5). Counts of at the three longest-term sites followed the drought pattern, at least through 2001 (Fig. 8). Counts at the Goshutes continued to decline after 2001, whereas those at the Manzanos increased, and those at the Wellsvilles remained stable. Overall, there were significant

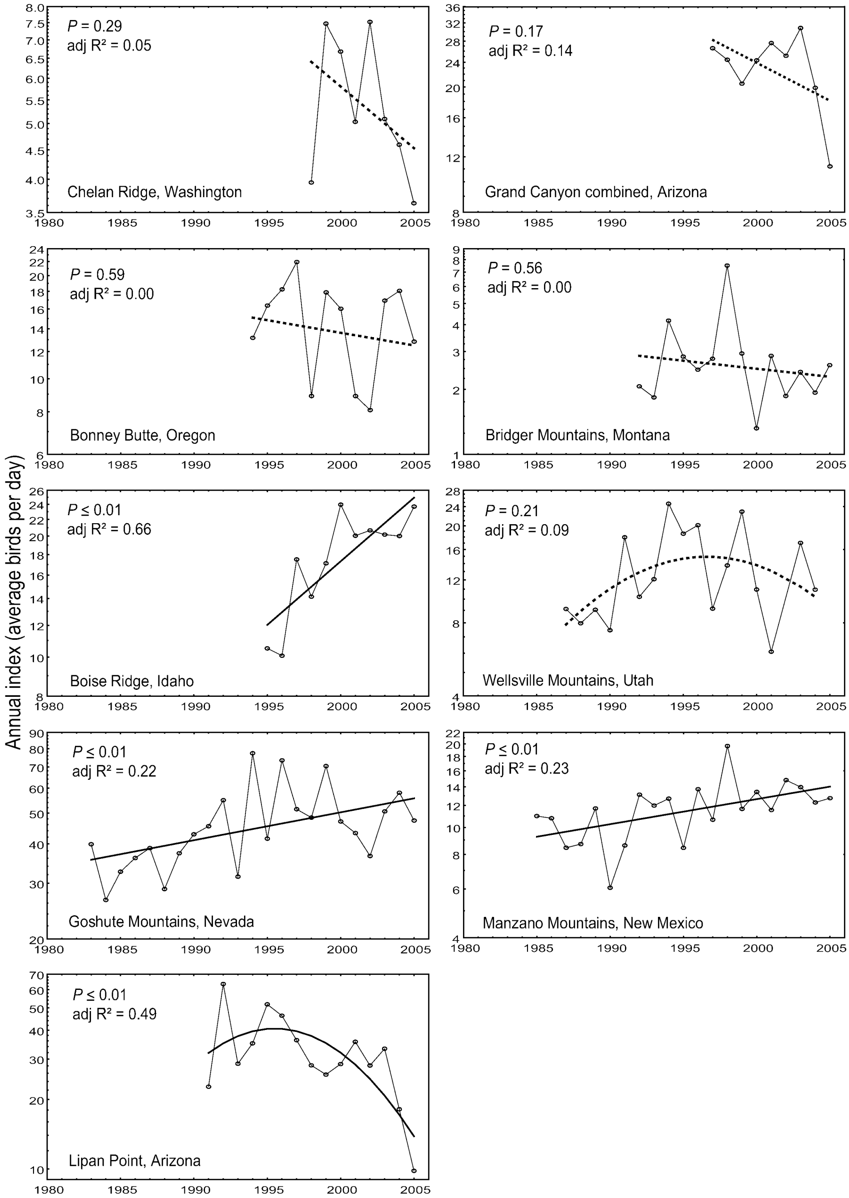

Fig. 13. Trends in annual count indexes of Red-tailed Hawks (*Buteo jamaicensis*) at western migration sites since the early 1980s. Solid lines illustrate significant ($P \leq 0.10$) regression models; dashed lines illustrate nonsignificant ($P > 0.10$) best-fit models.

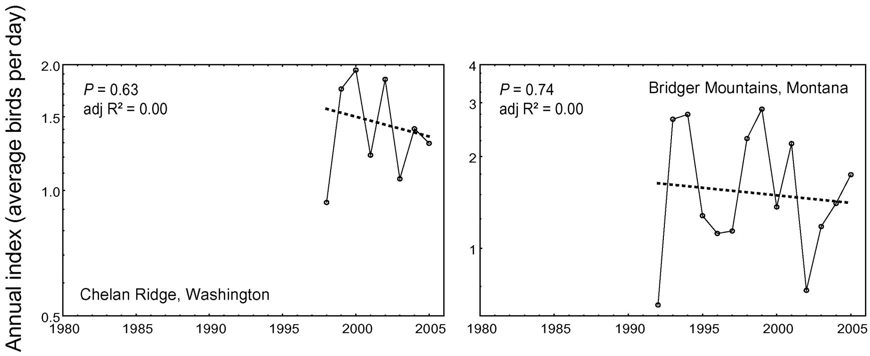

Fig. 14. Trends in annual count indexes of Rough-legged Hawks (*Buteo lagopus*) at western migration sites since the early 1980s. Dashed lines illustrate nonsignificant ($P > 0.10$) best-fit models.

declines at four of eight sites since 1998, but a significant increase in the Manzanos (Table 5).

Cooper's Hawk.—We calculated trends for this species at nine watchsites (Tables 3–5). In general, trends for Cooper's Hawks were similar to those for Sharp-shinned Hawks (Tables 3–5). At the Bridger Mountain site and at Lipan Point in the Grand Canyon, Cooper's Hawks declined more steeply than Sharp-shinned Hawks since 1998 (Fig. 9), whereas the reverse was true at Chelan Ridge. In the Manzanos, Cooper's Hawks increased at twice the rate of Sharp-shinned Hawks.

Northern Goshawk.—We calculated trends for this species at six watchsites (Tables 3–5). Northern Goshawks are relatively sedentary across most of North America, with dispersal and migration generally restricted to <200 km, and irruptive movements largely limited to northern populations (Mueller et al. 1977, Squires and Reynolds 1997, Sonsthagen et al. 2006). This suggests that migration counts typically reflect local rather than regional population trends. Numbers of the species declined significantly at the Goshutes and at Chelan Ridge (Tables 3–5 and Fig. 10). Irruptive movements peaking in 1992–1993 occurred at the Goshutes, Wellsvilles, and Bridger Mountains (Hoffman and Smith 2003). Even so, the species clearly exhibited drought-related patterns at the Goshutes, Chelan Ridge, and, possibly, the Bridgers.

Broad-winged Hawk.—Broad-winged Hawks are less common in western North America than in eastern North America (Goodrich et al. 1996). The highest average counts in the West, a long-term average of slightly more than 100 birds, occur at the Golden Gate Raptor Observatory on the Marin Headlands of central California (A. Fish pers. comm.).

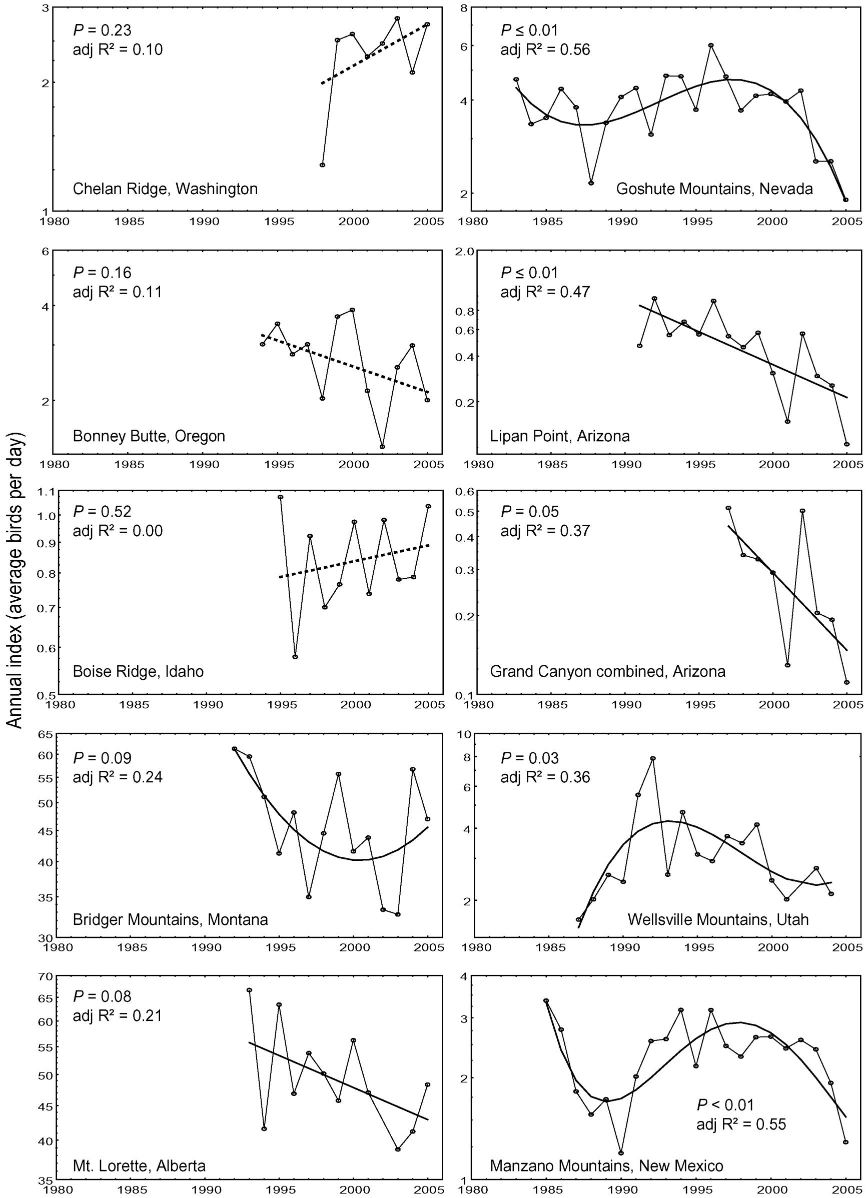

Fig. 15 Trends in annual count indexes of Golden Eagles (*Aquila chrysaetos*) at western migration sites since the early 1980s. Solid lines illustrate significant ($P \leq 0.10$) regression models; dashed lines illustrate nonsignificant ($P > 0.10$) best-fit models.

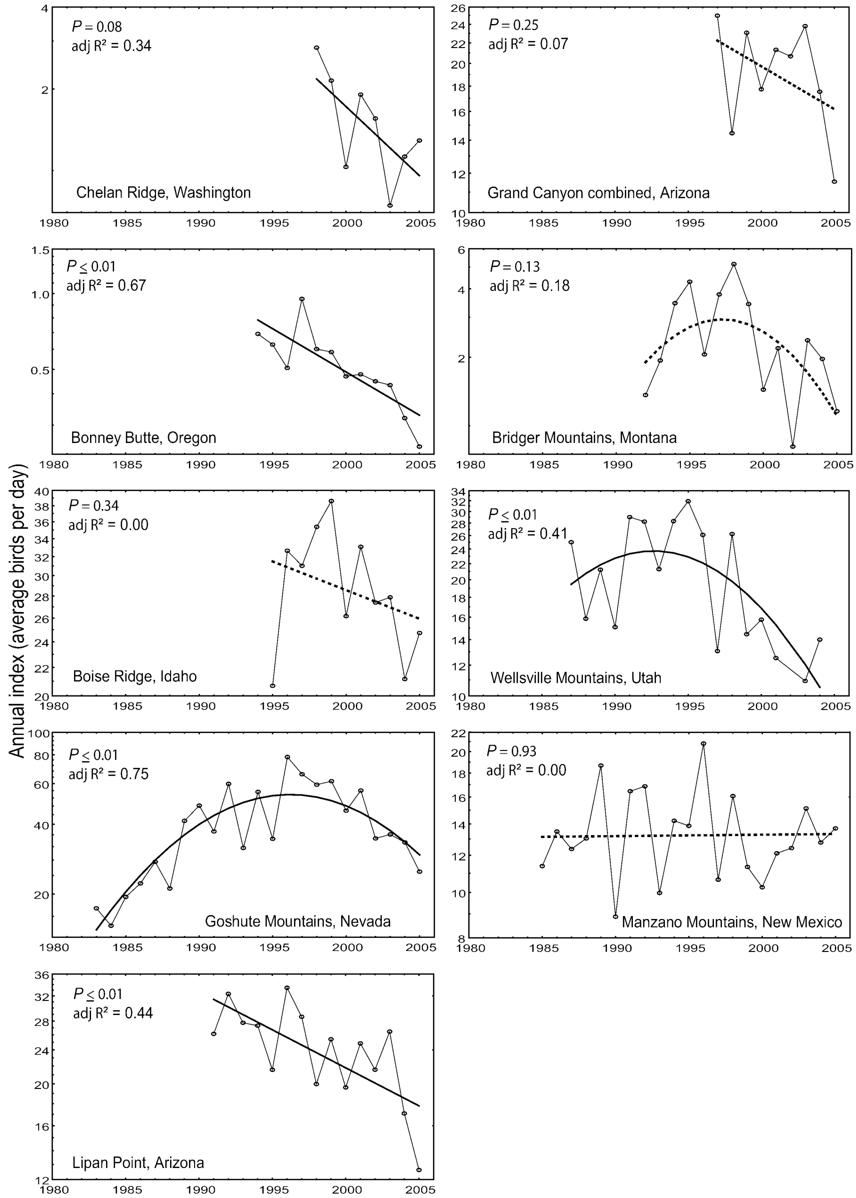

Fig. 16. Trends in annual count indexes of American Kestrels (*Falco sparverius*) at western migration sites since the early 1980s. Solid lines illustrate significant ($P \leq 0.10$) regression models; dashed lines illustrate nonsignificant ($P > 0.10$) best-fit models.

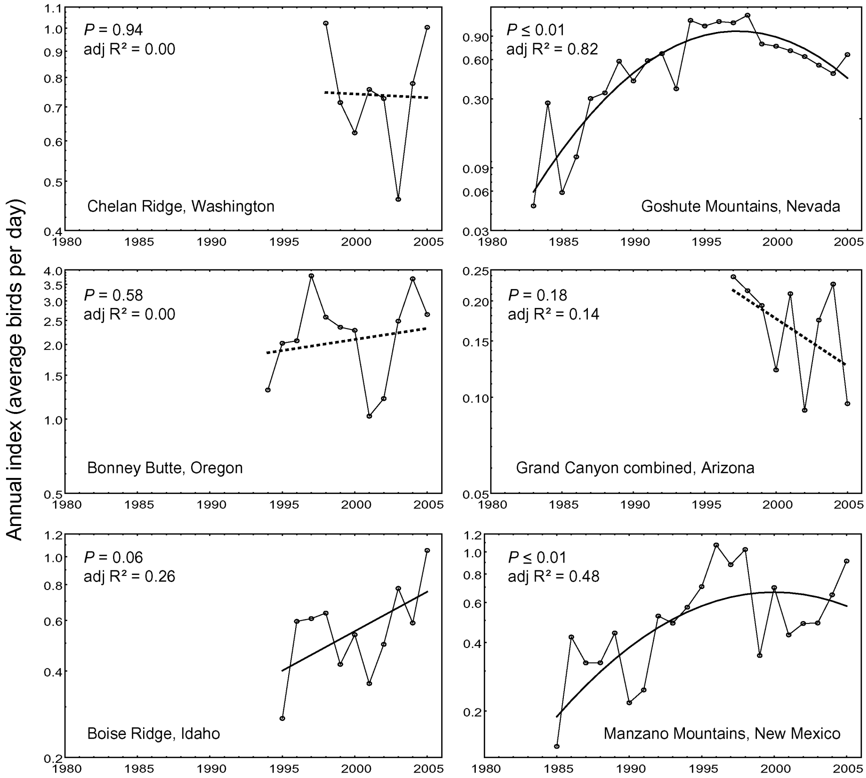

Fig. 17. Trends in annual count indexes of Merlins (*Falco columbarius*) at western migration sites since the early 1980s. Solid lines illustrate significant ($P \leq 0.10$) regression models; dashed lines illustrate nonsignificant ($P > 0.10$) best-fit models.

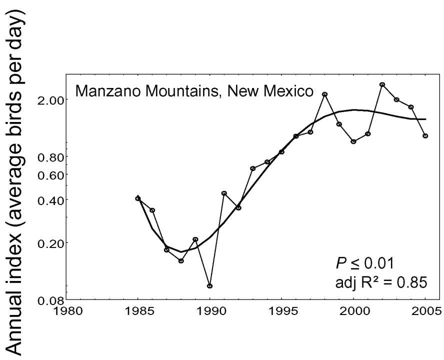

Fig. 18. Trends in annual count indexes of Peregrine Falcons (*Falco peregrinus*) at western migration sites since the early 1980s. The solid line illustrates a significant ($P \leq 0.10$) regression model.

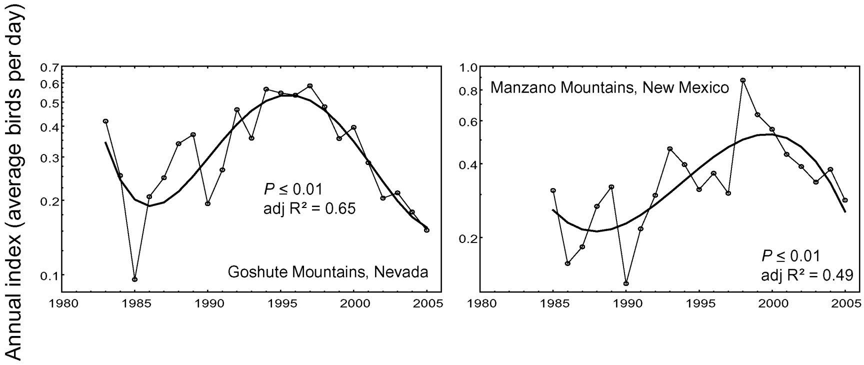

Fig. 19. Trends in annual count indexes of Prairie Falcons (*Falco mexicanus*) at western migration sites since the early 1980s. Solid lines illustrate significant ($P \leq 0.10$) regression models.

We calculated trends for this species at two watchsites (Tables 2–5). There was a significant long-term increase at the Goshutes, with numbers stabilizing after 1999 (Tables 3–5 and Fig. 11). Counts at the Grand Canyon declined significantly after 1997 (Table 5).

Swainson's Hawk.—We calculated trends for Swainson's Hawks at five watchsites (Tables 3–5). Significant long-term increases occurred at the Goshutes and Lipan Point. The Wellsvilles, Goshutes, Manzanos, and Lipan Point indicated increases through the late 1990s, and brief declines thereafter (except at Lipan Point) followed by increases (Fig. 12).

Red-tailed Hawk.—We calculated trends for this species at nine watchsites (Tables 3–5). Significant long-term increases in counts occurred at the Goshutes and Manzanos, with a significant short-term increase at Boise Ridge since 1995 (Fig. 13). A significant long-term decline occurred at Lipan Point. Numbers at the combined Grand Canyon and Wellsville sites followed the drought pattern (Tables 3–5).

Rough-legged Hawk.—We calculated trends for Rough-legged Hawks at two watchsites (Table 3 and Fig. 14). There were no significant trends at either Chelan Ridge or the Bridger Mountains sites. Late-season snowfall limits full-season mountaintop counts of this species (cf. Bechard and Swem 2002).

Golden Eagle.—We calculated trends for Golden Eagles at 10 watchsites. Numbers declined significantly at five sites and were stable or increasing at five sites (Fig. 15). The Goshutes and Manzanos showed significant long-term declines of similar magnitude (Table 3). Farther south, the combined Grand Canyon count exhibited a similar trend (Table 5). Mt. Lorette and Bridger Mountains, both of which count thousands of individuals annually (Table 2), exhibited trends similar to those seen at most other sites (Fig. 15), with declines beginning in the early 1990s (Table 3).

American Kestrel.—We calculated trends for American Kestrels at eight watchsites. Long-term trends were mixed, but numbers declined at seven of the sites since 1997 (Tables 3–5). Counts at the Goshutes and Boise ridge followed the drought pattern (Table 5 and Fig. 16), but long-term trends were increasing (Table 3). Trends at the combined Grand Canyon were similar, but the post-1997 decline there was less steep than at the Goshutes (Table 5). Numbers at the Manzanos were stable. Numbers at the Wellsvilles and Bridgers tracked the drought, and long-term trends at the two sites were negative, significantly so at the Wellsvilles. Declines also occurred at Bonney Butte and Chelan Ridge in the Pacific Coast corridor.

Merlin.—We calculated trends for this species at six watchsites. Numbers increased at the Goshutes and at Boise Ridge but declined at the combined Grand Canyon (Tables 3–5 and Fig. 17). Numbers at the Manzanos tracked the drought, but increased significantly in the long-term. There were no significant trends at Bonney Butte or Chelan Ridge (Table 5). Recent declines at the Goshutes and Grand Canyon, but not at Boise Ridge, combined with the fact that Merlins do not breed in the Great Basin, suggest that birds shifted their movements geographically in response to the drought.

Peregrine Falcon.—We calculated trends for this species at one watchsite. Numbers increased 9.6% annually at the Manzanos (Table 3 and Fig. 18), with numbers following the drought pattern. Nearly identical patterns of long-term variation were evident at the Goshutes and Wellsville sites (see Hoffman and Smith 2003).

Prairie Falcon.—We calculated trends for this species at two watchsites (Tables 3–5). Numbers at the Goshutes and Manzanos sites followed the drought pattern similar to Northern Goshawks and Golden Eagles (Fig. 19). Numbers declined significantly at the Goshutes over the long term, whereas recent counts at the Manzanos are above those from the 1980s.

Summary of Trends

Western counts of six species increased since the early 1980s, whereas those of three species declined. Three species showed mixed trends, and counts of Northern Harriers were relatively stable (Table 6). Counts of 13 species appear to have been affected by a regional drought, with increases up to 1998, and declining or stable numbers thereafter.

Acknowledgments

The analyses presented here could not have been accomplished without the efforts of hundreds of volunteer migration counters. Each migration

Table 6. Summary of trends at western watchsites.

Species	1980s to 2005 (three sites)	1980s to 1997 (five sites)	1998–2005 (nine sites)	Overall pattern
Turkey Vulture	Stable–Increase	Stable–Increase	Variable	Uniformly stable to increasing, except for a decline in New Mexico since 1998.
Osprey	Increase	Increase	Variable	Long-term and pre-1998 increases at most pre-mid-1990s sites; declines common since 1998.
Bald Eagle	–	Stable	Stable	No trends in Montana, Arizona, and Oregon.
Northern Harrier	Stable	Variable	Decrease	No long-term or 1980s to 1997 trends at most pre-mid-1990s sites; declines common since 1998.
Sharp-shinned Hawk	Variable	Variable	Variable	Increases common pre-1998; declines common since.
Cooper's Hawk	Increase	Increase	Variable	Long-term and 1980s to 1997 increases at most pre-mid-1990s sites; declines common since 1998.
Northern Goshawk	Stable–Decrease	Stable	Stable–Decrease	Uniformly stable or slight declines except for long-term decline in Nevada and a recent decline in Washington.
Broad-winged Hawk	Increase	Increase	Stable–Decrease	Long-term increase in Nevada, but stable there since 1998; recent decline in Arizona.
Swainson's Hawk	Stable-Increase	Increase	Variable	Uniformly increasing 1980s to 1997; mixed trends since 1998.
Red-tailed Hawk	Increase	Increase	Variable	Mostly long-term and 1980s to 1997; mostly stable or slight declines since 1998.
Rough-legged Hawk	–	Stable	Stable	Stable or slight declines in Montana since 1992 and in Washington since 1998.
Golden Eagle	Decrease	Stable–Decrease	Stable–Decrease	Declines at most long-term and at both high-volume northern Rockies sites; declines common since 1998.

Table 6. Continued.

Species	1980s to 2005 (three sites)	1980s to 1997 (five sites)	1998–2005 (nine sites)	Overall pattern
American Kestrel	Variable	Variable	Decrease	Variable long-term and 1980s to 1997 trends; declines common since 1998.
Merlin	Increase	Increase	Variable	Uniformly increasing long-term and pre-1998; mostly stable to decreasing after 1997.
Peregrine Falcon	Increase	Increase	Stable	Long-term and 1980s to 1997 increases in New Mexico; stable or slight declines since 1998.
Prairie Falcon	Stable–decrease	Increase	Decrease	Long-term decline in Nevada; long-term stable or slight increase in New Mexico, with increases at both sites before 1998, then declines.

Notes: Decrease = significant ($P \leq 0.10$) decreases at most sites and no significant increases; Increase = significant increases at most sites and no significant decreases; Stable–Decrease = most of trends nonsignificant, but at least one significant decrease and no significant increases; Stable-Increase = most trends nonsignificant, but at least one significant increase and no significant decreases; Variable = at least one significant decrease and one significant increase; Stable = no significant trends.

season, these individuals spent long hours and endured harsh conditions to advance our understanding of raptor ecology, and we heartily thank them for their service and dedication.

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7

Trends in Autumn Counts of Migratory Raptors Around the Gulf of Mexico, 1995–2005

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Abstract.—We estimated trends in autumn counts of migrating diurnal raptors collected at four watchsites around the Gulf of Mexico: Florida Keys Raptor Migration Project at Curry Hammock State Park in the Florida Keys (1999–2005); Smith Point Raptor Migration Project and Corpus Christi Raptor Migration Project, Texas (1997–2005); and Veracruz River of Raptors, Mexico (a two-site transect, 1995–2005) (Chapter 8). Four species—Turkey Vulture (*Cathartes aura*; 35–40%), Broad-winged Hawk (*Buteo platypterus*; 35–40%), Swainson's Hawk (*B. swainsoni*; 15–20%), and Mississippi Kite (*Ictinia mississippiensis*; 2–5%)—make

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up >90% of the Texas and Veracruz totals. We estimated geometric-mean rates of change in annual count indexes for 17 species. Seven species—Turkey Vulture, Osprey (*Pandion haliaetus*), Swallow-tailed Kite (*Elanoides forficatus*), Mississippi Kite, Swainson's Hawk, Zone-tailed Hawk (*B. albonotatus*), and Peregrine Falcon (*Falco peregrinus*)—increased significantly at one or more sites. Northern Harriers (*Circus cyaneus*) and Sharp-shinned Hawks (*Accipiter striatus*) were the only species that declined at all sites. Both declined significantly ($P \leq 0.10$) in Florida, and Northern Harriers also declined significantly in Veracruz. American Kestrels (*F. sparverius*) and Merlins (*F. columbarius*) declined significantly in Florida. Red-shouldered Hawks (*B. lineatus*) were stable at Smith Point but declined at Corpus Christi. No trends were detected for Black Vultures (*Coragyps atratus*) in Texas, for Red-tailed Hawks (*B. jamaicensis*) in Texas and Veracruz, and for Cooper's Hawks (*A. cooperii*) at any site. Precision of trend estimates was low because of brief monitoring periods (i.e., ≤11 years) and relatively high interannual variability in counts.

Introduction

Each autumn, more than 30 species of diurnal raptors migrate around or across the Gulf of Mexico on their way to wintering grounds farther south (Zalles and Bildstein 2000). Most can be readily observed as they migrate past traditional watchsites, where trained observers monitor their numbers (e.g., Smith et al. 2001, Ruelas 2005, Lott 2006).

We analyzed migration counts spanning periods of different lengths between 1995 and 2005 from four migration watchsites around the Gulf of Mexico, from the Florida Keys west to Veracruz, Mexico (Table 1 and Fig. 1). The conservation status of species and the implications of trends are discussed in Chapter 9.

The Veracruz River of Raptors watchsite in southeastern Mexico monitors the world's largest known concentration of migratory raptors, with 4–6 million migrants passing each autumn (Ruelas et al. 2000, Bildstein 2006). Flights there include most of the world populations of Mississippi Kites (*Ictinia mississippiensis*), Broad-winged Hawks (*Buteo platypterus*), and Swainson's Hawks (*B. swainsoni*), all of which winter in Central and South America (Bildstein 2006). The Veracruz flight also includes a large proportion of the western North American population of Turkey Vultures (*Cathartes aura*), which, together with Broad-winged Hawks, are the most abundant raptors counted there.

The largest concentrations of migrating raptors in the United States and Canada appear at the Corpus Christi Raptor Migration Project (Smith et al. 2001, Bildstein 2006). Turkey Vultures, Mississippi Kites, Swainson's Hawks, and, especially, Broad-winged Hawks typically comprise >98% of the flight.

The Florida Keys Raptor Migration Project monitors the largest known migratory concentration of Peregrine Falcons (*Falco peregrinus*) in the United States and Canada, with an average annual total exceeding 1,800 birds (Lott 2006).

Table 1. Details of watchsites included in this analysis.

Watchsites	Latitude	Longitude	Count years	Count season	Mean (range) days $season^{-1}$	Mean ± SD h day^{-1}	Standardized daily window (n h)
Curry Hammock State Park, Florida [a]	24°44′N	80°59′W	1999–2005	15 Sept.–13 Nov. [b]	54 (37–60)	7.5 ± 1.3	0800–1600 (8)
Smith Point, Texas [c]	29°31′N	94°45′W	1997–2005	15 Aug.–15 Nov.	91 (86–94)	8.2 ± 2.0	0600–1500 (9)
Corpus Christi, Texas [d]	27°52′N	97°38′W	1997–2005	15 Aug.–15 Nov.	90 (83–93)	7.4 ± 2.0	0700–1500 (8)
Veracruz River of Raptors, Mexico [e]	19°22′N	96°22′W	1995–2005	20 Aug.–20 Nov.	92 (90–93)	9.3 ± 1.3	0800–1700 (9)

[a] Counts were made from second-story balcony of a building.

[b] 23 September to 30 October 1999; 15 September to 7 November 2005 (purposeful adjustment of ending date).

[c] Counts made from 7-m tower.

[d] Two count sites. Given coordinates are for site at Cardel, where counts were made from atop a five-story hotel in the middle of the city. In Chichicaxtle (19°21′N, 96°28′W), counts were made from a 7-m tower near a soccer field.

Fig. 1. Autumn raptor-migration monitoring sites around the Gulf of Mexico.

We treated the four sites together because of their common geographic location around the Gulf of Mexico. This is not meant to imply that the four sites necessarily draw from the same source populations.

For species such as the Broad-winged Hawk, which breed mainly in the eastern half of the continent and move into Central and South America for the winter (Goodrich et al. 1996), the progression of migrants from Smith Point to Corpus Christi to Veracruz (Fig. 1) probably results in replication of sampling. Similarly, Mississippi Kites and Swainson's Hawks accumulate along the principal flight-line during their southbound migrations (England et al. 1997), so that hundreds pass Smith Point, thousands pass Corpus Christi, and hundreds of thousands pass Veracruz (Fuller et al. 1998). All three species also are seen in the Florida Keys in relatively low numbers.

Satellite tracking and band recoveries indicate that Peregrine Falcons passing through the Florida Keys include those breeding in western Canada and Alaska as well in Greenland and eastern North America (Fuller et al. 1998; Chapter 2). Satellite tracking also indicates that some Ospreys (*Pandion haliaetus*) from the upper Midwest travel through the Florida Keys before crossing to Cuba on their way south, whereas others travel through Texas and around the western Gulf Coast (Martell et al. 2001). Most other species reported around the Gulf Coast are short- or moderate-distance partial migrants whose winter ranges overlap some or all of the four sites (e.g., Sharp-shinned Hawks [*Accipiter striatus*], Bildstein and Meyer 2000).

The Texas and Veracruz sites are on broad coastal plains where thermals provide lift for migrating raptors. In such cases, obligate-soaring migrants (*sensu* Alerstam 1992) travel in narrow-front migrations following *thermal pathways* (Schüz et al. 1971, Berthold 2001), the distribution of which changes depending on the weather (Kerlinger 1989, Bildstein 2006). Shifts in flight-line locations can be important when monitoring obligate "super-flocking" species (*sensu* Bildstein 2006), such as Turkey Vultures, Mississippi Kites, Broad-winged Hawks, and Swainson's Hawks, which are the most abundant migrants in Texas and Veracruz. Because such species generally travel in large flocks, any significant shift in the predominant flight line can dramatically affect counts and increase annual variability, potentially making it difficult to determine long-term trends. The presence of such sources of extrinsic variation unrelated to population change may require longer time series (20–25 years) to provide adequate statistical power for detecting underlying population trends (Lewis and Gould 2000; Chapter 8).

Methods

Data Collection

We used hourly counts to develop annual indexes and trend estimates. Site coverage ranged from 7 to 11 years (Table 1). Counts were conducted as described in Chapters 5 and 6. Daily monitoring for eight to nine hours between early to mid-morning and mid- to late afternoon was the standard target at all sites. Inclement weather sometimes reduced daily coverage, whereas large flights sometimes resulted in expanded daily coverage. We truncated data as described in Chapter 5 to reduce the effect of such variability.

Data-collection protocols are described in Lott (2006) for the Florida Keys, Smith et al. (2001) for the two sites in Texas, and Ruelas (2005) for Veracruz. Counts in Florida and Texas occurred at single observation points. Veracruz counts were made at two observation points 11 km apart (see Chapter 8).

Counts in Florida and at Smith Point were conducted by two primary observers, with local volunteers assisting as substitutes at Smith Point and others opportunistically assisting at both sites. Counts in Corpus Christi were conducted by three, full-season observers, with local volunteers assisting. Counts in Veracruz were conducted by a rotating group of six primary observers and three recording assistants, with two primary counters and one assistant working each site daily on a two-day-on, one-day-off work shift.

Trend Analysis

We used analytical methods outlined in Chapter 5, with one exception. We followed a special approach outlined in Hussell (1981) and Francis and Hussell (1998) to combine counts from the two Veracruz sites to derive integrated annual count indexes. Because of irregularities in the data, we excluded the 1997 counts at Veracruz for four large-volume, obligate-flocking migrants (i.e., Turkey Vultures, Broad-winged Hawks, Swainson's Hawks, and Mississippi Kites).

Results and Discussion

Approximately 5 million raptors of 20 species were counted each year at the four watchsites from 1995 to 2005 (e.g., see Table 2). They included nearly the entire North American populations of Mississippi Kites, Broad-winged Hawks, and Swainson's Hawks. Precision was low for all trend estimates, at least in part because of the short durations of all monitoring records (Table 3). Even so, 29 of 53 (55%) cases had 95% confidence intervals (CI) of ±10% per year or less, which suggests a high likelihood that 20–25 years of data will produce at least moderate-precision estimates (see Chapter 6).

Regional Patterns in Trends

Species with declining trends.—Only Northern Harriers (*Circus cyaneus*) and Sharp-shinned Hawks declined at all four sites. Both showed significant declines in the Florida Keys. Harriers also declined significantly at

Table 2. Average autumn migration counts (coefficient of variation [CV]) for 17 species of raptors seen at Gulf Coast watchsites.

Species	Florida Keys, Florida	Smith Point, Texas	Corpus Christi, Texas	Veracruz, Mexico
Black Vulture (*Coragyps atratus*)	–[a]	177 (81)	551 (79)	–
Turkey Vulture (*Cathartes aura*)	–[a]	1,529 (56)	20,996 (57)	1,988,826 (23)
Osprey (*Pandion haliaetus*)	1,154 (24)	65 (20)	167 (30)	2,969 (28)
Hook-billed Kite (*Chondrohierax uncinatus*)	–	<1	<1	177 (34)
Swallow-tailed Kite (*Elanoides forficatus*)	10 (75)	82 (54)	30 (69)	167 (34)
Mississippi Kite (*Ictinia mississippiensis*)	19 (92)	4,320 (51)	7,020 (40)	155,651 (46)
Northern Harrier (*Circus cyaneus*)	533 (33)	330 (40)	159 (47)	407 (55)
Sharp-shinned Hawk (*Accipiter striatus*)	2,971 (47)	2,913 (40)	1,076 (33)	4,542 (55)
Cooper's Hawk (*A. cooperii*)	536 (54)	1,125 (14)	663 (45)	2,529 (33)
Red-shouldered Hawk (*Buteo lineatus*)	14 (96)	47 (42)	52 (51)	10 (56)
Broad-winged Hawk (*B. platypterus*)	3,737 (28)	38,643 (73)	609,719 (45)	1,919,949 (13)
Swainson's Hawk (*B. swainsoni*)	81 (60)	298 (98)	6,209 (77)	915,104 (32)
Zone-tailed Hawk (*B. albonotatus*)	–	–	3 (105)	137 (41)
Red-tailed Hawk (*B. jamaicensis*)	2 (109)	141 (76)	173 (38)	192 (35)
American Kestrel (*Falco sparverius*)	2,596 (41)	1,334 (28)	506 (38)	8,252 (95)
Merlin (*F. columbarius*)	524 (33)	57 (36)	31 (38)	174 (48)
Peregrine Falcon (*F. peregrinus*)	1,826 (28)	89 (20)	155 (37)	745 (42)
Total raptors	13,981 (19)	51,275 (57)	639,551 (41)	5,260,871 (19)

[a] Vultures were not counted at this site.

Veracruz (Tables 3 and 4). Red-shouldered Hawks (*B. lineatus*), American Kestrels (*Falco sparverius*), and Merlins (*F. columbarius*) also declined at one or more sites.

Species with increasing trends.—Swainson's Hawks increased significantly at both Texas sites and in Veracruz (Tables 3 and 4). Mississippi Kites increased at Veracruz and Smith Point, most clearly so at Veracruz. Interannual fluctuations in vulture counts were too great at Smith Point and Corpus Christi to yield reasonably precise trend estimates (Table 3). Overall, Ospreys increased from 2.8% to 9.0% per year at all four sites (Fig. 4). Ospreys increased at Veracruz until the late 1990s and declined thereafter. Swallow-tailed Kites (*Elanoides forficatus*) increased at all three sites at which they were analyzed (Table 3). Peregrine Falcons increased at Smith Point but not at other sites. Zone-tailed Hawks (*B. albonotatus*) increased at Veracruz, which was the only site analyzed for the species (Table 3).

Numbers of Sharp-shinned Hawks, Cooper's Hawks (*A. cooperii*), Broad-winged Hawks, American Kestrels, Merlins, and Peregrine Falcons fluctuated similarly at Veracruz, which suggests that a factor or factors other than population change was involved.

Table 3. Trends (mean percentage of change per year ±95% confidence interval [a]) in autumn migration counts of 17 species of raptors at Gulf Coast watchsites, 1995–2005.

Species	Florida Keys, Florida (1999–2005)	Smith Point, Texas (1997–2005)	Corpus Christi, Texas (1997–2005)	Veracruz, Mexico (1995–2005)
Black Vulture	–	0.3 ± 21.2	1.9 ± 12.9	–
Turkey Vulture	–	0.0 ± 18.8	16.9 ± 25.6§	5.7 ± 5.9†
Osprey	9.0 ± 7.6‡	4.7 ± 4.3‡	7.2 ± 8.2†	2.8 ± 6.5§
Hook-billed Kite	–	–	–	3.3 ± 6.1
Swallow-tailed Kite	–	7.6 ± 5.9‡	13.1 ± 17.5§	7.3 ± 4.2*
Mississippi Kite	–	10.0 ± 10.2†	5.4 ± 21.7	15.4 ± 11.5‡
Northern Harrier	–8.4 ± 10.4†	–6.2 ± 12.0§	–2.9 ± 9.5§	–8.4 ± 8.2‡
Sharp-shinned Hawk	–12.8 ± 7.9*	–4.2 ± 10.0§	–2.6 ± 13.8	–7.5 ± 9.3†
Cooper's Hawk	7.3 ± 22.7§	–1.0 ± 5.8	3.2 ± 14.2	1.9 ± 6.2
Red-shouldered Hawk	–	1.4 ± 7.5	–8.6 ± 9.7†	–
Broad-winged Hawk	6.1 ± 15.8§	8.2 ± 14.2§	–6.7 ± 20.1§	3.1 ± 9.5§
Swainson's Hawk	–	10.0 ± 7.1‡	18.5 ± 12.8*	13.6 ± 12.2‡
Zone-tailed Hawk	–	–	–	15.7 ± 7.2*
Red-tailed Hawk	–	–0.4 ± 14.7	–2.6 ± 4.8§	–3.3 ± 5.6§
American Kestrel	–8.8 ± 9.6†	–2.9 ± 6.8§	6.7 ± 13.4§	0.0 ± 7.3
Merlin	–13.4 ± 10.7‡	4.6 ± 11.4§	2.3 ± 8.7	0.4 ± 7.4
Peregrine Falcon	6.9 ± 12.0§	5.8 ± 4.6‡	3.2 ± 11.3	3.2 ± 6.5§

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

Table 4. Summary trends for Gulf Coast watchsites, 1995–2005.

Species	Florida Keys, Florida	Smith Point, Texas	Corpus Christi, Texas	Veracruz, Mexico	Summary
Black Vulture	–	Unclear	Unclear	–	No significant trends, high variability, very low precision estimates
Turkey Vulture	–	Unclear	Unclear	Increase	Increasing at Veracruz; no significant trends, high variability, and very low precision estimates in Texas
Osprey	Increase	Increase	Increase	No trend	Positive rates of change at all sites, significant in Florida and Texas; comparatively high precision
Hook-billed Kite	–	–	–	No trend	No trend but slight positive rate of change; fair precision
Swallow-tailed Kite	–	Increase	Unclear	Increase	Positive rates of change at all sites, significant at Smith Point and Veracruz; fair precision except at Corpus Christi
Mississippi Kite	–	Increase	Unclear	Increase	Positive rates of change at all sites, significant at Smith Point and Veracruz; low precision at all sites, especially Corpus Christi
Northern Harrier	Decrease	Unclear	No trend	Decrease	Negative rates of change at all sites, significant in Florida and Veracruz; marginal precision at all sites but should improve with time
Sharp-shinned Hawk	Decrease	No trend	Unclear	No trend	Negative rates of change at all sites, significant in Florida; low precision at Corpus Christi
Cooper's Hawk	Unclear	No trend	Unclear	No trend	No significant trends but positive rates of change except at Smith Point; low precision for Corpus Christi and especially Florida
Red-shouldered Hawk	–	No trend	Decrease	–	Decreasing at Corpus Christi; no trend at Smith Point; fair precision

Table 4. Continued.

Species	Florida Keys, Florida	Smith Point, Texas	Corpus Christi, Texas	Veracruz, Mexico	Summary
Broad-winged Hawk	Unclear	Unclear	Unclear	No trend	No significant trends but positive rates of change except at Corpus Christi; very low precision except at Veracruz
Swainson's Hawk	–	Increase	Increase	Increase	Uniformly increasing; precision highest at Smith Point with lowest count
Zone-tailed Hawk	–	–	–	Increase	Increasing in Veracruz; fair precision
Red-tailed Hawk	–	Unclear	Unclear	No trend	No significant trends but slight negative rates of change at all sites; fair precision for Veracruz and Corpus Christi, low for Smith Point
American Kestrel	Decrease	No trend	Unclear	No trend	Decreasing in Florida; no significant trends elsewhere; fair precision except at Corpus Christi
Merlin	Decrease	Unclear	No trend	No trend	Decreasing in Florida; no significant trends elsewhere; fair precision for Corpus Christi and Veracruz, lower for Florida and Smith Point
Peregrine Falcon	Unclear	Increase	Unclear	No trend	Positive rates of change at all sites, significant at Smith Point; fair precision for Smith Point and Veracruz, lower for Florida and Corpus Christi

Notes: Decrease = significant at $P \leq 0.10$; increase = significant at $P \leq 0.10$; no trend = not significant at $P \leq 0.10$ and with a 95% CI of less than or equal to ±10% per year; unclear = no significant trend and a 95% CI greater than ±10% per year (i.e., precision of estimate outside the threshold expected to yield at least moderate precision [95% CI less than or equal to ±3.5% per year] with 20–25 years of data).

Stable species.—Black Vulture (*Coragyps atratus*; Texas only), Hook-billed Kite (*Chondrohierax uncinatus*; Veracruz only), Cooper's Hawk, Broad-winged Hawk, and Red-tailed Hawk (*B. jamaicensis*; Texas and Veracruz only) appeared to be stable over the periods analyzed (Tables 3 and 4).

Species Trends

Black Vulture.—We calculated trends for this species at two watchsites. Black Vultures were recorded in moderate numbers (hundreds) at Smith Point and Corpus Christi (Table 2). We did not detect significant trends at either site (Tables 3 and 4; Fig. 2). Annual variability was high, especially at Smith Point. The species is a partial, short-distance migrant in the region (Buckley 1999), and separating migrants from wandering residents is challenging. Consequently, migration counts may be misleading indicators of regional population trends.

Turkey Vulture.—We calculated trends for this species at three watchsites. Turkey Vultures were recorded in high numbers at Smith Point, Corpus Christi, and, especially, at Veracruz (Table 2). The species was not monitored in the Florida Keys. Increases occurred at Veracruz, where a large portion of the western North American population migrates (Table 2), and at Corpus Christi (Tables 3 and 4; Fig. 3).

Osprey.—We calculated trends for this species at four watchsites. Low numbers of Ospreys (≤200) were recorded in Texas (Table 2). Counts exceeded 1,000 individuals in the Florida Keys and at Veracruz. The species increased significantly at all sites at rates of 2.8–9.0% per year (Tables 3 and 4; Fig. 4).

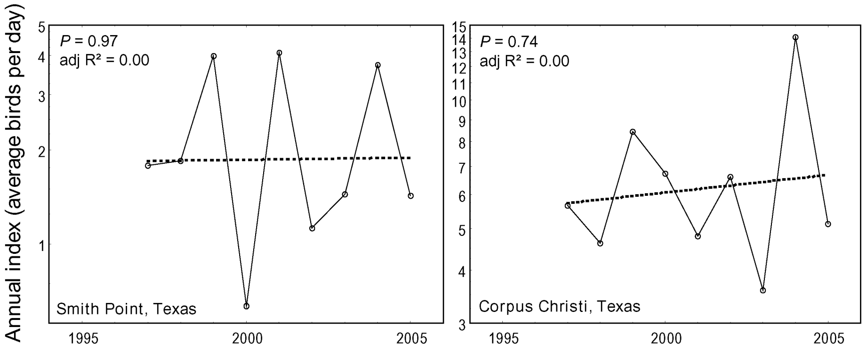

Fig. 2. Trends in autumn passage rates of Black Vultures (*Coragyps atratus*) at watchsites on the Texas Gulf Coast since 1997. Dashed lines illustrate nonsignificant ($P > 0.10$) best-fit models.

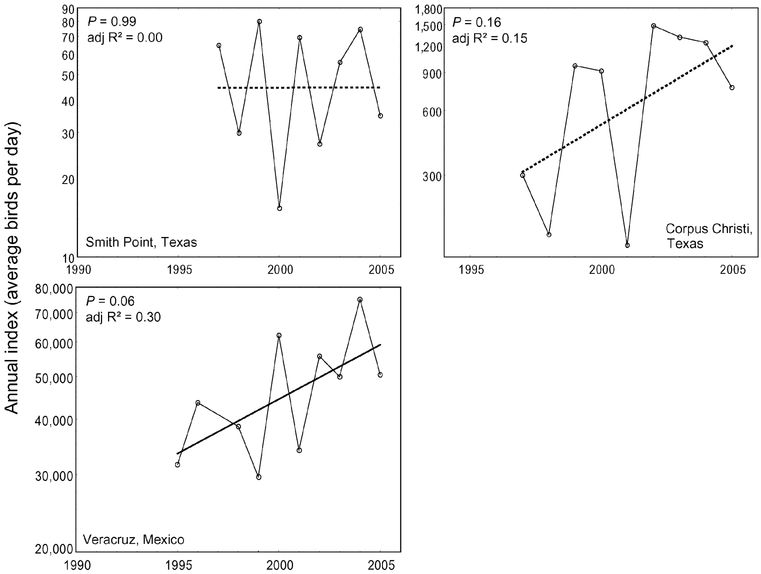

Fig. 3. Trends in autumn passage rates of Turkey Vultures (*Cathartes aura*) at Gulf Coast watchsites since the mid-1990s. Solid lines illustrate significant ($P \leq 0.10$) regression models; dashed lines illustrate nonsignificant ($P > 0.10$) best-fit models.

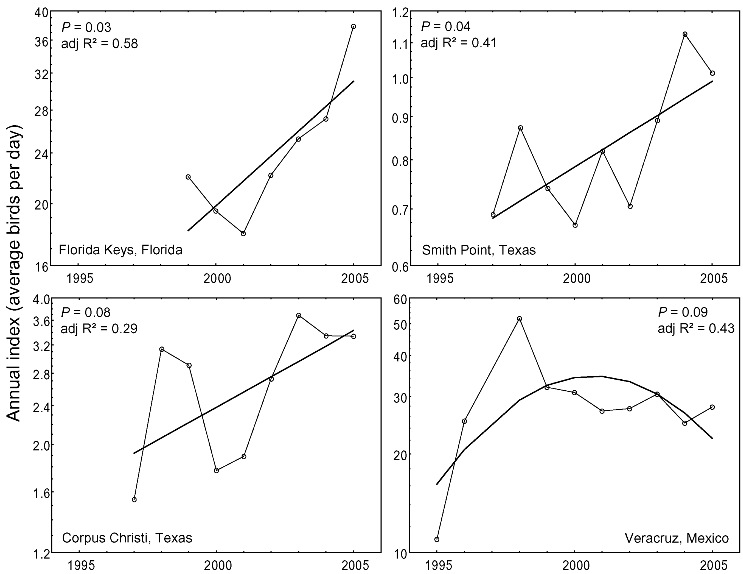

Fig. 4. Trends in autumn passage rates of Ospreys (*Pandion haliaetus*) at Gulf Coast watchsites since the mid-1990s. Solid lines illustrate significant ($P \leq 0.10$) regression models.

Hook-billed Kite.—We calculated trends for this species at one watchsite. Single Hook-billed Kites were recorded at Smith Point and Corpus Christi. At least 100–300 individuals are counted at Veracruz each year (Table 2), where their numbers increased significantly (Tables 3 and 4; Fig. 5).

Swallow-tailed Kite.—We calculated trends for this species at three watchsites. Swallow-tailed Kites were recorded in low to moderate numbers at all sites (Table 2), primarily because they begin to migrate earlier than the operation dates of watchsites (Meyer 1995). Individuals satellite tracked from Georgia suggest a tendency for the species to follow the perimeter of the Gulf rather than cross it (K. Meyer pers. comm.), as is likely true for birds from a small and growing population in southeastern Texas and southwestern Louisiana (e.g., Brown et al. 1997, Shackelford and Simons 2000). Peninsular Florida birds, however, cross the Gulf beginning in July.

Swallow-tailed Kites increased from 7.3% to 13.1% per year at all three analyzed sites (Tables 3 and 4; Fig. 6). Patterns of variation at Smith Point and Corpus Christi were roughly similar (Fig. 6), but the estimated rate of change—albeit relatively imprecise—was almost twice as high at the latter site (Table 3). Overall, there is a common pattern of increase since the mid- to late-1990s.

Mississippi Kite.—We calculated trends for this species at three watchsites. Mississippi Kites were recorded in high to very high numbers in Texas and Veracruz, whereas small numbers in Florida precluded analysis there (Table 2). The Veracruz count likely monitors passage of most of the world population of the species (Parker 1999, Ruelas et al. 2000). Mississippi

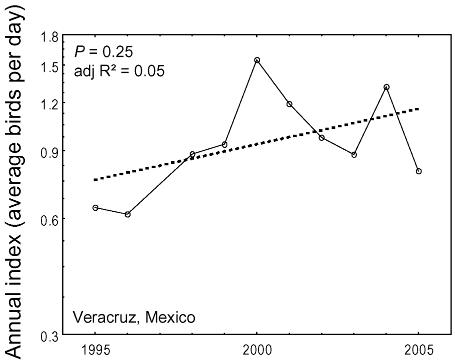

Fig. 5. Trends in autumn passage rates of Hook-billed Kites (*Chondrohierax uncinatus*) in Veracruz, Mexico since 1995. The dashed line illustrates a nonsignificant ($P > 0.10$) best-fit model.

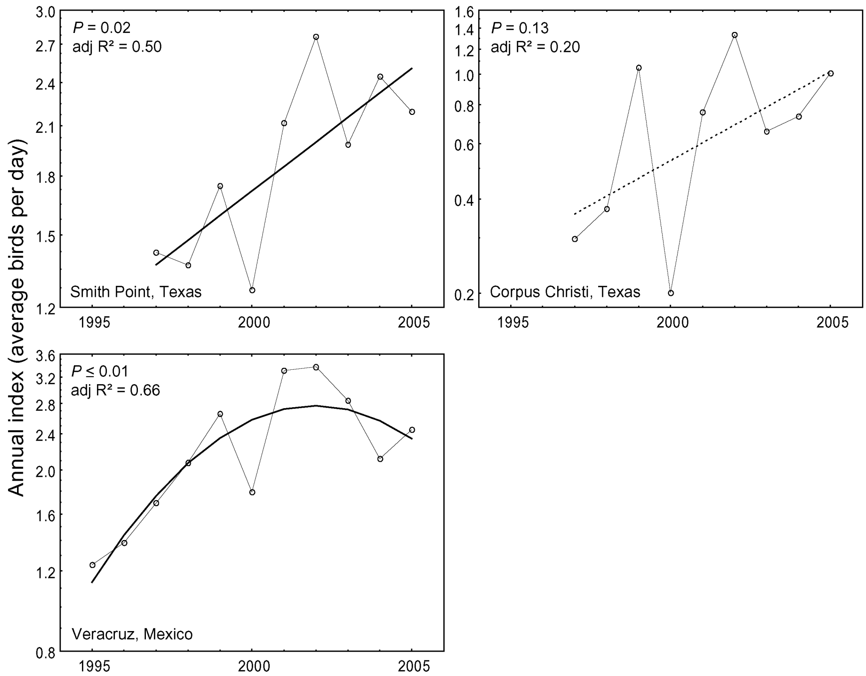

Fig. 6. Trends in autumn passage rates of Swallow-tailed Kites (*Elanoides forficatus*) at Gulf Coast watchsites since the mid-1990s. Solid lines illustrate significant ($P \leq 0.10$) regression models; dashed lines illustrate nonsignificant ($P > 0.10$) best-fit models.

Kites increased significantly in Veracruz (Tables 3 and 4), where the average count is more than an order of magnitude higher than in Texas (Table 2). Annual variation at the three sites was similar, which suggests that all three counts may monitor essentially the same population (Fig. 7).

Northern Harrier.—We calculated trends for this species at four watchsites. Recorded in moderate numbers at all four sites (Table 2), Northern Harriers declined throughout the region, most clearly so at Veracruz (Tables 3 and 4). The four sites also shared roughly similar patterns of annual variation (Fig. 8).

Sharp-shinned Hawk.—We calculated trends for this species at four watchsites. Sharp-shinned Hawks occurred in high numbers at all four sites (Table 2). Annual declines of –2.6% to –12.8% were recorded, with recent declines in Florida and Veracruz most pronounced (Tables 3 and 4; Fig. 9).

Cooper's Hawk.—We calculated trends for this species at four watchsites and detected no significant, overall trends (Tables 2– 4; Fig. 10).

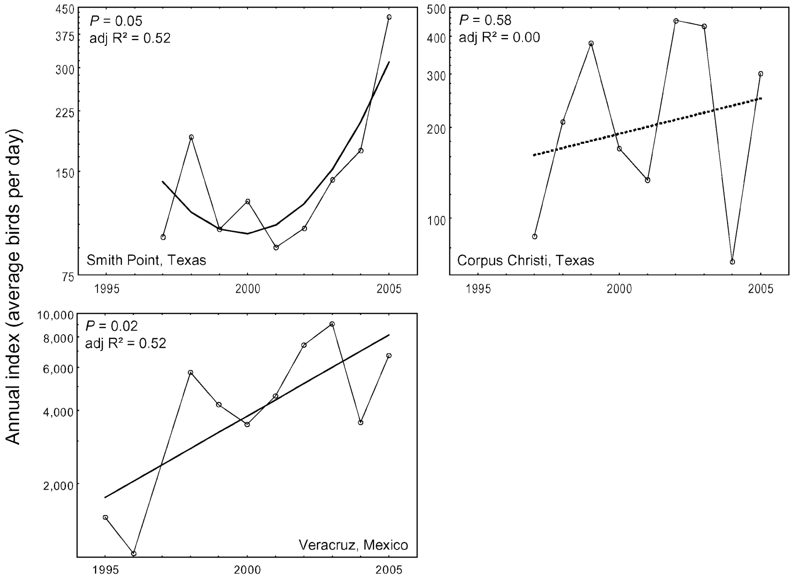

Fig. 7. Trends in autumn passage rates of Mississippi Kites (*Ictinia mississippiensis*) at Gulf Coast watchsites since the mid-1990s. Solid lines illustrate significant ($P \leq 0.10$) regression models; dashed lines illustrate nonsignificant ($P > 0.10$) best-fit models.

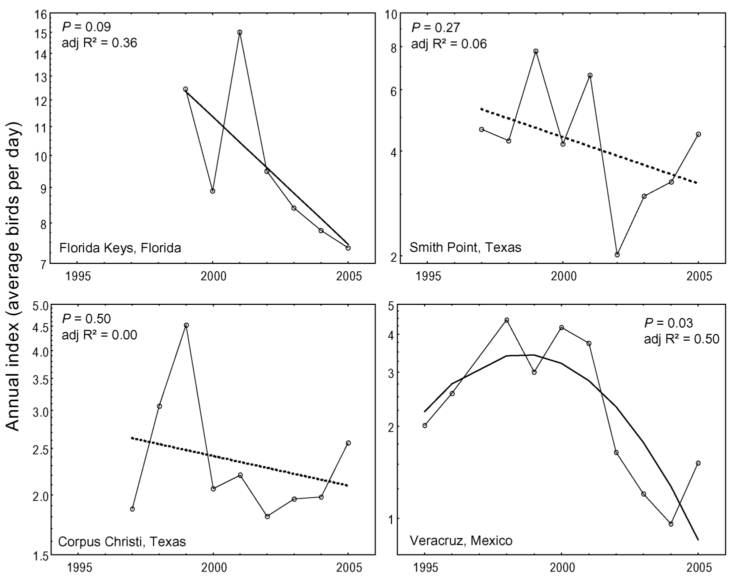

Fig. 8. Trends in autumn passage rates of Northern Harriers (*Circus cyaneus*) at Gulf Coast watchsites since the mid-1990s. Solid lines illustrate significant ($P \leq 0.10$) regression models; dashed lines illustrate nonsignificant ($P > 0.10$) best-fit models.

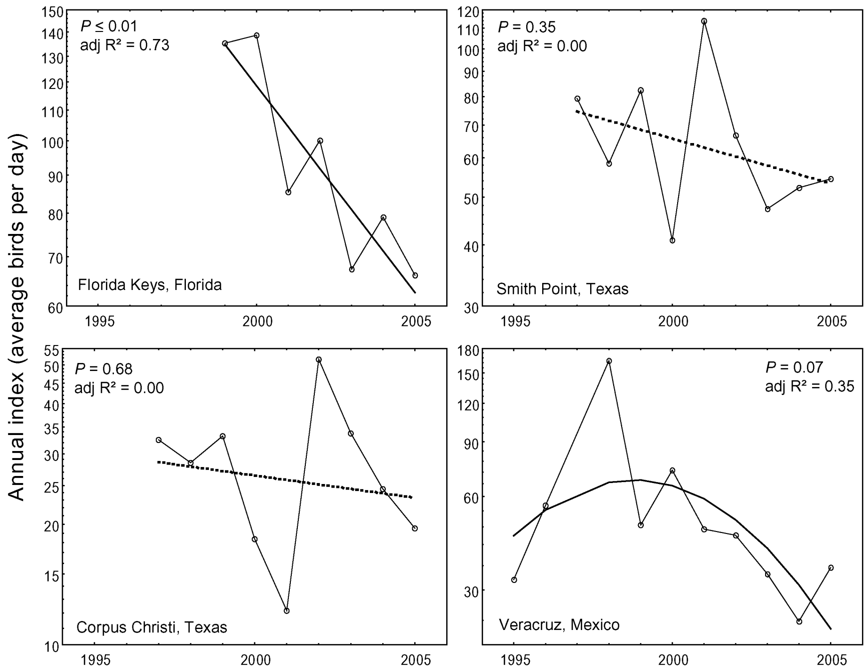

Fig. 9. Trends in autumn passage rates of Sharp-shinned Hawks (*Accipiter striatus*) at Gulf Coast watchsites since the mid-1990s. Solid lines illustrate significant ($P \leq 0.10$) regression models; dashed lines illustrate nonsignificant ($P > 0.10$) best-fit models.

Red-shouldered Hawk.—We calculated trends for this species at two watchsites. About 50 Red-shouldered Hawks are recorded each year at Smith Point and Corpus Christi (Table 2). Numbers declined significantly at Corpus Christi, particularly after 2003 (Tables 3 and 4). Patterns of variation at Corpus Christi and Smith Point were almost mirror images of each other after 2000 (Fig. 11). Low counts at the Florida Keys and Veracruz precluded analyses there (Table 2). The species is a partial, short- and intermediate-distance migrant in the region (Crocoll 1994), and counts may reflect movements of regional residents rather than birds from farther north.

Broad-winged Hawk.—We calculated trends for this species at four watchsites. Broad-winged Hawks were recorded in high to very high numbers at all four sites (Table 2). Inter-annual variation in count indexes was high at all sites and, consequently, no significant long-term trends were detected (Tables 3 and 4; Fig. 12).

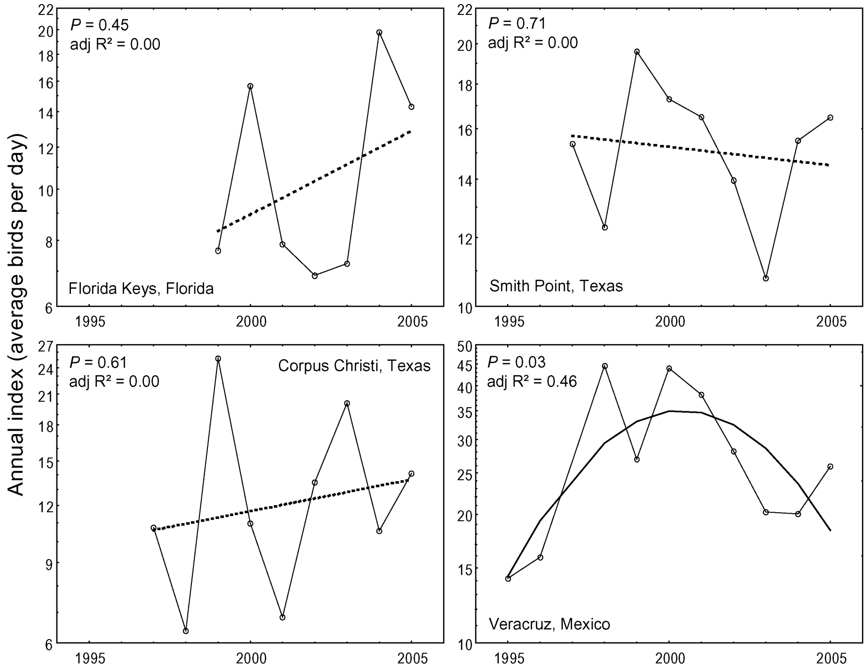

Fig. 10. Trends in autumn passage rates of Cooper's Hawks (*Accipiter cooperii*) at Gulf Coast watchsites since the mid-1990s. Solid lines illustrate significant ($P \leq 0.10$) regression models; dashed lines illustrate nonsignificant ($P > 0.10$) best-fit models.

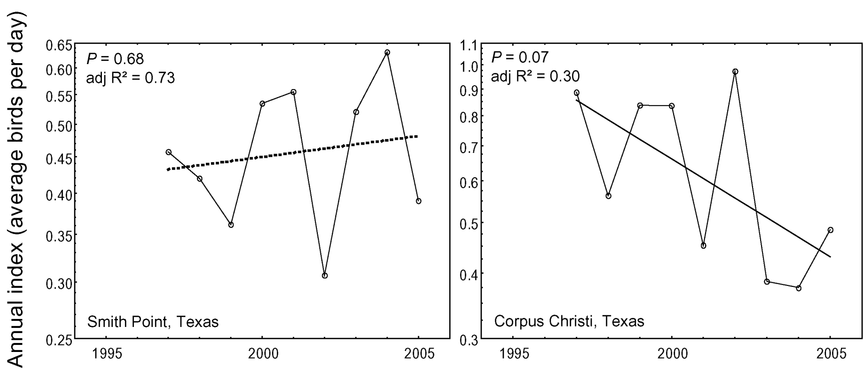

Fig. 11. Trends in autumn passage rates of Red-shouldered Hawks (*Buteo lineatus*) at Gulf Coast watchsites since the mid-1990s. Solid lines illustrate significant ($P \leq 0.10$) regression models; dashed lines illustrate nonsignificant ($P > 0.10$) best-fit models.

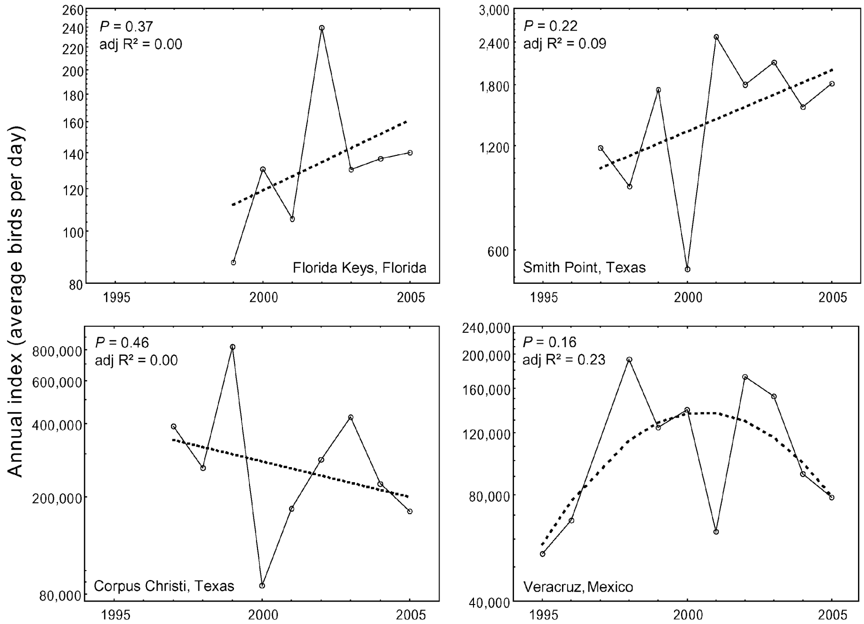

Fig. 12. Trends in autumn passage rates of Broad-winged Hawks (*Buteo platypterus*) at Gulf Coast watchsites since the mid-1990s. Dashed lines illustrate nonsignificant ($P > 0.10$) best-fit models.

Swainson's Hawk.—We calculated trends for this species at three watchsites. Swainson's Hawks were recorded in moderate to very high numbers at Veracruz and the Texas watchsites, where they increased by 10–18% per year (Tables 3 and 4; Fig. 13). We did not calculate trends for Florida, where counts were comparatively low (Table 2).

Zone-tailed Hawk.—We calculated trends for this species at one watchsite. Veracruz records >100 Zone-tailed Hawks each year. The species is recorded in most years at Corpus Christi, but low numbers precluded analysis there (Table 2). Overall, Zone-tailed Hawks increased significantly at Veracruz, at an average rate of 16% per year; however, numbers remained relatively stable between 1999 and 2003 (Table 3; Fig. 14).

Red-tailed Hawk.—We calculated trends for this species at three watchsites. Red-tailed Hawks were recorded in moderate numbers at both Texas sites and at Veracruz, but were too uncommon in Florida for analysis (Table 2). Numbers varied considerably among years at all analyzed sites, and no long-term trends were detected (Tables 3 and 4; Fig. 15).

American Kestrel.—We calculated trends for this species at four watchsites. American Kestrels occurred in moderate to high numbers at all sites

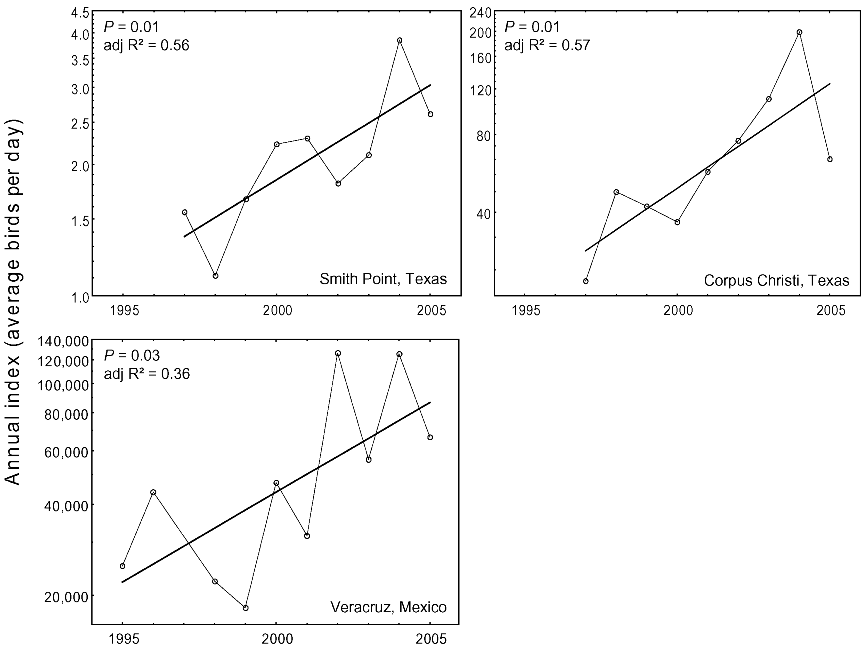

Fig. 13. Trends in autumn passage rates of Swainson's Hawks (*Buteo swainsoni*) at Gulf Coast watchsites since the mid-1990s. Solid lines illustrate significant ($P \leq 0.10$) regression models.

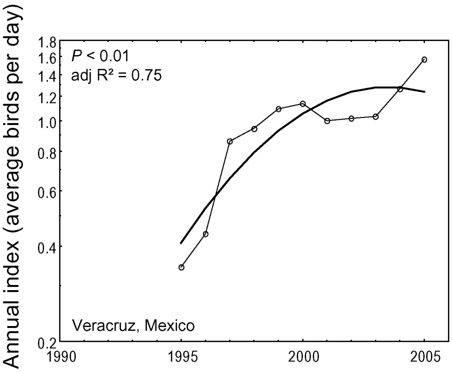

Fig. 14. Trends in autumn passage rates of Zone-tailed Hawks (*Buteo albonotatus*) in Veracruz, Mexico since 1995. The solid line illustrates a significant ($P \leq 0.10$) regression model.

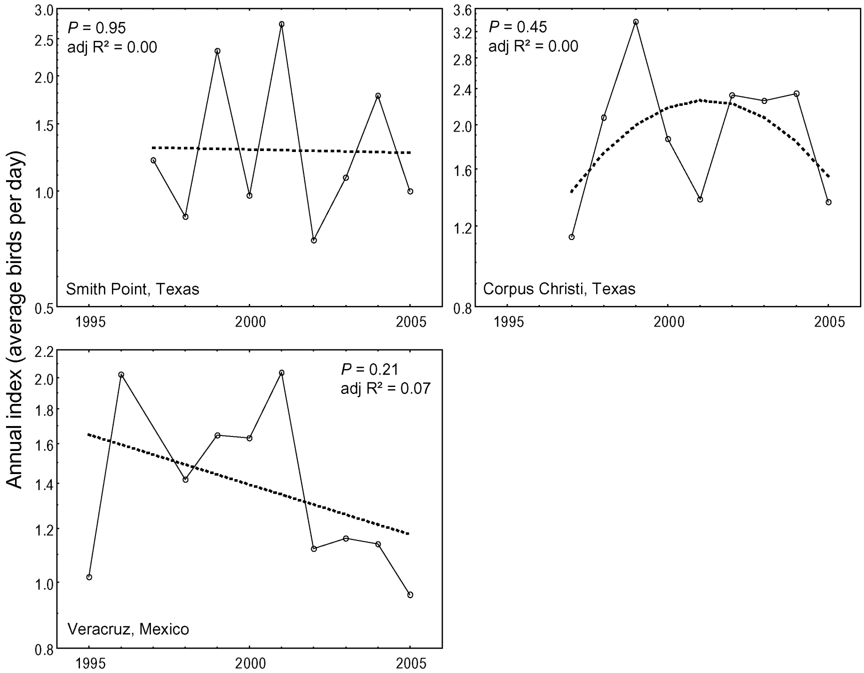

Fig. 15. Trends in autumn passage rates of Red-tailed Hawks (*Buteo jamaicensis*) at Gulf Coast watchsites since the mid-1990s. Dashed lines illustrate non-significant ($P > 0.10$) best-fit models.

(Table 2). A significant 8.8% annual decline occurred in Florida (Tables 3 and 4; Fig. 16). Data from all sites except Corpus Christi suggested declines after 1998 or 1999 (Fig. 16).

Merlin.—We calculated trends for this species at four watchsites. Merlins were recorded in low numbers in Texas, and in moderate numbers in Veracruz and Florida (Table 2). Numbers declined by 13% per year in Florida (Tables 3 and 4; Fig. 17).

Peregrine Falcon.—We calculated trends for this species at four watchsites. The average of ~1,800 individuals per year in Florida (Table 2) is the largest for any watchsite in the United States or Canada (Lott 2006). Estimated rates of increase ranged from 3% to 7% per year at all sites, but the trend was significant only at Smith Point (Tables 3 and 4; Fig. 18).

Summary of Trends

Numbers of seven species increased since 1995, whereas those of three species declined. Three additional species showed mixed trends and the

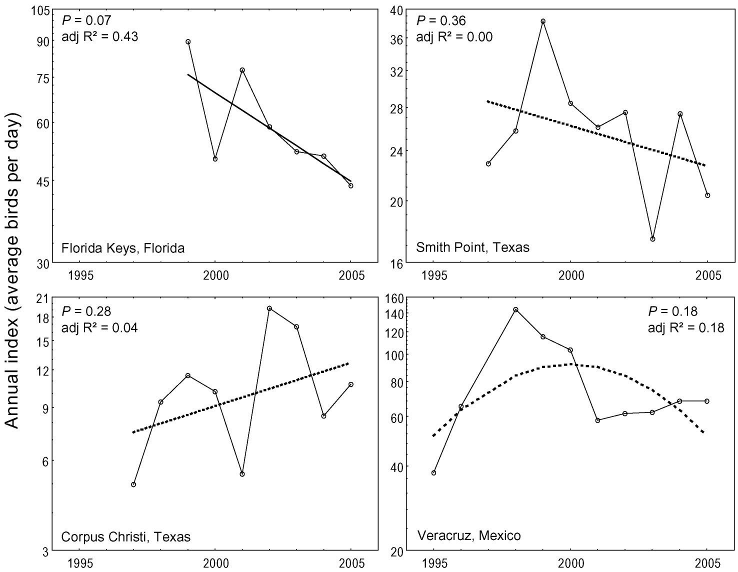

Fig. 16. Trends in autumn passage rates of American Kestrels (*Falco sparverius*) at Gulf Coast watchsites since the mid-1990s. The solid line illustrates a significant ($P \leq 0.10$) regression model; dashed lines illustrate nonsignificant ($P > 0.10$) best-fit models.

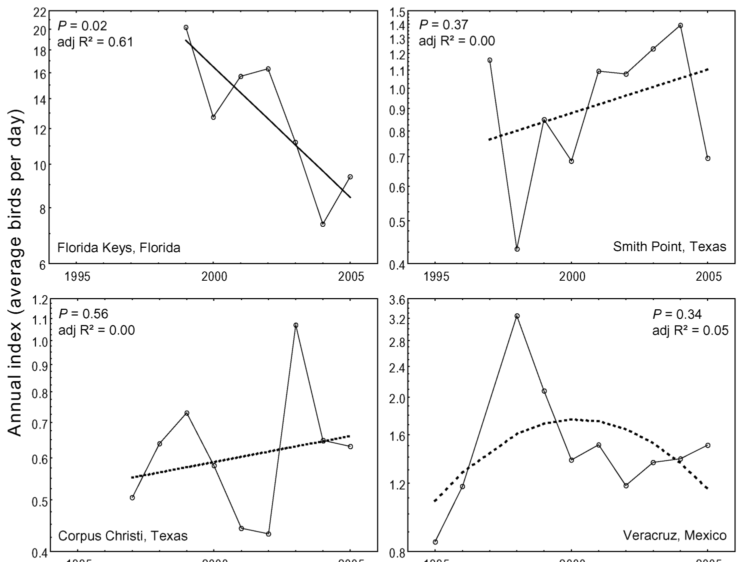

Fig. 17. Trends in autumn passage rates of Merlins (*Falco columbarius*) at Gulf Coast watchsites since the mid-1990s. The solid line illustrates a significant ($P \leq 0.10$) regression models; dashed lines illustrate nonsignificant ($P > 0.10$) best-fit models.

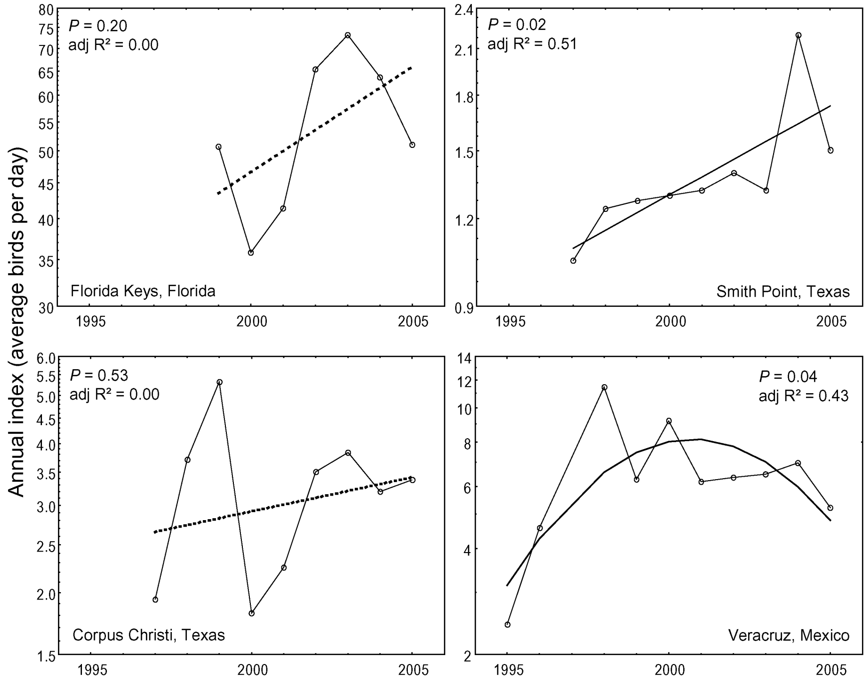

Fig. 18. Trends in autumn passage rates of Peregrine Falcons (*Falco peregrinus*) at Gulf Coast watchsites since the mid-1990s. Solid lines illustrate significant ($P \leq 0.10$) regression models; dashed lines illustrate nonsignificant ($P > 0.10$) best-fit models.

status of two species was uncertain (Table 4). Three species for which watchsites in this region monitor near entire world populations either increased uniformly (Mississippi Kite, Swainson's Hawk) or showed no detectable trends (Broad-winged Hawk). Watchsites in the region monitor a large part of the western North American population of Turkey Vultures, and counts of this species increased over the last decade.

Four species, Hook-billed Kite, Swallow-tailed Kite, Mississippi Kite, and Zone-tailed Hawk, are not monitored by other watchsites in North America, making counts along the Gulf Coast especially important in monitoring their populations.

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This paper would not have been possible without the efforts of dozens of volunteer migration counters. Each migration season, these dedicated individuals endured long hours and often-harsh conditions to advance our understanding of raptor ecology, and we thank them heartily for their service and dedication.

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8

Raptor-migration Watchsite Descriptions

Ernesto Ruelas Inzunza[1]

Abstract.—This chapter contains descriptions of 22 raptor-migration watchsites on which trend analyses described in this work were based. The descriptions are grouped geographically. Fifteen of the sites are within protected areas. Eleven of the sites are on mountain ridges, two are on canyon rims, five are in coastal plains, two are in river valleys, one is along a lake, and one is on a small island. Volunteers conducted the counts at many sites, particularly in the East. My objective here is to provide information on site location, operations, and species monitored, and to provide summaries of counts for each watchsite for the past 10 years.

Introduction

More than 380 raptor-migration watchsites have been used to monitor raptor populations worldwide (Zalles and Bildstein 2000). Europe and North America have the highest densities of watchsites, and the overwhelming majority of watchsites are in North America. Most are operated by volunteers and are found along *leading lines* or *diversion lines* that form traditional migration corridors for raptors (Bildstein 2006). Most watchsites count migrants during autumn rather than in spring, but some operate during both migration periods, and some operate only in spring (Zalles and Bildstein 2000). Here, I provide a general overview of the geographic distribution, seasonal coverage, site operations, and species monitored at each of 22 watchsites on which analyses in this book are based (Table 1). My goal is to give details about the watchsites so that readers of chapters 5–7 will understand the local and regional geography

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Table 1. Raptor-migration watchsites used in trend analyses presented in chapters 5–7.

Watchsite name	State or province	Watchsite type
Eastern		
Audubon's Hawk Watch at Waggoner's Gap	Pennsylvania	Mountaintop
Cape May Bird Observatory	New Jersey	Coastal-plain
Hawk Mountain Sanctuary	Pennsylvania	Mountaintop
Hawk Ridge Bird Observatory	Minnesota	Mountaintop
Holiday Beach Migration Observatory	Ontario	Lakeside
Lighthouse Point Hawk Watch	Connecticut	Coastal-plain
Montclair Hawk Lookout	New Jersey	Mountaintop
Observatoire d'oiseaux de Tadoussac	Québec	River-valley
Western		
Boise Ridge	Idaho	Mountaintop
Bonney Butte Raptor Migration Project	Oregon	Mountaintop
Bridger Mountains Raptor Migration Project	Montana	Mountaintop
Chelan Ridge Raptor Migration Project	Washington	Mountaintop
Goshute Mountains Raptor Migration Project	Nevada	Mountaintop
Grand Canyon Raptor Migration Project–Lipan Point	Arizona	Canyon-rim
Grand Canyon Raptor Migration Project–Yaki Point	Arizona	Canyon-rim
Manzano Mountains Raptor Migration Project	New Mexico	Mountaintop
Mount Lorette	Alberta	River-valley
Wellsville Mountains Raptor Migration Project	Utah	Mountaintop
Gulf Coast		
Corpus Christi Raptor Migration Project	Texas	Coastal-plain
Florida Keys Raptor Migration Project	Florida	Small island
Smith Point Raptor Migration Project	Texas	Coastal-plain
Veracruz River of Raptors	Veracruz	Coastal-plain

of each site, who collected the data, and what species and how many individuals of each are seen at each of the watchsites. Contact information for each site also is provided.

Geographic Distribution

I have grouped the watchsites into three major regions: Eastern, including the Northeast and Great Lakes (n = 8 sites), Western (n = 10), and Gulf Coast (n = 4). Eighteen watchsites are in the United States, three are in Canada, and one is in México. Most of the sites are along mountain ridges (n = 11), two are on canyon rims, five are along coasts, two in river valleys, one on a small island, and one along a lake.

To be chosen for analysis, watchites had to have been active for at least 7 years, and in each year each site had to have counted raptors for at least 150 hours. Analyses included 10–30 years for eastern sites (1974–2004, Chapter 5), 8–22 years for western sites (1983/1998–2005, Chapter 6), and 7–10 years for Gulf Coast sites (1995/1999–2005, Chapter 7).

Operation of Watchsites

Raptor-migration watchsites have been established in places with a array of owners, institutional affiliations, and financial arrangements for the collection and management of data. Many are owned or operated by non-governmental organizations (NGOs). Many NGOs are supported by membership programs, and a few have affiliations with academic institutions (Bildstein 1998). Fifteen of the 22 watchsites described below are within protected areas.

Sites are staffed by either professional or volunteer hawkwatchers, or by a combination of the two. Eastern sites rely more heavily on volunteers, although many hire principal counters and site coordinators to oversee the counts. Most watchsites use a standard data collection protocol (HMANA 2008). In some sites, this protocol has been modified and expanded to make it site-specific (Pronatura Veracruz 1999, Barber et al. 2001, Vekasy and Smith 2002). Counts at western and Gulf Coast watchsites usually are made by paid counters. The rotation of volunteer and professional observers is a common practice among watchsites.

Local, regional, and national governments sometimes provide access to and financial support for watchsites. Migrating hawks are more frequently counted in autumn than in spring. This is because of the greater volume of migration in autumn and the more spectacular concentrations of migrants that occur then. Spring routes followed by hawks often differ from those followed in autumn, so watchsites active in the autumn may not be suitable during spring. Only four of the 22 sites—Hawk Mountain Sanctuary, Hawk Ridge Bird Observatory, Montclair Hawk Lookout, and Mount Lorette—are active during both autumn and spring.

The average duration of the field season is 84 days (range: 45–153). Nineteen of the 22 watchsites currently submit daily or hourly counts to HawkCount.org (Chapter 10).

Watchsite Descriptions

Audubon's Hawk Watch at Waggoner's Gap.—Waggoner's Gap is a mountaintop watchsite with a 270° view along the Kittatinny Ridge, the southeastern-most ridge in the east-northeast–west-southwest-oriented Central Appalachian Mountains of eastern Pennsylvania.

Mixed deciduous forest dominates the site, which is surrounded by lowland farms. Counts are made from an exposed boulder field. Trees on

Table 2. Raptors observed at Audubon's Hawk Watch at Waggoner's Gap, 1995–2004 (16 species, mean = 18,392 individuals). The site, which is operated by Audubon Pennsylvania, is 40 km west of Harrisburg, Pennsylvania (40°16′37″N, 77°16′33″W; elevation 460 m).

Species	Mean count	Minimum (year)	Maximum (year)
Black Vulture *Coragyps atratus*	84	50 (1995)	122 (2003)
Turkey Vulture *Cathartes aura*	961	274 (1995)	1,492 (2003)
Osprey *Pandion haliaetus*	423	302 (1995)	522 (2003)
Bald Eagle *Haliaeetus leucocephalus*	126	57 (1995, 1996)	190 (2002)
Northern Harrier *Circus cyaneus*	278	121 (1996)	457 (2003)
Sharp-shinned Hawk *Accipiter striatus*	5,353	4,335 (2002)	6,536 (1998)
Cooper's Hawk *A. cooperii*	727	460 (1997)	933 (1998)
Northern Goshawk *A. gentilis*	101	48 (1998)	218 (1999)
Red-shouldered Hawk *Buteo lineatus*	338	260 (2004)	441 (1996)
Broad-winged Hawk *B. platypterus*	4,891	2,015 (1996)	9,559 (2002)
Red-tailed Hawk *B. jamaicensis*	4,469	3,672 (2000)	5,731 (1999)
Rough-legged Hawk *B. lagopus*	11	3 (2002)	30 (1995)
Golden Eagle *Aquila chrysaetos*	196	146 (1995)	234 (2003)
American Kestrel *Falco sparverius*	320	192 (1995)	474 (1999)
Merlin *F. columbarius*	65	40 (1996)	98 (2002)
Peregrine Falcon *F. peregrinus*	49	30 (1996)	62 (2003)

the ridge limit visibility of low-flying birds, and prevent detection of low-flying birds coming down the ridge until they are close to the observation point. Counts are made by one official volunteer observer. Migration is most pronounced on northwest and, secondarily, south winds (Table 2).

The site contact is Dave Grove, Compiler, Audubon Pennsylvania, 1865 Alexander Spring Road, Carlisle, Pennsylvania 17013; URL: http://user.pa.net/~waggap/; E-mail: waggap@pa.net; Phone: (717) 258-5253.

Boise Ridge.—Boise Ridge (a.k.a. Lucky Peak) is a mountaintop watchsite on the southwestern-most peak of northwest–southeast-oriented Boise Ridge, overlooking the Boise River Valley, and Snake River Plain to the southwest. The site is accessible on foot and via four-wheel-drive vehicles.

Mixed conifer forest on northern and eastern slopes, and sagebrush steppe on the southern and western slopes dominate the site. Riparian areas are dominated by willow and birch (*Salix* and *Betula* spp.) scrub. Banding and counts are conducted by two field biologists. Migration is more pronounced during high-pressure conditions and light northwest winds (Table 3).

The site contact is Gregory S. Kaltenecker, Project Director, Idaho Bird Observatory, Department of Biology, Boise State University, 1910 University Drive, Boise, Idaho 83725; URL: www.boisestate.edu/biology/ibo; E-mail: gregorykaltenecker@boisestate.edu; Phone: (208) 426-4354.

Bonney Butte Raptor Migration Project.—Bonney Butte is a mountaintop watchsite at the southern end of Surveyor's Ridge. The site, which has a 360° view, is southeast of Mount Hood, east of the White River, and west of Boulder Creek.

Table 3. Raptors observed at Boise Ridge, 1996–2005 (17 species, mean = 5,946 individuals). The Boise Ridge watchsite is on Lucky Peak, Boise River Wildlife Management Area, 12 km east of Boise, Idaho (43°37′N, 116°03′W; elevation 1,845 m).

Species	Mean count	Minimum (year)	Maximum (year)
Turkey Vulture	1,077	320 (1996)	1,811 (2003)
Osprey	62	33 (1999)	91 (1998)
Bald Eagle	6	1 (1998)	13 (2002)
Northern Harrier	241	132 (2004)	442 (2005)
Sharp-shinned Hawk	1,238	961 (2004)	1,902 (1992)
Cooper's Hawk	845	612 (2001)	1,519 (2005)
Northern Goshawk	43	15 (2001)	79 (2000)
Broad-winged Hawk	19	7 (1996)	33 (1998)
Swainson's Hawk *Buteo swainsoni*	69	18 (2000)	141 (1998)
Red-tailed Hawk	1,061	541 (1996)	1,495 (2005)
Ferruginous Hawk *B. regalis*	6	0 (2000)	9 (2002)
Rough-legged Hawk	5	2 (1998, 2005)	11 (1997)
Golden Eagle	51	29 (1996)	65 (2005)
American Kestrel	1,180	781 (2004)	1,402 (1998)
Merlin	33	19 (2001)	70 (2005)
Peregrine Falcon	7	2 (2001)	21 (2004)
Prairie Falcon *Falco mexicanus*	9	2 (1996)	14 (2004)

Coniferous forest and forest openings dominate the site. Shrub-steppe lies to the east. Surveyor's Ridge originates near Hood River, Oregon, and extends southward 50 km, ending southeast of Mount Hood, which overlooks the site. Counts are made from the highest point on the butte. Banding occurs 500 m north of the count site. Counts are made by two full-time, trained volunteers, assisted by others. Migration is slightly more pronounced on northeast winds (Table 4).

The site contact is Jeff P. Smith, Conservation Science Director, HawkWatch International, 2240 S. 900 East, Salt Lake City, Utah 84106; URL: www.hawkwatch.org; E-mail: jsmith@hawkwatch.org; Phone: (801) 484-6808 ext. 109.

Bridger Mountains Raptor Migration Project.—Bridger Mountains is a mountaintop watchsite with a near 360° view in the Bridger Mountains along the eastern front range of the Rocky Mountains atop the Bridger Bowl Ski Area.

Coniferous forest dominates the site. The Bridger Mountains are a relatively small primarily north–south range that runs from 2,950-m Sacagawea Peak south 40 km to the Gallatin Valley 5 km northeast of Bozeman, Montana. Access involves at a 2-km walk up 780 m in elevation. Counts are made from a helicopter-landing pad at the Bridger Bowl Ski

Table 4. Raptors observed at Bonney Butte Raptor Migration Project, 1996–2005 (17 species, mean = 2,860 individuals). Bonney Butte is in Mount Hood National Forest, 10 km east-southeast of Government Camp, and 80 km east-southeast of Portland, Oregon (45°15′46″N, 121°35′31″W; elevation 1,754 m).

Species	Mean count	Minimum (year)	Maximum (year)
Turkey Vulture	318	133 (1997)	553 (2000)
Osprey	71	50 (2002)	106 (2000)
Bald Eagle	49	33 (1997)	66 (2003)
Northern Harrier	31	7 (2001)	56 (1998)
Sharp-shinned Hawk	1,170	600 (2002)	1,789 (2004)
Cooper's Hawk	349	233 (2002)	485 (2004)
Northern Goshawk	27	8 (2002)	39 (1996)
Broad-winged Hawk	9	0 (3 years)	75 (1999)
Swainson's Hawk	<1	0 (5 years)	2 (1997, 1998)
Red-tailed Hawk	624	410 (1998)	931 (1999)
Ferruginous Hawk	<1	0 (5 years)	1 (5 years)
Rough-legged Hawk	13	3 (2005)	29 (2000)
Golden Eagle	96	56 (2002)	176 (1999)
American Kestrel	21	9 (2005)	35 (1997)
Merlin	71	33 (2001)	105 (2004)
Peregrine Falcon	7	0 (1996)	14 (2004, 2005)
Prairie Falcon	4	0 (1996)	10 (1998)

Table 5. Raptors observed at Bridger Mountains Raptor Migration Project, 1996–2005 (17 species, mean = 2,442 individuals). The Bridger Mountains site is in Gallatin National Forest, 20 km north of Bozeman, and 190 km west of Billings, Montana (45°50′N, 110°57′W; elevation 2,610 m).

Species	Mean count	Minimum (year)	Maximum (year)
Turkey Vulture	1	0 (6 years)	6 (1997)
Osprey	7	1 (2004)	14 (1996)
Bald Eagle	83	55 (2002)	128 (2000)
Northern Harrier	56	12 (2002)	230 (1998)
Sharp-shinned Hawk	356	190 (2000)	612 (1998)
Cooper's Hawk	179	102 (2002)	343 (1997)
Northern Goshawk	33	2 (2002)	61 (1999)
Broad-winged Hawk	10	3 (2002)	38 (2001)
Swainson's Hawk	1	0 (4 years)	6 (1997)
Red-tailed Hawk	118	45 (2000)	276 (1998)
Ferruginous Hawk	3	0 (2002)	7 (1998)
Rough-legged Hawk	35	11 (2002)	75 (1999)
Golden Eagle	1,451	1,057 (2005)	1,859 (1996)
American Kestrel	78	16 (2002)	145 (1997)
Merlin	9	2 (2002)	24 (1997)
Peregrine Falcon	9	1 (2000, 2002)	18 (1999)
Prairie Falcon	13	6 (2002)	20 (2005)

Area. Two full-time, trained volunteers, assisted by other local volunteers, conduct the count. Migration is most pronounced on southwest and westerly winds (Table 5).

The site contact is Jeff P. Smith (see Bonney Butte above).

Cape May Bird Observatory.—Cape May is a coastal-plain watchsite at the southern tip of New Jersey and the eastern lip of Delaware Bay.

Dune scrub, salt marsh, tidal creeks, and coastal scrub dominate the site. Southbound migrants following the Atlantic seaboard concentrate at the tip of the peninsula before making the 18-km water-crossing to Delaware. Some migrants double back along the bay shore to make a shorter water-crossing farther north. Counts are made from a platform by one paid counter assisted by volunteers. Highest counts are during northwesterly winds (Table 6). Cape May is renowned as a concentration point for migrating passerines.

The site contact is David Mizrahi, Vice President for Research, New Jersey Audubon Society, 600 Route 47 North, Cape May Court House, New Jersey 08210; URL: www.njaudubon.org/Sites/HwCMBO.html; E-mail: david.mizrahi@njaudubon.org; Phone: (609) 861-0700.

Chelan Ridge Raptor Migration Project.—Chelan Ridge is a mountaintop watchsite in the eastern Cascade Mountains of Washington, with a 360° view.

Table 6. Raptors observed at Cape May Bird Observatory, 1995–2004 (18 species, mean = 49,728 individuals). The site is at Cape May Point, New Jersey (38°55′57″N, 74°57′28″W; elevation 1 m).

Species	Mean count	Minimum (year)	Maximum (year)
Black Vulture	186	104 (2001)	369 (1997)
Turkey Vulture	2,680	776 (2000)	6,420 (1996)
Osprey	3,176	1,643 (2001)	6,734 (1996)
Mississippi Kite *Ictinia mississippiensis*	<1	0 (9 years)	2 (1998)
Bald Eagle	187	131 (2000)	284 (1996)
Northern Harrier	1,721	743 (2000)	2,458 (2003)
Sharp-shinned Hawk	23,388	12,927 (2001)	48,992 (1997)
Cooper's Hawk	3,861	1,874 (2001)	5,046 (2004)
Northern Goshawk	39	8 (2003)	89 (1997)
Red-shouldered Hawk	480	232 (2000)	723 (2003)
Broad-winged Hawk	1,468	452 (2002)	2,844 (1996)
Swainson's Hawk	2	1 (4 years)	10 (1998)
Red-tailed Hawk	2,507	921 (2002)	5,135 (1996)
Rough-legged Hawk	3	0 (3 years)	13 (1999)
Golden Eagle	16	9 (1998)	38 (1996)
American Kestrel	7,074	2,672 (2004)	11,768 (1999)
Merlin	1,857	1,085 (2000)	2,694 (1999)
Peregrine Falcon	1,083	588 (2001)	1,793 (1997)

Snags and post-fire regenerating vegetation, mainly Scouler willow (*Salix scouleri*), big sagebrush (*Artemisia tridentata*), and lodgepole pine (*Pinus contorta*), lie southeast of the site. Elsewhere, conifer forest featuring lodgepole and Ponderosa pine (*P. ponderosa*) dominates. A banding station operates at the site. Counts are made by two full-time, trained volunteers, assisted by other crew members and local volunteers. Migration, which is northwest to southeast at the site, is most pronounced during moderate southwesterly winds (Table 7).

The site contact is Jeff P. Smith (see Bonney Butte above).

Corpus Christi Raptor Migration Project.—Corpus Christi is a coastal-plain watchsite with a 105° view from the northeast to the west on the southern bank of the Nueces River in Texas. The site is about 8 km from the Gulf of Mexico along an extensive, forested river corridor and situated atop the highest point in the region.

A transitional riparian forest, the Nueces River bottomlands, dominates the immediate surroundings. Open farmland dominates to the north and south, open ranchland to the west. Corpus Christi Bay lies to the East. Counts are made by three full-time, trained volunteers assisted by additional local volunteers. Migration is northeast to southwest at the site and is most pronounced during northwest winds, which concentrate migrants along the coast (Table 8).

Table 7. Raptors observed at Chelan Ridge Raptor Migration Project, 1998–2005 (18 species, mean = 1,814 individuals). The site is in the Okanogan and Wenatchee National Forests, 21 km north-northwest of Chelan, Washington (48°01′13″N, 120°05′39″W; elevation 1,729 m).

Species	Mean count	Minimum (year)	Maximum (year)
Turkey Vulture	31	14 (2001)	58 (2005)
Osprey	42	24 (1998)	71 (2000)
White-tailed Kite *Elanus leucurus*	<1	0 (7 years)	1 (2003)
Bald Eagle	5	1 (2003)	15 (2000)
Northern Harrier	113	59 (2004)	167 (1999)
Sharp-shinned Hawk	796	420 (2003)	1,050 (2000)
Cooper's Hawk	212	136 (2003)	247 (1998)
Northern Goshawk	28	13 (2005)	50 (1999)
Broad-winged Hawk	5	2 (2004)	9 (2002)
Swainson's Hawk	7	2 (2000)	17 (1999)
Red-tailed Hawk	302	182 (1998)	450 (1999)
Ferruginous Hawk	<1	0 (7 years)	1 (2000)
Rough-legged Hawk	28	13 (2001)	53 (2000)
Golden Eagle	127	55 (1998)	174 (2000)
American Kestrel	66	33 (2003)	107 (1998)
Merlin	38	21 (2003)	55 (1998)
Peregrine Falcon	6	1 (2000)	14 (2003)
Prairie Falcon	8	4 (2005)	19 (2003)

The site contact is Jeff P. Smith (see Bonney Butte above).

Florida Keys Raptor Migration Project.—Florida Keys is a small-island watchsite on Little Crawl Key, south of peninsular Florida.

Native grasses and mixed small and native tree species, primarily red mangrove (*Rhizophora mangle*) and buttonwood (*Conocarpus erectus*), dominate the site. The site is famous for its falcon migrations. Counts are made by two full-time observers and volunteers. Migration is most pronounced on light winds of any direction and on northerly winds of >28 km h^{-1}(Table 9).

The site contact is Casey A. Lott, Project Director, HawkWatch International, 111 Hillwood Drive, Huntington Station, New York 11746; URL: www.hawkwatch.org; E-mail: clott@abcbirds.org; Phone: (631) 470-5776.

Goshute Mountains Raptor Migration Project.—Goshute Mountains is a mountaintop watchsite at the southern end of the north-to-south Goshute Mountains, a 100-km-long ridge west of the Great Salt Lake Desert in northeastern Nevada.

Coniferous forest, dominated by limber pine (*P. flexilis*) and white fir (*Abies concolor*) in upper elevations and by singleleaf pinyon (*P. monophylla*)

Table 8. Raptors observed at Corpus Christi Raptor Migration Project, 1997–2005 (27 species, mean = 714,873 individuals). The site is in Hazel Bazemore County Park, outside of Corpus Christi and 240 km southeast of San Antonio, Texas (27°52′03″N, 97°38′30″W; elevation 28 m).

Species	Mean count	Minimum (year)	Maximum (year)
Black Vulture	539	138 (1998)	1,398 (1999)
Turkey Vulture	21,123	4,870 (2001)	42,536 (2002)
Osprey	160	81 (1997)	241 (2005)
Hook-billed Kite *Chondrohierax uncinatus*	<1	0 (9 years)	1 (2003)
Swallow-tailed Kite *Elanoides forficatus*	35	0 (2000)	57 (2002)
White-tailed Kite	4	1 (2003)	9 (2005)
Mississippi Kite	6,599	2,974 (1997)	10,155 (2001)
Bald Eagle	2	1 (2002)	4 (2005)
Northern Harrier	154	92 (1997)	331 (1999)
Sharp-shinned Hawk	1,106	698 (2001)	1,869 (2002)
Cooper's Hawk	647	260 (1998)	1,092 (1999)
Northern Goshawk	<1	0 (8 years)	1 (2002)
Harris's Hawk *Parabuteo unicinctus*	14	5 (1998)	28 (1999)
Red-shouldered Hawk	55	24 (2004)	92 (2002)
Broad-winged Hawk	677,518	263,101 (2005)	989,957 (2004)
Swainson's Hawk	6,036	300 (1997)	14,751 (2004)
White-tailed Hawk *Buteo albicaudatus*	9	4 (1997)	25 (2005)
Zone-tailed Hawk *B. albonotatus*	3	1 (2001)	10 (2005)
Red-tailed Hawk	167	96 (2001)	282 (1999)
Ferruginous Hawk	3	1 (2001)	14 (1999)
Rough-legged Hawk	1	1 (1997)	4 (1999)
Golden Eagle	1	1 (2004)	4 (1999)
Crested Caracara *Caracara cheriway*	11	1 (1998)	21 (2001)
American Kestrel	492	189 (1997)	860 (2003)
Merlin	32	18 (2002)	57 (2003)
Peregrine Falcon	153	65 (2000)	241 (1999)
Prairie Falcon	9	2 (2004)	33 (1999)

Table 9. Raptors observed at the Florida Keys Raptor Migration Project, 1999–2005 (18 species, mean = 16,174 individuals). The site is in Curry Hammock State Park, northeast of Marathon on Little Crawl Key, Florida (24°44′50″N, 80°59′00″W; elevation 2 m).

Species	Mean count	Minimum (year)	Maximum (year)
Black Vulture	<1	0 (3 years)	2 (2000)
Turkey Vulture	7,366	2,800 (1999)	11,932 (2000) [a]
Osprey	1,165	925 (2004)	1,657 (2002)
Swallow-tailed Kite	10	1 (2005)	21 (2003)
Mississippi Kite	19	6 (2005)	57 (2001)
Bald Eagle	15	11 (1999, 2005)	21 (2002)
Northern Harrier	534	332 (2005)	786 (1999)
Sharp-shinned Hawk	2,972	1,001 (2005)	4,741 (1999)
Cooper's Hawk	536	289 (2002)	1,036 (2004)
Red-shouldered Hawk	14	1 (2002)	35 (2000)
Broad-winged Hawk	3,737	2,803 (2005)	5,237 (2003)
Short-tailed Hawk			
Buteo brachyurus	25	6 (2005)	38 (2004)
Swainson's Hawk	81	31 (1999)	146 (2000)
Zone-tailed Hawk	<1	0 (6 years)	1 (2005)
Red-tailed Hawk	2	0 (2000, 2005)	5 (2001)
American Kestrel	2,606	1,437 (2005)	4,338 (2001)
Merlin	525	317 (2004)	834 (1999)
Peregrine Falcon	1,828	1,344 (2005)	2,858 (2003)

[a] Turkey Vulture counts were discontinued after 2000.

and Utah juniper (*Juniperus osteosperma*) in lower elevations, dominates the site. The site hosts one of the largest known concentrations of migratory raptors in the western United States. Counts are made by two full-time, trained, volunteer observers, assisted by short-term volunteers. Migration is most pronounced on light to moderate southwesterly winds and moderate to strong westerly winds (Table 10).

The site contact is Jeff P. Smith (see Bonney Butte above).

Grand Canyon Raptor Migration Project–Lipan Point.—Lipan Point is a canyon-rim watchsite on the south side of the Grand Canyon, due south of the Kaibab Plateau, with a 360° view overlooking the Grand Canyon to the north, east, and west.

Big sagebrush, cliffrose (*Cowania mexicana*), Utah juniper, two-needle pinyon (*P. edulis*), and, away from the canyon rim, Ponderosa pine dominate the site. Southbound migrants flow across the Kaibab Plateau in a broad front, most likely avoiding the Painted Desert to the east, and cross the canyon at Lipan and Yaki points (see below) where the canyon is relatively narrow. Lipan Point and Yaki Point together constitute a 20-km east–west transect. Counts are made by two trained volunteers organized in rotating teams with those at Yaki Point, and assisted by site educators,

Table 10. Raptors observed at the Goshute Mountains Raptor Migration Project, 1996–2005 (18 species, mean = 17,031 individuals). The site is in the Goshute Wilderness Study Area, 42 km southwest of Wendover and 190 km west of Salt Lake City, Utah (40°25′27″N, 114°16′16″W; elevation 2,745 m).

Species	Mean count	Minimum (year)	Maximum (year)
Turkey Vulture	432	243 (2002)	732 (1998)
Osprey	125	83 (2005)	187 (1997)
Bald Eagle	11	6 (3 years)	31 (1999)
Northern Harrier	205	96 (2004)	356 (1999)
Sharp-shinned Hawk	5,429	2,973 (2005)	9,598 (1998)
Cooper's Hawk	3,712	2,260 (2005)	6,736 (1998)
Northern Goshawk	86	11 (2002)	241 (1996)
Red-shouldered Hawk	<1	0 (8 years)	2 (1996)
Broad-winged Hawk	72	27 (1996)	160 (1998)
Swainson's Hawk	372	91 (2002)	904 (2003)
Red-tailed Hawk	3,692	2,922 (1997)	5,137 (1999)
Ferruginous Hawk	16	8 (2004)	25 (1999)
Rough-legged Hawk	15	1 (2003)	50 (1999)
Golden Eagle	265	130 (2005)	344 (1996)
American Kestrel	2,501	1,468 (2005)	3,393 (1997)
Merlin	53	22 (2004)	91 (1998)
Peregrine Falcon	18	9 (2003)	29 (2001)
Prairie Falcon	27	9 (2005)	50 (1998)

additional local volunteers, and park staff. Migration is most pronounced on light westerly winds (Table 11).

The site contact is Jeff P. Smith (see Bonney Butte above).

Grand Canyon Raptor Migration Project–Yaki Point.—Yaki Point is a canyon-rim watchsite on the south side of the Grand Canyon, due south of the Kaibab Plateau. The site has nearly a 360° view overlooking the Grand Canyon to the north, east, and west.

Yaki Point and Lipan Point (see above) make up a 20-km east–west transect. Counts are made by two trained volunteers organized in rotating teams with those at Yaki Point, and assisted by others. Migration is most pronounced with light westerly winds (Table 12).

The site contact is Jeff P. Smith (see Bonney Butte above).

Hawk Mountain Sanctuary.—Hawk Mountain is a mountaintop watchsite on the Kittatinny Ridge, a 300-km long, northeast-to-southwest ridge in the Central Appalachian Mountains of eastern Pennsylvania. The 1,100-ha sanctuary includes more than a dozen ridgetop outcrops overlooking the Kempton Valley to the southeast, and the Ridge-and-Valley physiographic province to the north. The latter is a belt of Appalachian mountains characterized by long, even-topped ridges interspersed by long, continuous valleys.

Second-growth mixed deciduous forest, including oak–maple (*Quercus* and *Acer* spp.) associations and eastern hemlock (*Tsuga canadensis*)

Table 11. Raptors observed at the Grand Canyon Raptor Migration Project–Lipan Point, 1996–2005 (17 species, mean = 5,096 individuals). The site is in Grand Canyon National Park, 110 km north of Flagstaff and 310 km north of Phoenix, Arizona (36°02′N, 111°51′W; elevation 2,125 m).

Species	Mean count	Minimum (year)	Maximum (year)
Osprey	80	52 (2002)	125 (1997)
Bald Eagle	16	9 (2001)	25 (1997)
Northern Harrier	73	39 (2001)	130 (1999)
Sharp-shinned Hawk	1,342	880 (2005)	1,650 (1996)
Cooper's Hawk	996	316 (2004)	1,696 (1998)
Northern Goshawk	4	0 (2003, 2004)	12 (2000)
Broad-winged Hawk	12	0 (2004)	35 (1998)
Swainson's Hawk	50	21 (2000)	103 (2003)
Zone-tailed Hawk	1	1 (1997)	2 (2003)
Red-tailed Hawk	1,426	594 (2005)	2,236 (1996)
Ferruginous Hawk	4	1 (2004, 2005)	7 (1997, 1999)
Rough-legged Hawk	<1	0 (9 years)	1 (2002)
Golden Eagle	19	3 (2001)	47 (1996)
American Kestrel	1,049	615 (2005)	1,565 (1996)
Merlin	11	4 (2002)	24 (1997)
Peregrine Falcon	8	6 (2000, 2001)	14 (2002)
Prairie Falcon	5	1 (2002)	9 (2000)

Table 12. Raptors observed at the Grand Canyon Raptor Migration Project–Yaki Point, 1997–2005 (17 species, mean = 4,605 individuals). Yaki Point is in Grand Canyon National Park, 110 km north of Flagstaff, 310 km north of Phoenix, Arizona (36°03′31″N, 112°05′02″W; elevation 2,025 m).

Species	Mean count	Minimum (year)	Maximum (year)
Osprey	40	27 (1999)	51 (2002)
Bald Eagle	18	9 (2004)	45 (2002)
Northern Harrier	39	27 (2004)	53 (1999)
Sharp-shinned Hawk	1,627	981 (2005)	2,247 (2003)
Cooper's Hawk	1,054	510 (2005)	1,649 (2003)
Northern Goshawk	5	1 (2005)	10 (2001)
Broad-winged Hawk	11	2 (2005)	19 (2004)
Swainson's Hawk	40	8 (2000)	145 (2003)
Zone-tailed Hawk	<1	0 (6 years)	1 (3 years)
Red-tailed Hawk	991	754 (2005)	1,248 (2003)
Ferruginous Hawk	6	1 (2004)	11 (1999)
Golden Eagle	10	2 (1999)	24 (1997)
American Kestrel	742	384 (1998)	920 (1997)
Merlin	10	5 (2000)	20 (2001)
Peregrine Falcon	7	1 (2000)	18 (1998)
Prairie Falcon	5	2 (2005)	9 (1997)

on the ridgetops and mountain slopes; rolling, partly wooded farmland, and Christmas-tree plantations in the valleys, dominate the surrounding landscape. "The Sanctuary" straddles the Kittatinny Ridge and abuts the Appalachian Trail to the east. Facilities include a visitor center and a biological field station. The principal observation point, the North Lookout, is a rocky outcrop 1.5 km from the visitor-center parking lot, with a 240° view to the southeast and northwest. Counts are made by professional biologists or educators during the week and trained volunteers on weekends. Migration is most pronounced on northwest winds, especially during the first three days following the passage of a cold front (Table 13).

The site contact is Laurie J. Goodrich, Senior Monitoring Biologist, Hawk Mountain Sanctuary, Acopian Center for Conservation Learning, 410 Summer Valley Road, Orwigsburg, Pennsylvania 17961; URL: www.hawkmountain.org; E-mail: goodrich@hawkmtn.org; Phone: (570) 943-3411, ext. 106.

Hawk Ridge Bird Observatory.—Hawk Ridge is a mountaintop watchsite near the eastern tip of Lake Superior in suburban Duluth, Minnesota. The site is at the southern end of the northeast–southwest-oriented Sawtooth Mountains.

White birch (*Betula papyrifera*) and aspen (*Populus* spp.) forests dominate the ridges surrounding the site. Counts are made from the ridgetop at

Table 13. Raptors observed at Hawk Mountain Sanctuary, 1995–2004 (autumn only; 17 species, mean = 18,230 individuals). The site is 40 km west-northwest of Allentown, Pennsylvania, and 40 km north of Reading, Pennsylvania (40°38′29″N, 75°59′29″W; elevation 465 m).

Species	Mean count	Minimum (year)	Maximum (year)
Black Vulture	46	9 (2000)	80 (1999)
Turkey Vulture	242	169 (2000)	367 (1999)
Osprey	610	468 (1995)	705 (2002)
Bald Eagle	155	96 (1996)	211 (2003)
Northern Harrier	223	127 (1996)	314 (1999)
Sharp-shinned Hawk	4,427	2,967 (2004)	6,217 (1995)
Cooper's Hawk	740	534 (2004)	1,118 (1998)
Northern Goshawk	72	31 (2004)	170 (1999)
Red-shouldered Hawk	286	195 (2000)	399 (1995)
Broad-winged Hawk	7,056	1,774 (1996)	11,854 (2002)
Swainson's Hawk	<1	0 (9 years)	1 (2004)
Red-tailed Hawk	3,528	2,360 (1997)	4,953 (1999)
Rough-legged Hawk	6	2 (2000)	14 (1999)
Golden Eagle	109	85 (2001)	159 (2003)
American Kestrel	545	352 (1996)	784 (1998)
Merlin	137	97 (2003)	176 (2001)
Peregrine Falcon	47	28 (1995)	62 (2002)

Main Overlook on the Skyline Parkway, 3.3 km from Lake Superior, and from a banding station 0.5 km down ridge from the Main Overlook. The Main Overlook is accessible by car; the research station requires a short walk. Counts are made by two full-time counters assisted by volunteers. Migration is most pronounced on west and northwest winds (Table 14).

The site contact is Janelle Wesley, Executive Director, Hawk Ridge Bird Observatory, P.O. Box 3006, Duluth, Minnesota 55803-3006; URL: www.hawkridge.org; E-mail: mail@hawkridge.org; Phone: (218) 428-6209.

Holiday Beach Migration Observatory.—Holiday Beach is a lakeside watchsite on the Niagara Peninsula, along the north shore of Lake Erie in southwestern Ontario, in the Holiday Beach Conservation Area.

The site is surrounded by farmland. Freshwater marsh, open deciduous woodland (*Acer* and *Populus* spp.), agricultural fields, and pine and cedar stands to the north dominate the landscape. The Niagara Peninsula funnels migrants in the region. Southbound migrants soaring on thermals over flat farmland are diverted to the east by the shoreline of Lake Erie. Counts are made by two volunteers. Migration is most pronounced on north and northwest winds (Table 15).

Table 14. Raptors observed at Hawk Ridge Bird Observatory, 1995–2004 (autumn only; 19 species, mean = 89,661 individuals). The site is in the Hawk Ridge Nature Reserve, Duluth, 200 km north-northeast of Minneapolis, Minnesota (46°45′N, 92°02′W; elevation 350 m).

Species	Mean count	Minimum (year)	Maximum (year)
Black Vulture	56	0 (8 years)	562 (2001)
Turkey Vulture	1,417	768 (2001)	1,952 (1996)
Osprey	419	293 (2003)	568 (1997)
Mississippi Kite	<1	0 (8 years)	3 (2004)
Bald Eagle	2,900	1,812 (1995)	3,754 (2002)
Northern Harrier	526	214 (2000)	1,100 (1999)
Sharp-shinned Hawk	17,167	11,790 (2001)	21,352 (1997)
Cooper's Hawk	169	103 (1995)	259 (1999)
Northern Goshawk	904	206 (1998)	3,408 (1995)
Red-shouldered Hawk	3	0 (2004)	6 (2002)
Broad-winged Hawk	54,220	8,558 (1998)	160,703 (2003)
Swainson's Hawk	7	0 (2004)	17 (1999)
Red-tailed Hawk	8,815	4,842 (2000)	12,663 (2003)
Rough-legged Hawk	518	287 (2001)	812 (1999)
Golden Eagle	122	69 (1995)	172 (2002)
American Kestrel	2,141	1,248 (2003)	3,637 (2002)
Merlin	213	101 (2003)	362 (1997)
Gyrfalcon *Falco rusticolus*	<1	0 (8 years)	1 (1996, 2001)
Peregrine Falcon	64	34 (2003)	100 (1997)

Table 15. Raptors observed at Holiday Beach Migration Observatory, 1995–2004 (autumn only; 16 species, mean = 79,405 individuals). The site is in the Holiday Beach Conservation Area, 40 km south of Windsor, Ontario (42°01′59″N, 83°02′43″W; elevation 90 m).

Species	Mean count	Minimum (year)	Maximum (year)
Turkey Vulture	20,000	14,752 (2004)	32,186 (2001)
Osprey	109	68 (2000)	173 (1995)
Bald Eagle	58	27 (1996)	83 (2003)
Northern Harrier	821	272 (2004)	1,276 (1999)
Sharp-shinned Hawk	11,447	5,506 (2004)	15,344 (1995)
Cooper's Hawk	468	355 (1997, 1998)	755 (1995)
Northern Goshawk	36	16 (2000)	59 (1995)
Red-shouldered Hawk	633	403 (2004)	1,042 (1997)
Broad-winged Hawk	37,386	4,887 (2002)	107,877 (1996)
Swainson's Hawk	<1	0 (5 years)	2 (2003)
Red-tailed Hawk	5,745	2,771 (2004)	10,987 (1995)
Rough-legged Hawk	75	26 (2003)	170 (1995)
Golden Eagle	69	28 (1998)	134 (1999)
American Kestrel	2,432	1,369 (2004)	4,884 (1995)
Merlin	77	47 (1996)	120 (1995)
Peregrine Falcon	49	15 (2004)	82 (1995)

The site contact is Bob Hall-Brooks, Chair, Holiday Beach Migration Observatory, 1215 Huntwick Place, La Salle, Ontario N9H 2B4, Canada; URL: www.hbmo.org; E-mail: bhall-brooks@cogeco.ca; Phone: (519) 972-5736.

Lighthouse Point Hawk Watch.—Lighthouse Point is a coastal-plain watchsite in Lighthouse Point Park, New Haven, on Long Island Sound, and has a 360° view.

Open lawns, parking lots, picnic areas, swimming-beach facilities, fragments of upland oak forest, and an area of old dredging spoils in various stages of secondary succession dominate the site. Large numbers of diurnal-migrating passerines also are seen at the site. Counts are made by a group of volunteers, with each volunteer counting on the same day of the week in subsequent years. Counters are assisted by additional experienced observers. Migration is most pronounced on north and northwest winds (Table 16).

The site contact is Ronald G. Bell, Lighthouse Point Count Coordinator, New Haven Bird Club, 89 Peck Hill Road, Woodbridge, Connecticut 06525; URL: www.battaly.com/nehw; E-mail: ronald.g.bell@snet.net; Phone: (203) 387-3815.

Manzano Mountains Raptor Migration Project.—Manzano Mountains is a mountaintop watchsite atop the central north–south-oriented Manzano Mountains, a southern extension of the Sangre de Cristo Mountains in the front range of the Rocky Mountains. The observation point is on a

Table 16. Raptors observed at Lighthouse Point Hawk Watch, 1995–2004 (17 species, mean = 13,358 individuals). The site is in Lighthouse Point Park, a city park in southeastern suburban New Haven, Connecticut (41°14′59″N, 72°54′05″W; elevation 15 m).

Species	Mean count	Minimum (year)	Maximum (year)
Black Vulture	1	0 (8 years)	9 (2002)
Turkey Vulture	299	178 (2001)	586 (2004)
Osprey	1,282	853 (2001)	1,796 (1997)
Bald Eagle	46	23 (2001)	84 (2004)
Northern Harrier	495	259 (1996)	795 (1998)
Sharp-shinned Hawk	6,496	4,605 (2000)	8,213 (1997)
Cooper's Hawk	776	537 (1996)	1,146 (2003)
Northern Goshawk	15	3 (2001)	34 (2003)
Red-shouldered Hawk	79	25 (1998)	157 (2004)
Broad-winged Hawk	1,095	307 (2001)	3,690 (2004)
Swainson's Hawk	1	0 (7 years)	6 (2003)
Red-tailed Hawk	569	207 (1997)	968 (1999)
Rough-legged Hawk	2	0 (1997)	6 (1998)
Golden Eagle	3	0 (1995)	10 (2002)
American Kestrel	1,836	1,426 (2004)	2,602 (1998)
Merlin	305	205 (1996)	402 (1999)
Peregrine Falcon	58	33 (2000)	84 (2001)

northwest–southeast-oriented outcrop along a limestone ridge, with good views except to the southeast.

Gambell oak (*Quercus gambelli*), Rocky Mountain Douglas-fir (*Pseudotsuga menziesii*), white fir, Ponderosa pine, pinyon pine, New Mexico locust (*Robinia neomexicana*), and bigtooth maple (*Acer grandidentatum*) dominate the site. Banding occurs at the site. Counts are made by two full-time, trained volunteers, assisted by other crew members and volunteers. Migration is most pronounced with light to moderate southwest winds. Relatively uncommon light east and northeast winds also produce flights (Table 17).

The site contact is Jeff P. Smith (see Bonney Butte above).

Montclair Hawk Lookout.—Montclair is a mountaintop watchsite with a 240° view to the northeast, on First Watchung Mountain, the first ridge west of the Hudson River near New York City.

The site, which is a New Jersey Audubon Sanctuary, is an exposed cliff top next to Mills Reservation (a forested county park) and Cedar Grove Reservoir. In some years, exceptional numbers of Broad-winged Hawks (*Buteo platypterus*) are seen at the site.

Mixed secondary forest and suburbia dominate the surrounding landscape. Access is by a 102-step, 200-m-long staircase. Counts are made from a stone-filled platform. The view from the platform to the south and

Table 17. Raptors observed at Manzano Mountains Raptor Migration Project, 1996–2005 (18 species, mean = 5,535 individuals). This site is in Manzano Mountains Wilderness Area in Cibola National Forest, 55 km south-southeast of Albuquerque and 125 km southwest of Santa Fe, New Mexico (34°42′01″N, 106°24′00″W; elevation 2,805 m).

Species	Mean count	Minimum (year)	Maximum (year)
Turkey Vulture	471	164 (2001)	1,116 (1998)
Osprey	36	14 (1999)	86 (2003)
Bald Eagle	2	0 (1996)	8 (2003)
Northern Harrier	56	27 (2004)	133 (1998)
Sharp-shinned Hawk	1,705	1,032 (2001)	2,585 (1998)
Cooper's Hawk	1,256	913 (2001)	2,025 (1998)
Northern Goshawk	16	9 (1996, 1997)	42 (2000)
Broad-winged Hawk	8	3 (2000)	16 (2003)
Swainson's Hawk	368	19 (2000)	867 (1996)
Zone-tailed Hawk	<1	0 (4 years)	3 (2000)
Red-tailed Hawk	783	591 (2000)	1,151 (1998)
Ferruginous Hawk	9	3 (2000)	14 (2002)
Rough-legged Hawk	<1	0 (7 years)	1 (3 years)
Golden Eagle	125	71 (2005)	159 (1999)
American Kestrel	562	362 (2004)	905 (1996)
Merlin	32	14 (1999)	56 (1998)
Peregrine Falcon	79	49 (2000)	127 (2002)
Prairie Falcon	27	16 (2005)	58 (1998)

east includes the Verrazano Narrows Bridge and the New York City skyline, including the Statue of Liberty, all the way northeast to the Palisades along the Hudson River. Counts are made by one paid counter assisted by volunteers. Migration is most pronounced on northwest winds (Table 18).

The site contact is Else M. Greenstone, Hawkwatch Coordinator, New Jersey Audubon Society, 10 Moss Lane, Cranford, New Jersey 07016; URL: www.njaudubon.org/sites/hwmont.html; E-mail: wglaw2@cs.com; Phone: (908) 276-4605.

Mount Lorette.—Mount Lorette is a river-valley watchsite with a 360° view of the Front Range of the Rocky Mountains along a major Golden Eagle migration corridor in both spring and autumn.

Mountain meadows surrounded by coniferous forests (*Pinus* and *Picea* spp.) and aspen (*Populus* spp.), interspersed with grass–shrub openings, dominate the site. Counts are made by two volunteers. Migration is most pronounced on southwest and westerly winds (Table 19).

The site contact is Peter F. Sherrington, Research Director, Rocky Mountain Eagle Research Foundation, P.O. Box 63154, 2604 Kensington Road N.W., Calgary, Alberta T2N 4S5, Canada; URL: www.eaglewatch.ca; E-mail: psherrin@telusplanet.net; Phone: (403) 932-5183.

Table 18. Raptors observed at Montclair Hawk Lookout, 1994–2005 (autumn only; 17 species, mean = 14,254 individuals). The site is a New Jersey Audubon Sanctuary 10 km north of Newark, New Jersey (40°50′47″N, 74°12′46″W; elevation 155 m).

Species	Mean count	Minimum (year)	Maximum (year)
Black Vulture	28	0 (1995)	120 (2001)
Turkey Vulture	970	495 (1995)	1,458 (2001)
Osprey	498	301 (1996)	737 (1999)
Bald Eagle	74	39 (2002)	123 (1999)
Northern Harrier	124	45 (1996)	201 (2003)
Sharp-shinned Hawk	2,540	1,907 (1996)	3,937 (1999)
Cooper's Hawk	253	108 (1996)	474 (2004)
Northern Goshawk	5	2 (1998)	12 (1999)
Red-shouldered Hawk	216	106 (2002)	385 (1999)
Broad-winged Hawk	8,069	2,225 (2003)	15,814 (2000)
Swainson's Hawk	1	0 (8 years)	16 (2000)
Red-tailed Hawk	770	440 (2000)	1,568 (1999)
Rough-legged Hawk	1	0 (4 years)	4 (1999)
Golden Eagle	2	1 (3 years)	4 (1999)
American Kestrel	601	422 (2003)	964 (1999)
Merlin	71	38 (1995)	131 (1999)
Peregrine Falcon	31	11 (1995)	48 (1999)

Table 19. Raptors observed at Mount Lorette, 1996–2005 (autumn only; 18 species, mean = 4,761 individuals). The site is in a Provincial Park 40 km east of Banff and 75 km west-southwest of Calgary, Alberta (50°56′08″N, 115°07′54″W; elevation 1,440 m).

Species	Mean count	Minimum (year)	Maximum (year)
Turkey Vulture	<1	0 (8 years)	1 (1998)
Osprey	10	5 (1998)	18 (2004)
Bald Eagle	374	276 (2003)	628 (2000)
Northern Harrier	23	15 (2001)	35 (1999)
Sharp-shinned Hawk	212	152 (1998)	291 (2001)
Cooper's Hawk	43	37 (2001)	50 (2004)
Northern Goshawk	63	9 (1996)	146 (2000)
Broad-winged Hawk	12	5 (2001)	27 (1999)
Swainson's Hawk	1	0 (1996)	4 (1999)
Red-tailed Hawk	77	41 (2004)	131 (1998)
Ferruginous Hawk	<1	0 (7 years)	2 (1998)
Rough-legged Hawk	67	34 (2003)	89 (1998)
Golden Eagle	3,842	3,395 (1998)	4,753 (2000)
American Kestrel	11	5 (2000)	18 (1996)
Merlin	14	8 (1998)	22 (2001)
Gyrfalcon	3	0 (1996)	9 (2004)
Peregrine Falcon	7	5 (2005)	14 (2004)
Prairie Falcon	2	1 (3 years)	4 (3 years)

Observatoire d'oiseaux de Tadoussac.—Tadoussac is a river-valley watchsite overlooking the Saint Lawrence River estuary in southeastern Québec.

A sand terrace covered with birch, tamarack (*Larix laricina*), and mixed coniferous–deciduous forest, surrounded by forested hills, dominates the site. Counts are made by two full-time counters from Explos-Nature, a non-profit organization devoted to education and research. Migration is more pronounced on northwest winds (Table 20). In addition to raptors, the site also counts boreal songbirds, woodpeckers, and waterbirds.

Site contact is Émilie Berthiaume, Coordinator, Observatoire d'oiseaux de Tadoussac, Corporation Explos-Nature, 302 rue de la Rivière, Les Bergeronnes, Québec G0T 1G0, Canada; URL: www.explos-nature.qc.ca/oot; E-mail: oot@explos-nature.qc.ca; Phone: (418) 232-6249.

Smith Point Raptor Migration Project.—Smith Point is a coastal-plain watchsite on the Gulf of Mexico, at the southern tip of a peninsula in Galveston Bay.

Coastal marshes interspersed with weedy, fallow fields and earthen mounds covered by oak (*Quercus* spp.) dominate the site. Counts are made from a 7-m tower at the southwestern tip of the peninsula. Much of the flight follows the mainland toward Smith Point. On days with favorable north winds, many migrants proceed directly from Smith Point across the bay to Eagle Point 12 km to the west, or head southwest across the bay toward the tip of Bolivar Peninsula. During unfavorable winds, many

Table 20. Raptors observed at Observatoire d'oiseaux de Tadoussac, 1995–2004 (15 species, mean = 16,286 individuals). The site is in Parc du Saguenay National Park, 4 km northeast of Tadoussac, on the north shore of the St. Lawrence River estuary, ~220 km northeast of Québec City, Québec (48°09′00″N, 69°40′00″W; elevation 50 m).

Species	Mean count	Minimum (year)	Maximum (year)
Turkey Vulture	8	0 (3 years)	22 (2003)
Osprey	668	272 (1996)	1,227 (1998)
Bald Eagle	109	47 (1996)	178 (2003)
Northern Harrier	302	62 (1996)	432 (1995)
Sharp-shinned Hawk	5,310	2,626 (1996)	7,914 (1999)
Northern Goshawk	260	154 (1998)	381 (2000)
Broad-winged Hawk	1,437	474 (1996)	2,443 (2002)
Swainson's Hawk	<1	0 (9 years)	1 (2004)
Red-tailed Hawk	5,780	2,271 (1996)	10,232 (1999)
Rough-legged Hawk	481	179 (1997)	958 (1999)
Golden Eagle	56	26 (2004)	105 (1999)
American Kestrel	1,598	461 (1996)	2,361 (2000)
Merlin	203	89 (1996)	334 (1999)
Gyrfalcon	<1	0 (5 years)	2 (1995)
Peregrine Falcon	74	44 (1997)	129 (2003)

migrants turn back to the east or northeast along the peninsula, with some returning later to try the crossing under more favorable conditions. Counts are made by two full-time, trained volunteers, assisted by other volunteers (Table 21).

The site contact is Jeff P. Smith (see Bonney Butte above).

Veracruz River of Raptors.—A two-site (Cardel and Chichicaxtle) coastal-plain transect, 7 to 17 km from the Gulf of Mexico in southern Veracruz, México.

Cattle pasture and sugar cane, together with isolated patches of tropical deciduous forest, second-growth vegetation, and mid-elevation oak forest (*Q. oleoides*) dominate the site. Counts at Chichicaxtle, the more inland count site, are made from a 6-m tower at the edge of town. Counts at Cardel are made from the top of a six-story hotel in the center of town. The transect monitors movements of the largest concentration of migrating raptors in the world. Teams of three observers count at each site.

Table 21. Raptors observed at Smith Point Raptor Migration Project, 1997–2005 (24 species, mean = 51,217 individuals). The site is in the Candy Abshier State Wildlife Management Area, near the town of Smith Point, 25 km north of Galveston and 65 km southeast of Houston, Texas (29°31′34″N, 94°45′57″W; elevation 1 m).

Species	Mean count	Minimum (year)	Maximum (year)
Black Vulture	177	4 (2000)	379 (2001)
Turkey Vulture	1,529	581 (1998)	3,091 (2004)
Osprey	65	48 (2002)	87 (2004)
Hook-billed Kite	<1	0 (8 years)	1 (2003)
Swallow-tailed Kite	82	34 (1998)	150 (2002)
White-tailed Kite	17	7 (2002)	26 (2001)
Mississippi Kite	4,324	2,124 (1997)	7,952 (2005)
Bald Eagle	3	1 (2004)	7 (2000)
Northern Harrier	331	144 (2002)	537 (1999)
Sharp-shinned Hawk	2,917	1,484 (2000)	4,780 (1997)
Cooper's Hawk	1,126	738 (2003)	1,281 (2001)
Harris's Hawk	1	2 (2001)	3 (2005)
Red-shouldered Hawk	47	23 (2002)	88 (2004)
Broad-winged Hawk	38,646	16,137 (1998)	103,612 (2001)
Swainson's Hawk	299	56 (1998)	1,036 (2004)
White-tailed Hawk	11	1 (1998)	24 (2005)
Red-tailed Hawk	141	35 (1998)	331 (1997)
Ferruginous Hawk	1	1 (2004)	2 (2003)
Rough-legged Hawk	1	2 (1999)	3 (2001)
Golden Eagle	1	1 (1999)	3 (1997)
Crested Caracara	10	3 (1998)	26 (2004)
American Kestrel	1,341	816 (2003)	1,949 (2002)
Merlin	58	26 (1998)	88 (1997)
Peregrine Falcon	89	65 (1997)	129 (2004)

Migration is most pronounced on north and northeast winds, as affected by periodic fronts (Table 22).

The site contact is Ernesto Ruelas Inzunza, VRR Data Curator and Project Associate, Cornell Lab of Ornithology, 159 Sapsucker Woods Road, Ithaca, New York 14850; URL: www.pronaturaveracruz.org; E-mail: er99@cornell.edu; Phone: (607) 254-2464.

Wellsville Mountains Raptor Migration Project.—The Wellsville is a mountaintop watchsite with a 360° view, at the north end of the Wellsville Mountains, southeast of the Snake River plains and 31 km north-northeast of the Great Salt Lake in northern Utah. Subalpine fir (*Abies lasiocarpa*),

Table 22. Raptors observed at Veracruz River of Raptors, 1996 and 1998–2005 (27 species, mean = 4,986,761 individuals). This is a two-site transect (Cardel and Chichicaxtle; 19°22′00″N, 96°22′00″W; elevation 29 m; and 19°21′N, 96°28′W; elevation 120 m, respectively) 30 km north of Veracruz City, México.

Species	Mean count	Minimum (year)	Maximum (year)
Turkey Vulture	2,001,537	1,474,797 (1999)	2,677,355 (2002)
Osprey	3,219	2,232 (2004)	5,072 (1998)
Hook-billed Kite	178	84 (1996)	300 (2000)
Swallow-tailed Kite	176	95 (1996)	286 (2001)
White-tailed Kite	<1	0 (6 years)	2 (3 years)
Mississippi Kite	171,852	32,568 (1996)	306,274 (2002)
Plumbeous Kite *Ictinia plumbea*	2	0 (5 years)	11 (2001)
Bald Eagle	<1	0 (8 years)	1 (1999)
Northern Harrier	443	106 (2004)	850 (2000)
Sharp-shinned Hawk	4,284	2,199 (2005)	10,462 (1998)
Cooper's Hawk	2,581	1,667 (1996)	4,019 (2001)
Northern Goshawk	<1	0 (8 years)	1 (2002)
Gray Hawk *Buteo nitidus*	322	0 (4 years)	1,271 (2005)
Common Black Hawk	2	0 (6 years)	10 (2001)
Harris's Hawk	7	0 (1999)	12 (2003)
Red-shouldered Hawk	11	1 (2002)	27 (1996)
Broad-winged Hawk	1,941,335	1,534,556 (2000)	2,389,232 (2002)
Swainson's Hawk	851,977	388,916 (1998)	1,201,484 (2005)
White-tailed Hawk	<1	0 (8 years)	2 (2003)
Zone-tailed Hawk	140	52 (1996)	238 (2005)
Red-tailed Hawk	199	115 (2005)	352 (1996)
Ferruginous Hawk	<1	0 (6 years)	2 (2002)
Golden Eagle	1	0 (6 years)	3 (2002, 2003)
Crested Caracara	1	1 (9 years)	2 (2003)
American Kestrel	7,541	3,092 (1996)	21,642 (1998)
Merlin	175	94 (1996)	383 (1998)
Peregrine Falcon	777	461 (2005)	1,469 (1998)

Table 23. Raptors observed in the Wellsville Mountains Raptor Migration Project, 1995–2001, 2003–2004 (17 species, mean = 3,634 individuals). This site is in Wellsville Wilderness Area of Wasatch-Cache National Forest, immediately west of Mendon, 16 km west of Logan, and 100 km north of Salt Lake City, Utah (41°41′18″N, 112°02′54″W; elevation 2,617 m).

Species	Mean count	Minimum (year)	Maximum (year)
Turkey Vulture	30	17 (1998)	47 (1997)
Osprey	29	14 (2003)	40 (1995)
Bald Eagle	2	0 (1998, 2001)	10 (2004)
Northern Harrier	314	171 (1997)	487 (1999)
Sharp-shinned Hawk	893	650 (1997)	1,216 (1995)
Cooper's Hawk	537	241 (2004)	873 (1995)
Northern Goshawk	20	14 (1998)	33 (2003)
Broad-winged Hawk	4	1 (4 years)	13 (1995)
Swainson's Hawk	189	29 (2000)	466 (1995)
Red-tailed Hawk	690	357 (2001)	1,087 (1999)
Ferruginous Hawk	10	2 (2000)	18 (1995)
Rough-legged Hawk	2	0 (1995–2003)	6 (1997)
Golden Eagle	156	104 (2004)	245 (1999)
American Kestrel	713	515 (2003)	1,324 (1995)
Merlin	12	6 (2004)	20 (2000)
Peregrine Falcon	14	8 (1996)	24 (1999)
Prairie Falcon	19	12 (1998)	28 (1999)

quaking aspen (*Populus tremuloides*), Douglas-fir, bigtooth maple, Rocky Mountain maple (*Acer glabrum*), and Sitka mountain-ash (*Sorbus sitchensis*) dominate the slopes; grasses and big sagebrush dominate the ridgetop; and agriculture dominates the surrounding valleys. The site is in the Wellsville Wilderness Area of Wasatch-Cache National Forest. Counts are made by two full-time, trained volunteers. Migration is most pronounced on light southwest or moderate to strong west–northwest winds (Table 23).

The site contact is Jeff P. Smith (see Bonney Butte above).

Acknowledgments

I thank watchsite contacts Patty Beasley (Corpus Christi), Ronald G. Bell (Lighthouse Point), Émilie Berthiaume (Tadoussac), Bob Hall-Brooks (Holiday Beach), Dave Carman (Hawk Ridge), Christopher J. Farmer and Laurie J. Goodrich (Hawk Mountain), Wayne Greenstone (Montclair), David Grove (Waggoner's Gap), Gregory S. Kaltenecker (Boise Ridge), Casey A. Lott (Florida Keys), Peter F. Sherrington (Mount Lorette), Jeff P. Smith (Bonney Butte, Bridger Mountains, Chelan Ridge, Corpus Christi, Goshutes, Lipan Point, Manzanos, Smith Point, Wellsvilles, and Yaki Point), Jason Sodergren (Holiday Beach), and P.

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9

Conservation Status of North America's Birds of Prey

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Abstract.—We assessed the conservation status of 20 species of North American birds of prey by examining historical and recent estimates of trends in counts of raptors at migration watchsites. We compared these trend estimates with trends in *Breeding Bird Surveys* (BBSs), *Christmas Bird Counts* (CBCs) (terms in italics are defined in the book's glossary), and other available population indexes for areas believed to be either the origin or destination of migrants passing watchsites in each of three geographic regions. Long-term trend estimates indicated mostly increasing migration counts for nine species, mostly decreasing trends for five species, and mixed trends for six species. In the most recent decade, trends were geographically mixed for most species, with annual declines beginning in the late 1990s for many species in the West. We found evidence of widespread declines in populations of American Kestrels (*Falco sparverius*), and long-term increases for Bald Eagles (*Haliaeetus leucocephalus*), Swainson's Hawks (*Buteo swainsoni*), Merlins (*F. columbarius*), and Peregrine Falcons (*F. peregrinus*). Species with geographically mixed trends included the Broad-winged Hawk (*B. platypterus*), Red-shouldered Hawk (*B. lineatus*), Red-tailed Hawk (*B. jamaicensis*), Rough-legged Hawk (*B. lagopus*), and Golden Eagle (*Aquila chrysaetos*). Considered together, evidence from migration counts, BBSs, and CBCs suggests changes in migratory activity, rather than population changes, as the cause of decreasing migration counts of several species since 1974.

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Introduction

This chapter consists of conservation-status reports that include physical and ecological descriptions and historical and current population trends, together with assessments of the current conservation status of 20 species of North American raptors. Italicized terms in the chapter are defined in the book's glossary. Each report is divided into six sections: Species Description, Ecology and Migration, Population Status, Historical Conservation Concern, Current Status and Concerns, and Summary.

Species Description

- **Common name** and **Scientific name**.—The common name and species binomial according to the American Ornithologists' Union's (AOU) Check-list of North American Birds, seventh edition (AOU 1998) and its supplements.
- **French name**.—Common name(s) in French according to Poole and Gill (2005).
- **Spanish name**.—Common name(s) in Spanish according to Poole and Gill (2005).
- **Body length**.—Range in centimeters (cm) (with female and male means or ranges as available) according to Clark and Wheeler (1987) and Poole and Gill (2005).
- **Wingspan**.—Range in centimeters (cm) (with female and male means or ranges as available) according to Clark and Wheeler (1987) and Poole and Gill (2005).
- **Mass**.—Range in grams (g) (with female and male means or ranges as available) according to Clark and Wheeler (1987) and Poole and Gill (2005).
- **Type of migrant**.—Either a *complete*, *partial*, *local*, or *irruptive migrant* according to Bildstein (2006).
- **Nest type**.—Brief description of a typical nest according to Poole and Gill (2005).
- **Food habits**.—Summary of principal dietary components according to Poole and Gill (2005).
- **Migration flight**.—Principal type of flight during migration according to Poole and Gill (2005).
- **Estimated world population**.—According to Ferguson-Lees and Christie (2001).

Ecology and Migration

The ecology of the species, including migration, according to Poole and Gill (2005), and references therein.

Population Status

A synopsis of historical population trends and more recent trend estimates from migration monitoring, presented in subsections for three geographic regions: Northeastern North America including the Great Lakes, Western North America, and around the Gulf of Mexico. For each region, there are separate sections detailing (1) previous watchsite analyses, (2) Raptor Population Index (RPI) analyses, and (3) other analyses (*Breeding Bird Surveys* [BBSs], *Christmas Bird Counts* [CBCs], and other surveys where applicable). We present RPI trend estimates for the most recent decade, and refer to long-term RPI trend estimates presented in the regional trends reports (Chapters 5–7). We use the following regions in the analysis of BBS and CBC data:

- **BBS northeastern North America**.—Connecticut, Massachusetts, Maine, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, New Brunswick, Nova Scotia, Ontario east of 79°W, and Québec.
- **BBS western region**.—Arizona, California, Idaho, Nevada, Oregon, Utah, Washington, western Montana, western Wyoming, western Colorado, western New Mexico, and British Columbia.
- **CBC northeastern North America**.—Massachusetts, Maine, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, New Brunswick, Nova Scotia, Ontario, and Québec.
- **CBC southeastern North America**.—Delaware, Florida, Georgia, Kentucky, Maryland, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia.
- **CBC western North America**.—Alaska, Arizona, California, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, Wyoming, Alberta, British Columbia, Northwest Territories, and Yukon Territory.
- **Northeastern United States**.—Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, Virginia, and West Virginia (i.e., U.S. Fish and Wildlife Service Region 5).
- **Southwestern United States**.—Arizona, New Mexico, Oklahoma, and Texas (i.e., U.S. Fish and Wildlife Service Region 2).
- **Southeastern United States**.—Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, Puerto Rico and the U.S. Virgin Islands, South Carolina, and Tennessee (i.e., U.S. Fish and Wildlife Service Region 4).

J. Sauer provided an analysis of a BBS northeastern North American region. All other analyses of BBS and CBC data were performed using the web-based utilities at the respective survey websites.

Trend estimates are interpreted in light of the biology of each species. We consider trends to be significant if the probability of getting the stated estimate is ≤5% (i.e., $P \leq 0.05$) when the actual trend equals zero. We consider trends to be marginally significant if $0.05 < P \leq 0.10$, and nonsignificant if $P > 0.10$. Actual P-values are reported in the regional-trends reports (Chapters 5–7).

Historical Conservation Concerns

A summary of historical conservation threats in North America.

Current Status and Concerns

A synopsis of current conservation status of each species in North America, drawn from migration monitoring, U.S. Fish and Wildlife Service and Canadian Wildlife Service status estimates, Partners in Flight North American Landbird Monitoring Plan status, and International Union for Conservation of Nature and Natural Resources (IUCN) status estimates. The following terminology, derived from these sources, is used to characterize the conservation status of each species:

- **Species of concern**.—Species that, without additional conservation actions, are likely to become candidates for listing in the United States under the Endangered Species Act.
- **Endangered**.—In danger of extinction throughout all or a significant portion of the species' range.
- **Extirpated**.—Eliminated from an area.
- **Not at Risk**.—Evaluated and found to be not at risk of extinction given current circumstances.
- **Secure**.—Common; widespread and abundant.
- **Special Concern**.—May become threatened or endangered because of a combination of biological characteristics and identified threats.
- **Threatened**.—Likely to become an endangered species within the foreseeable future throughout all or a significant portion of the species' range.

Figures

Each species conservation status report contains a figure depicting the geographic pattern of migration monitoring trends (% change per year). The trend at each raptor-migration count is represented by an arrow. Arrows pointing upward indicate increasing trends; downward arrows indicate declines. Arrows to both sides indicate that the estimated rate of change is 0% per year. Solid arrows indicate significant trends ($\alpha = 0.05$);

open arrows indicate marginally significant and nonsignificant trends. The relative size of each arrow indicates the magnitude of the trend (≤1%, 1–5%, or >5% per year). Standard periods of analysis for the maps are 1994 to 2004 for northeastern sites, and 1995 to 2005 for western and Gulf Coast sites. Footnotes indicate the period of analysis for shorter-term counts. Inset maps depict long-term (1974 to 2004) trends in northeastern North America.

Tables

Tables 1–2 in the Appendix provide detailed conservation status estimates for bird conservation regions, states, and provinces.

Data Sources

Estimates of world population are from Ferguson-Lees and Christie (2001). Estimates of the percentage of world population in the United States and Canada are taken from Rich et al. (2004). Population status is drawn from the U.S. Fish and Wildlife Service (2002), Canadian Wildlife Service (2006), IUCN (IUCN 2004), and Partners in Flight North American Landbird Monitoring Plan (Rich et al. 2004). The sources listed below were used for migration-count data, BBS trend estimates, CBC data, and conservation-status summaries. The list includes locations of watchsites referred to by name in the conservation status reports. Geographic coordinates of these watchsites are in Chapters 5–8.

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Black Vulture

Scientific name:	*Coragyps atratus*
French name:	*Urubu noir*
Spanish name:	*Zopilote negro*
Body length:	59–74 cm
Wingspan:	141–160 cm
Mass:	1,600–2,300 g
Type of migrant:	Partial
Nest type:	Does not build a nest. Lays eggs directly on ground under cover (e.g., caves, abandoned buildings, hollow logs, etc.).
Food habits:	Carrion, plant material, and some live prey.
Migration flight:	Short glides interspersed with rapid, shallow flapping. Soars with wings held flat.
Estimated world population:	>1,000,000

Ecology and Migration

The Black Vulture is one of the most abundant vultures in the New World and is often seen in large groups at communal roosts and large animal carcasses. Many roost sites are occupied year-round, and some are used for many years. Black Vultures occur in open and partially forested habitats, often close to human settlements or farms. The species recently expanded its range northward in the eastern United States and increasingly is seen in New England and southern Canada. Black Vultures are opportunistic feeders that feed on many types of animal carcasses and that sometimes kill domestic piglets, lambs, and calves, and also take bird eggs and young birds, small mammals, hatchling turtles, small fish, vegetable material, and animal feces. The species lacks the sense of smell of the Turkey Vulture, and often watches the behavior of Turkey Vultures to locate carcasses.

Many individuals are sedentary. In northern parts of the breeding range most migrate south during autumn.

Population Status

Partners in Flight estimates that <10% of the estimated worldwide population of >1,000,000 breeds in the United States and Canada (Appendix). Data from *raptor migration counts*, *BBSs*, and *CBCs* indicate that populations of Black Vultures have (1) increased in northeastern North America since 1974, coinciding with an expansion of breeding range northward and westward, and (2) increased or remained stable around the Gulf of Mexico.

Eastern North America

Previous watchsite analyses.—None.

RPI analysis.—Migration counts indicate that populations of the Black Vulture have increased substantially in parts of northeastern North America since the mid-1970s (Chapter 5). From 1994 to 2004, a significant annual increase of 5.2% was recorded at Waggoner's Gap, Pennsylvania. During this period, a significant annual decline of –6.7% occurred at Cape May, New Jersey, and a nonsignificant decline of –4.2% occurred at Hawk Mountain, Pennsylvania (Fig. 1). Holiday Beach Migration Observatory, Ontario, and Hawk Ridge Bird Observatory, Minnesota, occasionally recorded migrating Black Vultures, whereas no sightings were recorded at l'Observatoire d'oiseaux de Tadoussac, Québec, and Lighthouse Point Hawk Watch, Connecticut. The species' breeding range has recently expanded north into southern New England

Population indexes and fitted trajectories for Black Vultures at these sites (Chapter 5) suggest that this species first occurred as a migrant in Pennsylvania in the 1980s and that numbers have stabilized after a period of rapid increase. Counts at Cape May appear to have declined since 2000, but it is unknown whether this represents a normal fluctuation, change in migration geography, or population decline. Continued population change at the 1994–2004 rates would lead to a 50% increase of Black Vulture source populations in ~13 years at Waggoner's Gap, and 50% declines in 10 years at Cape May and in 17 years at Hawk Mountain.

Other analyses.—BBSs show a significant annual increase of 6.9% in Black Vulture populations in the northeastern United States from 1974 to 2004. This region includes the areas from which seven northeastern watchsites receive migrants. CBCs for northeastern North America from 1975 to 2004 suggest a significant annual increase of 12.8%, but the number of counts reporting the species was quite low in most years (1974 was excluded because no Black Vultures were reported), and the estimate should be interpreted in that light. From 1994 to 2004, Black Vultures were reported on ≥30 CBCs annually, and the estimated trend was a significant annual increase of 8.0%. Significant annual increases of 3.9% and 4.7% occurred in CBCs for southeastern North America from 1974 to 2004 and from 1994 to 2004.

In sum, migration counts, BBSs, and CBCs indicate that Black Vulture populations are increasing in the eastern United States. Increases in the number of CBC counts reporting the species in the Northeast suggest that the species' range is expanding northward.

Western North America

Black Vultures are not recorded regularly at watchsites in western North America.

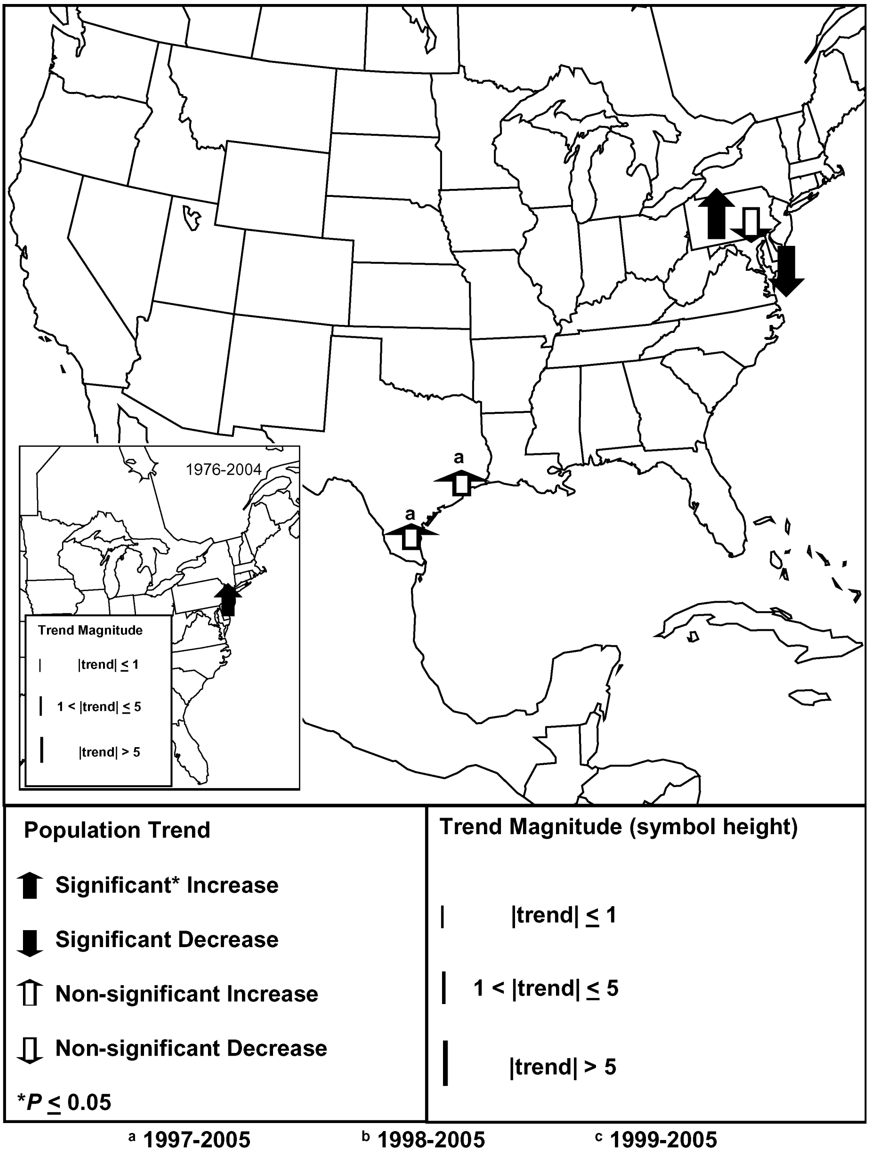

Fig. 1. Population trends for Black Vultures (*Coragyps atratus*) at three northeastern (1994–2004) and two Gulf of Mexico (1997–2005) raptor migration counts in North America, and the long-term (1976–2004) trend at Cape May Bird Observatory, New Jersey (inset). Trends are expressed in percent change per year.

Gulf of Mexico

Previous watchsite analyses.—None.

RPI analysis.—Migration counts indicate that Black Vulture populations migrating through coastal Texas have remained stable or possibly increased slightly since 1997 (Chapter 7), but *P*-values for trend estimates were high (>0.50), and confidence intervals were wide and encompassed zero, giving us little confidence that the actual trends differed from zero.

Other analyses.—BBSs (8.4%) and CBCs (3.5%) indicate significant annual increases in numbers of breeding and wintering Black Vultures in Texas from 1995 to 2005.

Historical Conservation Concerns

Direct persecution in the form of shooting and trapping once threatened Black Vultures, but these activities no longer impose high mortality. Organochlorine pesticides, such as DDT, caused thinning of eggshells between 1947 and 1972 in numerous raptors, but the effects on vulture populations are unknown (Kiff et al. 1983).

Previously published accounts do not report trends for the Black Vulture (e.g., Bednarz et al. 1990, Titus and Fuller 1990, Hussell and Brown 1992) in North America, so little is known about the species' status historically.

Current Conservation Concerns

Black Vultures benefit from a variety of human activities, including livestock-rearing, fishing, and garbage dumps. Vultures also benefit from high densities of roads and their attendant road-killed wildlife, but roads also lead to vulture mortalities due to collisions with vehicles. Ingestion of lead shot in carcasses has been known to affect other avian scavengers, and may affect Black Vultures as well, but these effects have not been studied for this species (Mossman 1991).

Globally, the Black Vulture is listed as a species of least concern and it is not a species of concern in the United States (Appendix).

Summary

Raptor migration counts, BBSs, and CBCs all indicate that populations of Black Vultures have increased in eastern North America during the last several decades. Since 2000, breeding range has expanded into southern New England. Although migration trends indicate a decline during the most recent decade in portions of eastern North America, the increased recording of the species at more westerly watchsites suggests that it has recently expanded its range westward. Migration monitoring in coastal Texas indicates that the species is probably stable in southern North America, although breeding and winter surveys indicate population increases during this period.

Turkey Vulture

Scientific name:	*Cathartes aura*
French name:	*Urubu à tête rouge*
Spanish name:	*Zopilote aura*
Body length:	64–81 cm
Wingspan:	160–181 cm
Mass:	1,600–2,400 g
Type of migrant:	Partial
Nest type:	Does not build a nest. Lays eggs directly on the ground under cover (e.g., caves, abandoned buildings, hollow logs, etc.); sometimes makes a scrape or rearranges the substrate.
Food habits:	Small and large carrion; sometimes plant material, such as grapes and juniper berries (Hiraldo et al. 1991).
Migration flight:	Soars with wings in a dihedral and often flexed, frequently rocks from side-to-side, occasionally pumps and flaps.
Estimated world population:	>1,000,000

Ecology and Migration

The Turkey Vulture is the most widely distributed vulture in the world. The species has a keen sense of smell, an unusual trait for a bird, which it uses, along with sight, to find carcasses.

Turkey Vultures search for food in both open and forested habitats, sometimes close to human settlements and farms where carrion, both wild and domestic, is available. Turkey Vultures often form large, communal roosts in trees, rock outcroppings, utility towers, and buildings. Northern populations tend to be highly migratory, whereas southern populations are often sedentary. During migration, northern populations typically pass over southern populations and winter farther to the south, a pattern called *leap-frog migration*. Western individuals are more migratory than their eastern counterparts, and many birds from the western United States and Canada winter in Central and South America. The species also undertakes short-term, local movements in eastern North America when weather becomes unfavorable. Because they are *obligate soaring migrants*, large flocks tend to concentrate along *leading lines*, *diversion lines*, and *thermal corridors*, making them easy to monitor on migration.

Population Status

Partners in Flight estimates that approximately one-quarter of the estimated worldwide population of >1,000,000 breeds in the United States and Canada (Appendix). Migration counts along the Mesoamerican Land Corridor (Chapter 7) indicate that the North American population exceeds 2,000,000. Raptor migration counts, BBSs, and CBCs indicate that populations of Turkey Vultures have (1) increased substantially throughout northeastern North America since the 1970s and have expanded their range northward; (2) increased since the early 1980s in western North America, but declined since the onset of regional drought in the late 1999s; and (3) increased or remained stable in regions (primarily western) that contribute migrants seen at watchsites along the Gulf of Mexico.

Eastern North America

Previous watchsite analyses.—Most early accounts of raptor population trends did not include Turkey Vultures. Hussell and Brown (1992) reported a nonsignificant annual increase of 3.9% at Hawk Ridge, Minnesota, from 1974 to 1989 and a significant annual increase of 11.7% at Grimsby, Ontario (a spring watchsite), from 1975 to 1990.

RPI analysis.—Migration counts indicate that populations of Turkey Vultures have increased substantially in northeastern North America since the mid-1970s (Chapter 5). From 1994 to 2004, significant increases of 5.6%, 13.7%, 16.7%, and 3.9% were recorded at Lighthouse Point, Connecticut, Hawk Mountain, Pennsylvania, Waggoner's Gap, Pennsylvania, and Hawk Ridge, respectively. Nonsignificant increases of 1.5%, 1.8%, and 5.0% were recorded at Cape May, New Jersey, Montclair, New Jersey, and Holiday Beach, Ontario, respectively (Fig. 2). Tadoussac, Québec, counted <20 birds per year, and we did not estimate trends at that watchsite. The species first appeared at the site in 1999, and counts increased from 5 in 1999 to 22 in 2003 (unpublished data, available at www.explos-nature.qc.ca/oot).

These patterns suggest that populations of Turkey Vultures have increased substantially in eastern North America since 1990, when watchsites in the region began counting consistently. Continued population change at the 1994–2004 rates would lead to a 50% increase of Turkey Vulture source populations in ~12 years at Lighthouse Point, 39 years at Montclair, 5 years at Hawk Mountain, 4 years at Waggoner's Gap, and 18 years at Hawk Ridge.

Other analyses.—BBSs showed significant annual increases of 4.6% from 1974 to 2004 and 4.2% from 1994 to 2004 in the northeastern United States. CBCs indicated significant annual increases of 7.5% from

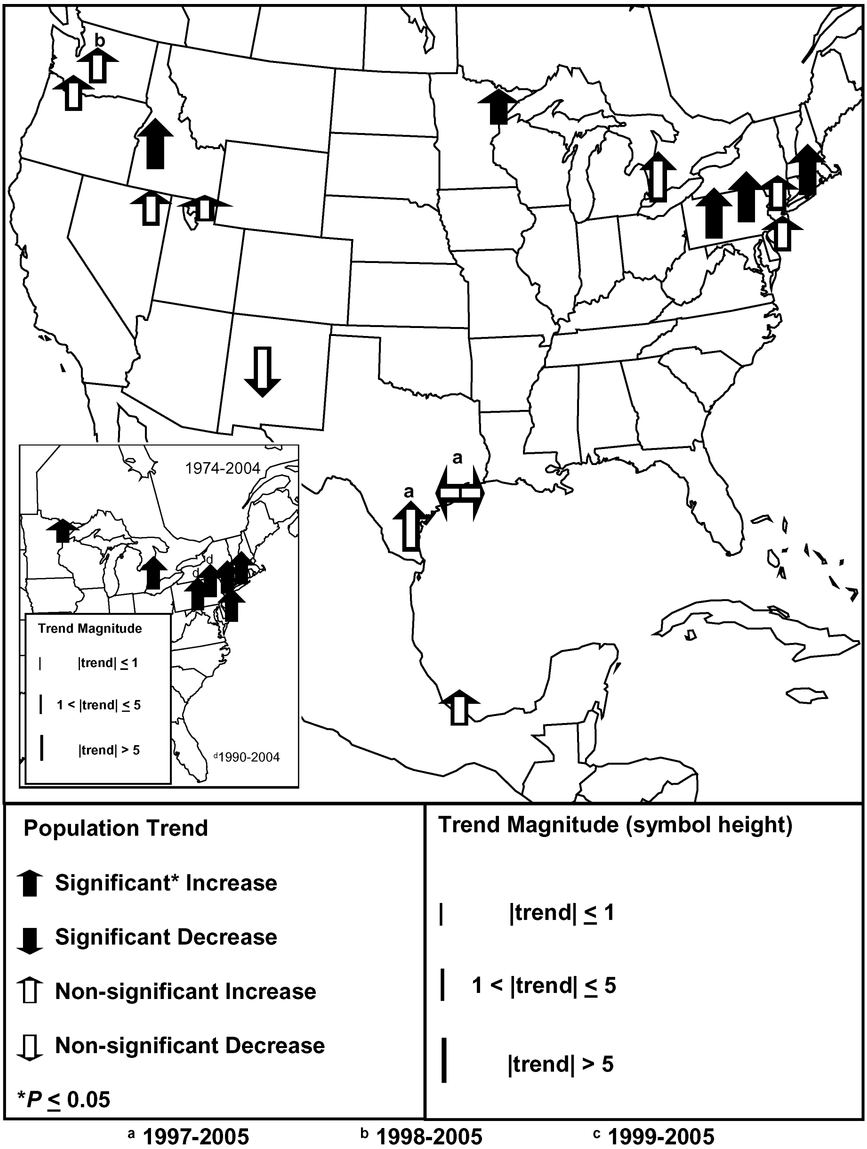

Fig. 2. Population trends for Turkey Vultures (*Cathartes aura*) at eight northeastern (1994–2004), eight western (1995–2005), and three Gulf of Mexico (1995–2005) raptor migration counts in North America and long-term trends (1974–2004) at seven northeastern raptor migration counts (inset). Trends are expressed in percent change per year. A bi-directional arrow indicates that the estimated trend is 0% per year.

1974 to 2004 and 5.2% from 1994 to 2004 in northeastern North America. Significant annual increases of 4.2% and 4.0% were recorded by CBCs in southeastern North America from 1974 to 2004 and from 1994 to 2004, respectively.

In sum, migration counts, BBSs, and CBCs indicate that Turkey Vulture populations are increasing throughout northeastern North America. Migration counts suggest that increases are more pronounced inland than along the coast (Fig. 2).

Western North America

Previous watchsite analyses.—Hoffman and Smith (2003) reported significant increases in numbers of migrating vultures at the Goshute Mountains Raptor Migration Project, Nevada, from 1983 to 2001, the Wellsville Mountains Raptor Migration Project, Utah, from 1987 to 2001, the Manzano Mountains Raptor Migration Project, New Mexico, from 1983 to 2001, and the Sandia Mountains Raptor Migration Project, New Mexico (spring watchsite), from 1985 to 2001. No significant trends were recorded at the Grand Canyon Raptor Migration Project (Lipan Point), Arizona, from 1991 to 2001, or at the Bridger Mountains Raptor Migration Project, Montana, from 1992 to 2001.

RPI analysis.—Migration counts indicate that Turkey Vulture populations increased in the western United States between the mid-1980s and late 1990s and then began to stabilize or decline following the onset of a regional drought in 1999 (Chapter 6). From 1995 to 2005, a significant annual increase of 18.3% occurred at Boise Ridge, Idaho, and a marginally significant annual increase of 5.5% was recorded at Bonney Butte Raptor Migration Project, Oregon. Nonsignificant annual increases of 5.5%, 1.5% and 0.3% occurred at Chelan Ridge Raptor Migration Project, Washington, from 1998 to 2005, the Goshutes from 1995 to 2005, and the Wellsvilles from 1995 to 2004. In contrast to these short-term trends, the Manzanos recorded a marginally significant annual decrease of –8.2%.

The counts suggest either that the regional drought affected Rocky Mountain populations more than those farther west, or that the drought and factors coinciding with it resulted in a geographic shift of vulture migration away from the Rocky Mountains and toward the Pacific Coast. Overall migration-count data suggest that western populations of vultures have been increasing during the past two decades, at an average annual rate of 2.5% since the mid-1980s.

Other analyses.—BBSs detected a significant 1.7% annual increase from 1983 to 2005, and a nonsignificant 0.3% decline from 1995 to 2005. CBCs indicated a significant annual increase of 1.5% from 1983 to 2005, and a nonsignificant annual decline of 0.6% from 1995 to 2005.

Gulf Coast

Previous watchsite analyses.—None.

RPI analysis.—Migration counts indicate that Gulf Coast populations are stable or increasing (Chapter 7).

Other analyses.—Survey-wide (i.e., throughout Canada and the United States) BBSs indicate a significant annual increase of 2.5% in breeding populations of Turkey Vultures in North America from 1995 to 2005. BBSs in Texas also increased significantly at 2.4% annually, but those in Florida underwent a nonsignificant –1.7% annual decline during this period.

Historical Conservation Concern

Direct persecution in the form of shooting and trapping by ranchers and farmers once threatened Turkey Vultures, but these activities no longer kill many birds. Organochlorine pesticides, including DDT, caused eggshell thinning but population effects are unknown (Kiff et al. 1983).

Current Status and Concerns

Turkey Vultures benefit from many human actions, including livestock-rearing, fishing, and garbage disposal at landfills. Vultures benefit from high densities of roads and the road-kills that result, but roadways also kill vultures. Ingestion of lead shot and bullet fragments lodged in carcasses also probably impact this species (Carpenter et al. 2003).

The Turkey Vulture is a species of least concern globally, is not listed as a species of concern in the United States, and is not at risk in Canada (Appendix). Kirk and Hyslop (1998) suggested that the species was increasing or stable and expanding its range in Canada.

Summary

Notwithstanding the indication that drought in western North America may have affected Turkey Vultures in the Rocky Mountains, populations appear to be stable or increasing throughout most of North America, and have been doing so for several decades.

Osprey

Scientific name:	*Pandion haliaetus*
French name:	*Balbuzard pêcheur*
Spanish name:	*Gavilán pescador, Águila pescadora*
Body length:	51–66 cm
Wingspan:	150–180 cm
Mass:	1,400–2,000 g
Type of migrant:	Complete. Often long-distance and transequatorial.
Nest type:	Large stick nest near water in a tree or other large platform.
Food habits:	Eats fish primarily. Other items, including birds, mammals, mollusks, and snakes reported, but uncommon.
Migration flight:	Slow, deep, stiff-winged flapping flight interspersed with soaring on crooked, "M"-shaped wings. Crosses water regularly.
Estimated world population:	<100,000.

Ecology and Migration

The Osprey is a cosmopolitan raptor that breeds or over-winters on all continents except Antarctica. In North America, it nests in coastal areas and around lakes, rivers, marshes, and reservoirs, generally within a few kilometers of water. The largest concentrations of breeding pairs occur around marine bodies of water.

The Osprey is a *complete migrant* whose diet of live fish makes migration away from many high-latitude areas necessary as fish move to deeper water in autumn and many bodies of water freeze over in winter. Most North American populations make long migratory movements into Central and South America in winter, but some in Florida, Mexico, and elsewhere in the Caribbean Basin remain on their breeding range year-round. Ospreys from eastern North America generally migrate farther south into South America than those from western North America, which winter mainly in Mexico or Central America.

Population Status

Numbers in the United States were estimated at 8,000 breeding pairs in 1983 (Henny 1983) and 16,000–19,000 pairs in 2001 (Poole et al. 2002). The estimated number of breeding pairs in Canada in the early 1990s was 10,000–12,000 (Kirk et al. 1995). Partners in Flight estimates the population of Ospreys in the United States and Canada to be approximately one-half of the world population of <100,000 (Appendix). Migration counts and BBSs indicate that populations of the Osprey have (1) increased in eastern North America since 1974 and, apparently, stabilized there in the last 10 years; (2) increased or remained stable in western North America since the early 1980s; and (3) increased more strongly in eastern and midwestern North America than in the Great Lakes or western North America, based on count trends in the Gulf of Mexico.

Eastern North America

Previous watchsite analyses.—Bednarz et al. (1990) reported a nonsignificant increase in counts of Ospreys at Hawk Mountain, Pennsylvania, from 1934 to 1942. A significant decline in counts was recorded from 1946 to 1972, and a significant, post-DDT Era increase was reported for the period 1973 to 1986 (Bednarz et al. 1990), but no estimates were made of the rates of change. In a study of six watchsites in eastern North America, Titus and Fuller (1990) reported a significant annual increase of 8.9% from 1972 to 1987. Hussell and Brown (1992) reported a significant annual increase of 5.8% at Hawk Ridge, Minnesota, from 1974 to 1989, and a significant annual increase of 6.2% at Grimsby, Ontario (a spring watchsite), from 1975 to 1990. At Cedar Grove Ornithological Station, Wisconsin, Mueller et al. (2001) reported a significant increase in counts from 1936 to 1999, and a nonsignificant decline from 1989 to 1999.

RPI analysis.—Migration counts indicate that populations of the Osprey have increased steadily in northeastern North America since 1974 (Chapter 5). From 1994 to 2004, nonsignificant annual increases of 2.7%, 1.0%, and 4.1% were recorded at Montclair, New Jersey, Hawk Mountain, and Waggoner's Gap, Pennsylvania, respectively; whereas nonsignificant annual declines of –1.8%, –6.0%, –3.1%, –1.7%, and –0.1% were recorded at Tadoussac, Québec, Lighthouse Point, Connecticut, Cape May, New Jersey, Holiday Beach, Ontario, and Hawk Ridge, respectively, from 1994 to 2004 (Fig. 3). Thus, the species increased throughout the region over the last 30 years, primarily due to increases in the 1970s and 1980s, but was largely stable in the last decade.

Other analyses.—BBSs indicate significant annual increases of 4.6% from 1976 to 2003 in northeastern North America, and 6.7% from 1994 to 2004 in the northeastern United States. Osprey populations are not well sampled by BBSs, and their trend estimates should be considered in this light.

Western North America

Previous watchsite analyses.—The species increased significantly at the Goshutes, Nevada (1983 to 2001), Wellsvilles, Utah (1987 to 2001),

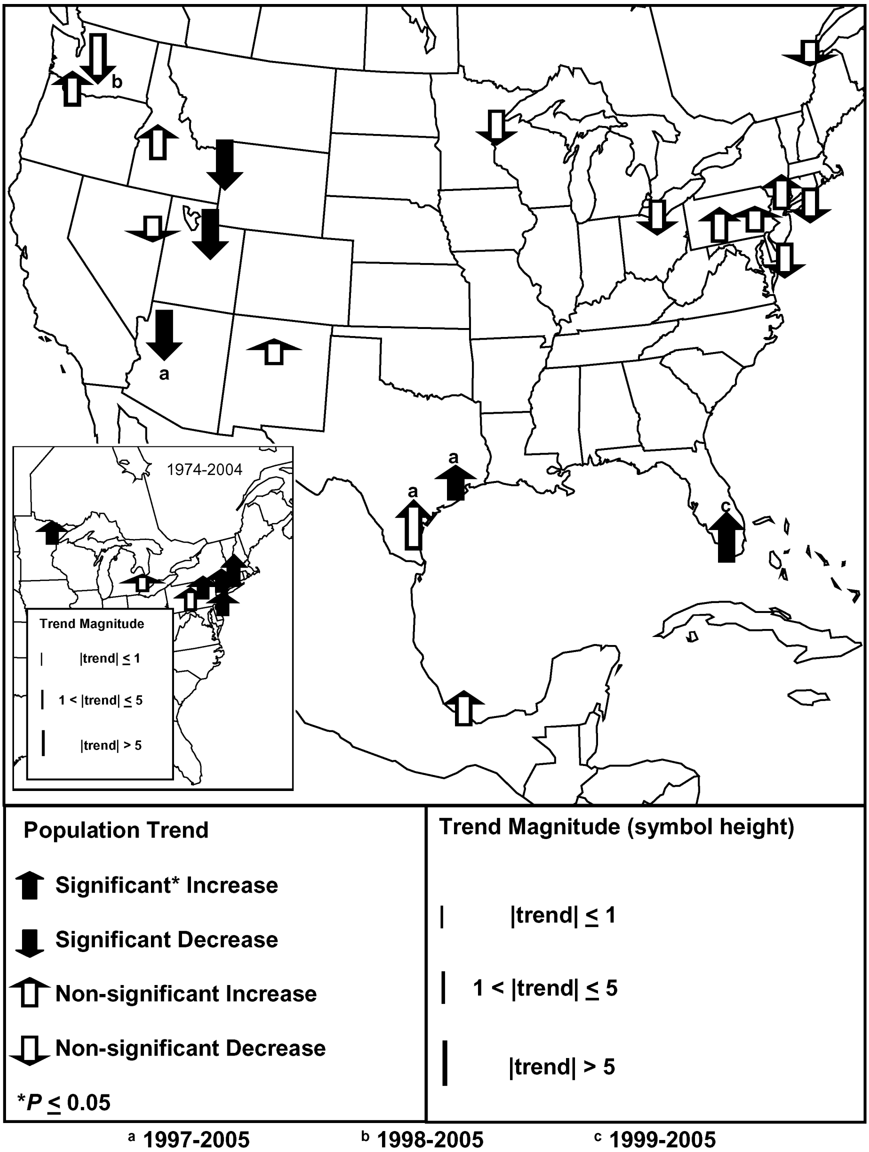

Fig. 3. Population trends for Ospreys (*Pandion haliaetus*) at eight northeastern (1994–2004), eight western (1995–2005), and four Gulf of Mexico raptor migration counts in North America, and long-term trends (1974–2004) for seven northeastern counts (inset). Trends are expressed in percent change per year.

Manzanos, New Mexico (1983 to 2001), Grand Canyon, Arizona (Lipan Point) (1991 to 2001), and the Sandias, New Mexico (a spring watchsite) (1985 to 2001); but no significant trend was recorded at the Bridger Mountains, Montana (1992 to 2001) (Hoffman and Smith 2003).

RPI analysis.—Migration counts suggest that populations of Ospreys have increased or remained stable in parts of the western United States since the mid-1980s (Chapter 6). In the last decade, significant declines of –7.1%, –12.6%, and –5.0%, respectively, occurred in counts at the Wellsvilles and at shorter-term watchsites at the Bridger Mountains and the Grand Canyon (Lipan Point). The Grand Canyon, Arizona (Lipan Point and Yaki Point, combined), recorded a marginally significant annual decline of –4.4% from 1997 to 2005, and there were nonsignificant declines of –1.0%, –6.0%, and –2.2% at the Goshutes, Chelan Ridge, Washington (1998 to 2005), and Bonney Butte, Oregon, respectively. No net change (0.0%) was observed at the Manzanos in the last decade (Fig. 3).

When trend estimation is restricted to the drought period (i.e., post-1998), there were significant annual declines of –10.0% and –4.4%, respectively, at the Wellsvilles and the Grand Canyon (Lipan Point and Yaki Point, combined). A significant annual increase of 4.4% occurred at Boise Ridge, Idaho, whereas a nonsignificant annual increase of 2.2% occurred at Bonney Butte.

Other analyses.—BBSs showed significant annual increases of 6.3% and 6.0% from 1983 to 2004 and 1995 to 2005, respectively.

Overall, these data suggest an expansion of western Osprey populations between the early 1980s and mid-1990s, most likely reflecting a combination of recovery from the effects of DDT and increased use of reservoirs and artificial nesting structures (Hoffman and Smith 2003). The positive effects of moist El Niño periods in the early to mid-1980s and early to mid-1990s on foraging habitat also may have aided this expansion. It appears that the onset of a regional drought in 1998, which dried up some water courses and caused large fish kills, may have altered the migration geography of the species.

Gulf of Mexico

Previous watchsite analyses.—None.

RPI analysis.—Migration counts recorded annual increases throughout the Gulf region (Chapter 7, Fig. 3). Migrants recorded in the Florida Keys and Smith Point, Texas, are primarily of eastern and midwestern origin, whereas those counted at Corpus Christi, Texas, and Veracruz originate primarily in the Great Lakes and western North America (Martell et al. 2001), and differences in the magnitude and significance of trends among these watchsites suggest that Ospreys have increased more strongly in eastern than in western North America during the last decade. Unfortunately, confidence intervals around the trends in this region are relatively wide due to the relatively short time series available for analysis, limiting our ability to distinguish between stable and increasing trends.

Other analyses.—BBSs estimate a nonsignificant annual decline of –0.7% in Florida from 1995 to 2005, and a nonsignificant annual increase of 0.7% in the southeastern United States.

Historical Conservation Concerns

Ospreys in many parts of North America, particularly those breeding in coastal areas in the Northeast, were negatively affected by organochlorine pesticides, including DDT, in the middle of the last century (Spitzer et al. 1978). Osprey populations also were affected, historically, by shooting, although to a lesser extent than many raptors. Poole and Agler (1987) reported that U.S. banding data from 1972 to 1984 showed 30% of recovered banded Ospreys were shot, mostly on the winter range in Central and South America.

Current Status and Concerns

Shooting still occurs at low levels in North America, and there are higher rates of shooting in South America. Ospreys are generally tolerant of human activity, and land development *per se* does not appear to affect them negatively. However, limitation of suitable nest sites can limit populations unless mitigated with artificial nest platforms (e.g., Watts et al. 2004).

The Osprey is a species of least concern globally and is not listed as a species of concern in the United States (Appendix). Kirk and Hyslop (1998) rated the Osprey as increasing or stable in most of Canada.

Summary

Migration monitoring and BBSs indicate that Osprey populations in eastern and western North America increased over the last 20–30 years but that these gains have slowed or been reversed in the most recent decade. Overall numbers are believed to be close to pre-DDT Era levels (A. Poole pers. comm.), and the recent changes probably indicate stabilization of populations after a period of increase. Recent trends at raptor migration counts around the Gulf of Mexico suggest that more southerly populations are increasing.

Swallow-tailed Kite

Scientific name:	*Elanoides forficatus*
French name:	*Le Milan de la Caroline*
Spanish names:	*Gavilán tijereta, Gavilán cola de tijera*
Body length:	50–64 cm
Wingspan:	119–136 cm
Mass:	325–500 g
Type of migrant:	Complete
Nest type:	Loose, circular to oval, twig-and-lichen nest high in a dominant tree near the edge of open habitat.
Food habits:	Preys primarily on insects, frogs, and lizards, but also takes nestling birds, lizards, snakes, small mammals, and, occasionally, bats, fruit, and small fish.
Migration flight:	Graceful, buoyant soaring with frequent changes in position of long, forked tail. Powered flight with slow, flexible flaps.
Estimated world population:	100,000–1,000,000

Ecology and Migration

The Swallow-tailed Kite is a gregarious, medium-sized raptor that breeds in the southeastern United States, southern Mexico, and Central America. Individuals spend much of their day aloft, gracefully soaring while flapping only rarely but constantly adjusting their tail. The species frequently "kites" or hangs motionless by turning into the wind.

Swallow-tailed Kites nest primarily in dominant trees in woodlands with open, uneven canopy structure, adjacent to open habitats. Most common nesting habitats in the United States consist of hardwood and cypress swamps, lowland pine forests, and marshes.

Most individuals that breed in the United States migrate south out of North America. Two main pathways are used, from Florida to the Yucatan across the Gulf of Mexico, and around the Gulf Coast south through eastern Mexico. Satellite-tracking has revealed that most migrants spend the winter in South America after having flown across the Gulf of Mexico from Florida (K. Meyer pers. comm.). Late-summer staging of thousands of birds at communal roosts occurs in south-central Florida, especially near Lake Okeechobee. The timing of the species' migration, with departure in late July for many birds, limits its detection at watchsites that begin their counts in mid-August.

Population Status

Partners in Flight estimates that the population of Swallow-tailed Kites in the United States and Canada comprises <10% of the global population of 100,000 to 1,000,000 (Appendix; Meyer and Collopy 1990). Data from migration counts and BBSs suggest that Swallow-tailed Kite populations have increased since 1995 in southeastern North America. Previously published summaries of raptor migration counts in North America have not included trend estimates for this species.

Eastern North America

Swallow-tailed Kites are not regularly seen at watchsites in eastern North America and, consequently, migration trends cannot be calculated.

Western North America

Swallow-tailed Kites are not seen at watchsites in western North America and, consequently, migration trends cannot be calculated.

Gulf of Mexico

Previous watchsite analyses.—None.

RPI analysis.—Migration counts in this region indicate that at least some northern populations are increasing (Chapter 7), with increases reported in counts in Texas and Mexico (Fig. 4). The average counts at all three watchsites were relatively small and represent only a small sample of the species' overall North American population. Swallow-tailed Kites also are observed at the Florida Keys, Florida, but counts there begin too late to cover the early-season (i.e., late July to early August) movements of this species. The relatively high magnitudes of the estimated increases in Texas and Veracruz indicate that the migration volume of Swallow-tailed Kites passing around the northern and western Gulf of Mexico is increasing. Whether this reflects a population increase or a shift in migration geography is unknown. Improved seasonal coverage of this early-season migrant and an expansion of efforts across a broader network of sites are needed to improve our understanding of the species' status. Other sites with useful data for monitoring this species include Kekoldi, Costa Rica, and the Ocean-to-Ocean count in Panama (Chapter 2). Systematic monitoring at the large premigration roosts in Florida also represents a potentially valuable tool for monitoring the species.

Other analyses.—BBSs suggest a nonsignificant annual increase of 2.2% in Florida from 1995 to 2005. BBS trend estimates for the species are of low reliability, because the species is detected on a low number of routes, and this trend should be considered in this light.

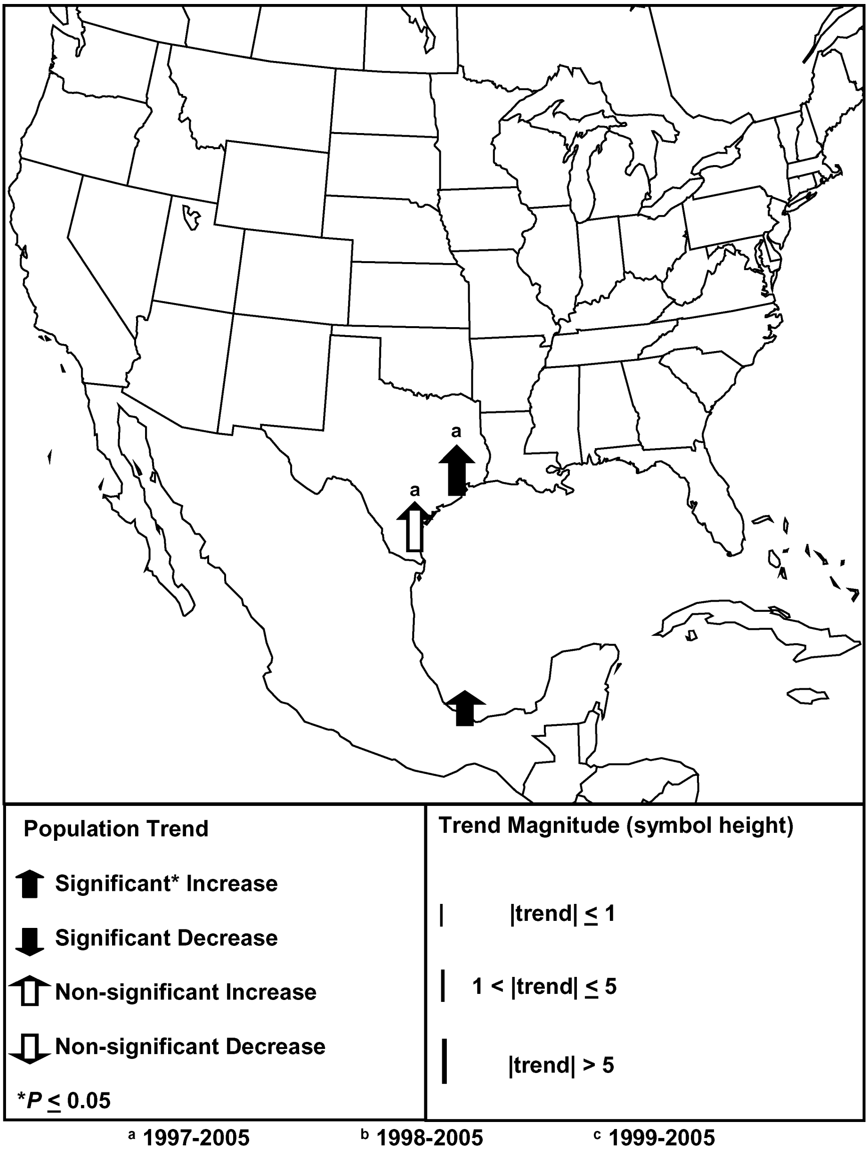

Fig. 4. Population trends (1995–2005) for Swallow-tailed Kites (*Elanoides forficatus*) at three Gulf Coast raptor migration counts. Trends are expressed in percent change per year.

Historical Conservation Concerns

Historically, the species nested throughout Florida, the southeastern coastal United States, and along major drainages of the Mississippi River Valley north to Minnesota. The species declined dramatically and its range in the United States contracted between 1880 and 1940 (Cely 1979), likely because of agricultural development in the Mississippi Valley, logging of many bottomland forests, and direct persecution. Persecution included collecting eggs and shooting the conspicuous adults.

Current Status and Concerns

Changes in land use in the southeastern United States pose the greatest threat to Swallow-tailed Kites. Activities such as logging, human development, and flood control lead to loss or degradation of nesting, foraging, and roosting habitats. Short timber rotations in actively managed coastal pine forests reduce nesting habitat and prey abundance in some areas. Some nesting attempts fail because poor quality, exotic nest trees are selected for nesting, which provide marginal support in high winds. Shooting and pesticides may threaten birds on their winter range and during migration. The propensity of this species to form large pre-migration and winter roosts increases its vulnerability to disturbance events. The Yucatan Peninsula of Mexico appears to be an important stopover point for this species, and more research is needed to identify sites or habitats being used and their level of protection.

The Swallow-tailed Kite is a species of least concern globally, but is a species of concern in the United States and receives special protection in Mexico (Appendix).

Summary

Monitoring programs suggest that Swallow-tailed Kite populations may be increasing in North America, but current data are not sufficient to resolve the rates of increase accurately. Given the range of conservation threats to the species, rates of land-use change in its breeding range, and the fragmented nature of the population, increased monitoring is needed. Conservation and monitoring at critical habitats, including long-term nesting, roosting, and migration-stopover sites, also should be considered.

Mississippi Kite

Scientific name:	*Ictinia mississippiensis*
French name:	*Milan du Mississippi*
Spanish names:	*Milano de Mississippi, Gavilán de Mississippi, Gavilán grisillo, Milano migratorio*
Body length:	Female: 35–37 cm Male: 34–36 cm
Wingspan:	Range: 75–83 cm
Mass:	Female: 270–388 g Male: 214–304 g
Type of migrant:	Complete
Nest type:	Loosely compacted, circular to oval twig nest in the fork of a limb or main trunk.
Food habits:	Preys primarily on medium to large insects; also takes small mammals, small birds, amphibians, reptiles, and road kills. Known for acrobatic aerial hunting.
Migration flight:	Light, buoyant flight, dominated by soaring and gliding on flat wings with tips often flared upward. Migrates in flocks.
Estimated world population:	100,000–1,000,000

Ecology and Migration

The Mississippi Kite is a medium-sized raptor whose eastern populations are associated primarily with old-growth forests or mature riparian habitat. Individuals often forage and roost in groups. This gregarious habit, combined with a tendency to hunt in open areas, from exposed perches or on the wing, makes the species relatively conspicuous.

In the Southeast, Mississippi Kites nest primarily in old-growth trees within large (>80 ha) contiguous stands, near the edge of more open habitats. In the Great Plains, the species nests in individual trees, woodlots, and "shelterbelts" of trees planted to act as wind barriers. Sometimes nests in suburban and even urban woodlots.

Most individuals migrate south into South America in autumn.

Population Status

The Mississippi Kite is a North American endemic with a breeding population of 100,000 to 1,000,000 (average count at Veracruz, Mexico is >200,000). The estimate from Veracruz represents a substantial increase over the population estimate of Ferguson-Lees and Christie (2001; 10,000 to 100,000) (Appendix). Migration counts and BBSs suggest that Mississippi Kite populations have increased since 1995. Previously published summaries of raptor migration counts in North America have not included trend estimates for this species.

Eastern North America

Mississippi Kites are seen only rarely at watchsites in eastern North America and, consequently, no migration trends can be calculated for the species in this region. Since 1974, autumn counts have included a total of seven individuals at Cape May, New Jersey, and two at Hawk Mountain, Pennsylvania. Ten other eastern watchsites have reported sightings (Chapter 2).

Western North America

Mississippi Kites are seen only rarely at watchsites in western North America and, consequently, no migration trends can be calculated for the species in this region. Single individuals have been recorded in the Grand Canyon, Arizona, and at the Sandia Mountains, New Mexico (spring watchsite).

Gulf of Mexico

Previous watchsite analyses.—None.

RPI analysis.—Migration counts indicate that populations of this species are increasing, with large annual increases recorded in counts in Texas and Mexico (Chapter 7, Fig. 5). Counts at the two Texas watchsites and, particularly, at Veracruz monitor nearly the entire population of North America. Unfortunately, high variability at these watchsites provides low confidence in estimates of rates of increase. Other sites with useful data for monitoring this species include Kekoldi, Costa Rica, and the Ocean-to-Ocean count in Panama (Chapter 2).

Other analyses.—BBSs recorded nonsignificant annual increases from 1995 to 2005 in the southwestern (3.0%) and southeastern (5.0%) United States. Due largely to its patchy distribution and inconspicuous nature in parts of the breeding range, the species was detected on a low number of BBS routes in each region, and the resulting high variance in counts gives these trend estimates low precision.

Historical Conservation Concerns

Breeding populations in the southeastern United States are believed to have declined in the late 19th and into the early 20th century. Nesting success was low in some areas in the 1970s (Glinski and Ohmart 1983), when weather and predation caused many failures. Habitat destruction, persecution, egg-collecting, pesticide use, and shooting are believed to have contributed to earlier widespread declines and range retractions (Meyer 1990, Franson 1994). This species' low reproductive rate and its

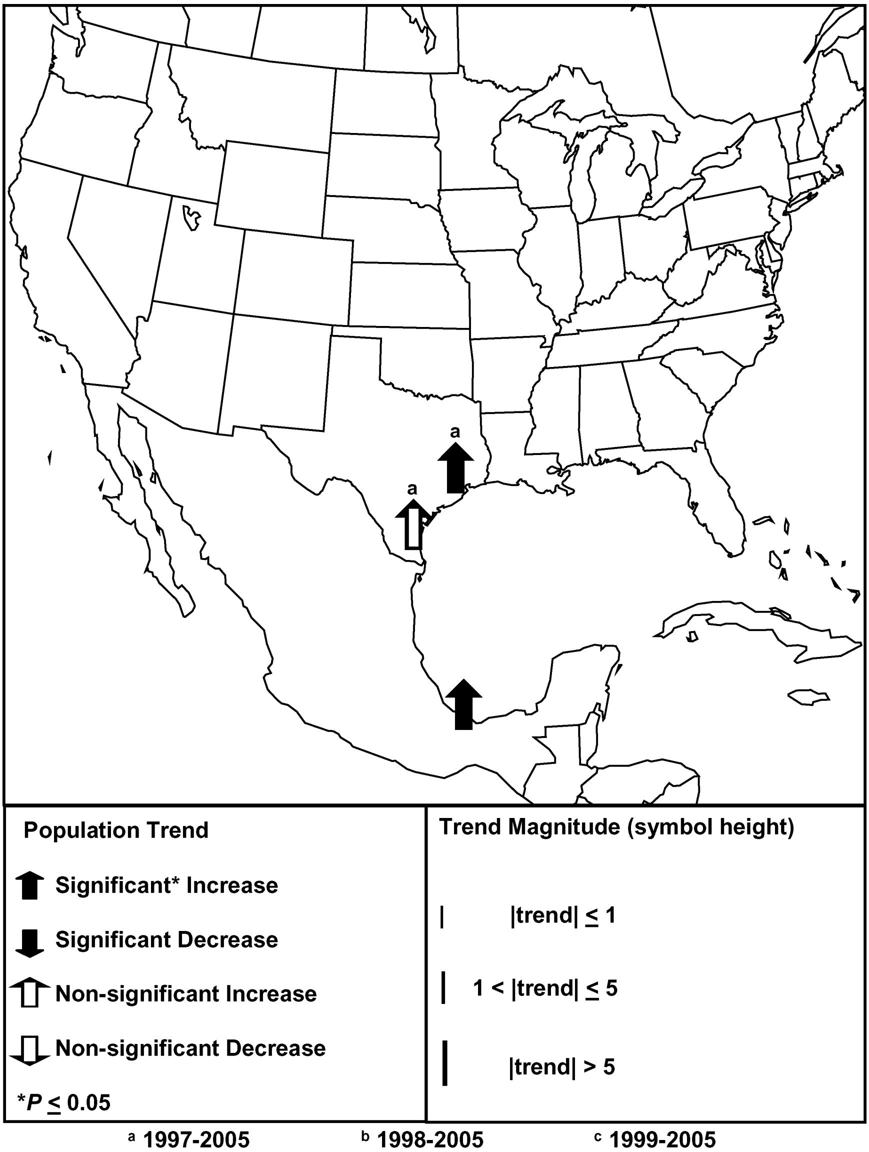

Fig. 5. Population trends (1995–2005) for Mississippi Kites (*Ictinia mississippiensis*) at three Gulf Coast raptor migration counts. Trends are expressed in percent change per year.

penchant for invertebrate prey may make it particularly susceptible to negative impacts from pesticide applications, although apparently it was not heavily affected by DDT (Parker 1976). Further research and monitoring of nesting success and pesticide loads is warranted.

Current Status and Concerns

Breeding populations began increasing in the Great Plains region in the mid-20th century, coinciding with the establishment of shelterbelts throughout the region. Less pronounced increases occurred at the same time in the southeastern United States (Parker and Ogden 1979, Meyer 1990). More recently, urban populations of kites have grown rapidly (Parker 1996). Although shooting and egg-collecting have decreased, some individuals are shot in response to aggressive nest defense at golf courses and houses (Parker 1988).

The Mississippi Kite is a species of least concern globally, and is not listed as a species of concern in the United States (Appendix).

Summary

Monitoring programs suggest that Mississippi Kite populations are increasing in North America, but the precision of current trend estimates is not sufficient to resolve the rates of increase. The use of data from additional watchsites in Central America will aid in monitoring. The low reproductive rates that characterize some populations merit further study.

Bald Eagle

Scientific name:	*Haliaeetus leucocephalus*
French name:	*Pygargue à tête blanche*
Spanish name:	*Águila cabeza blanca, Águila calva*
Body length:	70–96 cm
Wingspan:	180–244 cm
Mass (northern subspecies):	Female: 4,600–6,400 g Male: 3,700–4,800 g
Type of migrant:	Partial
Nest type:	Large stick nest in a high fork, typically in an emergent, usually live, tree.
Food habits:	Opportunistic. Eats primarily fish, but takes small mammals, reptiles and amphibians, crustaceans, birds, including waterfowl, and carrion, including carcasses of fish, birds, and mammals. Sometimes frequents garbage dumps. Also steals food from other raptors, including Ospreys.
Migration flight:	Slow, powerful gliding and soaring flight, interspersed with flapping. Soars mainly on flat wings.
Estimated world population:	100,000–1,000,000

Ecology and Migration

One of 10 species of "sea eagles" worldwide. Migration in Bald Eagles is complex, with the degree of movement changing with age and breeding status. Most non-adults migrate or move nomadically. Adults are migratory in some populations and largely sedentary in others. Outbound migrations occur from August through January in most areas, with some individuals moving shorter distances than others. Bald Eagles begin nesting in Florida in November and December, and young fledge in late winter. In spring and summer, young-of-the-year and many older "Florida birds" fly north and over-summer in the mid-Atlantic States, New England, and eastern Canada. They return to Florida in late summer to early winter. As a result, eastern watchsites, such as Hawk Mountain, Pennsylvania, experience two peaks in eagle migration in autumn; a late-August to September flight of Florida birds on return migration, and a lesser November–December flight of outbound northern birds.

Population Status

Bald Eagles are North American endemics with an estimated breeding population of 100,000–1,000,000 birds (Appendix). Surveys of breeding pairs conducted for the U.S. Fish and Wildlife Service indicate a total of ~10,000 breeding pairs in the lower 48 states, and an estimated additional 40,000 total birds in Alaska (U.S. Fish and Wildlife Service 2007). Data from migration counts, BBSs, and CBCs indicate that populations of the Bald Eagle have (1) increased since 1974 in northeastern North America and (2) increased slightly or remained stable in much of western North America.

Eastern North America

Previous watchsite analyses.—Bednarz et al. (1990) reported a nonsignificant decline in autumn numbers of Bald Eagles at Hawk Mountain, Pennsylvania, from 1934 to 1942, a significant decline from 1946 to 1972, and a significant post-DDT-era increase from 1973 to 1986. Titus and Fuller (1990) reported a significant annual increase of 13.5% per year from 1972 to 1987 in counts at six autumn watchsites in the Northeast. Hussell and Brown (1992) reported significant annual increases of 18.7% at Hawk Ridge, Minnesota, from 1974 to 1989, and 13.5% at Grimsby, Ontario (a spring watchsite), from 1975 to 1990. Mueller et al. (2001) reported a significant increase in autumn counts at Cedar Grove, Wisconsin, from 1936 to 1999 and a nonsignificant decline from 1989 to 1999.

RPI analysis.—Migration counts indicate that populations of the Bald Eagle have increased steadily in northeastern North America since 1974 (Chapter 5). From 1994 to 2004, significant annual increases of 4.7%, 9.8%, 8.6%, 5.3%, 8.7%, and 7.9% were recorded at Tadoussac, Québec, Lighthouse Point, Connecticut, Montclair, New Jersey, Hawk Mountain, Waggoner's Gap, Pennsylvania, and Hawk Ridge, respectively. Cape May, New Jersey (4.2%), and Holiday Beach, Ontario (5.1%), recorded nonsignificant annual increases from 1994 to 2004 (Fig. 6). Continued change at 1994–2004 rates would lead to a 50% increase in ~15 years at Tadoussac, 7 years at Lighthouse Point, 8 years at Montclair, 13 years at Hawk Mountain, 8 years at Waggoner's Gap, and 9 years at Hawk Ridge.

Other analyses.—BBSs in northeastern North America increased a nonsignificant 5.9% annually from 1976 to 2003, and 2.4% from 1994 to 2004 in the northeastern United States. Bald Eagles increased a significant 19.9% per year from 1976 to 2003, and 12.2% per year from 1994 to 2004 in the southeastern United States over the same time span. CBCs in northeastern North America increased a significant 7.2% annually from 1976 to 2003. In southeastern North America, they increased a significant 6.7% annually from 1974 to 2004. Steenhof et al. (2002) reported a significant 6.1% annual increase in northeastern winter counts from 1986 to 2000, as well as a nonsignificant 1.5% annual increase in southeastern counts.

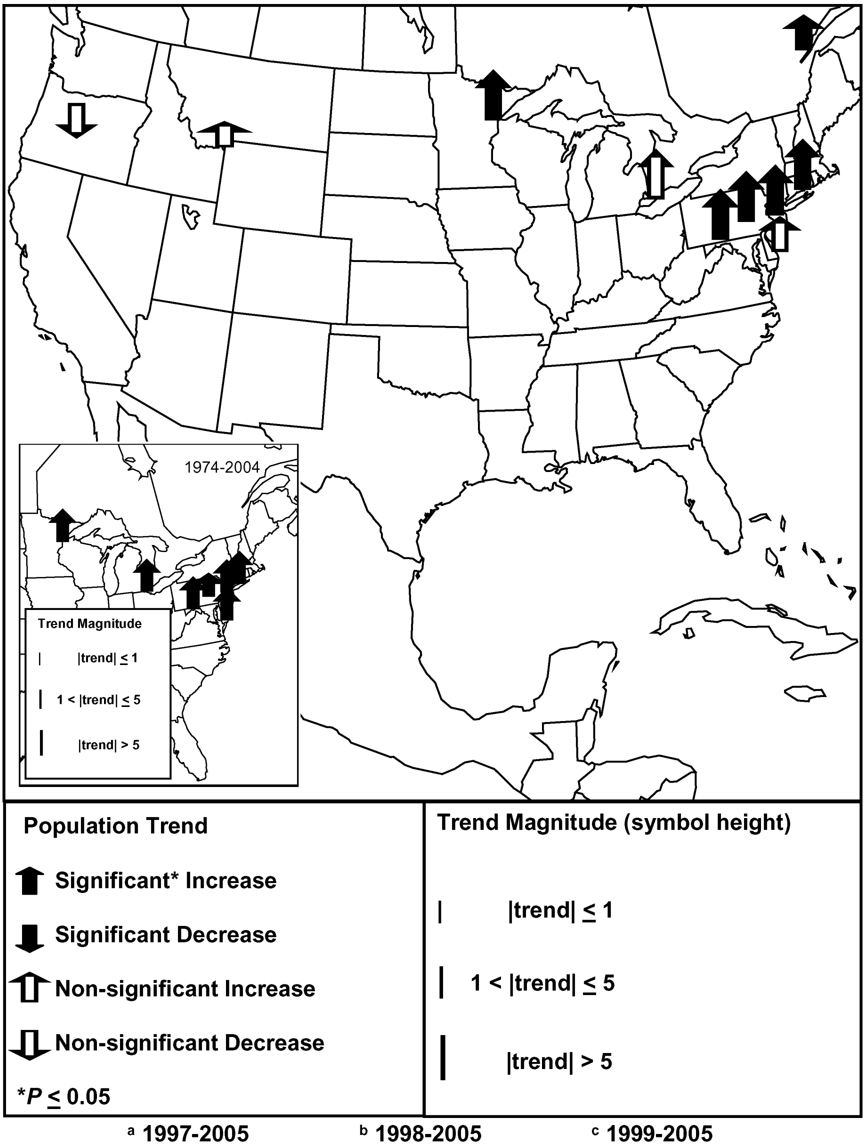

Fig. 6. Population trends for Bald Eagles (*Haliaeetus leucocephalus*) at eight northeastern (1994–2004) and two western (1995–2005) raptor migration counts in North America, and long-term trends (1974–2004) for seven northeastern counts (inset). Trends are expressed in percent change per year.

Western North America

Previous watchsite analyses.—None.

RPI analysis.—Sufficient numbers of Bald Eagles to estimate trends (≥20 per year) occurred only at Bonney Butte, Oregon, and the Bridger Mountains, Montana (Chapter 6), where, from 1995 to 2005, the two sites recorded nonsignificant annual declines of –2.0% and –0.4%, respectively (Fig. 6).

Other analyses.—Steenhof et al. (2002) reported nonsignificant annual increases of 1.3% in winter counts of Bald Eagles in the Great Basin from 1983 to 2005, as well as a nonsignificant 1.6% annual increase for the Pacific Coast, a nonsignificant –0.3% decline for the Rocky Mountains, and a nonsignificant –1.2% decline for the Southwest Desert region of the United States for the same period. BBSs showed a nonsignificant annual increase of 3.3% from 1983 to 2004 and a significant annual increase of 4.0% from 1995 to 2004. CBCs indicated a significant 2.5% annual increase from 1983 to 2005, and nonsignificant 1.0% annual increase from 1995 to 2005.

Historical Conservation Concerns

The Bald Eagle was endangered and nearly extirpated in the lower 48 states by the middle of the 20th century, mainly because of persecution and the use of organochlorine pesticides, including DDT. Hawk Mountain Sanctuary was the only watchsite where eagles were counted before, during, and after the DDT Era, and Rachel Carson (1962) used these counts to help make her case against the widespread use of pesticides in *Silent Spring*. Of individual Bald Eagles examined by the U.S. Geological Survey from 1963 to 1984, 23% died of trauma (mostly collisions), 22% from gunshots, 11% from poisoning, 9% from electrocution, 5% from trapping, and 30% from malnutrition, disease, or unknown causes (Wood et al. 1990).

Counts of immature and adult Bald Eagles at Hawk Mountain reveal a pattern that is characteristic of population recovery. Numbers of immature Bald Eagles began to increase steadily in the early 1970s, corresponding closely with bans on the widespread use of DDT in Canada and the United States (Fig. 7), whereas counts of adults continued to decline and did not begin to increase consistently until nearly a decade later. Most likely, this time lag was caused by the ≥5-year generation time of the species.

Current Status and Concerns

Migration counts, BBSs, and CBCs for Bald Eagles indicate a strong comeback since the DDT Era. Humans remain the greatest single threat to eagles, both directly, through persecution and poisoning, and indirectly, through land-use change, including recreational activities along rivers

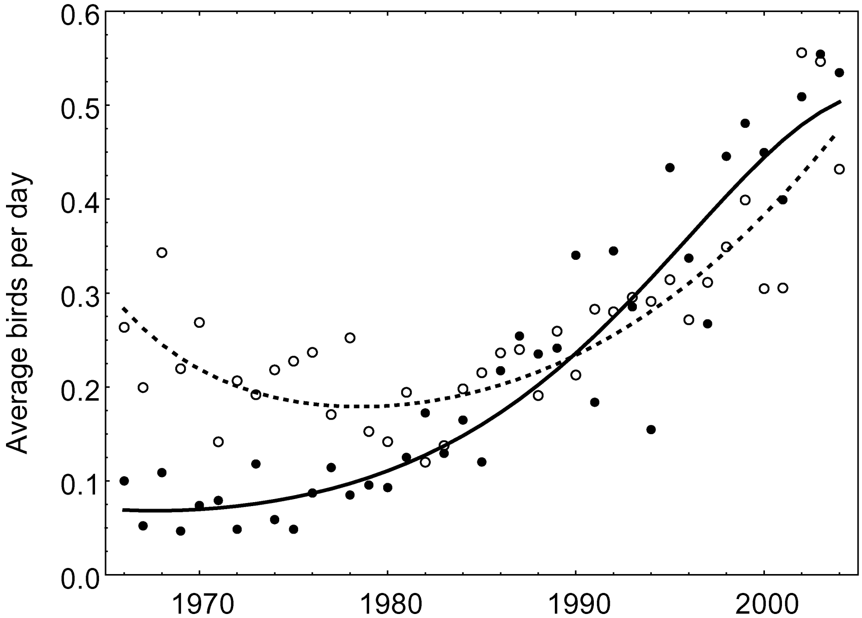

Fig. 7. Bald Eagle (*Haliaeetus leucocephalus*) population indexes (average birds per day) for Hawk Mountain Sanctuary, Pennsylvania. From 1966 to 2004, the overall count increased a significant 3.1% annually. Adults (open circles) increased an annual 1.7%, whereas immatures (solid circles) increased 5.3%. The lines indicate trajectories in these counts.

in western and northwestern North America (Steidl and Anthony 1996, 2000). Like other scavengers, Bald Eagles also are at risk from lead shot.

The Bald Eagle is a species of least concern globally, is not at risk in the United States or Canada, but is listed as endangered in Mexico (Appendix). It is protected in the United States by The Bald and Golden Eagle Protection Act, and by the Migratory Bird Treaty Act of 1918 as amended in 1972. Until June 2007 it also was protected under The Endangered Species Act. Most nest sites in the United States are protected by buffer zones, but the size of these zones varies among regions and states.

Summary

Overall, evidence suggests that Bald Eagles are increasing in much of their range. Even so, trajectories from migration counts in northeastern North America (Chapter 5) suggest that populations are now stable. In western North America, where migration counts are less useful because of the low numbers of birds counted at watchsites in the lower 48 states, BBSs and CBCs indicate that Bald Eagles are increasing or stable.

Northern Harrier

Scientific name:	*Circus cyaneus*
French name:	*Busard Saint-Martin*
Spanish name:	*Aguilucho colinegro, Aguilucho pálido, Gavilán rastrero*
Body length:	41–50 cm
Wingspan:	97–122 cm
Mass:	290–600 g
Type of migrant:	Partial
Nest type:	Small ground-nest of herbaceous plants in a clump of tall vegetation in upland meadows, hay fields, and marshes.
Food habits:	Preys primarily on small mammals and birds.
Migration flight:	Buoyant soaring, often close to vegetative cover, with wings in a shallow dihedral, interspersed with deep, slow flapping.
Estimated world population:	100,000–1,000,000

Ecology and Migration

North America's only harrier, the Northern Harrier is sexually dimorphic, with females 13% to 50% heavier than males. Northern Harriers hunt primarily on the wing, while coursing low over the open habitats, including farmland. The species uses sound to locate prey to a greater extent than do other diurnal raptors (Rice 1982).

Generally, individuals breeding in northern parts of the species' range are long-distance migrants. Although harriers concentrate along *leading lines* and *diversion lines* during migration, they do so less than many other species. Harriers migrate in a variety of weather conditions, including light rains and snow. Harriers also make long flights over water. Migrants use a mixture of flapping and gliding flight close to the ground and are less frequently observed soaring on *thermals* and deflection updrafts.

Population Status

Partners in Flight estimates that one-quarter to one-half of the global population (100,000 to 1,000,000) of Northern Harriers nests in the United States and Canada (Appendix). Migration counts, BBSs, and CBCs indicate that populations of Northern Harriers have (1) remained stable or declined in northeastern North America since 1974; (2) increased in western North America during the 1980s and early to mid-1990s, then declined thereafter; and (3) declined around the Gulf of Mexico since 1995.

Eastern North America

Previous watchsite analyses.—Bednarz et al. (1990) reported a significant, long-term increase in counts of Northern Harriers at Hawk Mountain, Pennsylvania from 1934 to 1986 and a nonsignificant increase from 1971 to 1986, but did not estimate rates of change. In a study of six raptor migration counts in eastern North America, Titus and Fuller (1990) reported a nonsignificant annual increase of 5.1% from 1972 to 1987. Hussell and Brown (1992) reported a nonsignificant annual decline of –3.7% at Hawk Ridge, Minnesota, from 1974 to 1989 and a significant annual increase of 5.3% at Grimsby, Ontario (a spring watchsite), from 1975 to 1990. At Cedar Grove, Wisconsin, counts declined significantly from 1936 to 1999 and from 1951 to 1999 but increased nonsignificantly from 1989 to 1999 (Mueller et al. 2001).

RPI analysis.—Migration counts indicate that populations of Northern Harriers generally have remained stable or declined in northeastern North America since 1974 (Chapter 5). From 1994 to 2004, significant annual declines of –3.7%, –4.3%, and –13.1% were recorded at Lighthouse Point, Connecticut, Hawk Mountain, and Holiday Beach, Ontario, respectively. Nonsignificant annual increases of 1.3%, 2.4%, 2.5%, and 0.6%, respectively, occurred at Tadoussac, Québec, Montclair, New Jersey, Waggoner's Gap, Pennsylvania, and Hawk Ridge; and a nonsignificant decline of –0.7% occurred at Cape May, New Jersey (Fig. 8). Continued change at the 1994–2004 rates would lead to a 50% decline in ~19 years at Lighthouse Point, 16 years at Hawk Mountain, and 5 years at Holiday Beach.

Other analyses.—BBSs showed a nonsignificant annual decline of –2.1% from 1976 to 2003 in northeastern North America. Unfortunately, the inconspicuous nature of this species during the breeding season limits the value of BBSs as a population-monitoring tool. CBCs indicate significant annual increases in winter counts of 1.5% in northeastern North America and 0.5% in southeastern North America from 1974 to 2004. In the last decade (1994 to 2004), annual increases in CBCs were nonsignificant in northeastern (0.8%) and southeastern (0.9%) North America.

In sum, raptor migration counts and BBSs suggest that populations in northeastern North America have declined over the last 30 years. Increases in CBCs during the same period, however, suggest alternative explanations, including increased *broad-frontal migration*, population losses in northern populations coincidental with population increases in more southerly populations, *migratory short-stopping*, or combinations of these possibilities.

Western North America

Previous watchsite analyses.—Hoffman and Smith (2003) reported a significant increase from 1983 to 2001 in the Goshutes, Nevada, and

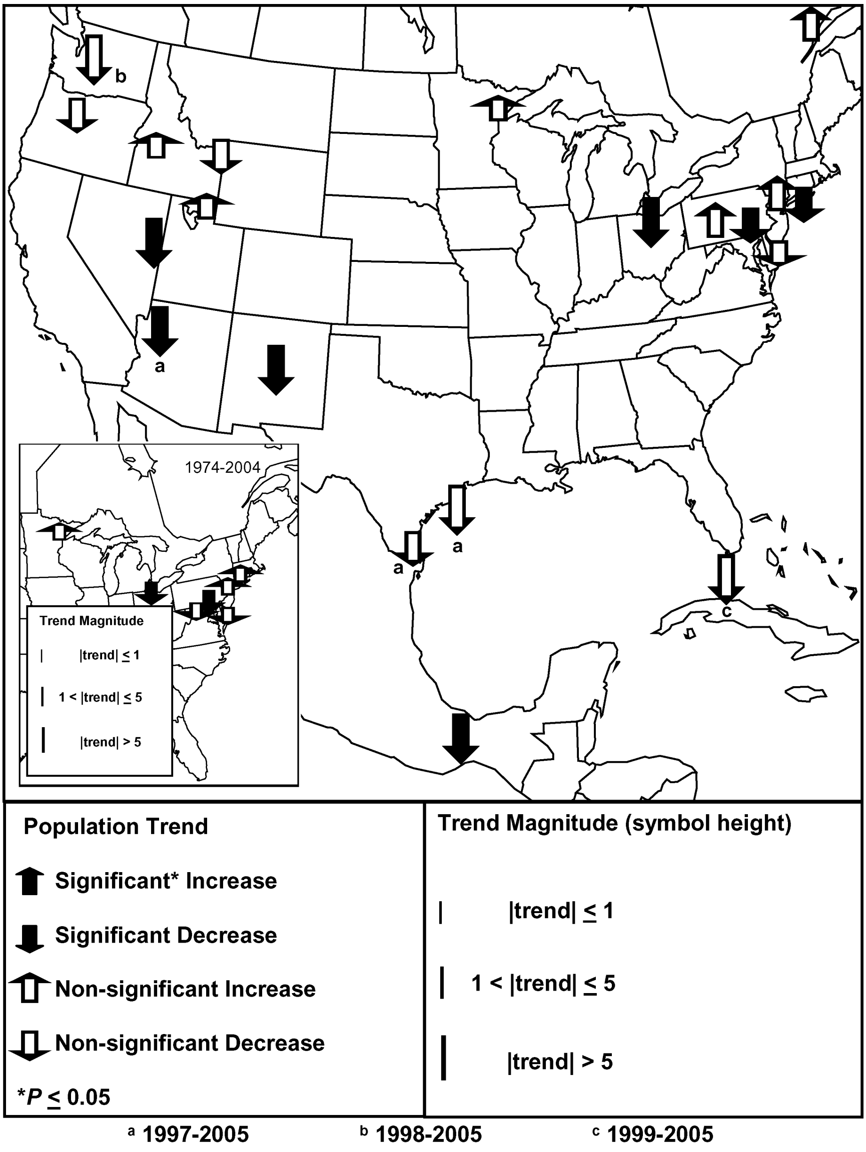

Fig. 8. Population trends for Northern Harriers (*Circus cyaneus*) at eight northeastern (1994–2004), eight western (1995–2005), and four Gulf of Mexico raptor migration counts in North America, and long-term trends (1974–2004) for seven northeastern counts (inset). Trends are expressed in percent change per year.

nonsignificant increases or stable counts at the Wellsvilles, Utah (1987 to 2001), Manzanos, New Mexico (1983 to 2001), Sandias, New Mexico (a spring watchsite, 1985 to 2001), Bridger Mountains, Montana (1992 to 2001), and Grand Canyon, Arizona (Lipan Point) (1991 to 2001).

RPI analysis.—Migration counts suggest that populations of Northern Harriers increased markedly in some areas of western North America between the early 1980s and mid- to late 1990s, but declined in concert with a regional drought subsequently (Chapter 6). Since 1998, when drought occurred across much of the interior West, significant declines of –10.6%, –8.2%, and –10.6%, respectively, were recorded in the Goshutes, in the Manzanos, and at the Grand Canyon (Lipan Point and Yaki Point, combined), and a marginally significant annual decline of –10.1% also occurred at Chelan Ridge, Washington. Nonsignificant annual declines of –3.3%, –2.4% and –0.3%, respectively, were recorded at Bonney Butte, Oregon, the Bridger Mountains, and the Wellsvilles, and a nonsignificant annual increase of 0.3% was recorded at Boise Ridge, Idaho (Fig. 8).

Other analyses.—BBSs showed nonsignificant annual declines of –0.9% from 1983 to 2004, and –2.0% from 1995 to 2005. Unfortunately, the fact that Northern Harriers normally do not nest near roads limits the value of BBSs as a population monitoring tool. CBCs indicated that wintering populations underwent nonsignificant annual declines of –0.5% from 1983 to 2005 and –2.1% from 1995 to 2005.

In sum, Northern Harriers may have responded favorably to the relatively moist El Niño period of the early to mid-1990s, but have shown marked declines in most areas since the late 1990s, when a regional drought began across much of the interior West (Chapter 6). Significant annual declines since 1998 ranging from –5.3 to –10.6% occurred at five of nine western sites. There were nonsignificant declines ranging from –2.3 to –3.3% at two other sites, and no significant increases for any sites. A sustained annual decline of 5% per year would result in a 50% decline in the population in ~14 years.

Gulf of Mexico

Previous watchsite analyses.—None.

RPI analysis.—Migration counts indicate declines in Northern Harrier counts throughout the Gulf region (Chapter 7, Fig. 8). Although each count exhibited a high degree of annual variability, all suggest that substantial declines occurred after highs between 1998 and 2000. These declines are consistent with a possible decline in northern, long-distance migrants coincidental with an increase in mid-Atlantic and southeastern short-distance migrants.

Historical Conservation Concerns

Northern Harriers were shot less often than most other raptors at migration hot spots in the early 20th century, both because they were considered beneficial because of their diet of small mammals and because they tended not to concentrate at such sites. Use of DDT caused decreased eggshell thickness in harriers between 1947 and 1969 (Anderson and Hickey 1972), and this likely led to population declines prior to the banning of DDT use.

Current Status and Concerns

The Northern Harrier, a species of least concern globally, is a species of concern in the United States but is not at risk in Canada (Appendix). The U.S. Fish and Wildlife Service ranks the Northern Harrier as a species of concern in Arizona, Colorado, Kansas, Montana, Nebraska, New Mexico, North Dakota, Oklahoma, South Dakota, Texas, Utah, and Wyoming, in most of the Bird Conservation Regions from the Mississippi River to the Rockies, south of the Dakotas, and nationally (Appendix). Harriers are threatened in these areas primarily by the draining of wetlands, the conversion of prairies to intensive agricultural use, the overgrazing of pastures, and the early mowing of grasslands. Shooting also remains a concern for harriers in communal roosts in the southeastern United States.

Kirk and Hyslop (1998) rated the species as stable in Canada but noted that it was declining in some of the Boreal Plains ecozone due to intensive agriculture. Monitoring of the Northern Harrier at watchsites is particularly important because it is not well-monitored by BBSs on the breeding grounds, and much of its breeding range is north of BBS coverage.

Summary

The Northern Harrier is considered secure in most of North America, but is a species of concern regionally in many of the Bird Conservation Regions east of the Mississippi River. Migration monitoring suggests that the species has recently declined in all three of the regions for which migration counts are currently available. Totals from CBCs have increased slightly in eastern North America during the same period, which suggests that changes in the species' migration geography may have occurred. Inclusion of additional raptor migration counts and addition of focused breeding-season surveys should help clarify the Northern Harrier's conservation status.

Sharp-shinned Hawk

Scientific name:	*Accipiter striatus*
French name:	*Épervier brun*
Spanish name:	*Gavilán pajarero*
Body length:	Female: 29–34 cm Male: 24–27 cm
Wingspan:	Female: 58–65 cm Male: 53–56 cm
Mass:	Female: 150–218 g Male: 87–114 g
Type of migrant:	Partial
Nest type:	Small, broad, flat, twig nest, often lined with bark or greenery.
Food habits:	Preys mainly upon small birds. Occasionally takes small mammals and large insects.
Migration flight:	A series of three to six quick, shallow wingbeats, interspersed with gliding and soaring.
Estimated world population:	100,000–1,000,000

Ecology and Migration

Sharp-shinned Hawks are secretive breeders that typically nest in dense forests, usually containing conifers. Difficult to detect and survey on breeding grounds, populations are best monitored by migration counts.

Feeds primarily on small songbirds, although it sometimes takes birds as large as American Robins (*Turdus migratorius*) and jays (e.g., *Cyanocitta* spp.) (Storer 1966, Duncan 1980, Joy et al. 1994). Sharp-shinned Hawks hunt from perches and from low-level flapping flight, darting rapidly at their target, while using natural and manmade structures to conceal their approach. They are common predators at bird feeders (Dunn and Tessaglia 1994).

In eastern North America, northern populations are more migratory than southern populations. In western North America, the species exhibits *chain migration*, with northern birds migrating later in autumn and wintering farther north than southern birds (Smith et al. 2003).

Population Status

Partners in Flight estimates that half or more of the estimated world population of 100,000 to 1,000,000 breeds in the United States and Canada (Appendix). The remainder breeds in Central and South America. Data from migration counts, BBSs, and CBCs indicate that Sharp-shinned Hawks have (1) become less migratory in the Northeast since the 1970s; (2) increased slightly in western North America from the early 1980s to the mid-1990s, and then declined with the onset of a drought in the late 1990s; and (3) declined along the Gulf Coast at least since 1995.

Eastern North America

Previous watchsite analyses.—Bednarz et al. (1990) reported a significant increase in autumn migration counts of Sharp-shinned Hawks at Hawk Mountain, Pennsylvania, from 1934 to 1942, with a nonsignificant decline during the DDT Era from 1946 to 1972, and a nonsignificant increase from 1971 to 1986. Titus and Fuller (1990) reported a nonsignificant annual increase of 0.4% from 1972 to 1987 at six autumn watchsites in the Northeast. Hussell and Brown (1992) reported a nonsignificant –0.8% annual decline from 1974 to 1989 at Hawk Ridge, Minnesota, and a significant annual increase of 4.8% at Grimsby, Ontario (spring watchsite). At Cedar Grove, Wisconsin, Mueller et al. (2001) reported a significant increase in autumn counts from 1936 to 1999, but a nonsignificant trend from 1951 to 1999.

RPI analysis.—Long-term trend estimates are mixed but indicate that the species decreased in the Mid-Atlantic states and was stable or increased in New England and the western Great Lakes (Chapter 5). From 1994 to 2004, significant annual declines of –9.3% and –3.7% occurred at Cape May, New Jersey, and Hawk Mountain, respectively, whereas no net change was recorded at Lighthouse Point, Connecticut (0.0%), a nonsignificant increase (0.9%) was recorded at Tadoussac, Québec, and nonsignificant declines of –0.5%, –0.6%, –2.7%, and –1.8% occurred at Montclair, New Jersey, Waggoner's Gap, Pennsylvania, Holiday Beach, Ontario, and Hawk Ridge, respectively. Continued change at the 1994–2004 rates would lead to a 50% decline in Sharp-shinned Hawk numbers in ~7 years at Cape May and 19 years at Hawk Mountain.

Other analyses.—BBSs showed a nonsignificant annual increase of 3.0% in northeastern North America. These surveys, however, do not sample this secretive forest species well, and trends derived from them should be considered in this light. CBCs from 1974 to 2004 indicated significant annual increases of 2.1% in southeastern and 5.4% in northeastern North America.

Differences among trends from seven northeastern watchsites, as well as differences between migration counts and other population indexes, highlight the need to include counts from multiple watchsites and multiple surveys when attempting to assess population status. One possible explanation for the differences is a decline in the more migratory northern populations together with an increase in less-migratory individuals farther south. Another is increased migratory *short-stopping* (see Viverette et al. 1996). A significant decline in counts in Florida (see below) is consistent with both of these hypotheses.

Western North America

Previous watchsite analyses.—Sharp-shinned Hawks increased significantly at the Goshutes, Nevada, from 1983 to 2001, and nonsignificantly at the Wellsvilles, Utah (1987 to 2001), Grand Canyon, Arizona (Lipan Point) (1991 to 2001), the Bridger Mountains, Montana (1992 to 2001), the Manzanos, New Mexico (1985 to 2001), and the Sandias, New Mexico (a spring watchsite) (1985 to 2001) (Hoffman and Smith 2003), but counts at most of these sites began to decline in 1998.

RPI analysis.—Long-term trends were positive or stable at most western watchsites until 1997 (Chapter 6). Significant annual declines of –12.8%, –8.3%, –5.7%, and –3.4% occurred in the last decade at Chelan Ridge, Washington, the Goshutes, the Wellsvilles, and the Grand Canyon (Lipan Point), respectively. Nonsignificant annual declines of –0.1% and –6.3% occurred at Bonney Butte, Oregon, and the Bridger Mountains, Montana. On the other hand, the Manzanos recorded a significant annual increase of 2.2%, and nonsignificant annual increases of 4.4% and 0.7% were recorded at the Grand Canyon (Lipan Point and Yaki Point combined) and Boise Ridge, Idaho (Fig. 9).

Other analyses.—BBSs indicated a nonsignificant, long-term annual increase of 1.5% from 1983 to 2005 and a nonsignificant annual increase of 2.2% from 1995 to 2005. CBCs recorded a significant annual increase of 0.7% from 1983 to 2005 and a nonsignificant annual decline of 1.0% from 1995 to 2005.

In sum, Sharp-shinned Hawks increased between the 1980s and mid-1990s but began to decline overall in the late 1990s, coincidental with a regional drought in western North America. Continued declines in the central Great Basin (Goshutes) and Grand Canyon may reflect drought-related shifts in migration routes (Chapter 6).

Gulf of Mexico

Previous watchsite analyses.—None.

RPI analysis.—Declines were recorded at all watchsites in the Gulf region, but significant or marginally significant declines occurred only at the Florida Keys, Florida, and Veracruz, Mexico (Chapter 7). Confidence intervals for trends in this region are broad, presumably because of their brief runs. The high magnitudes of the trend estimates, however, suggest that the declines are real.

Historical Conservation Concerns

Sharp-shinned Hawks were heavily persecuted in the early and mid-20th century, when they were perceived by many to be "vicious enemies"

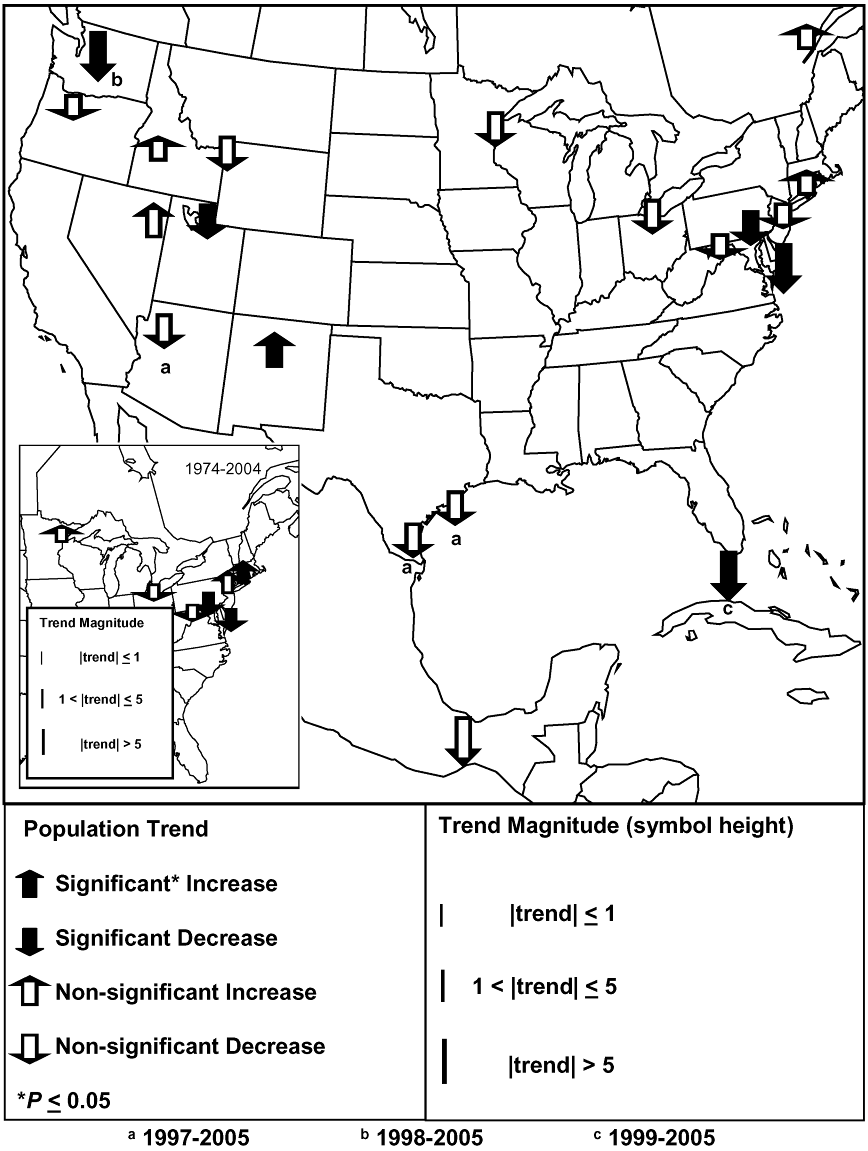

Fig. 9. Population trends for Sharp-shinned Hawks (*Accipiter striatus*) at eight northeastern (1994–2004), eight western (1995–2005), and four Gulf of Mexico raptor migration counts in North America, and long-term trends (1974–2004) for seven northeastern counts (inset). Trends are expressed in percent change per year.

of small songbirds (Chapter 1). Persecution all but ceased in 1972, when the Migratory Bird Treaty Act was amended to include birds of prey. The use of organochlorine pesticides (particularly DDT) also likely contributed to population declines between the late 1940s and early 1970s (Bednarz et al. 1990).

Current Status and Concerns

Declines in eastern watchsites in the late 1980s and early 1990s have been attributed to pesticides, natural population cycles, aging forests, declining populations of Neotropical migrant songbirds, migratory short-stopping, and cycles of spruce budworm infestation in the boreal forests of eastern Canada (Duncan 1996, Viverette et al. 1996, Wood et al 1996, Kirk and Hyslop 1998, Bolgiano 2006). Our analyses indicate no consistent geographic pattern of change for counts in the region.

The Sharp-shinned Hawk is a species of least concern globally, is not listed as a species of concern in the United States, and is not at risk in Canada. It is accorded special protection in Mexico (Appendix). Kirk and Hyslop (1998) rated the species as potentially declining in Atlantic Canada, possibly because of spruce budworm population cycles, acid rain, changes in insect abundance, and the use of organochlorine contaminants. Blood samples of migrant Sharp-shinned Hawks collected in the early 1990s showed some individuals carried organochlorine loads that might impede reproduction (Wood et al. 1996). Throughout Canada, BBSs suggest stable or increasing trends.

Summary

The number of Sharp-shinned Hawks counted at watchsites in the Northeast and along the Gulf Coast has declined since the early 1980s. Taken together, migration counts and CBCs suggest that at least some of the count declines are due to migratory short-stopping (Duncan 1996, Viverette et al. 1996). Although numbers at watchsites in western North America have increased overall in the last 20 years, declines since the late 1990s may be linked to widespread drought in the region.

Cooper's Hawk

Scientific name:	*Accipiter cooperii*
French name:	*Épervier de Cooper*
Spanish name:	*Gavilán pollero*
Body length:	Female: 42–47 cm Male: 37–41 cm
Wingspan:	Female: 79–87 cm Male: 70–77 cm
Mass:	Female: 479–678 g Male: 302–402 g
Type of migrant:	Partial
Nest type:	Broad, flat or conical twig nest, often lined with bark or greenery.
Food habits:	Preys mainly upon medium-sized birds and mammals, and occasionally on reptiles, amphibians, and large insects.
Migration flight:	A series of three to six quick, shallow wingbeats, separated by brief periods of gliding; regularly soars on migration.
Estimated world population:	100,000–1,000,000

Ecology and Migration

The species nests in a variety of wooded and non-forested habitats, sometimes in solitary trees in prairie habitats, and, increasingly, in suburban and urban settings, and are common predators at bird feeders (Dunn and Tessaglia 1994). Cooper's Hawks can be difficult to detect and survey on breeding grounds, and migration counts provide an important monitoring opportunity in many parts of North America.

Some individuals migrate, whereas others remain on the breeding range year-round. Northern populations tend to be more migratory than southern populations.

Population Status

Partners in Flight estimates that >90% of the species' global population of 100,000 to 1,000,000 breeds in the United States and Canada (Appendix). Data from migration counts, BBSs, and CBCs indicate that populations of Cooper's Hawks have (1) increased in northeastern North America since 1974; (2) increased in western North America since the early 1980s, but recently declined in the northern Rocky Mountains and intermountain regions coincidental with a regional drought that began in the late 1990s; and (3) increased around the Gulf of Mexico since 1995.

Eastern North America

Previous watchsite analyses.—Bednarz et al. (1990) reported a nonsignificant, long-term decline at Hawk Mountain, Pennsylvania, from 1934 to 1986 and a significant increase for the period 1971 to 1986, but no estimates were made of the rates of change. In a study of six raptor migration counts in eastern North America, Titus and Fuller (1990) reported a significant annual increase of 7.8% from 1972 to 1987. Hussell and Brown (1992) reported a nonsignificant decline at Hawk Ridge, Minnesota, from 1974 to 1989 and a significant annual increase of 4.6% at Grimsby, Ontario (a spring watchsite), from 1975 to 1990. At Cedar Grove, Wisconsin, Mueller et al. (2001) reported a significant decline in counts of Cooper's Hawks from 1936 to 1999 and a significant increase from 1951 to 1999.

RPI analysis.—Migration counts provide evidence of long-term increases in populations in northeastern North America since 1974 (Chapter 5). Significant annual increases of 10.2%, 4.1%, and 5.1% continued from 1994 to 2004 at Montclair, New Jersey, Hawk Mountain, and Waggoner's Gap, Pennsylvania, respectively. A nonsignificant increase of 0.3% was recorded at Cape May, New Jersey, during this period. A significant decline of –3.7% occurred at Holiday Beach, Ontario, and nonsignificant declines of –1.6% and –3.0%, respectively, were recorded at Lighthouse Point, Connecticut, and Hawk Ridge (Fig. 10). Cooper's Hawks do not occur regularly at Tadoussac, Québec. Continued population change at the 1994–2004 rates would lead to a 50% increase in ~7 years at Montclair, 17 at Hawk Mountain, and 14 at Waggoner's Gap, and a 50% decline in 19 years at Holiday Beach.

Other analyses.—BBSs showed a nonsignificant annual increase of 3.6% in northeastern North America from 1976 to 2003 and a significant annual increase of 4.9% in the northeastern United States from 1974 to 2004. CBCs from 1974 to 2004 indicated significant annual increases of 6.8% in northeastern North America and 5.2% in southeastern North America.

Western North America

Previous watchsite analyses.—Hoffman and Smith (2003) reported a significant increase from 1983 to 2001 at the Goshutes, Nevada, but no significant trends at other western watchsites. Most western migration counts increased through the mid-1990s and then declined beginning in 1999, coincidental with the onset of a regional drought (Hoffman and Smith 2003).

RPI analysis.—Migration counts indicated mostly increasing trends in the western United States between the mid-1980s and late 1990s, but mostly strong declines since then, coincidental with the occurrence of regional drought (Chapter 6). From 1995 to 2005, a significant annual

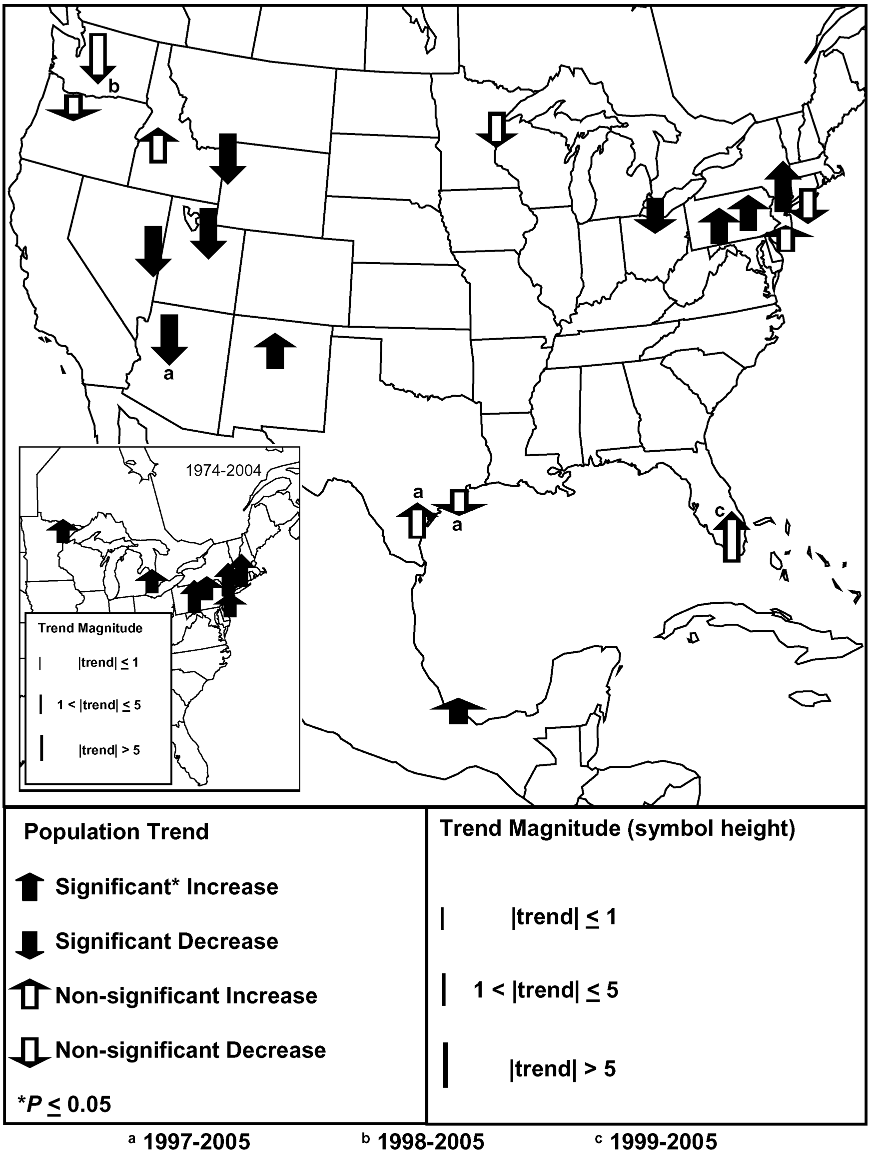

Fig. 10. Population trends for Cooper's Hawks (*Accipiter cooperii*) at seven northeastern (1994–2004), eight western (1995–2005), and four Gulf of Mexico (1995–2005) raptor migration counts in North and Central America, and long-term trends (1974–2004) at seven northeastern raptor migration counts (inset). Trends are expressed in percent change per year.

increase of 4.5% occurred at the Manzanos, New Mexico. Significant annual declines of –6.2%, –7.0%, –10.9%, and –12.0%, respectively, occurred at the Bridger Mountains, Montana, the Goshutes, the Wellsvilles, Utah (1995 to 2004), and the Grand Canyon, Arizona (Lipan Point and Yaki Point combined). A marginally significant annual decline (–6.3%) was recorded at Chelan Ridge, Washington, from 1998 to 2005, a nonsignificant decline occurred at Bonney Butte, Oregon (–0.9%), from 1995 to 2005, and a nonsignificant increase occurred at Boise Ridge, Idaho (2.1%) (Fig. 10).

Other analyses.—BBSs for western North America indicate a nonsignificant annual decline of –0.4% from 1983 to 2004 and a significant annual increase of 7.7% from 1995 to 2004. These estimates, however, are based on a low number of routes (e.g., 65 for 1995 to 2004), and they should be considered in that light. CBCs for western North America indicate a significant annual increase of 0.5% annually from 1983 to 2005, and an identical 0.5% annual increase from 1995 to 2005.

It appears that Cooper's Hawks fared well between the 1980s and mid-1990s in the interior West, increasing gradually across most monitored sites. Declines started with the onset of a regional drought in 1998, except at the Manzanos. Ongoing declines in the Great Basin (Goshutes) and in the Grand Canyon (Lipan Point and Yaki Point) suggest that the drought may have reshaped the migration geography of migrants there (Chapter 6).

Gulf of Mexico

Previous watchsite analyses.—None.

RPI analysis.—Migration counts recorded nonsignificant annual increases at most watchsites in the Gulf region during the last decade (Chapter 7). Overall, the species appears to be increasing slightly in this region.

Other analyses.—BBSs for the southeastern United States indicated a nonsignificant annual increase of 2.1% from 1995 to 2005.

Historical Conservation Concerns

The Cooper's Hawk was heavily persecuted in the early 20th century, primarily because it was perceived as a "vicious enemy" of songbirds and domestic chickens. Hundreds of Cooper's Hawks were shot annually while migrating past concentration points such as Hawk Mountain and Cape May (Stone 1937, Broun 1949). With the passage of protective legislation, most notably when the Migratory Bird Treaty Act was amended to include raptors in 1972 (Chapter 1), shooting ceased to be a significant source of mortality in North America.

The use of pesticides (particularly DDT) is believed to have contributed to Cooper's Hawk population declines in eastern North America from the 1940s to early 1970s (Bednarz et al. 1990).

Current Status and Concerns

The Cooper's Hawk, a species of least concern globally, is not of concern in the United States or Canada but receives special protection in Mexico (Appendix). Kirk and Hyslop (1998) rated the Cooper's Hawk stable in most of Canada, but noted that demographic data were lacking for the species.

Recovery of populations from DDT-Era lows was well underway by the late 1970s to early 1980s (Bednarz et al. 1990, Titus and Fuller 1990). Our analyses reveal a consistent geographic pattern of population increase for Cooper's Hawks in northeastern North America since 1974. These increases continued through the last decade at watchsites in the Atlantic Coastal Plain and Appalachian Mountains, but weakened or were reversed in coastal New England, New Jersey, and the southern Great Lakes. Western populations showed stable or increasing trends since the early to mid-1980s in the intermountain and Rocky Mountain regions, but counts at most watchsites have declined in the last decade, coincidental with a regional drought. Breeding populations of Cooper's Hawks appear to be increasing in at least some areas in the Midwest (e.g., North Dakota; Nenneman et al. 2002). Whether or not other factors are involved in the recent declines is unknown. Several factors, including release from persecution and pesticide use, reforestation and forest maturation throughout the region, and the increased use of suburban and urban habitats, may be responsible for long-term increases in migration counts. Recent stable and decreasing trends in the Northeast may be the result of habitat saturation.

Summary

Migration count data suggest that Cooper's Hawks have increased throughout North America over the last 20–30 years, with recent stability or declines at some sites in the Northeast, and declines in the West. On the other hand, BBSs and CBCs do not indicate recent declines in these areas. Long-term increases also appear to have occurred in the southeastern United States and Mexico. These increases are probably the result of recovery from the declines in the DDT Era and the ability of the species to exploit urban and suburban habitats, now that direct persecution has ended.

Northern Goshawk

Scientific name:	*Accipiter gentilis*
French name:	*Autour des palombes*
Spanish name:	*Gavilán pollero, Gavilán azor, Gavilán norteño*
Body length:	Female: 53–62 cm Male: 46–51 cm
Wingspan:	Female: 105–115 cm Male: 98–104 cm
Mass:	Female: 860–1,364 g Male: 631–1,099 g
Type of migrant:	Partial (Europe and Asia); irruptive (North America).
Nest type:	Broad, flat, or conical stick nest lined with green branches or, occasionally, bark.
Food habits:	Preys mainly upon small to medium-sized birds and mammals.
Migration flight:	A series of quick, shallow wingbeats, separated by brief periods of gliding. Wingbeats are slower and deeper than those of Cooper's Hawks and Sharp-shinned Hawks.
Estimated world population:	100,000–1,000,000

Ecology and Migration

Northern Goshawks typically nest in deciduous, mixed-deciduous, and evergreen forests with large trees and open understories. Generally intolerant of intruders near the nest, they are known to attack humans approaching nests. The species can be extremely secretive and elusive and often nests in remote forests.

Northern populations are more migratory than those breeding to the south, and juveniles disperse and wander more during winter than adults. Satellite tracking of breeding adults in Utah demonstrates diverse winter movement patterns ranging from completely sedentary, to altitudinal migration, to short-distance latitudinal migrations of ≤200 km (Sonsthagen et al. 2006). Satellite tracking of mainly juveniles that were captured in autumn in Oregon, Washington, Nevada, New Mexico, and Wyoming indicated regional residency for most individuals (HawkWatch International unpubl. data). *Irruptive migrations*, primarily of northern populations, occur periodically in years of low prey availability.

Population Status

Partners in Flight estimates that the United States and Canada contain approximately one-half of the global population of 100,000 to 1,000,000 birds (Appendix). Migration counts, BBSs, and CBCs indicate that Northern Goshawks have (1) declined or remained stable in eastern North America since 1974, perhaps following an increase since the early 20th century; and (2) declined in much of western North America since the early 1980s.

Eastern North America

Previous watchsite analyses.—Bednarz et al. (1990) reported a nonsignificant increase in counts of Northern Goshawks at Hawk Mountain, Pennsylvania, from 1934 to 1986 and a significant decline for the period 1971 to 1986, but no estimates were made of the rates of change. In a study of six migration counts in eastern North America, Titus and Fuller (1990) reported a nonsignificant annual decline of –3.8% from 1972 to 1987. At Cedar Grove, Mueller et al. (2001) reported no significant changes in counts from 1936 to 1999, but noted that the periodic irruptive migrations made it difficult to identify population trends in the species.

RPI analysis.—Migration counts provide mixed evidence of changes in populations of the Northern Goshawk in northeastern North America since 1974 (Chapter 5). From 1994 to 2004, nonsignificant annual declines of –2.8% and –4.5% were recorded at Tadoussac, Québec, and Cape May, New Jersey, respectively. Nonsignificant annual increases of 0.3%, 0.1%, 4.6%, and 1.7% were recorded at Hawk Mountain, Waggoner's Gap, Pennsylvania, Holiday Beach, Ontario, and Hawk Ridge, respectively (Fig. 11). Low counts (<20 per year) at Lighthouse Point, Connecticut, and Montclair, New Jersey, precluded analyses there.

With the exception of Hawk Ridge and Tadoussac, watchsites in the region are near the southern edge of the species' winter range, and each counts fewer than 100 individuals annually (range of 5 to 78), so trends in these counts may not accurately reflect population trends. Furthermore, their interpretation is complicated by the *irruptive* nature of migratory movements of the species. Migration counts probably reflect reproductive output of local populations in non-irruption years.

Several irruptions can be inferred from indexes presented in Chapter 5 (e.g., early 1980s and 1990s). Trends reported for eastern North America therefore may represent either population change or a change in the frequency of irruption years. To test the latter possibility, we deleted from the Hawk Mountain data set years or sets of years in which the count exceeded 1.5× the previous year's count (i.e., 1975, 1981–83, 1986, 1993, 1995, 1999, and 2001). We then recalculated the long- and short-term trends in the reduced data set. The resulting trend estimates of –3.4% annually from 1974 to 2004 and 0.7% annually from 1994 to 2004 differed only slightly from those in the complete data set, which suggests that the trends are not attributable to the appearance of irruption years.

Other analyses.—BBSs in northeastern North America recorded a nonsignificant annual increase of 3.0% from 1976 to 2003. The BBS may not adequately sample this species, however, and this trend estimate should be

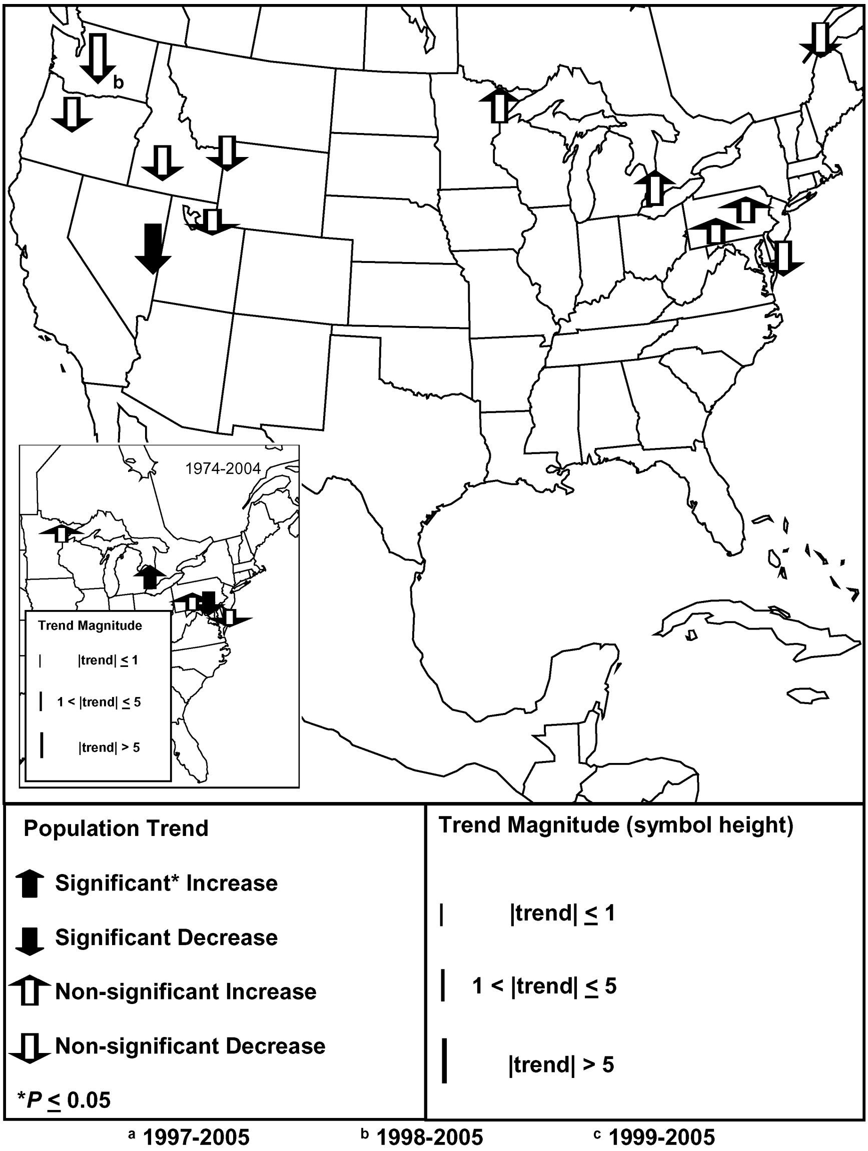

Fig. 11. Population trends for Northern Goshawks (*Accipiter gentilis*) at six northeastern (1994–2004) and six western (1995–2005) raptor migration counts in North America, and long-term trends (1974–2004) for six northeastern counts (inset). Trends are expressed in percent change per year.

considered in that light. CBCs in northeastern North America indicated a significant decline of –0.9% from 1974 to 2004. Goshawks were too rarely detected in CBCs in southeastern North America to provide a useful trend estimate.

Western North America

Previous watchsite analyses.—Although Hoffman and Smith (2003) reported a significant decline from 1992 to 2001 at the Bridger Mountains, Montana, the result was caused primarily by a high first-year count of adults due to an irruption. No significant trend was reported for immatures. Nonsignificant trends for adults and immatures occurred at the Wellsvilles, Utah, from 1987 to 2001, but a significant decline in the ratio of immatures to adults, and a significant reduction in the average abundance of immature birds counted occurred from 1977 to 1979 versus 1987 to 2001. A nonsignificant trend for immatures, but significant declines in adults and the ratio of immatures to adults, occurred at the Sandia Mountains, New Mexico (a spring watchsite), from 1985 to 2001. No significant trends were reported for the Goshutes, Nevada, from 1983 to 2001, the Grand Canyon, Arizona (Lipan Point) (1991 to 2001), or the Manzano Mountains, New Mexico (1985 to 2001) (Hoffman and Smith 2003).

RPI analysis.—Migration counts indicate that populations have declined in some areas of the western United States since the mid-1980s (Chapter 6). In the last decade, a marginally significant annual decline of –12.9% occurred at Chelan Ridge, Washington from 1998 to 2005, and nonsignificant annual declines of –2.3%, –4.6%, and –3.9%, respectively, occurred at Bonney Butte, Oregon, the Bridger Mountains, Montana, and Boise Ridge, Idaho (Fig. 11), from 1995 to 2005. Low sample sizes at other western watchsites precluded estimating trends there.

Overall, long-term migration counts suggest that two regional drought cycles have significantly affected goshawks in the northern Great Basin and Grand Canyon, but not in the southern Rocky Mountains, where populations appear to have remained relatively stable (Chapter 6).

Other analyses.—BBSs indicated a nonsignificant annual increase of 0.5% from 1983 to 2004, and a significant annual increase of 13.2% from 1995 to 2005. The precision of these estimates was low, due to the low number of routes on which the species was recorded, and they should be interpreted in this light. CBCs declined nonsignificantly at annual rates of –1.3% and –0.8% from 1983 to 2005 and 1995 to 2005, respectively.

Historical Conservation Concerns

Historically, the Northern Goshawk likely was a regular but uncommon breeding bird throughout much of northeastern North America, including portions of Pennsylvania (Bent 1937, Street 1955). With the extinction of the Passenger Pigeon (*Ectopistes migratorius*), goshawks became less common in Pennsylvania and other areas where pigeons had nested in abundance (Simpson 1909). The species was heavily persecuted in the early 20th century, primarily because it was perceived as a "vicious enemy" of poultry and upland game. The Pennsylvania Game Commission placed a bounty on the species from 1929 to 1951, and ~3,000 bounties were paid during this period (Broun 1949).

Current Status and Concerns

With the passage of protective legislation, most notably the amendment of the Migratory Bird Treaty Act of 1918 to include raptors in 1972, shooting ceased to be a major source of mortality (Chapter 1). Goshawk populations in New England and the mid-Atlantic region subsequently rebounded, and a southward expansion of breeding range also may have occurred (Temple and Temple 1976, Root and Root 1978, Andrle and Carroll 1988, Kimmel and Yahner 1994).

The Northern Goshawk is a species of least concern globally and is not of concern in the United States. In Canada, the species is not at risk, but the *laingi* subspecies found in coastal British Columbia is listed as threatened. The goshawk also is listed as threatened in Mexico (Appendix). Kirk and Hyslop (1998) ranked the species as stable in most of Canada and possibly declining in coastal British Columbia.

The widespread use of pesticides (particularly DDT) is not believed to have had a major effect on goshawk populations in North America. Timber harvest, particularly in western North America, is believed to be a threat to populations because of the removal of suitable nesting habitat (Reynolds 1989, Crocker-Bedford 1990). Secondary growth, maturity, and expansion of forests in some areas of the northeastern United States and, perhaps, in parts of the Upper Great Lakes, may have contributed to population increases and range expansions there. A recent review of the status of the Northern Goshawk in western North America concluded that too little is known about population trends, demography, and habitat relations to adequately assess the conservation status of the species and recommended intensive, long-term research to address these data gaps (Anderson et al. 2004).

Migration counts alone do not adequately estimate population trends for this species. At the more southerly latitudes sampled by six of the eastern watchsites, migration counts consist mostly of juveniles and, as such, probably monitor local productivity. In western North America, recent migration counts from the Grand Canyon (Lipan Point and Yaki Point) and goshawk productivity data from the Kaibab Plateau north of the canyon appear to be correlated (R. Reynolds pers. comm.). In addition, satellite tracking indicates that most western juveniles are regional residents that remain within 150 km of where they were caught. All of this suggests that age-specific watchsite counts may yield particularly valuable insight about local productivity. It also suggests that additional watchsites in boreal Canada may be needed to monitor populations there.

Summary

Goshawks appear to have remained stable or undergone long-term increases around the Great Lakes and in the Rocky Mountains. Long-term declines have occurred in the Great Basin and may have occurred inland in eastern North America as well (Chapter 5). The Northern Goshawk is not well monitored by BBSs or CBCs, and effective population monitoring will require a combination of migration monitoring in the north and breeding-season surveys throughout the breeding range.

Red-shouldered Hawk

Scientific name:	*Buteo lineatus*
French name:	*Buse á èpaulettes*
Spanish name:	*Gavilán ranero*
Body length:	38–47 cm
Wingspan:	94–107 cm
Mass:	460–930 g
Type of migrant:	Partial
Nest type:	Large stick nest in a fork of the main trunk of a tree or where a primary branch meets the trunk.
Food habits:	Preys primarily on small mammals, birds, amphibians, reptiles, and invertebrates.
Migration flight:	Flapping interspersed with gliding in a manner that resembles that of an *Accipiter*. Also soars on thermals and glides between them.
Estimated world population:	10,000–100,000

Ecology and Migration

Although the species is vocal early in the breeding season, it is secretive later, and populations are not well-monitored on the breeding grounds. Nests primarily in deciduous and mixed deciduous–conifer forests. In California, often nests in oak or mixed oak–sycamore stands with dense canopies and open, park-like understories.

In most years, most individuals from the northern half of the eastern breeding range migrate south ≤1,500 km. Southern populations do not appear to be migratory.

Population Status

The Red-shouldered Hawk was once a common breeding bird in forests of eastern North America, but studies indicate that it has declined as contiguous forests have diminished (Bednarz and Dinsmore 1981, Bryant 1986, Martin 2004). Partners in Flight estimates that >90% of the global population of 10,000 to 100,000 Red-shouldered Hawks occurs within the United States and Canada (Appendix). Migration counts and BBSs indicate that populations have (1) remained relatively stable in northeastern North America since 1974, (2) increased in western North America since the early 1980s, and (3) increased around the Gulf of Mexico.

Eastern North America

Previous watchsite analyses.—Bednarz et al. (1990) reported a nonsignificant decline in counts of Red-shouldered Hawks at Hawk Mountain, Pennsylvania, from 1934 to 1986 and a nonsignificant increase from 1971 to 1986 (Bednarz et al. 1990). In a study of six migration counts in eastern North America, Titus and Fuller (1990) reported a nonsignificant annual increase of 0.9% from 1972 to 1987. Hussell and Brown (1992) reported nonsignificant annual declines of –1.2% at Grimsby, Ontario (a spring watchsite), from 1975 to 1990. At Cedar Grove, Wisconsin, Mueller et al. (2001) reported a significant increase from 1936 to 1961, but no significant trend from 1936 to 1999.

RPI analysis.—Migration counts indicate that populations of Red-shouldered Hawks generally have remained stable in northeastern North America since 1974 (Chapter 5). From 1994 to 2004, a significant annual increase of 1.3% occurred at Montclair, New Jersey. Nonsignificant annual increases of 3.5% and 0.6% were recorded at Lighthouse Point, Connecticut, and Waggoner's Gap, Pennsylvania, and nonsignificant declines of –0.3%, –0.7%, and –1.8%, respectively, were recorded at Cape May, New Jersey, Hawk Mountain, and Holiday Beach, Ontario (Fig. 12). Continued change at 1994–2004 rates would lead to a 50% increase of Red-shouldered Hawk source populations in ~53 years at Montclair. The Red-shouldered Hawk is not counted at Tadoussac, Québec, and Hawk Ridge, Minnesota, records too few birds (<20 per year) to allow us to estimate trends.

Other analyses.—BBSs in northeastern North America suggested a nonsignificant annual decline of –6.0% from 1976 to 2003. Unfortunately, confidence intervals were broad, indicating an imprecise estimate, and the trend should be interpreted in this light. CBCs in northeastern and southeastern North America indicated significant annual increases from 1974 to 2004 of 2.7% and 2.9%, respectively.

Western North America

Previous watchsite analyses.—None.

RPI analysis.—Small numbers of migrating or dispersing Red-shouldered Hawks have been recorded at Bonney Butte, Oregon, Boise Ridge, Idaho, the Goshutes, Nevada, the Grand Canyon, Arizona (Lipan Point), and at a former spring monitoring site at Jordanelle Reservoir, Utah (HawkWatch International and Idaho Bird Observatory unpubl. data), but nowhere in sufficient numbers to allow trend analyses. The only watchsite in western North America that records >20 birds per year of this species is Golden Gate Raptor Observatory in the Marin Headlands north of San Francisco Bay, California.

Other analyses.—BBSs in California indicated significant annual increases of 8.2% from 1983 to 2005 and of 6.8% from 1995 to 2005.

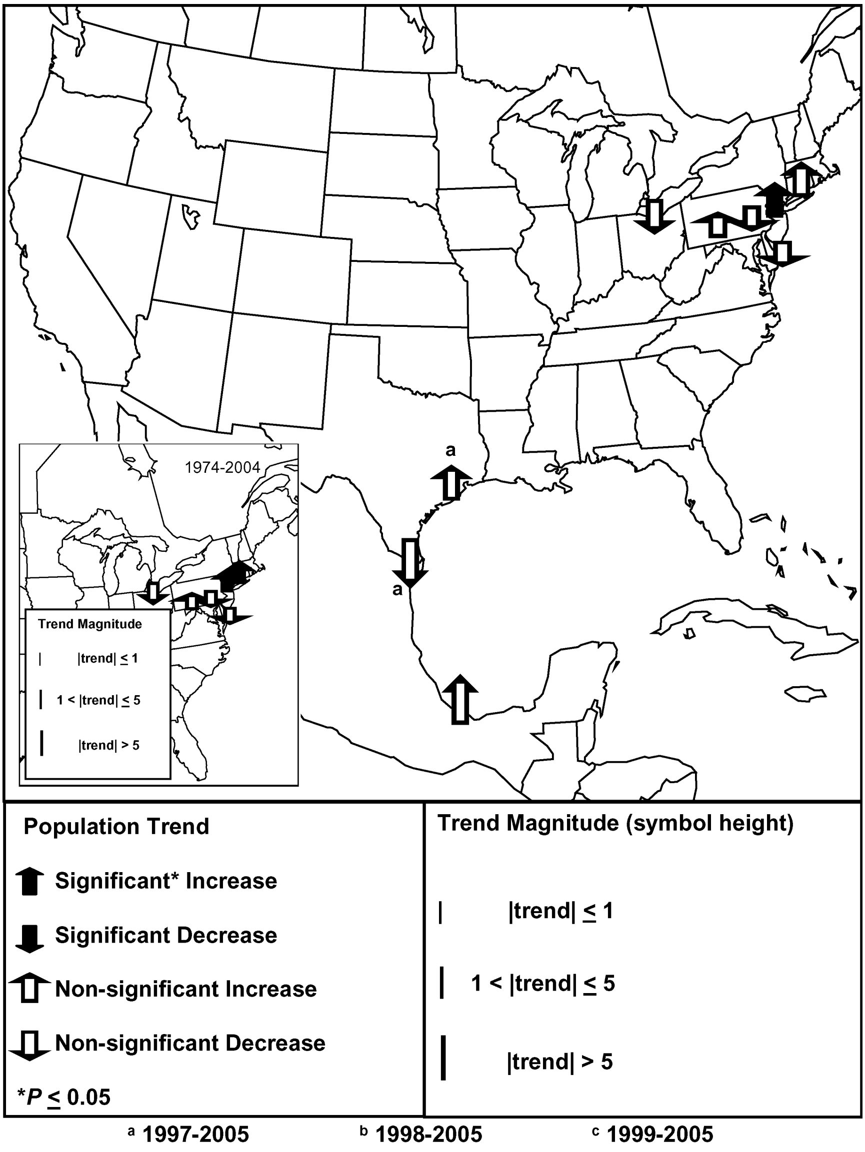

Fig. 12. Population trends for Red-shouldered Hawks (*Buteo lineatus*) at six northeastern (1994–2004) and three Gulf of Mexico raptor migration counts in North America, and long-term trends (1974–2004) for six northeastern counts (inset). Trends are expressed in percent change per year.

CBCs for California indicated significant annual increases of 2.3% from 1983 to 2005, and 2.4% from 1995 to 2005.

Gulf of Mexico

Previous watchsite analyses.—None.

RPI analysis.—Small numbers of Red-shouldered Hawks were counted at watchsites in Texas and Mexico, and the resulting trend estimates were mixed in this region (Chapter 7, Fig. 12). Southern populations of this species are not highly migratory, and these trends may represent changes in the degree of local movement or changes in more northerly populations, some of which migrate ≤1,500 km. Unfortunately, confidence intervals associated with the trend estimates also are wide and trend precision is low overall.

Other analyses.—BBSs recorded significant annual increases in Texas (5.1%) and Florida (4.2%) from 1995 to 2005, suggesting that migration counts were influenced more by local populations than by northern migrants.

Historical Conservation Concerns

Red-shouldered Hawks were shot on migration in the early 20th century. The species also suffered from eggshell thinning due to pesticide use during the DDT Era of 1945–1972. Eggshell thinning was less severe than in other species, and the impact on populations is unknown (Henny et al. 1973, Wiley 1975).

Current Status and Concerns

The Red-shouldered Hawk, a species of least concern globally, is not of concern in the United States or Canada but receives special protection in Mexico (Appendix). Kirk and Hyslop (1998) rated the Red-shouldered Hawk as probably stable in Canada.

Forest fragmentation and loss, particularly in northeastern North America, may threaten some populations. Migration counts, coupled with indications of declines of populations in northeastern North American BBSs and increasing numbers on CBCs, suggest that populations of the Red-shouldered Hawk may be currently stable or declining in much of northeastern North America, with probable increases in populations near the Atlantic coast. On the other hand, increases in CBCs may indicate that the species is becoming less migratory, complicating the interpretation of count data. There is relatively high variability in counts of this species at most watchsites (annual CVs 28–133%), and this variation reduces the power of raptor migration counts to detect small changes in numbers.

Monitoring of the Red-shouldered Hawk at watchsites remains important, because BBSs have very low precision for this species. Efforts should be made to improve detection rates for this species on migration. In particular, additional spring counts around the Great Lakes may provide useful information on Canadian populations. Furthermore, studies of migration behavior may shed light on incongruities among migration count, BBS, and CBC results.

Summary

Migration counts produced few significant trend estimates for this species. Although this may indicate that the monitored populations are stable, we believe that high inter-annual variability of counts and corresponding low precision of estimates may conceal trends. Considerable regional diversity is apparent in the migration trends, and this may reflect the species' short-distance migratory habits, a lower affinity to *leading lines*, or both. Efforts should be made to improve detection rates for this species on migration by adding more watchsites.

Broad-winged Hawk

Scientific name:	*Buteo platypterus*
French name:	*Petite buse*
Spanish name:	*Busardo aliancho, Gavilán aludo*
Body length:	34–44 cm
Wingspan:	81–100 cm
Mass:	265–560 g
Type of migrant:	Complete
Nest type:	Small, crude stick nest in a fork of the main trunk of deciduous and coniferous trees.
Food habits:	Preys primarily on small mammals, birds, amphibians, reptiles, and invertebrates.
Migration flight:	Soaring on thermals with occasional flapping. Glides between thermals.
Estimated world population:	>1,000,000

Ecology and Migration

The Broad-winged Hawk is one of the smallest and the only *complete migrant* among buteos in northeastern North America. A common breeding bird throughout deciduous forests of eastern North America, the Broad-winged Hawk is a secretive nester that is not commonly seen during breeding. The species forms large, conspicuous flocks during migration. Larger flocks or "kettles" can contain tens of thousands of birds, particularly at concentration points from south Texas through Central America. The species nests primarily in deciduous and mixed deciduous–coniferous forests in the temperate zone of North America. Nests are in large forests, often close to small forest openings and water sources.

The continental population is migratory; subspecies on islands in the Caribbean are not. Primarily a soaring migrant, the species depends on updrafts generated by thermals and mountain ridges. Because of this, they are one of the earliest migrants among North American birds of prey. This also leads to a very acute migration, with 95% of the species' annual flight passing migration watchsites like Hawk Mountain, Pennsylvania, within two weeks.

Population Status

The Broad-winged Hawk is a North American endemic with a population estimated to be >1,000,000 in the United States and Canada. Counts in excess of 2,000,000 individuals at Veracruz River of Raptors, Mexico, provide the best estimate of overall population size. Migration counts and BBSs indicate that populations of Broad-winged Hawks have (1) declined generally in northeastern North America since 1974; (2) increased in western North America since the early 1980s; and (3) remained stable or increased continent-wide since 1995, as measured by raptor migration counts near the Gulf of Mexico.

Eastern North America

Previous watchsite analyses.—Bednarz et al. (1990) reported a nonsignificant increase in counts of Broad-winged Hawks at Hawk Mountain, Pennsylvania, from 1934 to 1942 and a nonsignificant decline from 1971 to 1986, but no estimates were made of the rates of change. In a study of six migration counts in eastern North America, Titus and Fuller (1990) reported a nonsignificant annual decline of –2.7% from 1972 to 1987. Hussell and Brown (1992) reported that counts at Hawk Ridge, Minnesota, declined nonsignificantly from 1974 to 1989 at –3.0% annually, and those at Grimsby, Ontario (a spring count), declined significantly at –5.3% annually from 1975 to 1990. At Cedar Grove, Wisconsin, Mueller et al. (2001) reported that counts were stable from 1936 to 1999, and underwent a nonsignificant decline from 1989 to 1999. Miller et al. (2002) reported decreasing trends at Hawk Mountain and Montclair, New Jersey, from 1979 to 1998.

RPI analysis.—Migration counts indicate that the number of migrants of this species has declined in northeastern North America since 1974 (Chapter 5). From 1994 to 2004, statistically significant annual declines of –9.5%, –3.4%, and –1.1% were recorded at Montclair, New Jersey, Hawk Mountain, and Holiday Beach, Ontario, respectively, and a statistically significant annual increase of 7.8% was recorded at Waggoner's Gap, Pennsylvania. Nonsignificant annual declines of –3.6% and –1.4% were recorded at Lighthouse Point, Connecticut, and Cape May, New Jersey, respectively, and a nonsignificant increase of 1.1% was recorded at Hawk Ridge (Fig. 13). Continued change at the 1994–2004 rates would lead to a 50% increase of Broad-winged Hawk source populations in ~13 years at Waggoner's Gap, and 50% declines in 8 years at Montclair, 20 years at Hawk Mountain, and 63 years at Holiday Beach.

Other analyses.—BBSs in northeastern North America recorded a marginally significant annual increase of 2.0% from 1976 to 2003. Low detection rates make BBSs unreliable for monitoring Broad-winged Hawk populations, and the estimated trend should be interpreted in this light. The entire North American population of Broad-winged Hawks (with the exception of a few birds that winter in Florida, coastal Texas, and the Mississippi River delta) migrates to Central and South America; hence, there are no useful CBC data for this species.

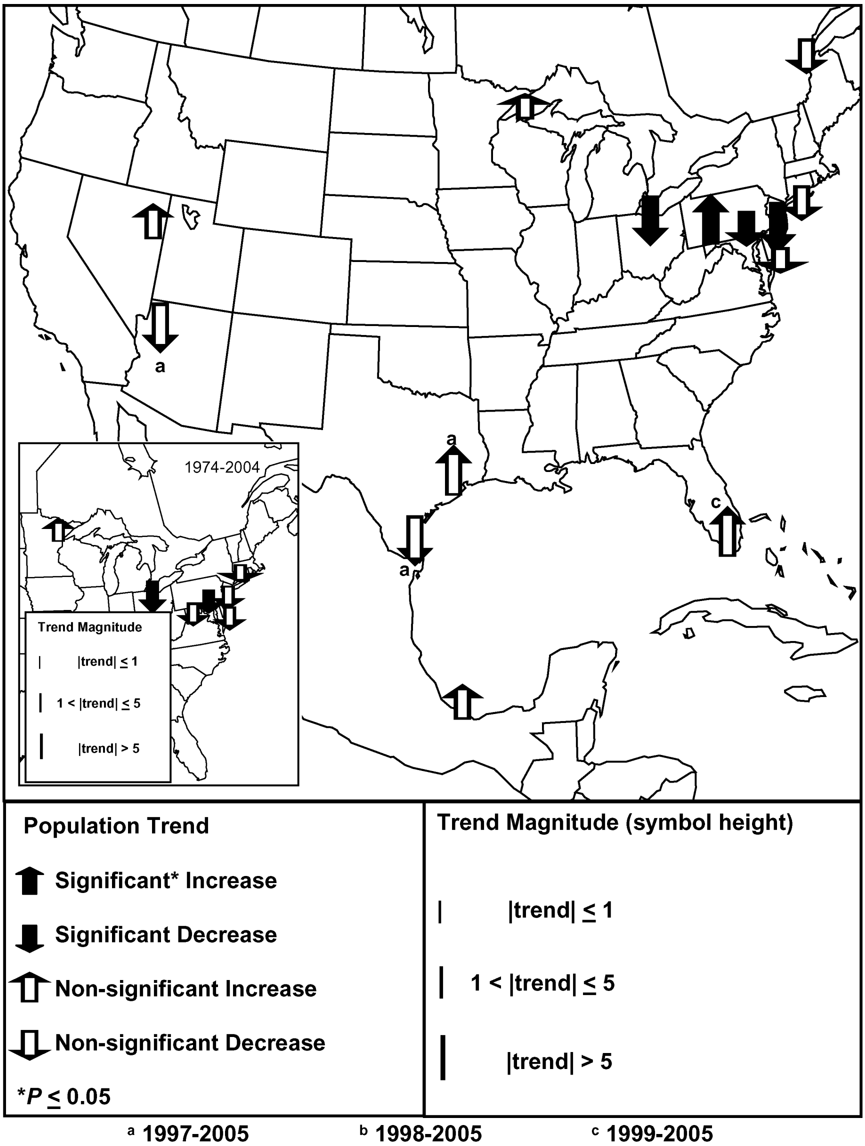

Fig. 13. Population trends for Broad-winged Hawks (*Buteo platypterus*) at eight northeastern (1994–2004), two western (1995–2005), and four Gulf of Mexico (1995–2005) raptor migration counts in North America, and long-term (1974–2004) trends at seven northeastern sites (inset). Trends are expressed in percent change per year.

Western North America

Previous watchsite analyses.—Smith et al. (2001) reported annual increases of 3% to 16% in counts at the Goshutes, Nevada, from 1983 to 1999; the Manzanos, New Mexico, from 1985 to 1999; the Sandias, New Mexico (a spring watchsite), from 1985 to 2001; the Bridger Mountains, from 1992 to 1999; and the Grand Canyon, Arizona (Lipan Point), from 1991 to 1999. Possible increases occurred at the Wellsvilles, Utah, in the late 1970s and from 1987 to 1999; at Bonney Butte, Oregon, from 1995 to 1999; and at Chelan Ridge, Washington, from 1997 to 1999. Hoffman and Smith (2003) reported significant increases at the Goshutes from 1983 to 2001 and at the Bridger Mountains and the Grand Canyon (Lipan Point) from 1992 to 2001. No significant trends were recorded at the Wellsvilles from 1987 to 2001 or Manzanos from 1983 to 2001. Smith et al. (2001) and Hoffman and Smith (2003) suggested that increasing trends in western North America reflect a westward shift in the breeding distribution of the species.

RPI analysis.—Migration counts support the hypothesis that populations of the Broad-winged Hawk have increased in portions of western North America since the mid-1980s (Chapter 6). From 1995 to 2005, a nonsignificant annual increase of 1.1% occurred at the Goshutes, and a nonsignificant decline of –6.5% occurred at the Grand Canyon (Lipan Point and Yaki Point combined, 1997 to 2005) (Fig. 13).

Other analyses.—BBSs showed nonsignificant annual declines of –4.5% from 1983 to 2004 and –9.2% from 1995 to 2005. BBS detection rates for this species are low, yielding small samples, and these trend estimates should be interpreted in that light.

Gulf of Mexico

Previous watchsite analyses.—None.

RPI analysis.—Nonsignificant annual increases occurred in counts at most watchsites in the Gulf region over the last decade (Chapter 7). A nonsignificant annual decline of –2.4%, recorded at Corpus Christi, Texas, from 1997 to 2005, may reflect the influence of recent hurricanes Katrina and Rita in 2005 (Fig. 13).

Historical Conservation Concerns

Broad-winged Hawks were shot along migration corridors in the early 20th century. Band-recovery data suggest that such persecution continued to affect the species on its wintering grounds into the 1980s (Robbins 1986). Although many raptors declined during the DDT Era of 1945 to 1972, there is little evidence that Broad-winged Hawks were significantly affected by pesticides.

Current Status and Concerns

Collisions with vehicles are a primary cause of death for birds wintering in the Florida Keys (Tabb 1973). Increased rates of forest fragmentation and loss, particularly in the boreal forest and on Caribbean Islands, may threaten populations there. Forest loss on migration routes and in wintering areas also may pose a threat. Migrants also are vulnerable to direct exploitation during migration in Central America and northern South America.

The Broad-winged Hawk is a species of least concern globally and is not listed as a species of concern in either the United States or Canada (Appendix). Kirk and Hyslop (1998) considered the species to be declining or stable in Canada, possibly as the result of timber harvests.

Migration monitoring is particularly important for this species because it is not well monitored by BBSs and is not present in most of North America during CBCs. Additional migration counts may further clarify patterns of population change in this species.

Summary

Judging from the nearly complete count of the continental population at Veracruz, the Broad-winged Hawk appears to be stable or increasing in North America. The ubiquity of decreasing long-term trend estimates in northeastern North America east of the central Great Lakes, however, suggests either (1) that regional declines are underway in eastern North America, perhaps as a consequence of logging in the boreal forest there, and that this is not happening elsewhere in the species' range; (2) that populations are stable in eastern Canada, but that changes in migration geography are causing declines in established counts in eastern North America; or (3) that both factors are operating.

Red-tailed Hawk

Scientific name:	*Buteo jamaicensis*
French name:	*Buse á queue rousse*
Spanish name:	*Gavilán colirroja, Aguililla colirroja, Aguililla parda*
Body length:	Female: 50–65 cm Male: 45–56 cm
Wingspan:	110–141 cm
Mass:	Female: 900–1,460 g Male: 690–1,300 g
Type of migrant:	Partial
Nest type:	Large stick nest in a fork of the main trunk or crown of a large, and often super-canopy, tree. Also on utility-line poles and transmission towers, Saguaro cactus, cliff ledges, and ledges of large buildings.
Food habits:	Preys primarily on small to medium-sized mammals, birds, amphibians, reptiles, and invertebrates, as well as on carrion, including road kills.
Migration flight:	Soars on broad, flat wings; glides with wings partially flexed.
Estimated world population:	>1,000,000

Ecology and Migration

This large, adaptable buteo occurs in open areas interspersed with woodlots and forest patches. Primarily a sit-and-wait predator, it often perches conspicuously near fields and along roadways. The species is one of North America's most familiar and frequently observed raptors. In addition to individual variability, there are distinctive regional variants; 14 subspecies are recognized in North America.

The species nests primarily in woodlots, forest patches, and tree rows, often in agricultural and suburban areas. Large expanses of dense forest and treeless areas generally are avoided.

In most years, most individuals from the breeding range north of the United States–Canada border migrate south. Many individuals from more southerly breeding areas also migrate south, and are replaced for the winter by migrants from the north. *Leap-frog migration* occurs. Recaptures of banded birds and satellite tracking indicate that young birds from southern California and northern Baja California disperse significant distances to the northeast (i.e., into Nevada, Montana, and Wyoming) in late summer before returning south in subsequent years to reside in their natal ranges (P. Bloom and HawkWatch International unpubl. data). Satellite tracking of adults captured in the West suggests that adults show high fidelity to migration routes, breeding ranges, and winter ranges (HawkWatch International unpubl. data).

Population Status

Approximately 90% of the global population of >1,000,000 birds is thought to occur in the United States and Canada (Appendix). Migration counts, BBSs, and CBCs reflect the complicated pattern of migration of Red-tailed Hawks that makes population trends difficult to discern. Nevertheless, they suggest that Red-tailed Hawks have (1) increased in northeastern North America year-round, and generally declined or remained stable in migration counts, from 1974 to 2004; (2) increased in the intermountain region of western North America since the early 1980s; (3) increased in the southern and declined in the northern Rocky Mountains since 1995; (4) remained stable in the Pacific Northwest since 1995; and (5) remained stable around the Gulf of Mexico.

Eastern North America

Previous watchsite analyses.—Bednarz et al. (1990) reported a nonsignificant decline in numbers at Hawk Mountain, Pennsylvania, from 1934 to 1986, and a significant decline from 1973 to 1986. In a study of six migration counts in eastern North America, Titus and Fuller (1990) reported a nonsignificant annual decline of –0.04% from 1972 to 1987. Hussell and Brown (1992) reported a nonsignificant annual decline of –4.8% at Hawk Ridge, Minnesota, from 1974 to 1989, and a –2.1% annual decline at Grimsby, Ontario (a spring watchsite), from 1975 to 1990. At Cedar Grove, Wisconsin, Mueller et al. (2001) reported significant increases from 1936 to 1999 and from 1951 to 1999. Overall, previous estimates of population trends indicate that populations passing western Great Lakes watchsites increased, whereas those east of the Great Lakes declined or remained stable from the 1970s to the late 1980s.

RPI analysis.—Trends in migration counts varied across the region from 1974 to 2004 (Chapter 5). Since 1994, a significant annual increase of 3.1% occurred at Lighthouse Point, Connecticut, whereas significant annual declines of –9.8% and –1.9% occurred at Cape May, New Jersey, and Hawk Mountain, respectively. Nonsignificant annual increases of 3.1% and 1.9% occurred at Waggoner's Gap, Pennsylvania, and Hawk Ridge, and nonsignificant declines of –0.4%, –1.5%, and –3.1% were recorded at Tadoussac, Québec, Montclair, New Jersey, and Holiday Beach, Ontario, respectively (Fig. 14). Continued change at the 1994–2004 rates would lead to a 50% increase in ~22 years at Lighthouse Point, and 50% declines in 7 years at Cape May and 39 years at Hawk Mountain.

Other analyses.—BBSs indicated significant annual increases in northeastern North America from 1976 to 2003 (2.8%), and a nonsignificant increase in the northeastern United States (1.8%) from 1994

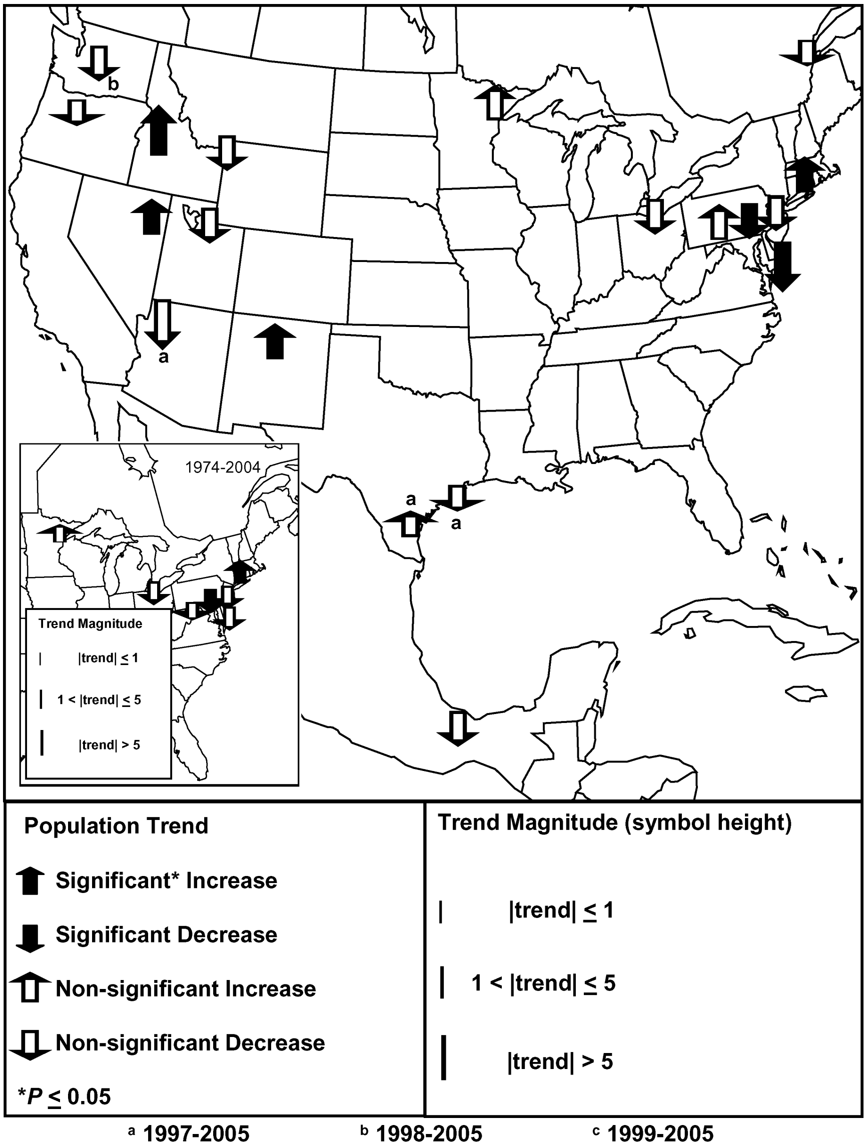

Fig. 14. Population trends for Red-tailed Hawks (*Buteo jamaicensis*) at eight northeastern (1994–2004), eight western (1995–2005), and three Gulf of Mexico (1995–2005) raptor migration counts in North America, and long-term trends (1974–2004) for seven northeastern counts (inset). Trends are expressed in percent change per year.

2004. CBCs in the northeastern and southeastern United States indicated significant annual increases of 2.7% and 3.3%, respectively, from 1974 to 2004.

Western North America

Previous watchsite analyses.—Hoffman and Smith (2003) reported significant increases at the Goshutes, Nevada, from 1983 to 2001; the Wellsvilles, Utah, from 1987 to 2001; the Manzanos, New Mexico, from 1985 to 2001; and the Sandias, New Mexico (a spring watchsite), from 1985 to 2001. No significant trends were recorded at the Grand Canyon, Arizona (Lipan Point), from 1991 to 2001, or the Bridger Mountains, Montana, from 1992 to 2001.

RPI analysis.—Migration counts indicate that populations mostly increased or remained stable in the western United States since the mid-1980s (Chapter 6). From 1995 to 2005, significant annual increases of 2.1%, 2.0%, and 7.3% were recorded at the Manzanos, the Goshutes, and Boise Ridge, Idaho, respectively. From 1995 to 2005, a significant annual decline of –10.7% occurred at the Grand Canyon (Lipan Point), whereas nonsignificant annual declines of –5.0%, –1.7%, –2.2%, –4.0%, and –6.2%, respectively, were recorded at Chelan Ridge, Washington (1998 to 2005), Bonney Butte, Oregon, the Bridger Mountains (1995 to 2005), the Wellsvilles (1995 to 2004), and the Grand Canyon (Lipan Point and Yaki Point combined, 1997 to 2005) (Fig. 14).

Other analyses.—BBSs indicated a significant annual increase of 1.5% from 1983 to 2005. CBCs indicated a significant annual increase of 1.3% from 1983 to 2005 and no net change (0.0%) from 1995 to 2005.

In sum, a long-term, regional increase appears to be underway in the northern intermountain region. Recent stabilization of previously increasing numbers in the Goshutes, and declines farther south at the Grand Canyon (Lipan Point and Yaki Point), may be related to possible shifts in migration geography due to the regional drought. Manzanos counts also indicate a long-term, regional increase for populations in the southern Rockies. Satellite tracking of several individuals outfitted during migration in the Manzanos showed summer ranges stretching from northern New Mexico into southwestern Montana and southern Wyoming, and demonstrated route connections among the three Rocky Mountain sites (HawkWatch International unpubl. data). Incongruities between trends at the Manzanos and the two more northerly sites may indicate that populations in the southern Rocky Mountains are more productive than those in the northern Rockies. Lastly, the short-term data sets available from the Pacific Northwest suggest that populations from northern Oregon through west-central British Columbia are relatively stable.

Gulf of Mexico

Previous watchsite analyses.—None.

RPI analysis.—Watchsites in this region recorded mixed trends for the Red-tailed Hawk (Chapter 7), suggesting a relatively stable regional population (Fig. 14). Given migration geography of the species, it is likely that only relatively local movements are monitored at watchsites in coastal Texas and Veracruz.

Other analyses.—BBSs from 1995 to 2005 increased nonsignificantly in Texas (1.7%), reinforcing the idea of stable populations in the region.

Historical Conservation Concerns

Changes in forest cover in northeastern North America and fire suppression and attendant changes in forest structure in western North America may have favored Red-tailed Hawks and led to population increases and range expansion in the 20th century (Brown 1964, Bock and Lepthein 1976, Houston and Bechard 1983).

Current Status and Concerns

Migration counts suggest that populations are stable or decreasing slightly in eastern North America, but BBSs and CBCs suggest population increases. This incongruity suggests that either some populations became less migratory in the last 30 years, or migratory populations declined in some areas whereas breeding populations of sedentary birds increased. Trends in all indexes in western North America indicate that populations increased there since the 1980s, but then stabilized or started to decline in the last decade, possibly because of a regional drought (Hoffman and Smith 2003). Migration counts of this species have limited monitoring value around the Gulf of Mexico, but they appear to have been stable over the most recent decade.

The Red-tailed Hawk is a species of least concern globally and is not of concern in the United States or Canada (Appendix). Kirk and Hyslop (1998) considered the species "not at risk" in most of Canada, with possible declines in the mixed-wood plains.

Summary

The Red-tailed Hawk appears to be secure throughout most of its range in North America. Migration counts have declined in eastern North America since 1995, but coincidental increases in BBS and CBC counts suggest that these migration trends may be the result of changes in migration geography or behavior. Elsewhere in North America, population monitoring generally indicates increasing or stable populations of this common raptor.

Rough-legged Hawk

Scientific name:	*Buteo lagopus*
French name:	*Buse pattue*
Spanish name:	*Ratonero calzado*
Body length:	46–59 cm
Wingspan:	110–143 cm
Mass:	715–1,400 g
Type of migrant:	Complete
Nest type:	Bulky stick nest on a cliff ledge, tree, or human-built structure.
Food habits:	Preys primarily on voles and lemmings in the Arctic during the breeding season and on voles and other small rodents in open shrub-steppe, grassland, and other open habitats on the wintering grounds.
Migration flight:	Soaring and gliding on broad, flat wings held in a dihedral.
Estimated world population:	100,000–1,000,000

Ecology and Migration

The Rough-legged Hawk is a relatively large buteo associated primarily with open habitats, including tundra in the breeding range and fields and meadows in the winter range. The species breeds throughout the Arctic and sub-Arctic in North America, Asia, and Europe. North American Rough-legged Hawks typically breed in the tundra and taiga habitats of northern and western Alaska and northern Canada. Rough-legged Hawks nest primarily in tundra associated with forested river valleys, on flat tundra, or on cliffs and steep banks of rivers. In areas of flat tundra, most nests are on steep-sided outcroppings or cliffs. The species also nests on steep hillsides, trees, and human-made structures.

In most years, most individuals migrate south as far as the northern and, sometimes, central United States, but areas of concentration vary among years.

Population Status

Partners in Flight estimates that populations in the United States and Canada comprise approximately one-half of the global population of >1,000,000 (Appendix). Migration counts and CBCs indicate that Rough-legged Hawks have (1) declined over the last 30 years in northeastern North America and (2) declined slightly since the mid-1980s in western North America.

Eastern North America

Previous watchsite analyses.—Bednarz et al. (1990) reported a significant long-term increase at Hawk Mountain, Pennsylvania, from 1934 to 1986 and a nonsignificant decline from 1971 to 1986. In a study of six migration counts in eastern North America, Titus and Fuller (1990) reported a nonsignificant annual increase of 1.1% per year from 1972 to 1987. Hussell and Brown (1992) reported a significant annual decline of –9.5% at Hawk Ridge, Minnesota, from 1974 to 1989, and a nonsignificant decline of –3.0% at Grimsby, Ontario (a spring watchsite), from 1975 to 1990. At Cedar Grove, Wisconsin, Mueller et al. (2001) reported a significant increase from 1936 to 1999, and a nonsignificant increase from 1951 to 1999.

In sum, previous estimates of population trend for Rough-legged Hawks suggest that populations may have increased in the first half of the 20th century and subsequently stabilized or declined.

RPI analysis.—Migration counts indicate that Rough-legged Hawk populations have declined over the last 30 years (Chapter 5). The irruptive nature of this species' migration into areas covered by these monitoring programs suggests that migration trends should be interpreted with caution, as they may result from decreased migratory activity independent of changes in population size. From 1994 to 2004, nonsignificant annual declines of –1.2%, –3.0%, and –1.7% occurred at Tadoussac, Québec, Holiday Beach, Ontario, and Hawk Ridge, respectively (Fig. 15). Counts at other watchsites averaged <20 birds per year during this period (Chapter 5).

Other analyses.—CBCs indicated declines during the past 30 years, with a nonsignificant annual decline of –0.3% in northeastern North America and a significant annual decline of –5.7% in southeastern North America from 1974 to 2004.

These results suggest that the migration geography of Rough-legged Hawks has changed over time, with fewer individuals migrating into the southeastern United States, and relatively constant numbers wintering in the northeastern part of the continent. Analyses of spring raptor migration counts around the Great Lakes may provide additional useful information.

Western North America

Previous watchsite analyses.—None.

RPI analysis.—Migration counts showed no statistically significant trends in the western United States since the mid-1980s, but did reveal slight declining trajectories (Chapter 6). In general, the value of western counts for this species is limited because monitoring seasons are limited by snowfall and cover only the first half of the species' migration period,

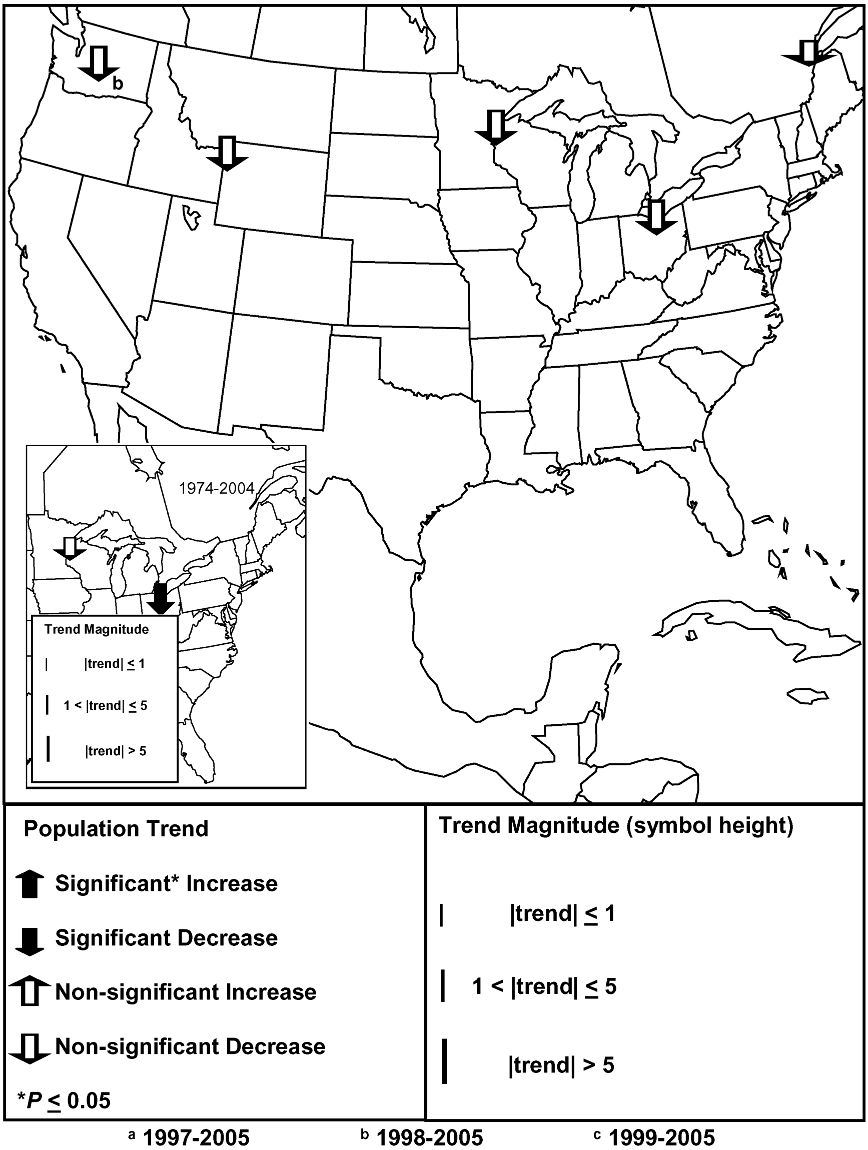

Fig. 15. Population trends for Rough-legged Hawks (*Buteo lagopus*) at three northeastern (1994–2004) and two western (1995–2005) raptor migration counts in North America, and long-term trends (1974–2004) for two northeastern counts (inset). Trends are expressed in percent change per year.

which typically extends well into November. Migration counts suggested nonsignificant declines of –2.2% and –1.1% at Chelan Ridge, Washington (1998 to 2005), and the Bridger Mountains, Montana (1992 to 2005) (Fig. 15). Counts at other watchsites averaged <20 birds per year during this period (Chapter 6).

Other analyses.—CBCs indicated that winter Rough-legged Hawk populations declined nonsignificantly at rates of –0.8% and –0.7% annually from 1983 to 2005 and 1995 to 2005, respectively.

Historical Conservation Concerns

Over-wintering Rough-legged Hawks were once perceived by farmers and ranchers to be a threat to livestock, and consequently were shot in the early part of the 20th century. They also were shot on migration. Although the species' eggs were found to contain DDT in 1971 (Cade et al. 1971), the degree to which pesticide use affected populations is unknown.

Current Status and Concerns

Pesticides, persecution, and collisions with vehicles may threaten the species on its wintering grounds (Keran 1981, Olson 2002). The species winters in agricultural areas, and evidence suggests that land-use change may displace wintering hawks and their prey (Garrison and Bloom 1993, Brouse 1999).

The Rough-legged Hawk is a species of least concern globally and is not of concern in the United States or Canada. Kirk and Hyslop (1998) considered the species stable in Canada but noted that it is difficult to monitor because of broad fluctuations in numbers and locations of breeding adults. Newly instituted winter surveys of raptors (see www.hmana.org) may offer a monitoring tool for over-wintering individuals.

Summary

Because of its northern distribution, the species is not well monitored by any of the surveys reviewed in this report. Available trends from migration counts, BBSs, and CBCs suggest a long-term decline in wintering populations in the United States. A combination of winter surveys and analysis of raptor migration counts around the Great Lakes and in Canada is needed to clarify its conservation status.

Swainson's Hawk

Scientific name:	*Buteo swainsoni*
French name:	*Buse de Swainson*
Spanish name:	*Gavilán longostero, Aguililla de swainson, Aguilucho langostero*
Body length:	Female: 51–56 cm Male: 48–51 cm
Wingspan:	120–137 cm
Mass:	Female: 937–1,367 g Male: 693–936 g
Type of migrant:	Complete
Nest type:	Bulky, disorganized stick nest in a solitary tree, bush, small grove, line of trees along a water course, or utility pole or transmission tower.
Food habits:	Preys primarily on small mammals, birds, and reptiles while breeding. Feeds almost exclusively on insects—primarily orthopterans—and other invertebrates while over-wintering.
Migration flight:	Gliding and soaring with wings flexed in a dihedral, often in large groups, or "kettles."
Estimated world population:	>1,000,000

Ecology and Migration

This large buteo is associated with open grasslands, shrublands, and woodlands. It typically nests in scattered trees within open landscapes. Almost all individuals vacate the breeding range in North America to over-winter in South America, primarily Argentina, traveling distances of ≤12,000 km between their breeding and winter ranges. Recent evidence suggests central California breeders may only move to the west coast of Mexico.

Population Status

The Swainson's Hawk is a North American endemic with a population estimated to be >1,000,000 (Appendix). Migration counts and BBSs indicate that populations of the Swainson's Hawk increased in western North America since the mid-1980s, significantly so at least since 1995.

Eastern North America

Swainson's Hawks are seen only rarely at watchsites in eastern North America, and, consequently, no population trends were calculated for this region.

Annual counts of this species average 0.4 at Lighthouse Point, Connecticut; 2.5 at Cape May, New Jersey; 0.7 at Montclair, New Jersey; 0.2 at Hawk Mountain, Pennsylvania; 0.4 at Waggoner's Gap, Pennsylvania; and 0.4 at Holiday Beach, Ontario. The median count is 0 at all sites except Cape May, where it is 2.0.

Western North America

Historical analyses.—Hoffman and Smith (2003) reported significant increases at the Wellsvilles, Utah, from 1987 to 2001 and the Manzanos, New Mexico, from 1983 to 2001; and marginally significant increases at the Goshutes, Nevada, from 1983 to 2001 and the Sandias, New Mexico (a spring watchsite), from 1985 to 2001. They reported increases until 1996–1997, followed by declines at the Grand Canyon, Arizona (Lipan Point) (1991 to 2001), and a marginally significant decline at the Bridger Mountains, Montana, from 1992 to 2001.

RPI analysis.—Our analyses confirmed long-term significant annual increases in the West (Chapter 6). A significant annual increase of 5.4% occurred at the Goshutes from 1995 to 2005, and a nonsignificant increase of 7.4% occurred at the Grand Canyon (Lipan Point and Yaki Point combined) from 1997 to 2005. Nonsignificant annual declines of –9.0%, –2.3%, –3.5%, respectively, occurred at the Wellsvilles (1995 to 2004), Boise Ridge, Idaho (1995 to 2005), and the Manzanos (1995 to 2005) (Fig. 16). The remaining watchsites in this region counted too few individuals to allow trend estimation.

Other analyses.—BBSs indicated a nonsignificant annual decline of –0.9% from 1983 to 2005 and a nonsignificant increase of 0.2% from 1995 to 2005. CBCs are not available for this species because it is a complete migrant, and most individuals leave North America during winter.

In sum, data for Swainson's Hawks indicate that increases generally occurred within both the Rocky Mountain and Intermountain Flyways between the mid- to late 1980s and mid- to late 1990s, with possibly drought-related downturns after that, except at the Grand Canyon. Unlike the trends for many other species, the strongest long-term increases were in the intermountain region and at the Grand Canyon, which suggests that the regional drought did not deter the species from migrating through the Great Basin. Indexes in the Rocky Mountains were comparatively stable from 2000 to 2005, but overall, the species appears to have increased in the interior West during the past 15 years. Estimated annual rates of increase of 5% in the Intermountain Flyway, if sustained, would result in a doubling of the current population in ~14 years.

Part of the increase may be attributable to a population rebound from pesticide kills of the early 1990s, in which ≥30,000 individuals are believed to have been killed within a two- to three-year period on the over-wintering

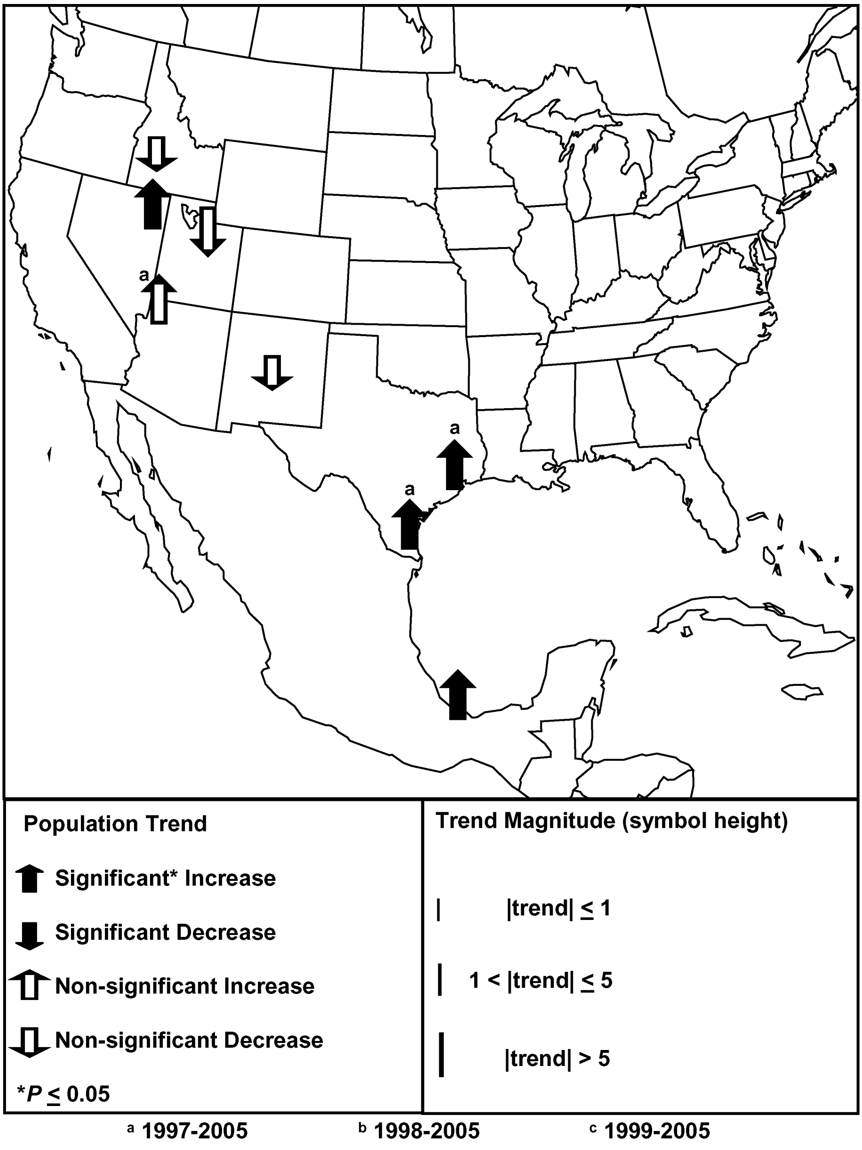

Fig. 16. Population trends (1995–2005) for Swainson's Hawks (*Buteo swainsoni*) at five western and three Gulf Coast raptor migration counts in North America. Trends are expressed in percent change per year.

grounds in Argentina (Woodbridge et al. 1995). Because the pesticide had been used since the mid-1980s, many birds may have been killed before the problem came to light. Alternatively, there are some indications that the species already was increasing in the 1990s.

Gulf of Mexico

RPI analysis.—Significant annual increases occurred at watchsites in this region in the last decade (Chapter 7, Fig. 16). Migration counts at these three watchsites monitor nearly the entire North American population (Chapters 2 and 7), and the increases recorded there may reflect recovery from earlier population declines (see Bloom 1980, Littlefield et al. 1984, Harlow and Bloom 1989, Woodbridge et al. 1995). Counts of this species at the Florida Keys watchsite were too small to analyze.

Historical Conservation Concerns

Although common in western North America at the beginning of the 20th century, Swainson's Hawks declined as native grasslands were converted to agriculture or developed (Bloom 1980, Littlefield et al. 1984, Harlow and Bloom 1989, Woodbridge et al. 1995). Direct persecution in the form of shooting was a significant source of mortality in the first half of the 20th century, but has since declined in North America (Houston and Schmutz 1995a). Swainson's Hawks wintering in Argentina were killed in large numbers by organophosphate pesticides in the 1990s (Woodbridge et al. 1995) but do not appear to have been harmed by pesticide use in North America during the DDT Era.

Current Status and Concerns

The species is susceptible to electrocution because of its habit of perching on utility poles. Direct persecution in the form of shooting may still be a threat during passage through Mesoamerica, given that the species roosts in large groups in agricultural habitats. Declines in reproductive output have been associated with declines in prey populations (Bechard 1983, Houston and Schmutz 1995b) and the lack of suitable nesting habitat because of land-use change (Olendorff and Stoddart 1974). Loss or conversion of grassland habitats to row-crop agriculture in both North and South America may be the largest threat to Swainson's Hawk populations, although the degree of habitat conversion has not been quantified (Ferguson-Lees and Christie 2001). On the other hand, some populations in the intermountain West and California have adapted well to hayfield agriculture, taking advantage of associated rodent populations. Additional research is needed to understand factors limiting Swainson's Hawk populations.

The Swainson's Hawk is a species of least concern globally, is a species of concern in the United States, is not at risk in Canada, and receives special protection in Mexico (Appendix). California Swainson's Hawks have reportedly declined by 90% since the mid-20th century (Ferguson-Lees and Christie 2001). Kirk and Hyslop (1998) considered the Swainson's Hawk to be declining or stable in Canada, with its status unknown in British Columbia.

Summary

Overall, the data suggest substantial increases in populations of Swainson's Hawks in the last two decades across much of North America. Monitoring of this species will be greatly enhanced with additional watch-sites in the Great Plains, the foothills of the eastern Rocky Mountains, and southern California.

Golden Eagle

Scientific name:	*Aquila chrysaetos*
French name:	*Aigle royal*
Spanish name:	*Águila real*
Body length:	70–84 cm
Wingspan:	185–220 cm
Mass:	Female: 3,400–6,100 g Male: 2,500–4,200 g
Type of migrant:	Partial
Nest type:	Large stick nest usually on a cliff, dominant tree, or manmade structure.
Food habits:	Opportunistic feeder. In western North America, primarily rabbits, hares, and squirrels, 500–2,000 g. In eastern United States, waterfowl and other birds.
Migration flight:	Soaring with wings in a slight dihedral, and flapping with slow, powerful wingbeats.
Estimated world population:	100,000–1,000,000

Ecology and Migration

Found in the Northern Hemisphere in both the New and Old World, the species is a "booted eagle," with legs feathered to the toes. Golden Eagles breed in open shrubland, grassland, farmland, tundra, and broken forest, and avoid heavily forested areas. Because of the distribution of such habitats, the species is much more common in western than in eastern North America.

Northern breeding populations usually are migratory and move farther from their breeding grounds than do southern populations. Most nesting south of 55°N in western North America are permanent residents. Satellite tracking in the intermountain West indicates that individuals wander extensively during their first few years of life (HawkWatch International unpubl. data).

Population Status

Partners in Flight estimates that Golden Eagles in the United States and Canada comprise approximately one-half of the global population of 100,000 to 1,000,000 (Appendix). A recent aerial survey estimated the Golden Eagle population of the continental northwestern United States at ~27,400 birds (Good et al. 2004). Migration counts and CBCs indicate that populations of Golden Eagles have (1) increased in eastern North America since 1974; and (2) declined in western North America since the early 1980s, with accelerating declines since 1998.

Eastern North America

Previous watchsite analyses.—Bednarz et al. (1990) reported a nonsignificant decline at Hawk Mountain, Pennsylvania, from 1934 to 1942, a significant decline from 1946 to 1972, a significant increase from 1973 to 1986, and a significant, long-term decline from 1934 to 1986. This paralleled a decline seen in eastern Bald Eagles and was thought to be related to exposure to organochlorines. In a study of six raptor migration counts in eastern North America, Titus and Fuller (1990) reported a nonsignificant annual increase of 3.0% from 1972 to 1987. Hussell and Brown (1992) reported a nonsignificant annual decline of –1.3% in counts at Hawk Ridge, Minnesota, from 1974 to 1989, and a significant annual increase of 8.1% at Grimsby, Ontario (a spring watchsite), from 1975 to 1990.

RPI analysis.—Migration counts indicate that populations have increased steadily in northeastern North America since 1974 (Chapter 5). More recently, significant annual increases of 2.1%, 3.9%, and 5.7% occurred at Hawk Mountain, Waggoner's Gap, Pennsylvania, and Hawk Ridge, respectively, from 1994 to 2004. Nonsignificant annual declines of –3.8% and –0.2% occurred at Tadoussac, Québec, and Holiday Beach, Ontario, respectively, during the same period (Fig. 17). We do not report trends at Lighthouse Point, Connecticut, Cape May, New Jersey, and Montclair, New Jersey, because of low numbers there.

Continued change at the 1994–2004 rates would result in a 50% increase of Golden Eagle source populations in ~33 years at Hawk Mountain, 18 years at Waggoner's Gap, and 12 years at Hawk Ridge.

Other analyses.—In northeastern North America, CBCs indicated a statistically significant annual increase of 4.1% from 1974 to 2004 and a nonsignificant annual increase of 6.9% from 1994 to 2004. In southeastern North America, CBCs recorded a significant annual increase of 2.1% from 1974 to 2004, and a nonsignificant annual increase of 5.2% from 1994 to 2004. These trends suggest steady increases in numbers of Golden Eagles wintering in eastern North America over the last 30 years. CBCs may have limited value for estimating trends in the species (see Kochert et al. 2002), and these estimates should be viewed in that light.

Western North America

Previous watchsite analyses.—Hoffman and Smith (2003) reported a significant increase in immature Golden Eagles at the Goshutes, Nevada, from 1983 to 2001; and significant declines in immatures at the Wellsvilles, Utah, from 1987 to 2001 and at the Grand Canyon, Arizona (Lipan Point), from 1992 to 2001. No significant trends were recorded at the Bridger Mountains, Montana, from 1992 to 2001; the Manzanos, New Mexico, from 1983 to 2001; or the Sandias, New Mexico (a spring watchsite), from 1985 to 2001. Population trajectories at all sites except Bridger Mountains were

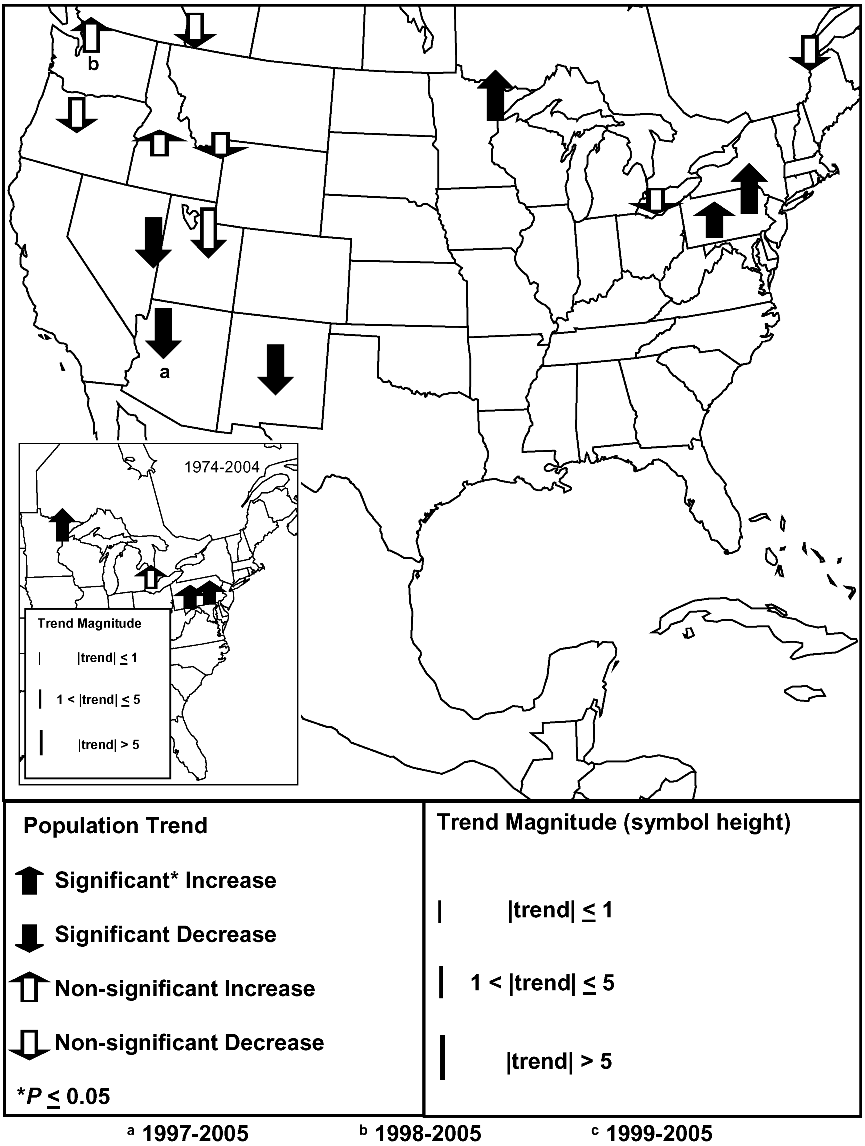

Fig. 17. Population trends for Golden Eagles (*Aquila chrysaetos*) at five northeastern (1994–2004) and nine western (1995–2005) raptor migration counts in North America, and long-term trends (1974–2004) at four northeastern raptor migration counts (inset). Trends are expressed in percent change per year.

quadratic, with declines in the early 1990s followed by increases in the mid-1990s (Hoffman and Smith 2003).

RPI analysis.—Migration counts indicated that populations have declined in much of the western United States since the mid-1980s (Chapter 6). From 1995 to 2005, the magnitude of significant annual declines increased to –8.6% and –5.3%, respectively, in the Goshutes and Manzanos; and a marginally significant decline of –6.0% occurred in the Wellsvilles from 1995 to 2004. A significant annual decline of –13.6% occurred at the Grand Canyon (Lipan Point and Yaki Point) from 1997 to 2005, a marginally significant decline of –2.2% occurred at Mount Lorette, Alberta, from 1995 to 2005, and a nonsignificant annual decline of –3.8% occurred at Bonney Butte from 1995 to 2005. Nonsignificant annual increases of 4.5% and 1.2% were recorded at Chelan Ridge, Washington, from 1998 to 2005 and at Boise Ridge, Idaho, from 1995 to 2005 (Fig. 17).

Other analyses.—CBCs indicated a nonsignificant annual decline of –0.4% from 1983 to 2005, and a significant decline of –3.4% from 1995 to 2005. The species is not monitored by BBSs in North America, making migration counts particularly important (e.g., Kochert and Steenhof 2002).

In sum, trends in migration counts and CBCs indicate that Golden Eagle populations are decreasing in our areas of coverage in western North America. The longest-active migration watchsites tracked regional drought patterns fairly well, with declining counts in both the mid-1980s and late 1990s through early 2000s coinciding with droughts in the interior West (see Chapter 6). Other factors possibly contributing to the observed patterns are responses to cyclical prey fluctuations or loss of shrub habitat to fire (Kochert et al. 1999).

Historical Conservation Concerns

Direct persecution, including shooting, trapping, and nest destruction, was the greatest threat historically. Unlike the Bald Eagle, which underwent population declines in the mid-20th century because of exposure to DDT and other organochlorine pesticides, Golden Eagles in the western United States and Canada were not severely affected. This may be due to the species' diet in the region, which consists largely of upland mammals and includes few birds or fish. In contrast, eastern Golden Eagles, which feed heavily on waterfowl and wading birds in both summer and winter, were negatively affected by the widespread use of organochlorine pesticides, resulting in declining trends during the DDT Era (Bednarz et al. 1990).

Current Status and Concerns

Although protected in the United States under the Bald and Golden Eagle Protection Act, the species still suffers from direct persecution, as well as from power-line electrocutions, collisions with human structures including wind turbines, and poisoning at contaminated carcasses. Land-use changes, including urbanization, agricultural development, mining and energy development, and reforestation, along with increased fires in the American West, may reduce the availability of suitable nesting and foraging habitat. Human activities account for ~70% of all direct mortality of Golden Eagles continent-wide, with accidental trauma (27%), electrocution (25%), gunshot (15%), and poisoning (6%) causing most of these deaths (Franson et al. 1995).

The Golden Eagle is a species of least concern globally, is not of concern in the United States or Canada, and is threatened in Mexico (Appendix). It is considered a species of regional concern in the west-central United States, including Colorado, Kansas, Montana, Nebraska, North Dakota, South Dakota, Utah, and Wyoming (Appendix). Kirk and Hyslop (1998) rated it as stable or possibly declining in Canada but determined that populations there were not at risk. Kochert and Steenhof (2002) considered the species to be stable in Canada.

Summary

Migration count data indicate that Golden Eagles have increased over the last 30 years in parts of northeastern North America (e.g., northern Québec). These increases have continued into the most recent decade. Data for western North America suggest long-term increases for this species, tempered by more recent declines presumably associated with regional drought, changes in prey abundance, changes in land cover, or a combination of these factors. Monitoring can be enhanced by the use of annual aerial surveys (Good et al. 2004).

American Kestrel

Scientific name:	*Falco sparverius*
French name:	*Crécerelle d'Amérique*
Spanish name:	*Cernícalo Americano*
Body length:	Female: 23–31 cm Male: 22–27 cm
Wingspan:	Female: 57–61 cm Male: 51–56 cm
Mass:	Female: 86–165 g Male: 80–143 g
Type of migrant:	Partial
Nest type:	Cavity (secondary) in a tree, cliff, nestbox, or abandoned building.
Food habits:	Insects, small rodents, and, less frequently, small birds.
Migration flight:	Flapping interspersed with gliding; some soaring on migration; quick, erratic wingbeats; buoyant flight.
Estimated world population:	>1,000,000

Ecology and Migration

North America's smallest falcon is commonly seen hunting over or perched near open fields in rural and suburban areas. Kestrels are common in farmlands and low-density suburban areas, as well as in open and semi-open natural habitats ranging from deserts to woodlands. They sometimes nest in urban areas. The species is an obligate secondary cavity-nester that does not excavate its own nest cavity.

Timing of migration coincides with that of potential prey, including green darners (*Anax junius*) (Nicoletti 1996). American Kestrels breeding in northern portions of their range are more migratory than those breeding farther south, and birds in northern areas migrate farther than those in southern areas. Many southern populations are sedentary, and this combination of factors produces a *leap-frog migration* pattern. Most kestrels breeding in North America over-winter in the United States and Mexico. A small proportion, however, migrate as far south as northern South America. Males winter farther north than females, and in more wooded habitats, possibly because females generally arrive on the winter range before males (Smallwood 1987), or because females competitively exclude males from optimal habitats (Ardia and Bildstein 1997).

Larger numbers are recorded at coastal migration counts in eastern North America, either because they themselves are pushed there by prevailing winds or because wind-drifted prey is more abundant there. As a result, annual population indexes at Cape May in coastal New Jersey are 10–20 times higher than those at Hawk Mountain in the central Appalachian

Mountains of Pennsylvania. In western North America, migrating kestrels are at least as common inland as along the coast.

Population Status

Partners in Flight estimates that approximately three-fourths of the global population of >1,000,000 breeds in the United States and Canada (Appendix). Migration counts, BBSs, and CBCs indicate that populations of the American Kestrel have (1) declined in much of northeastern North America since 1974; (2) increased or remained stable around the western Great Lakes; (3) declined in western North America since the early 1980s, with an acceleration of declines coinciding with the onset of a regional drought in the late 1990s; and (3) declined around the eastern part of the Gulf of Mexico, but increased or remained stable elsewhere in the region.

Eastern North America

Previous watchsite analyses.—Bednarz et al. (1990) reported a nonsignificant increase at Hawk Mountain, Pennsylvania, from 1934 to 1942. A significant increase in counts of kestrels occurred from 1942 to 1972, and a significant decline was reported for the period 1973 to 1986, but no estimates were made of the rates of change. In a study of six migration counts in eastern North America, Titus and Fuller (1990) reported a nonsignificant annual increase of 0.4% from 1972 to 1987. Hussell and Brown (1992) reported that counts at Hawk Ridge, Minnesota, were stable from 1974 to 1989, whereas those at Grimsby, Ontario (a spring watchsite), increased nonsignificantly at 1.0% annually from 1975 to 1990. At Cedar Grove, Wisconsin, Mueller et al. (2001) reported a significant increase from 1936 to 1999, but no significant trend from 1951 to 1999. Generally, previous estimates of population trend for kestrels indicated that populations passing western Great Lakes watchsites increased prior to 1990, whereas those east of the Great Lakes declined since the mid-1970s.

RPI analysis.—Migration counts indicate that populations of the American Kestrel have declined substantially in northeastern North America since the mid-1970s (Chapter 5). From 1994 to 2004, significant annual declines of –9.2%, –4.5%, –3.3%, –4.8%, and –4.1% occurred at Lighthouse Point, Connecticut, Cape May, New Jersey, Montclair, New Jersey, Hawk Mountain, and Holiday Beach, Ontario, respectively. At the same time, Tadoussac, Québec, and Hawk Ridge recorded nonsignificant annual declines of –1.8% and –0.7%, respectively, and Waggoner's Gap, Pennsylvania, recorded a nonsignificant increase of 0.9% (Fig.18).

Population indexes for American Kestrels at these watchsites (Chapter 5) suggest that declines for this species have accelerated since 2000 at Lighthouse Point, Hawk Mountain, and Waggoner's Gap, and remained

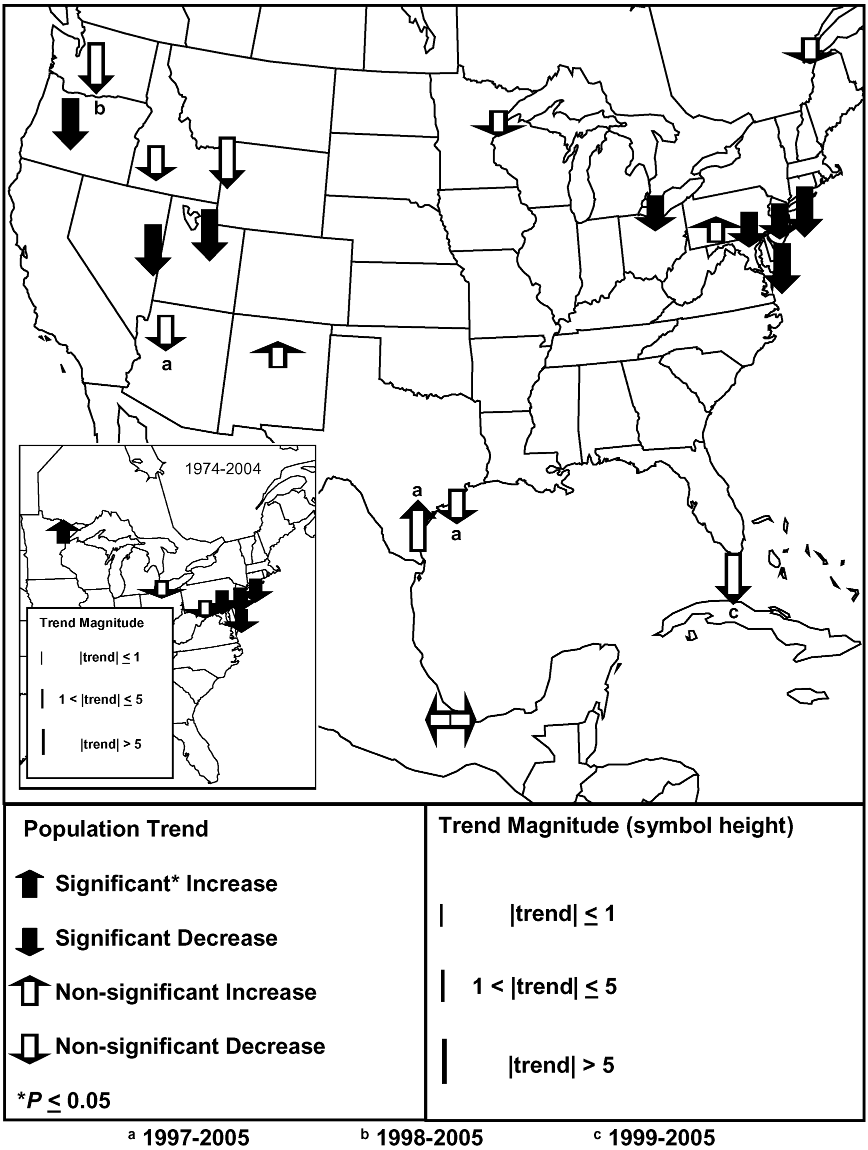

Fig. 18. Population trends for American Kestrels (*Falco sparverius*) at eight northeastern (1994–2004), eight western (1995–2005), and four Gulf of Mexico (1995–2005) raptor migration counts in North America, and long-term trends (1974–2004) for seven northeastern counts (inset). Trends are expressed in percent change per year. A bi-directional arrow indicates that the estimated trend is 0.0% per year.

relatively constant for the past 30 years at Cape May and Montclair. Continued population change at 1994–2004 rates would lead to a 50% decline of American Kestrel source populations in ~8 years at Lighthouse Point, 15 years at Cape May, 21 years at Montclair, 14 years at Hawk Mountain, and 17 years at Holiday Beach.

Other analyses.—BBSs indicated a significant annual decline of –1.4% from 1976 to 2003 in northeastern North America and a nonsignificant decline of –1.7% from 1994 to 2004 in the northeastern United States. CBCs for northeastern North America showed a significant annual decline of –4.6% from 1976 to 2003. CBCs in southeastern North America declined a significant –1.4% annually from 1974 to 2004.

In sum, migration counts, BBSs, and CBCs indicate that kestrel populations are declining in eastern North America, but that the rate of decline decreases west of the Appalachian Mountains. Results from Hawk Ridge and Holiday Beach suggest that breeding populations of the American Kestrel north of the Great Lakes were increasing or stable until recently, when they, too, began to decline.

Western North America

Previous watchsite analyses.—Hoffman and Smith (2003) reported a significant increase at the Goshutes, Nevada, from 1983 to 2001 and a significant decline at the Wellsvilles, Utah, from 1987 to 2001. No significant trends were recorded at the Grand Canyon, Arizona (Lipan Point), from 1991 to 2001; Bridger Mountains, Montana, from 1992 to 2001; the Manzanos, New Mexico, from 1985 to 2001; or the Sandias, New Mexico (a spring watchsite), from 1985 to 2001.

RPI analysis.—Migration counts indicate that populations of American Kestrels have declined in western North America since the early 1980s, particularly during the last decade (Chapter 6). From 1995 to 2005, significant annual declines of –7.9%, –5.9%, –4.1%, and –8.6% were recorded at Bonney Butte, Oregon, the Goshutes, the Grand Canyon (Lipan Point), and the Wellsvilles (1995 to 2004), respectively. Nonsignificant declines of –11.7%, –9.0%, –1.9%, and –4.0%, respectively, were recorded at Chelan Ridge, Washington, from 1998 to 2005; the Bridger Mountains from 1995 to 2005; Boise Ridge, Idaho, from 1995 to 2005; and the Grand Canyon (Lipan Point and Yaki Point), from 1997 to 2005. The notable exception in the interior West was the Manzanos, where a nonsignificant trend (0.1%) was recorded and no distinct pattern was evident from 1995 to 2005 (Fig. 18).

Other analyses.—BBSs detected significant annual declines of –1.7% from 1983 to 2005 and –2.7% from 1995 to 2005. CBCs indicate significant declines of –1.5% annually from 1983 to 2005 and –2.3% annually from 1995 to 2005.

In sum, kestrel counts declined during the past decade at all watchsites except the Manzano Mountains, suggesting that populations in the central and southern Rocky Mountains may be more secure than those in other regions of western North America. Whether the widespread declines are due to recent regional drought or to a combination of other factors is unknown, but further investigation is warranted. Average rates of change currently range from roughly –4 to –12% per year where declines are occurring. A 5% annual rate of decline would result in a 50% reduction of the population in ~14 years, and a 10% rate of decline would reduce the population 50% in ~7 years, and would drop the population to <15% of its original size in ~20 years.

Gulf of Mexico

Previous watchsite analyses.—None.

RPI analysis.—Watchsites in this region recorded mixed trends for the American Kestrel, most notably a high-magnitude, marginally significant decline at the Florida Keys (Chapter 7, Fig. 18). The trend in the Florida Keys coincides with significant declines reported for this species in northeastern North America, and the lack of significance may be due to the shorter time series analyzed (Chapter 7).

Other analyses.—BBSs recorded a nonsignificant annual decline of –0.2% in the southeastern United States from 1995 to 2005. See Eastern North America section for other BBS and CBC trends.

Historical Conservation Concerns

Historically, shooting, trapping, window strikes, and road kills were significant threats. The species also was affected by DDT, although the extent to which this occurred is unknown. Deforestation in the 19th and early 20th centuries probably benefited kestrels.

Current Status and Concerns

The American Kestrel is a species of least concern globally and is not listed as a species of concern in the United States (Appendix). Several Bird Conservation Regions in the southeastern United States list it as a species of concern (Appendix). Kirk and Hyslop (1998) ranked the American Kestrel as stable or increasing in Canada, with possible declines in the East.

Declines in migration counts may be attributable to several factors. Kestrels continued to be exposed to high levels of DDT well into the late 1970s, even after the pesticide was banned in the United States in 1972. Laboratory experiments show that DDT interferes with successful reproduction in the American Kestrel (Porter and Wiemeyer 1969, Lincer

1975). Populations of the Cooper's Hawk increased throughout northeastern North America from 1974 to 2004, and studies at Hawk Mountain Sanctuary and elsewhere indicate that the species preys upon American Kestrels (Farmer et al. 2006). Much of the region has been re-forested or developed, or is in more intensive agriculture, and grassland habitats have decreased. Since the late-1990s, *West Nile virus* has also affected numerous bird populations throughout the East. Although the impact of the virus on kestrel populations is unknown, researchers working with Hawk Mountain Sanctuary in 2004 found that 95% of the adults in a declining population using nest boxes in southeastern Pennsylvania in the vicinity of the sanctuary had been exposed to the virus.

Summary

Substantial declines in populations of American Kestrels are apparent across much of North America, and there is strong cause for conservation concern. A gradient from east to west is apparent in trend estimates for northeastern North America, with stronger declines occurring at coastal watchsites. This pattern may indicate that factors exerting negative influences on populations are strongest in source populations that migrate along the coast. Recent declines in western North America appear to coincide with a regional drought. The widespread, significant declines of the American Kestrel in North America clearly warrant further investigation to further clarify the causes.

Merlin

Scientific name:	*Falco columbarius*
French name:	*Faucon émerillon*
Spanish name:	*Esmerejón*
Body length:	24–30 cm
Wingspan:	53–68 cm
Mass:	Female: 180–310 g Male: 145–200 g
Type of migrant:	Partial
Nest type:	Primarily old stick-nests of other birds; rarely in cavities, on cliffs, or on the ground.
Food habits:	Preys primarily on small to medium-sized passerines <50 g and insects, at least on migration.
Migration flight:	Powerful, moderately deep-flapping with a rapid cadence; rarely soars.
Estimated world population:	>1,000,000

Ecology and Migration

This small falcon is a fast, powerful flier that appears pigeon-like in flight. Three subspecies breed in North America: the Black Merlin (*F. c. suckleyi*) of the Pacific Northwest, the Taiga Merlin (*F. c. columbarius*) of the boreal forest, and the Prairie Merlin (*F. c. richardsonii*) of the northern plains. Females in all subspecies are 20–30% larger than males. Merlins most often are seen in rapid, direct, flapping flight, and are seldom seen soaring or gliding.

Preferred breeding habitat consists of open or semi-open areas near forest openings, woodlots, and small groves, often near bodies of water. Urban populations breed in conifers in residential areas, parks, and cemeteries. Winter habitat includes open forests and grasslands, and Merlins also frequently hunt on tidal flats and near grain elevators and other features that attract passerines.

The Black Merlin is largely sedentary, with seasonal, relatively short-distance migrations limited to individuals breeding in the northern and inland portions of the subspecies' range; some move into California in winter. The Taiga Merlin is largely migratory, and some individuals make short-distance movements and winter throughout much of the western United States, along the eastern seaboard south of Massachusetts, and in the Gulf states. Others make long-distance migratory movements, ending up throughout Mexico, the Caribbean, Central America, and as far south as northern Peru in South America. The Prairie Merlin winters throughout much of the western United States and northern Mexico, although some individuals remain in and around urban centers throughout the breeding range. Recently, more Merlins (probably of the Taiga subspecies) have been wintering in the eastern mid-Atlantic states, which suggests migratory short-stopping, particularly on the part of urban breeders. Like Peregrine Falcons, Merlins often cross large bodies of water and may be seen along coastlines, not so much to avoid water, but rather because they are prime hunting areas during migration. In both eastern and western North America, coastal watchsites report many more Merlins than inland watchsites.

Population Status

Partners in Flight estimates that approximately one-half of the global population of >1,000,000 breeds in the United States and Canada (Appendix). Migration counts, BBSs, and CBCs indicate that Merlins have (1) increased throughout eastern North America since 1974; (2) increased in western North America since the early 1980s; and (3) declined in counts in the Florida Keys, but increased or remained stable elsewhere in the Gulf of Mexico.

Eastern North America

Previous watchsite analyses.—Bednarz et al. (1990) reported nonsignificant declines at Hawk Mountain, Pennsylvania, from 1934 to 1942, 1946 to 1972, and 1973 to 1986. In a study of counts at six raptor migration watchsites in eastern North America, Titus and Fuller (1990) reported a significant annual increase of 14.2% from 1972 to 1987. Similarly, Hussell and Brown (1992) reported that counts at Hawk Ridge, Minnesota, increased a significant 14.3% annually from 1974 to 1989, whereas counts at Grimsby, Ontario (a spring watchsite), increased 9.4% annually from 1975 to 1990. At Cedar Grove, Wisconsin, Mueller et al. (2001) reported significant increases in counts of Merlins from 1936 to 1999 and from 1951 to 1999, but noted a nonsignificant decline from 1991 to 2001.

Overall, previous estimates of population trends indicate that populations passing northern watchsites in eastern North America have increased steadily from the early 1970s to late 1980s.

RPI analysis.—Migration counts indicate that populations of Merlins have increased in northeastern North America since 1974 (Chapter 5). More recent trends indicate that population growth of this species is slowing in northeastern North America (Fig. 19). From 1994 to 2004, a significant annual increase of 10.2% occurred at Waggoner's Gap, Pennsylvania, whereas nonsignificant increases of 3.0% and 4.6% were recorded at Lighthouse Point, Connecticut, and Montclair Hawkwatch, New Jersey, respectively, along with nonsignificant declines of –0.8%, –2.1%, –0.4%, –1.2%, and –1.9% at Tadoussac, Québec, Cape May,

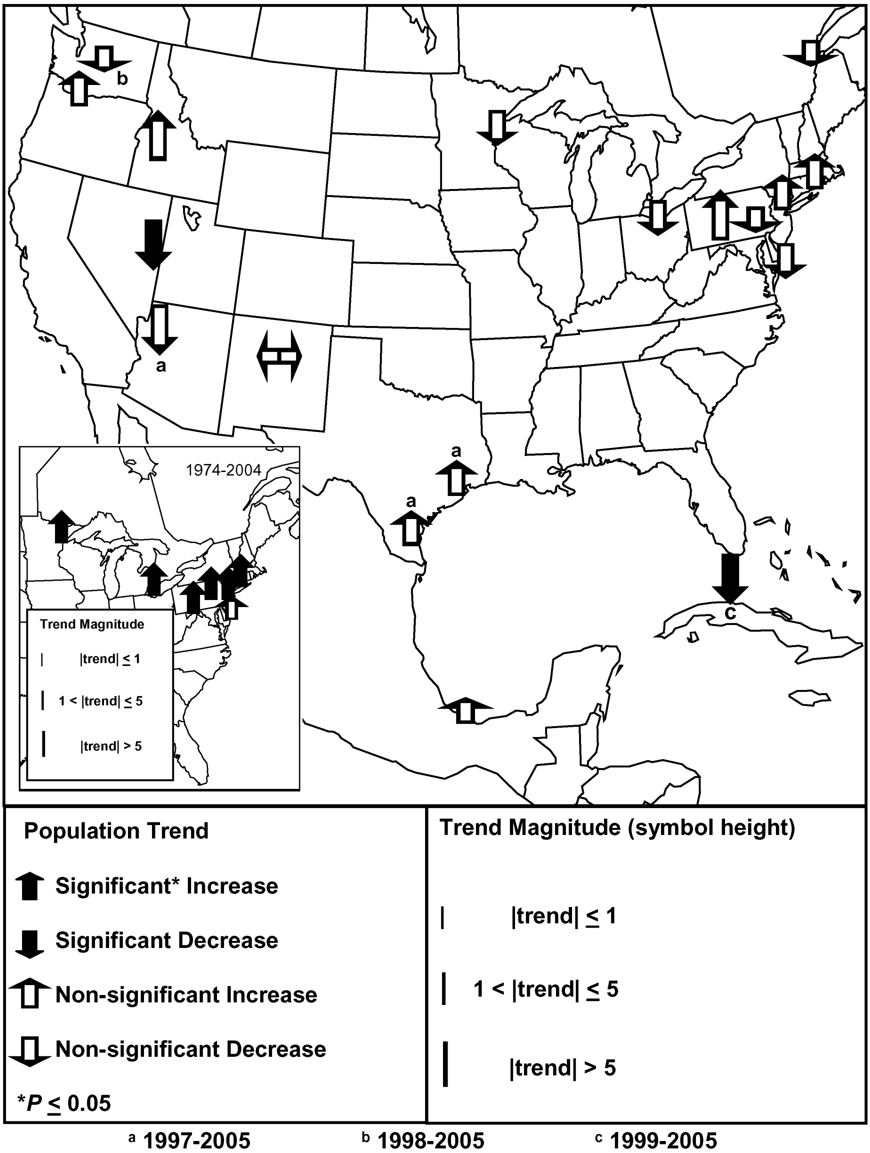

Fig. 19. Population trends for Merlins (*Falco columbarius*) at eight northeastern (1994–2004), six western (1995–2005), and four Gulf of Mexico (1995–2005) raptor migration counts in North America, and long-term trends (1974–2004) for seven northeastern counts (inset). Trends are expressed in percent change per year. Lateral, bi-directional arrows indicate that the estimated trend is 0.0% per year.

New Jersey, Hawk Mountain, Holiday Beach, Ontario, and Hawk Ridge, respectively. Continued population change at the 1994–2004 rates would lead to a 50% increase in Merlin source populations in ~7 years at Waggoner's Gap.

Other analyses.—BBSs indicated a significant annual increase of 13.6% in Merlin populations in northeastern North America from 1976 to 2003, but the precision of this estimate was low, and it should be considered in that light. CBCs in northeastern and southeastern North America indicated significant annual increases of 3.0% and 2.0%, respectively, from 1974 to 2004.

In sum, the data suggest long-term increases by this species in northeastern North America changing to recent stable or declining trends.

Western North America

Previous watchsite analyses.—Hoffman and Smith (2003) reported significant increases at the Goshutes, Nevada, from 1983 to 2001; the Wellsvilles, Utah, from 1987 to 2001; the Manzanos, New Mexico, from 1983 to 2001; and the Sandias, New Mexico (a spring watchsite), from 1985 to 2001. No significant trends were recorded at the Grand Canyon, Arizona (Lipan Point), from 1991 to 2001, or at the Bridger Mountains, Montana, from 1992 to 2001.

RPI analysis.—Migration counts indicated that Merlin populations have increased in the western United States since the mid-1980s (Chapter 6). A significant annual decline of –11.6% occurred in the Goshutes from 1998 to 2005. A marginally significant annual increase of 6.3% occurred at Boise Ridge, Idaho, from 1995 to 2005, and a nonsignificant increase of 2.1% occurred at Bonney Butte, Oregon, from 1995 to 2005. Nonsignificant declines of –0.4% and –6.8%, respectively, occurred at Chelan Ridge, Washington, from 1998 to 2005, and the Grand Canyon (Lipan Point and Yaki Point, combined) from 1997 to 2005 (Fig. 19). At other sites, counts were too low to calculate trends (Chapter 6).

Other analyses.—BBSs indicated a nonsignificant annual increase of 2.5% from 1983 to 2005, and a nonsignificant decline of –2.3% from 1995 to 2005. CBCs indicated a significant annual increase of 2.9% from 1983 to 2005, and a nonsignificant annual increase of 2.0% from 1995 to 2005.

In sum, the significant downturn in counts at the Goshutes, but not at Boise Ridge, coupled with the fact that Merlins do not breed in the Great Basin, suggests that the recent regional drought shifted migration routes away from the Great Basin (Chapter 6). More generally, migration counts and other population indexes suggest that western populations increased substantially between the early 1980s and mid-1990s and have since stabilized or continued to increase.

Gulf of Mexico

Previous watchsite analyses.—None.

RPI analysis.—Migration counts detected a significant annual decline of –13.4% at the Florida Keys, Florida, from 1999 to 2005 (Fig. 19). The remaining watchsites in the region recorded nonsignificant increases (Chapter 7). Confidence intervals for trend estimates at all four watchsites were fairly wide, indicating limited precision of the trend estimates.

Other analyses.—BBSs and CBCs indicated long-term and recent increases in most regions from which Gulf Coast watchsites receive migrants (see above).

Historical Conservation Concerns

Merlins were shot along with other hawks at well-known migration spots in the early 20th century. Merlin eggshells thinned during the DDT Era of 1945–1972, and reproductive success declined (Fox 1971). Although the widespread use of DDT was banned in Canada and the United States in 1971 and 1972, respectively, as recently as 1988, eggshells of Merlins breeding in Canada were found to contain sufficient concentrations of DDE to reduce reproductive success (Noble and Elliot 1988).

Current Status and Concerns

Studies indicate that shooting still contributed to mortality in parts of Canada as late as the mid-1980s (James et al. 1989). Counts of migrating Merlins at traditional watchsites began to increase in the late 1970s and have continued to increase in most areas since. Monitoring of migrants at watchsites is particularly important for this species because of the low precision of BBSs on the breeding grounds.

The Merlin is a species of least concern globally and is not of concern in the United States or Canada (Appendix). Kirk and Hyslop (1998) rated the Merlin "not at risk" in Canada, because populations were increasing and the species was beginning to nest and feed in urban areas.

Summary

Data collected from raptor migration counts indicate that Merlin populations increased dramatically in eastern and western North America in the last 20–30 years; however, increases have slowed at most sites in the last decade. BBS and CBC trends generally agree with this pattern, although the species is not well monitored by BBSs. The significant decline in raptor migration counts in the Florida Keys since 1999 most likely indicates a decrease in the distance migrated by individuals from the Northeast. Even so, additional study is needed to determine whether this decline represents migratory short-stopping or a decline in the source population.

Peregrine Falcon

Scientific name:	*Falco peregrinus*
French name:	*Faucon pélerin*
Spanish name:	*Halcón peregrino*
Body length:	Female: 45–58 cm Male: 36–49 cm
Wingspan:	Female: 102–117 cm Male: 94–100 cm
Mass:	Female: 800–1,600 g Male: 450–1,060 g
Type of migrant:	Partial
Nest type:	Small "scrape" or depression on a cliff ledge, crease, or cavity; also within large tree cavities, on the ground, and on ledges of urban buildings; sometimes in old stick-nests of other birds.
Food habits:	Preys primarily on birds of between 50 and 500 g, including pigeons and doves, passerines, waterfowl and shorebirds, and gallinaceous birds, as well as smaller raptors. Also takes mammals (primarily bats), amphibians, fish, and insects.
Migration flight:	Powerful, deep flapping flight; less frequent gliding and soaring.
Estimated world population:	10,000–100,000

Ecology and Migration

Three subspecies occur in North America: one subspecies (*F. p. anatum*) of North America south of the tundra, one subspecies (*F. p. tundrius*) of the Arctic tundra of North America and Greenland, and one subspecies (*F. p. pealei*) of the coastal Pacific Northwest. Females are 15–20% larger and 40–60% heavier than males in all subspecies.

The species is sparsely distributed in all but a few locations and, as such, is vulnerable to local extirpation (see Rabinowitz et al. 1986).

Migration begins across a broad front, but clearly defined routes become evident as the species concentrates along *leading* and *diversion lines*. Peregrine Falcons often cross large bodies of water and are seen along coastlines, not so much to avoid water, but rather because coastlines are prime hunting areas. The species regularly crosses the Gulf of Mexico and Caribbean Sea. In eastern North America, coastal watchsites report more migrants than inland watchsites, with the largest known migratory concentration of the species in North America occurring each autumn in the Florida Keys (Lott 2006).

Peregrines exhibit a *leap-frog migration* pattern in which breeders from northern areas over-winter south of the more southerly breeders.

Some individuals migrate distances of 13,000 km or more each way. Northern breeders in Greenland and Canada, over-winter as far south as central Argentina and Chile.

Population Status

Partners in Flight estimates that approximately one-fourth of the global population of 10,000 to 100,000 breeds in the United States and Canada (Appendix). Population estimates summarized in White et al. (2002) placed the continental population at 52,000–62,000 individuals at the end of the 20th century, which seems realistic given that the pre-DDT-Era population of North America has been estimated at 10,600–12,000 breeding pairs (Cade 2003). Migration counts and CBCs indicate that populations have (1) increased in eastern North America since 1974, and apparently began to stabilize around 1995; (2) increased in western North America since the early 1980s; and (3) increased in areas of North America monitored by migration counts in the Gulf of Mexico.

Eastern North America

Previous watchsite analyses.—Bednarz et al. (1990) reported a nonsignificant increase at Hawk Mountain, Pennsylvania, from 1934 to 1942. They reported a nonsignificant increasing trend from 1973 to 1986 and a significant decline from 1942 to 1972 (Bednarz et al. 1990). In a study of counts at six migration counts in eastern North America, Titus and Fuller (1990) reported a significant annual increase of 15.3% from 1972 to 1987. Hussell and Brown (1992) reported a significant annual increase of 6.1% at Hawk Ridge, Minnesota, from 1974 to 1989 and a significant annual increase of 27.8% at Grimsby, Ontario (a spring watchsite), from 1975 to 1990. At Cedar Grove, Wisconsin, Mueller et al. (2001) reported significant increases from 1936 to 1999 and from 1951 to 1999.

Overall, previous estimates of population trends for falcons indicate that populations passing northern watchsites increased steadily between the early 1970s and late 1990s.

RPI analysis.—Migration counts indicate that populations of Peregrine Falcons have increased in northeastern North America since 1974, coincidental with the start of reintroduction efforts (Chapter 5). From 1994 to 2004, significant annual increases of 7.2% and 7.8% occurred at Tadoussac, Québec, and Hawk Ridge, respectively. Nonsignificant annual increases of 3.2%, 7.1%, 1.6%, and 1.0% occurred at Lighthouse Point, Connecticut, Montclair, New Jersey, Hawk Mountain, and Waggoner's Gap, Pennsylvania, respectively, and nonsignificant declines of –1.3% and –2.7% recorded at Cape May, New Jersey, and Holiday Beach, Ontario (Fig. 20), indicate that the rates of increase are slowing or reversing. Continued

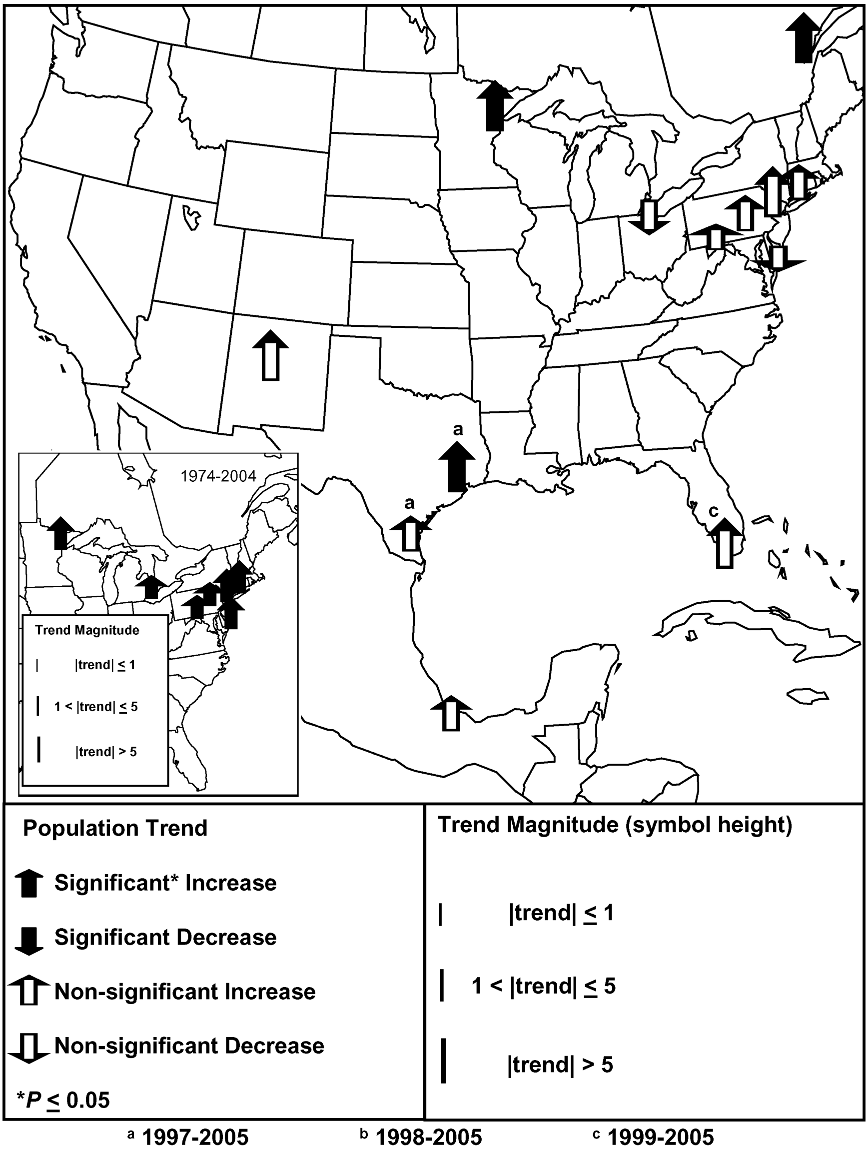

Fig. 20. Population trends for Peregrine Falcons (*Falco peregrinus*) at eight northeastern (1994–2004), one western (1995–2005), and four Gulf of Mexico (1995–2005) raptor migration counts in North America, and long-term trends (1974–2004) for seven northeastern counts (inset). Trends are expressed in percent change per year.

population change at 1994–2004 rates would lead to a 50% increase of Peregrine Falcon source populations in ~10 years at Tadoussac, and 22 years at Lighthouse Point.

Other analyses.—CBCs indicated significant annual increases in northeastern North America of 5.5% from 1976 to 2003 and 9.5% from 1994 to 2004. Significant annual increases of 16.4% and 9.6% occurred in CBCs for southeastern North America from 1976 to 2003 and from 1994 to 2004, respectively. BBSs do not include Peregrine Falcons, and no population trends are available from this source.

Western North America

Previous watchsite analyses.—Hoffman and Smith (2003) reported significant increases at the Goshutes, Nevada, from 1983 to 2001; the Wellsvilles, Utah, between the late 1970s and late 1980s and from 1987 to 2001; the Manzanos, New Mexico, from 1985 to 2001; and in the Sandias, New Mexico (a spring watchsite), from 1985 to 2001. In contrast, no significant trends were reported at the Grand Canyon, Arizona (Lipan Point), from 1991 to 2001 or at the Bridger Mountains, Montana, from 1992 to 2001.

RPI analysis.—Migration counts and CBCs suggest that populations have increased in parts of the western United States since the mid-1980s (Chapter 6). We were able to analyze migration counts only from the Manzanos because counts at all other western sites were too low (<20 per year). A nonsignificant annual increase of 5.0% occurred at the Manzanos from 1995 to 2005 (Fig. 20).

Other analyses.—CBCs for western North America indicated significant annual increases of 4.2% from both 1983 to 2005 and 1995 to 2005.

Gulf of Mexico

Previous watchsite analyses.—None.

RPI analysis.—Watchsites in the Gulf region recorded increases in counts of this species over the last decade (Chapter 7, Fig. 20).

Historical Conservation Concerns

Historically, Peregrine Falcons were subject to direct persecution, including shooting, trapping, egg collecting, and capture for use in falconry. During the DDT Era of 1945–1972, their numbers declined significantly, and the species was *extirpated* in the eastern United States by 1965, by which time reproductive failure was well documented throughout the continent (Hickey 1969). Research identified eggshell thinning as the cause of reproductive failure, and DDT residues (primarily the contaminant, DDE) as the cause of eggshell thinning.

The species was listed as endangered in the United States in 1970. Regional recovery plans for the species were established under the Endangered Species Act, all of which sought to reduce the environmental contamination caused by pesticides, and most of which also called for extensive captive propagation and release programs. The release and reintroduction of Peregrine Falcons propagated in captivity began in 1974 (see Cade et al. 1988). By 1998, almost 7,000 individuals had been released, and breeding pairs had reclaimed more than 700 territories vacated during the DDT Era. The combined effects of strict legal protection, restoration efforts, and the ban on the widespread use of DDT enabled Peregrine Falcon numbers to begin increasing in the late 1970s. Populations continued to increase in the 1980s and 1990s, and by the late 1990s most populations had almost fully recovered.

Current Status and Concerns

Migration counts at Cape May have declined a nonsignificant –9.0% annually since 1998, suggesting that the source population is stabilized or declining. Monitoring migrants at watchsites is particularly important for this species, because it is not monitored by BBSs on the breeding grounds and recent delisting may limit special breeding surveys.

The Peregrine Falcon is a species of least concern globally, but it is a species of concern in the United States and a species of special concern in Canada, and it receives special protection in Mexico (Appendix). Most of the U.S. Fish and Wildlife Service regions and Bird Conservation Regions still consider it a species of concern (Appendix). Kirk and Hyslop (1998) ranked the species as stable or increasing in Canada but noted that those in coastal British Columbia had not returned to historical levels as of 1998.

Summary

In the last 30 years, Peregrine Falcons largely have recovered from earlier population crashes. Dramatic increases in migration counts have occurred throughout northeastern North America, accompanied by more moderate increases in western North America. Migration counts along the Gulf of Mexico reinforce the conclusion that North American populations of the species are increasing. Recent trends in northeastern North America further suggest that populations are stabilizing after a long period of growth. Peregrine Falcons are not well monitored by BBSs and CBCs, and migration counts remain an important tool for monitoring populations of this raptor.

Prairie Falcon

Scientific name:	*Falco mexicanus*
French name:	*Faucon des prairies*
Spanish name:	*Halcón de las praderas, Halcón mexicano, Halcón pradeño, Halcon café, Halcón palido*
Body length:	Female: 42–47 cm Male: 37–40 cm
Wingspan:	Female: 105–113 cm Male: 91–97 cm
Mass:	Female: 675–975 g Male: 420–635 g
Type of migrant:	Partial
Nest type:	Small "scrape" or depression on a cliff ledge or in a rocky pothole, usually with overhead cover. Sometimes in stick-nests of other species in trees, on power poles and buildings, and in caves.
Food habits:	Preys primarily on ground squirrels, other small to medium-sized mammals, and birds; also on insects and reptiles.
Migration flight:	Powerful but shallow flapping, with infrequent gliding and soaring.
Estimated world population:	10,000–100,000

Ecology and Migration

The species is closely associated with arid, drought-prone areas of western North America. Individuals from the northern portion of the breeding range in Canada winter to the south. Breeding populations generally move seasonally in response to changes in food availability, migrating, for example, from dry breeding areas where ground squirrels aestivate in late summer to moister areas where squirrels remain available. Farther south, few individuals move directly southward to wintering areas in the autumn; instead, most migrate eastward or even northward in autumn before turning south later. Overall, the loop migrations of this species involve three distinct seasonal-use areas: breeding, late summer, and winter (Enderson 1964, Steenhof et al. 1984, Steenhof et al. 2005, Chapter 2).

Population Status

Partners in Flight estimates that >90% of the global population of 10,000 to 100,000 birds breeds in the United States and Canada (Appendix). Migration counts, BBSs, and CBCs suggest that Prairie Falcon populations have declined since 1995 in western North America; however, the complex migration pattern of the species and low rates of detection in

BBSs make data from all three surveys difficult to interpret. Conversely, CBCs on the Great Plains suggest that the species has increased in this portion of the West since the early 1980s.

Eastern North America

Prairie Falcons do not breed in eastern North America and are rarely observed at migration watchsites. As a result, no population trends are available for this region.

Western North America

Previous watchsite analyses.—Hoffman and Smith (2003) reported significant annual increases at the Goshutes, Nevada, from 1983 to 2001, and the Manzanos, New Mexico, from 1985 to 2001. Migration counts at the Grand Canyon, Arizona (Lipan Point), the Bridger Mountains, Montana, the Wellsvilles, Utah, and the Sandias, New Mexico (a spring watchsite), were relatively low throughout the period, suggesting that populations were stable in much of the region. In a 1994 review, White (1994) concluded that populations of the Prairie Falcon were stable through the 1980s, with possibly local declines in some areas. Nesting density in the Snake River Birds of Prey National Conservation Area, Idaho, declined from 1976 to 1997, coincidental with land-use changes that affected the distribution and abundance of ground squirrels (Steenhof et al. 1999).

RPI analysis.—We were able to analyze migration counts only from the Goshutes and Manzanos because of low counts (<20 per year) elsewhere (Chapter 6). From 1995 to 2005, the Goshutes recorded a significant annual decline of –12.3%, and a nonsignificant annual decline of –4.1% occurred at the Manzanos (Fig. 21). A common pattern of change at both watchsites, consisting of significant increases from the late 1980s until 1997–1998, followed by significant declines, coincides with the start of a regional drought in 1998 (Chapter 6). Even so, counts at both sites were higher in 2005 than in the early 1980s.

Other analyses.—BBSs suggested a nonsignificant annual decline of –1.0% from 1983 to 2005, and a recent, nonsignificant decline of –1.9%. The value of BBS trends for this species is limited, because of the low number of individuals counted, and the trends should be considered in this light. CBCs indicate a significant annual decline of –1.4% from 1983 to 2005 and a nonsignificant decline of –0.3% from 1995 to 2005. East of this region, CBCs for the Great Plains (i.e., Colorado, Kansas, Minnesota, Missouri, Nebraska, North Dakota, Oklahoma, South Dakota, and Texas) indicated that significant annual increases of 1.2% and 3.8% occurred from 1983 to 2005 and from 1995 to 2005, respectively. CBC trends may be unreliable because they are based on low numbers of individuals and should be considered in this light.

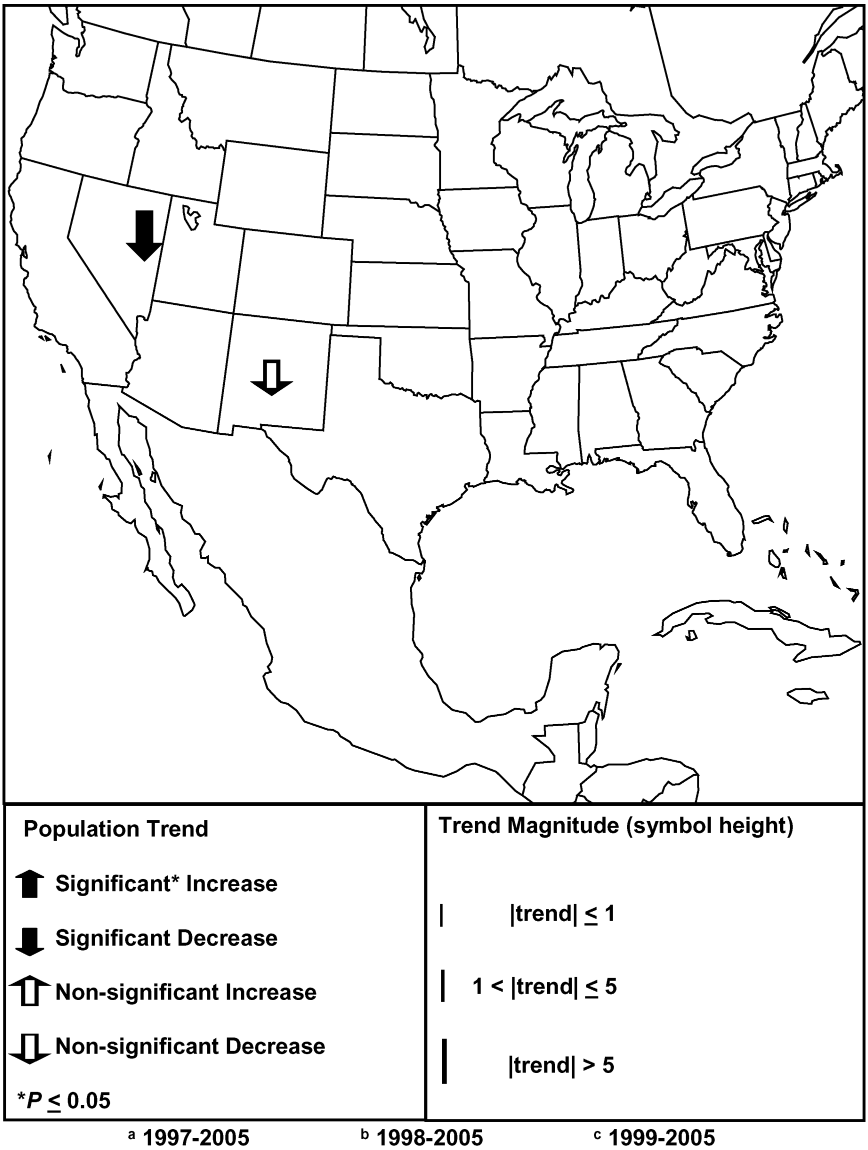

Fig. 21. Population trends (1995–2005) for Prairie Falcons (*Falco mexicanus*) at two western raptor migration counts in North America. Trends are expressed in percent change per year.

In sum, although recent declining patterns in both the Goshutes and Manzanos may be of concern, increasing counts of wintering birds on the Great Plains suggest that changes in distribution, possibly in response to a regional drought, may account for the decreased migration counts.

Gulf of Mexico

Prairie Falcons were not detected in sufficient numbers at raptor migration counts in this region to permit the calculation of trends.

Historical Conservation Concerns

Historically, the species was subject to several types of direct persecution, including shooting, trapping, and egg collecting. During the DDT Era of 1945–1972, numbers of Peregrine Falcons in North America declined significantly. Although the species appears to be physiologically more sensitive to the effects of DDT than Peregrine Falcons (Fyfe et al. 1988), its populations did not experience the same degree of declines as those of the latter, most likely because of the predominance of mammalian prey in the diet of Prairie Falcons.

Current Status and Concerns

Shooting continues to be a significant source of mortality for Prairie Falcons, especially juveniles. The species also is captured and used in falconry (Conway et al. 1995). Other threats include pesticides, mercury, and lead shot, all of which are ingested when eating contaminated prey. Another common source of mortality is collision with fences (Beauvais et al. 1992). The breeding distribution of the species is closely tied to the availability of cliffs, and the species, therefore, is susceptible to human activities that disturb nests or destroy or degrade this important nesting substrate. Large-scale agriculture that disturbs or destroys habitat for ground squirrels can reduce the prey base for Prairie Falcons (e.g., Garrett and Mitchell 1973, U.S. Department of the Interior 1979).

The Prairie Falcon is a species of least concern globally, is a species of concern in the United States, is not at risk in Canada, and is threatened in Mexico (Appendix). Kirk and Hyslop (1998) rated populations breeding in Canada as possibly stable, but noted that local declines had occurred in association with increased cultivation near nests.

Summary

Migration counts suggest that recent declines may have occurred in association with a regional drought in western North America. CBCs conducted in the Great Plains, however, contradict this finding, and suggest increases in wintering populations of the species. Taken together, these surveys may indicate that the migration geography or the breeding distribution of this species has changed in response to the drought or other conditions. Because neither raptor migration counts, BBSs, nor CBCs adequately monitor the Prairie Falcon, increased efforts to conduct regular nest surveys or winter road surveys will be needed to adequately monitor this species' status in the long term.

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Appendix

Tables 1 and 2 can be found on the following pages.

Table 1. Summary of conservation status designations of North American raptors at global and national levels.

Species	Scientific name	Estimated world population[a]	Proportion in U.S. & Canada[b]	Global status[c]	U.S. status[d]	Canada status[e]	Mexico status[f]
Species with RPI trend estimates							
Black Vulture	*Coragyps atratus*	$>10^6$	<10%	LC	NR	–	–
Turkey Vulture	*Cathartes aura*	$>10^6$	25%	LC	NR	NR	–
Osprey	*Pandion haliaetus*	10^4–10^5	50%	LC	NR	ND	–
Hook-billed Kite	*Chondrohierax uncinatus*	10^4–10^5	<10%	LC	T	–	–
Swallow-tailed Kite	*Elanoides forficatus*	10^5–10^6	<10%	LC	CC	–	SP
Mississippi Kite	*Ictinia mississippiensis*	10^4–10^5	>90%	LC	NR	–	–
Bald Eagle	*Haliaeetus leucocephalus*	10^5–10^6	>90%	LC	NR	NR	E
Northern Harrier	*Circus cyaneus*	10^5–10^6	25–50%	LC	CC	NR	–
Sharp-shinned Hawk	*Accipiter striatus*	10^5–10^6	≥50%	LC	NR	NR	SP
Cooper's Hawk	*Accipiter cooperii*	10^5–10^6	>90%	LC	NR	NR	SP
Northern Goshawk	*Accipiter gentilis*	10^5–10^6	50%	LC	NR	NR, T[g]	T
Red-shouldered Hawk	*Buteo lineatus*	10^4–10^5	>90%	LC	NR	NR	SP
Broad-winged Hawk	*Buteo platypterus*	$>10^6$	>90%	LC	NR	ND	SP
Swainson's Hawk	*Buteo swainsoni*	$>10^6$	>90%	LC	CC	NR	SP
Zone-tailed Hawk	*Buteo albonotatus*	10^3–10^4	<10%	LC	NR	–	SP
Red-tailed Hawk	*Buteo jamaicensis*	$>10^6$	90%	LC	NR	NR	–
Rough-legged Hawk	*Buteo lagopus*	10^5–10^6	50%	LC	NR	NR	–
Golden Eagle	*Aquila chrysaetos*	10^5–10^6	50%	LC	NR	NR	T
American Kestrel	*Falco sparverius*	$>10^6$	75%	LC	NR	ND	–
Merlin	*Falco columbarius*	$>10^6$	50%	LC	NR	NR	–
Peregrine Falcon	*Falco peregrinus*	10^4–10^5	25%	LC	CC	SC	SP
Prairie Falcon	*Falco mexicanus*	10^4–10^5	>90%	LC	CC	NR	T
Species without RPI trend estimates							
California Condor	*Gymnogyps californianus*	10^1–10^2	>90%	CE	E	–	–
White-tailed Kite	*Elanus leucurus*	10^5–10^6	25%	LC	NR	–	–

Table 1. Continued.

Species	Scientific name	Estimated world population[a]	Proportion in U.S. & Canada[b]	Global status[c]	U.S. status[d]	Canada status[e]	Mexico status[f]
Snail Kite	*Rostrhamus sociabilis*	10^5–10^6	<10%	LC	E	–	SP
Common Black Hawk	*Buteogallus anthracinus*	10^4–10^5	<10%	LC	NR	–	SP
Harris' Hawk	*Parabuteo unicinctus*	10^4–10^5	10%	LC	NR	–	SP
Gray Hawk	*Buteo nitidus*	10^5–10^6	<10%	LC	E	–	–
Short-tailed Hawk	*Buteo brachyurus*	10^4–10^5	<10%	LC	NR	–	
White-tailed Hawk	*Buteo albicaudatus*	10^4–10^5	<10%	LC	NR	–	SP
Ferruginous Hawk	*Buteo regalis*	10^3–10^4	>90%	NT	CC	SC	SP
Crested Caracara	*Caracara cheriway*	10^5–10^6	<10%	LC	NR	–	–
Aplomado Falcon	*Falco femoralis*	10^4–10^6	<10%	LC	E	–	SP
Gyrfalcon	*Falco rusticolus*	10^4–10^5	50%	LC	NR	NR	–

[a] World population according to Ferguson-Lees and Christie (2001).

[b] Percentage of population in United States and Canada according to Partners in Flight North American Landbird Conservation Plan: Appendix A.

[c] Global ranks according to International Union for Conservation of Nature and Natural Resources (IUCN) Red List (www.iucnredlist.org/): CE indicates "critically endangered," LC indicates "least concern," NT indicates "near threatened."

[d] United States status according to U.S. Fish and Wildlife Service (USFWS) Species of Conservation Concern 2002, http://migratorybirds.fws.gov/reports: CC indicates "species of concern," NR indicates that species does not appear in Species of Conservation Concern 2002. If federally listed in United States: E = endangered, T = threatened.

[e] Canada status according to Canadian Wildlife Service (www.speciesatrisk.gc.ca/): ND indicates no data available, NR indicates "not at risk," SC indicates "special concern," T indicates "threatened." A dash indicates that the species is not present in Canada,

[f] Mexico ranks equivalent to IUCN defined categories (Special Protection [SP] = "Subject to special protection, could become threatened in short or mid-term or status is uncertain") according to SEMARNAT 2002 (www.ine.gob.mx/). A dash indicates no special status or the species does not occur in Mexico.

[g] Threatened status applies only to *laingi* subspecies of British Columbia

Table 2. Summary of conservation status designations of North American raptors at regional levels. North American Partners in Flight (PIF) columns indicate continent-wide PIF scores and monitoring need ranks.

Species	Scientific name	Species of concern in USFWS region [a]	Species of concern in Bird Conservation Region [a]	Partners in Flight (PIF) score [b,c]	PIF monitoring need [b,d]
Species with RPI trend estimates					
Black Vulture	*Coragyps atratus*	–	–	5	–
Turkey Vulture	*Cathartes aura*	–	–	6	–
Osprey	*Pandion haliaetus*	–	–	8	2,3
Hook-billed Kite	*Chondrohierax uncinatus*	–	–	9	1
Swallow-tailed Kite	*Elanoides forficatus*	2,4,N	25,26,27,31,37	**16**	2
Mississippi Kite	*Ictinia mississippiensis*	–	19,26	13	2
Bald Eagle	*Haliaeetus leucocephalus*	–	–	10	3
Northern Harrier	*Circus cyaneus*	2,6,N	11,16,18, 9,21, 35–37	11	3
Sharp-shinned Hawk	*Accipiter striatus*	–	–	8	3
Cooper's Hawk	*Accipiter cooperii*	–	–	8	2
Northern Goshawk	*Accipiter gentilis*		5, 34	11	2,3
Red-shouldered Hawk	*Buteo lineatus*	–	–	8	–
Broad-winged Hawk	*Buteo platypterus*	–	–	9	–
Swainson's Hawk	*Buteo swainsoni*	1,3,6,N	9–11,16, 19,32,36	**14**	–
Zone-tailed Hawk	*Buteo albonotatus*	–	–	10	1
Red-tailed Hawk	*Buteo jamaicensis*	–	–	6	–
Rough-legged Hawk	*Buteo lagopus*	–	–	8	2,3
Golden Eagle	*Aquila chrysaetos*	6	9,10,16,17	11	3
American Kestrel	*Falco sparverius*		25,27,31	7	–
Merlin	*Falco columbarius*	–	–	7	2,3
Peregrine Falcon	*Falco peregrinus*	1 – 7,N	1–37,69	8	2,3
Prairie Falcon	*Falco mexicanus*	1,6,N	9,10, 16–18,32	12	2

Table 2. Continued.

Species	Scientific name	Species of concern in USFWS region [a]	Species of concern in Bird Conservation Region [a]	Partners in Flight (PIF) score [b,d]	PIF monitoring need [b, c]
Species without RPI trend estimates					
California Condor	*Gymnogyps californianus*	–	–	**20**	–
White-tailed Kite	*Elanus leucurus*	–	–	8	–
Snail Kite	*Rostrhamus sociabilis*	–	–	11	1
Common Black Hawk	*Buteogallus anthracinus*	2	34, 35	11	1
Harris' Hawk	*Parabuteo unicinctus*		36	12	–
Gray Hawk	*Buteo nitidus*	2	34	7	1
Short-tailed Hawk	*Buteo brachyurus*	4	27,31	10	1
White-tailed Hawk	*Buteo albicaudatus*	2	37	10	1
Ferruginous Hawk	*Buteo regalis*	2,6,N	9–11,16–18,34,35	13	–
Crested Caracara	*Caracara cheriway*	–	–	8	2
Aplomado Falcon	*Falco femoralis*	–	–	12	1
Gyrfalcon	*Falco rusticolus*	–	–	8	2,3

[a] Ranking from the U.S. Fish and Wildlife Service (USFWS) Species of Conservation Concern 2002, http://migratorybirds.fws.gov/reports, (N = national species of concern). USFWS Regions: 1 = Pacific, 2 = Southwest, 3 = Great Lakes–Big Rivers, 4 = Southeast, 5 = Northeast, 6 = Mountain–Prairie, 7 = Alaska. For BCR Regions, see map at www.partnersinflight.org. A dash indicates that the species did not meet criteria for inclusion on the list for any BCR or USFWS region.

[b] Data from Partners in Flight North American Landbird Conservation Plan: Appendix A.

[c] PIF score >14 = PIF Watchlist species; score with bold type indicates "watchlist" species.

[d] Monitoring need: 1 = little or no information on population status; 2 = trend information available from an existing survey, but trend precision is low; 3 = one-third or more of the Canadian–United States breeding range is not covered by a breeding-season survey (i.e., much of range north of BBS coverage); from Rich et al. (2004). A dash indicates that the BBS or a species-specific survey provides possibly acceptable data at the continental level.

10

The RPI Website

Jason Sodergren

ABSTRACT.—Hawkcount.org is an online database system that provides data submission, reporting, and storage services for hawk migration watchsites. Here, I outline current features of the online database system, implementation details, and plans for future system development.

Hawkcount.org is an online database system that provides count and observation data entry, storage, and reporting services for migration watchsites. This system was implemented in 1999–2000 as a single-site data reporting system for the Holiday Beach Migration Observatory watchsite near Amherstburg, Ontario, Canada. This early version provided functionality related to daily reporting of observed raptor counts at the site. Results were made available immediately on the Holiday Beach web site, and automated e-mail reports were submitted daily to various mailing lists, including the BIRDHAWK list maintained by the Hawk Migration Association of North America (HMANA), regional bird-related mailing lists, and others.

One of the primary goals of the original system involved the simplification of the hawk counters' daily reporting tasks, including eliminating the need to submit hard-copy daily paper forms. Each day, the counter (or other site representative) "reported" the day's results to several places, including a hard-copy daily report form or HMANA "greensheet" to be submitted to HMANA, various e-mail lists, and the Autumn HawkWatch system, an internet-based database system that, as the result of collaboration among Hawk Mountain Sanctuary, the Cornell Lab of Ornithology, and the Hawk Migration Association of North America, provided a database of

Hawk Migration Association of North America, P.O. Box 1593, Homer, Alaska 99603, USA

raptor migration counts for numerous watchsites (McCarty and Bildstein 2005). The initial version of the Hawkcount.org system automated these daily tasks. Daily counts could be entered online once. After entry, the system would generate e-mail reports that were sent to various e-mail lists, as well as automatically submit the day's results to the Autumn HawkWatch system by means of an emulated web browser session.

In 2002, the system was expanded to support multiple watchsites. The new multisite system was renamed and made available on the internet as http://Hawkcount.org/.

When the Autumn HawkWatch system was discontinued and taken offline, the Hawkcount.org system continued to provide its established e-mail reporting mechanisms. Recently, automated data transfer to the Avian Knowledge Network at the Cornell Lab of Ornithology has replaced Autumn HawkWatch as second repository for count data entered into Hawkcount.org.

During its first season as a multisite database, Hawkcount.org handled data from six autumn watchsites. By autumn 2006 it was handling data from more than 180 spring and autumn watchsites.

Hawkcount.org Implementation: Hardware and Software

Hawkcount.org currently runs on a single, primary server at a commercial data center in Troy, Michigan. The server provides web service, database service, SMTP (e-mail) service, and other components and services required by the system. Several redundant automated backup servers in various places in the United States maintain daily backup archives of the entire Hawkcount.org system, including all programs and data. In addition, Hawk Mountain Sanctuary maintains a DVD-based archive that is updated every three months. The Hawkcount.org system runs on freely available open-source software. Doing so provides adequate functionality and performance, and at the same time minimizes costs.

The primary Hawkcount.org server is an Intel/AMD x86-64 architecture computer running a modified GNU/Linux operating environment; in the past, the primary server was an x86-32 machine running GNU/Linux, an x86-32 machine running an OpenBSD operating environment, and a Sun SPARC-based machine running an OpenBSD operating environment.

The main server makes use of the Apache web-server package (http://www.apache.org) to provide the base http (web) service. This service receives requests for web pages from the network and launches the parts of the Hawkcount.org application that handle each request.

Hawkcount.org applications and ancillary programs primarily are written in the PHP scripting language (http://php.net/); PHP provides a programming language similar in many respects to C or Perl, but is optimized for web-based applications. PHP provides convenient access to webpage components such as data forms submitted by hawk counters and environmental data available on websites such as temperature, wind speed, and wind direction, while also providing interoperation with common database platforms, e-mail, and operating-system services such as file system access and shell execution. Currently, PHP version 5 is used. A few Hawkcount.org functions and services are written in the C language instead of PHP. The system uses the MySQL version 5.0 database server (http://mysql.com/) for all observation-related data storage (raw file storage is used for purposes such as error logging and user activity tracking). MySQL provides a relational database server package that understands database commands and queries that follow the standardized SQL (structured query language) format. Data are structured as several interrelated MySQL tables including one that tracks bird-sighting information, a second that tracks observation conditions (weather, observer information, etc.), and a third that tracks overall daily report notes. Other tables unrelated to observed data track application data such as user names, passwords, and site profiles.

A network of automated backup servers in Michigan and Alaska ensure that the unexpected failure of the primary server will not result in permanent data loss. Backup servers run either GNU/Linux or OpenBSD operating environments. Backup images of the entire system (both data and programs) are made nightly through communication of differential data to each of these backup systems: only the day's changes to data and programs are communicated over the internet, but the backup servers use this differential data to reconstruct an entire image of the system at that point in time. Each backup server maintains several months of daily backup images. In the case of complete failure of the main server, the system can be reconstituted with the backup image provided by any one of these redundant backup servers. This backup mechanism has been implemented as Unix shell scripts that make use of the "rdiff" differential file copy program. In addition to backup servers, nightly backup images are also stored on a separate physical hard disk within the primary server. Copies of backup images are periodically written to optical disks and placed in a bank's safe deposit box.

Watchsite Information

In addition to providing current watchsite count data, Hawkcount.org also attempts to serve as an up-to-date directory of North American watchsites by keeping record of site-specific details, including geographic parameters, site descriptions, contact information, and other site-specific attributes. Count summary statistics are calculated and provided on site profile pages.

The stored site-specific information serves several purposes; some of the information is used in the generation of publicly accessible site profiles and details. Other site-specific information controls the behavior of each site's data-entry facilities. Such details include the site's species checklist and details related to weather and flight parameter observation protocols, all of which can be customized. Permission and data-access settings allow each site to control public data accessibility and establish data release conditions.

Data Entry

Daily count data are entered via the web by representatives of each watchsite. Although daily or hourly data can be submitted, hourly data are encouraged. Access to the data-entry functions may be delegated by the user registered as the watchsite's leader. Each day's data entry session begins on a summary page that allows entry of the day's general observation notes, including selection of date, start and end times for the observation period, and general notes about raptor and non-raptor observations, visitors, and predictions for the next day (Fig. 1). The user is then guided through hourly or daily data entry pages. Hourly pages consist of three subsections: (1) a predefined list of qualified observers, (2) hourly flight observations (wind speed, wind direction, temperature, humidity, barometric pressure, cloud cover, visibility, direction of migrating birds' flight, and height of migrating birds' flight; Fig. 2), and (3) hourly counts of each species (Fig. 3). Daily pages follow the format of hourly pages, but without weather and flight parameter fields. Site-specific species checklists speed data entry. Drop menus containing a larger list of raptor species allows temporary addition of these species to the data entry form.

Data also can be imported from Excel spreadsheets. Imported spreadsheets must follow a scheme that defines each row as a count period (typically 1 h). Columns define the date, start and end times, weather parameters, and species counts for a single count period. The import mechanism "learns" about each spreadsheet column layout and can accommodate much variation. However, to encourage consistent input, the system produces template spreadsheets at a user's request. Templates reflect the specific checklist and field order configured for the user's site.

The system also allows data export via Excel spreadsheets for use by the site. Export start and end dates and other data detail options are selected on a web page that produces standardized exported spreadsheets. Special-purpose spreadsheet exports can be implemented to support data requests.

A second type of export generates paper copies of the data as PDF (Portable Document Format) files resembling an expanded version of the HMANA daily report form.

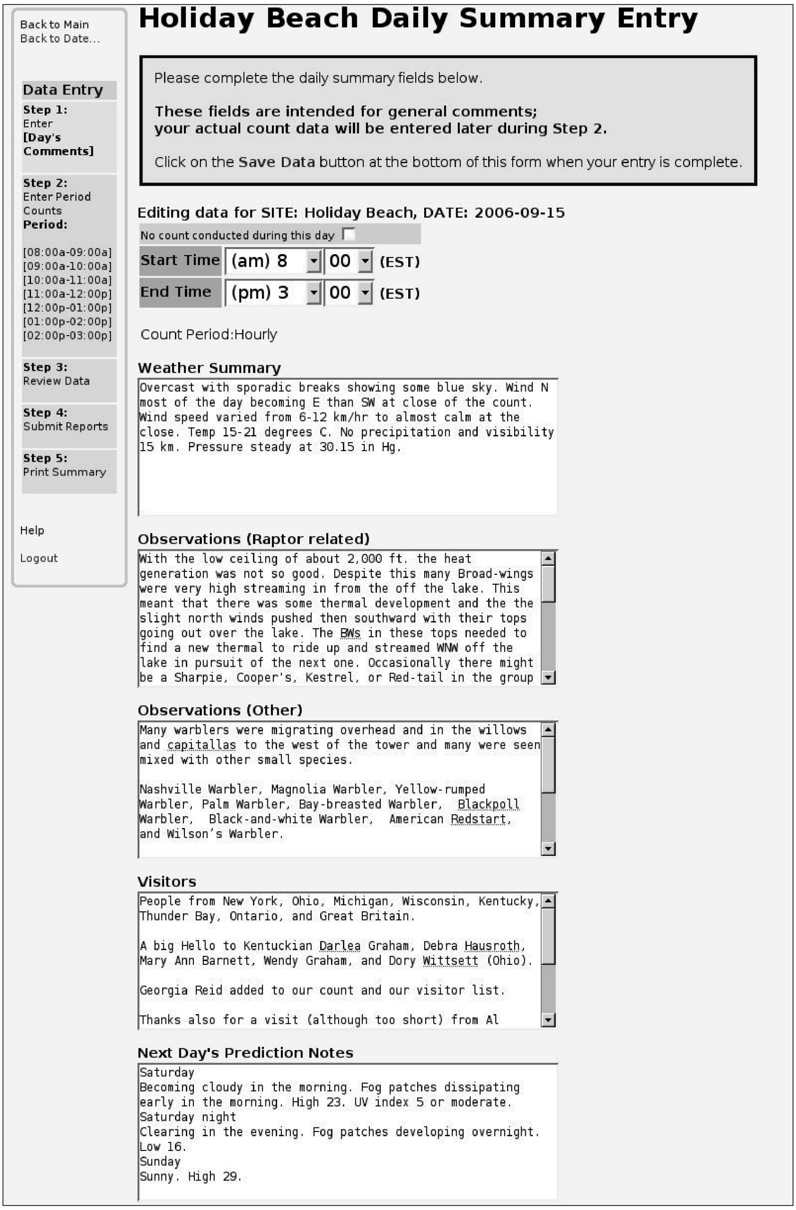

Fig. 1. Example of daily general notes entry on Hawkcount.org web page.

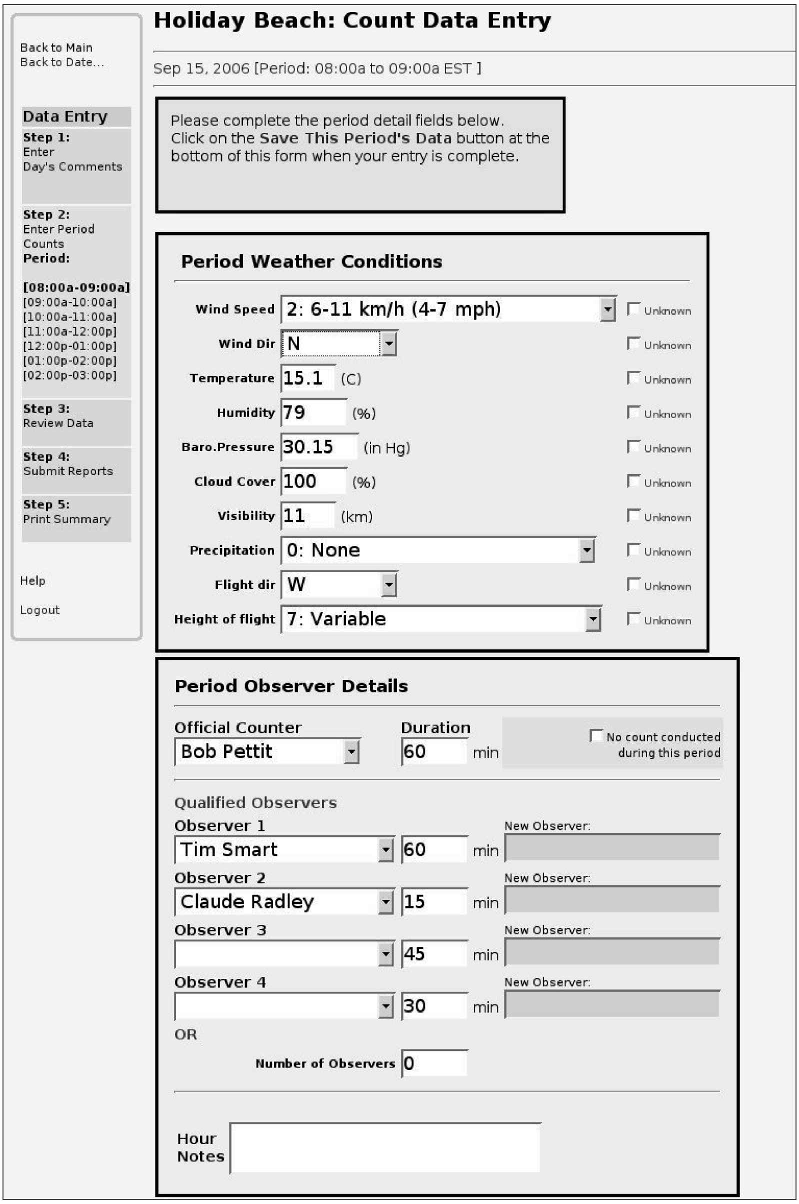

Fig. 2. Example of hourly data entry, including weather and observer information, on Hawkcount.org web page.

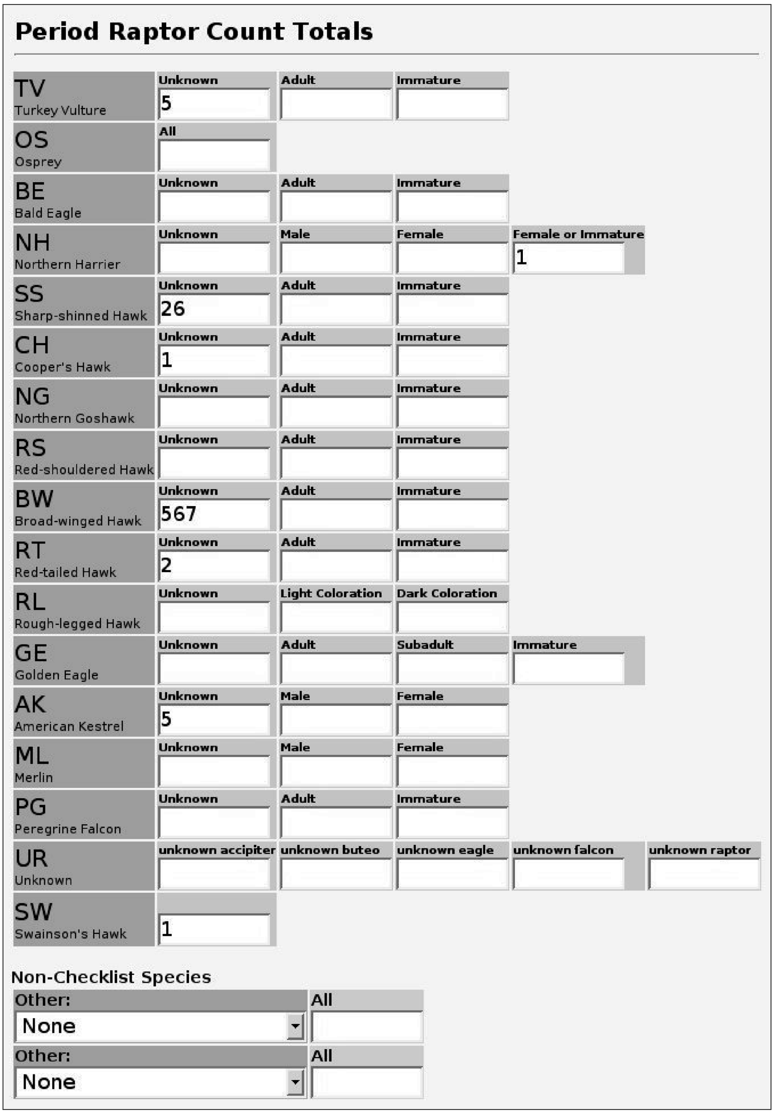

Fig. 3. Example of hourly species count entry including optional count breakdown based on age, sex, and phase attributes on Hawkcount.org web page.

Data Reporting

The system allows for automatic reporting of entered data to a variety of targets defined by each watchsite, including private e-mail addresses, public mailing lists, and the Avian Knowledge Network (http://

avianknowledge.net/) (Kelling and Stewart 2005), the latter by means of the DiGIR software package (http://digir.sourceforge.org/), which maps incoming XML (eXtensible Markup Language) requests to predefined database queries. Through this latter interaction, portions of the database can be integrated with other major bird monitoring datasets, which are available for broad distribution.

E-mail reports may contain either plain-text or HTML-formatted table summaries of a day's count result. Daily, monthly, and seasonal totals are provided for each species. General observation notes and observer names also are included. Each site defines lists of recipients of such e-mail reports. The system is subscribed to many popular e-mail list servers, including regional birding lists and the BIRDHAWK hawk watching exchange list, allowing sites to elect to have copies of their daily reports sent to these mailing lists.

Public Data Access

Publicly accessible areas of the Hawkcount.org web site allow browsing of participating watchsites' daily results and historical data (for those sites that have opted to allow public access). Site-profile pages provide site details, count statistics, data inventory, contact information, and access to site protocols or other site-specific documents. Summaries of watchsite results are provided in both daily and hourly format. The monthly summary view presents a table that summarizes daily totals for all observed species for the entire selected month (Fig. 4). Additionally, tables providing comparisons with previous years' observations for the same month also can be viewed. The daily summary view provides all details recorded for the day, including hourly count breakdown, observation notes, and weather and flight parameter details.

Each watchsite controls access to their data by means of controls available in their site settings within the system. The controls are based on HMANA data submission and release policies (http://hmana.org/data_policies/policies.php).

Watchsite Participation

During autumn 2006, approximately 80 of 183 active watchsites submitted count data daily. Others submitted data less frequently or via post-season spreadsheets. Overall, the system has been used to report counts of over 50 million raptors since its inception as a multiple-site recording system in 2001.

Holiday Beach
Ontario, Canada
(Site Profile)

Month Summary:Sep, 2006

Date	Obs Hrs	TV	OS	BE	NH	SS	CH	NG	RS	BW	RT	RL	GE	AK	ML	PG	UR	SW	TOTAL
2006-09-01	6	0	2	0	8	3	1	0	0	20	4	0	0	14	0	0		0	52
2006-09-02	7	0	2	0	8	12	0	0	0	8	0	0	0	2	0	0		0	32
2006-09-03	9	0	0	4	12	15	0	0	0	8	1	0	0	10	0	0		0	50
2006-09-04	10	0	2	0	3	2	0	0	0	0	0	0	0	7	0	0		0	14
2006-09-05	3	0	0	0	5	9	0	0	0	2	8	0	0	16	0	1		0	41
2006-09-06	4	0	0	0	1	4	0	0	0	1	0	0	0	5	0	0		0	11
2006-09-07	6	0	4	1	7	3	1	0	0	2	2	0	0	5	0	0		0	25
2006-09-08	5	0	1	0	3	0	0	0	0	0	0	0	0	0	0	1		0	5
2006-09-09	9	13	5	0	19	14	3	0	0	4	10	0	0	48	2	0		0	118
2006-09-10	10	0	8	1	65	300	8	0	0	28	6	0	0	346	6	1		0	769
2006-09-11	10	10	7	18	37	204	15	0	0	1116	31	0	0	45	6	5		0	1494
2006-09-12	6	0	0	0	6	45	0	0	0	0	0	0	0	2	3	0		0	56
2006-09-13	3.5	0	0	0	1	126	0	0	0	0	0	0	0	2	2	0		0	131
2006-09-14	9	0	1	4	20	489	15	0	0	482	8	0	0	223	1	4		0	1247
2006-09-15	7	1	3	0	18	226	12	0	0	549	11	0	0	112	2	1		1	936
Date	Obs Hrs	TV	OS	BE	NH	SS	CH	NG	RS	BW	RT	RL	GE	AK	ML	PG	UR	SW	TOTAL
2006-09-16	9.5	5	5	1	21	269	11	0	0	184	8	0	0	39	2	0		0	545
2006-09-17	9	0	4	0	8	301	7	0	0	3	1	0	0	70	3	1		0	398
2006-09-19	5	5	1	0	5	88	4	0	0	1	0	0	0	103	2	1		0	210
2006-09-20	8.5	17	1	0	12	319	8	0	0	1403	7	0	0	127	4	1	1	1	1901
2006-09-21	8.5	9	2	1	32	169	10	0	0	4	6	0	3	56	2	2		0	296
2006-09-22	6.5	42	12	0	2	70	6	0	0	0	0	0	0	9	4	5		0	150
2006-09-23	8.5	0	6	0	7	113	7	0	0	0	0	0	0	12	4	7		0	156
2006-09-24	7	18	4	0	7	303	4	1	0	2	4	0	0	81	3	2	1	0	430
2006-09-25	10	19	5	5	10	217	20	1	0	1	1	0	0	243	7	6		0	535
2006-09-26	8	76	7	8	47	158	16	1	0	1056	17	0	1	24	4	14	3	0	1432
2006-09-27	5	54	4	1	10	161	9	0	0	0	2	0	0	42	12	7		0	302
2006-09-28	5.5	51	0	1	11	251	19	0	0	845	21	0	0	45	1	0	1	0	1246
2006-09-29	8	420	9	6	38	512	3	0	0	1536	12	0	0	60	2	3		0	2601
2006-09-30	9	0	2	0	7	54	5	0	0	0	0	0	0	6	5	3		0	82
Total: Sep 2006	**212.5** hours	740	97	51	430	4437	184	3	0	7255	160	0	4	1754	77	65	6	2	**15265**
Total: Fall 2006	**212.5** hours	35665	111	124	1195	9814	760	28	492	7730	4248	30	63	2113	122	114	40	3	**62652**

Fig. 4. Example of open-access monthly count summary on Hawkcount.org web page.

The Future

Development plans for the Hawkcount.org system include improvements in public-data queries, integration of near-real-time statistics and trend analysis, further mapping and GIS integration, improved data import capacity, support of portable data recording devices, and implementation of additional live servers.

Public-data queries will be improved with species- and geographic-specific query ability. Additional statistics and simple trend analyses will be added to the system. Currently, mapping is included in the site location and profile pages provided by the system by means of the Google Maps API (http://maps.google.com/). Additional mapping ability is anticipated.

Import via additional spreadsheet formats (aside from the current Excel-97 or earlier format limitation) also is anticipated. Hawkcount.org also anticipates support of automated import of data recorded on portable devices, including laptop and handheld computers.

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Table 1. Hawkcount.org participating watchsites, 2001–2006.

Country	Province or state	Watchsite name
Canada	British Columbia	Kitsilano
		Rocky Point Bird Observatory
	Manitoba	St. Adolphe Hawkwatch
		Whytewold Hawkwatch
	Ontario	Beamer Backup
		Beamer Conservation Area auxiliary sites
		Niagara Peninsula Raptor Watch
		Cranberry Marsh Raptor Watch
		Grimsby Air Park
		Hawk Cliff Hawkwatch
		High Park Hawk Watch
		Holiday Beach Migration Observatory
		Innisfree
		Thunder Cape Bird Observatory
	Québec	Belvédère Raoul-Roy, Parc national du Bic
		Eagle Crossing
		Montreal West Island Hawkwatch
		Observatoire d'oiseaux de Tadoussac
		Plateau de Beaupre
Costa Rica	Talamanca	Kekoldi
Mexico	Veracruz	Tlacotalpan, Veracruz, Mexico
		Veracruz River of Raptors
Panama	Panama	Semaphore Hill (Canopy Tower)
USA	Alaska	Gunsight Mountain
	Arizona	Grand Canyon Raptor Migration Project at Lipan Point
		Grand Canyon Raptor Migration Project at Yaki Point
	California	Borrego Valley
		Lagoon Valley
	Connecticut	Beelzebub Street
		Bent of the River
		Booth Hill
		Botsford Hill
		Briggs Hill
		Chestnut Hill
		East Shore Park
		Flat Hill
		Flint Hill
		Good Hill
		Heritage Village
		Huntington State Park
		Johnycake Mountain
		Larson Sanctuary
		Lighthouse Point Hawk Watch

Table 1. Continued.

Country	Province or state	Watchsite name
USA	Connecticut	Maltby Lakes
		Middle School
		Osborne Hill
		Peak Mountain
		Quaker Ridge
		Southbury Training School Farm
		Taft School
		Taine Mountain
		Whippoorwill Hill
		White Memorial Foundation
	Delaware	Cape Henlopen Hawk Watch
		White Clay Creek State Park - Carpenter Recreation Area
	Florida	Guana Reserve
	Illinois	Illinois Beach State Park
		Lost Mound Refuge
	Iowa	Hitchcock Nature Center
	Maine	Bradbury Mountain State Park
		Cadillac Mountain, Arcadia National Park
	Maryland	Cromwell Valley Park
		Fort Smallwood Park
		Manchester Ridges
		Turkey Point Hawk Watch
		Washington Monument State Park
	Massachusetts	Alander Mountain
		Bare Mountain
		Barre Falls
		Blueberry Hill
		Little River Lookout
		Mount Tom
		Mount Wachusett
		Mount Watatic
		Pilgrim Heights Hawk Watch
		Pinnacle Rock
		Plum Island MA
		Shatterack Mountain
		Tuttle Hill
	Michigan	Meadowbrook Migration Area
		Muskegon Hawkwatch
		Port Huron Hawk Watch
		SMRR- Lake Erie Metropark
		SMRR- Pointe Mouillee State Game Area
		Straits of Mackinaw
		Whitefish Point Bird Observatory
	Minnesota	Hawk Ridge Bird Observatory
		West Skyline Hawk Count

Table 1. Continued.

Country	Province or state	Watchsite name
USA	Montana	Bridger Mountains Raptor Migration Project
	Nevada	Goshute Mountains Raptor Migration Project
	New Hampshire	Interlakes Elementary School
		Little Round Top
		Pack Monadnock Raptor Migration Observatory
		Peter Wood Hill
	New Jersey	Cape May Bird Observatory
		Kittatinny Mountain
		Montclair Hawk Lookout
		NJAMP at Chimney Rock
		NJAMP at Duke Farms
		Picatinny Peak Hawkwatch
		Raccoon Ridge
		Reed's Beach Autumn Hawk Watch
		Sandy Hook Migration Watch
		Scotts Mountain
		Sparta Migration Watch
		State Line Hawkwatch
		Sunrise Mountain
		Wildcat Ridge Hawkwatch
	New Mexico	Manzano Mountains Raptor Migration Project
	New York	Braddock Bay
		Chestnut Ridge Hawk Watch
		Derby Hill Bird Observatory
		Fire Island
		Franklin Mountain Hawkwatch
		Hamburg Hawk Watch
		Hook Mountain
		Kestrel Haven
		Lenoir Wildlife Sanctuary
		Mohonk Preserve
		Mount Peter Hawk Watch
		Ripley Hawk Watch
		Summitville Hawkwatch
	North Carolina	Big Bald
		Bullhead Mountain
		Mahogany Rock
		Mount Pisgah
		Pea Island National Wildlife Refuge
		Phoenix Mountain Hawk Watch
		Pilot Mountain State Park
	Oregon	Bonney Butte Raptor Migration Project
	Pennsylvania	Allegheny Front Hawk Watch
		Audubon's Hawk Watch at Waggoner's Gap

Table 1. Continued.

Country	Province or state	Watchsite name
USA	Pennsylvania	Bake Oven Knob
		Bald Eagle Mountain
		Brady's Bend
		BroadwingSEPT - Buckingham
		BroadwingSEPT - Core Creek
		BroadwingSEPT - Lake Nockamixon
		BroadwingSEPT – Lehigh
		BroadwingSEPT - Peace Valley
		BroadwingSEPT - Pipersville
		BroadwingSEPT – Pleasant Valley
		Cove Mountain
		Hawk Mountain Sanctuary
		Hopewell Fire Tower
		Jack's Mountain Hawk Watch
		Kirkridge
		Lehigh Gap Hawkwatch
		Little Gap
		Meadowood Bird Observatory
		Militia Hill
		Rose Tree Park Hawk Watch
		Second Mountain
		Stone Mountain Hawk Watch
		Tuscarora Summit
		Tussey Mountain Hawkwatch
	South Carolina	Caesars Head Hawk Watch
		Congaree Bluffs
		Trezevant's Landing
	Tennessee	Tara Woods East Collierville
	Texas	Bentsen Rio Grande Valley State Park
		Corpus Christi Raptor Migration Project
		Smith Point Raptor Migration Project
	Utah	Wellsville Mountain Raptor Migration Project
	Vermont	Putney Mountain
	Virginia	Bear Mountain Farm
		Candler Mountain
		Carvins Cove
		College Creek
		Harvey's Knob Overlook
		Hughes River Gap
		Kiptopeke Hawkwatch
		Rockfish Gap Hawk Watch
		Snickers Gap Hawkwatch
	Washington	Chelan Ridge Raptor Migration Project
	West Virginia	Hanging Rock Tower
	Wisconsin	Chequamegon Bay Hawkwatch
		Concordia University

11

The Future of Raptor-migration Monitoring

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Abstract.—The extent to which the Raptor Population Index (RPI) serves to monitor populations of North America's birds of prey will depend on those who choose to maintain and improve it. Much like the National Audubon Society's *Christmas Bird Counts*, and the U.S. Geological Survey's *Breeding Bird Surveys*, RPI depends on a cadre of expert volunteers to conduct the counts. Maintaining the enthusiasm of these volunteers is critical to RPI's long-term success. RPI areas in need of improvement include shortfalls in autumn coverage outside of eastern North America; shortfalls in spring coverage throughout the continent; potentially fragile analytic and interpretive protocols, particularly at mega-migration watchsites along the Mesoamerican Land Corridor in southern North America and Central America; and limited knowledge of the dynamic geography of raptor migration in North America. All areas in need of improvement can be addressed, and we believe that RPI has a bright and long-term future in conservation monitoring.

Introduction

Counting North America's migratory birds of prey for conservation dates from the early 1930s, when raptor enthusiasts at Cape May Point, New Jersey, and Hawk Mountain Sanctuary, Pennsylvania, first used migration counts in an attempt to reverse the growing threat of human persecution

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(Chapter 1, Bildstein 2006). Migration counts at Cape May Point, which were organized by the Audubon Association in 1931 (Allen and Peterson 1936), were suspended after 1937 and were not restarted on a regular basis until 1976 (Dunne and Sutton 1986). Migration counts at Hawk Mountain Sanctuary began in 1934 and have continued uninterrupted through the present, except for three years (1943–1945) during the Second World War when the watchsite's principal counter at the time, Maurice Broun, was serving in the U.S. Navy SeaBees (Bildstein and Compton 2000). Although counts at both sites were initiated principally to document the magnitude of the flight to enlist support for conservation efforts there (Broun 1935a, b; Allen and Peterson 1936), at Hawk Mountain, at least, it quickly became apparent that a series of annual counts would enable monitoring regional populations over time.

Writing in *The Auk* in 1939, Maurice Broun put it this way:

> *Since the second season (1935) uninterrupted daily censuses of hawk flights have been made, each season's observations covering an average of 575 hours. The accumulated data provide a more accurate picture of the migrations than that published prematurely for 1934* [Broun 1935b], *and also furnish a sounder basis for future statistical comparisons.*

Less than five years into the Hawk Mountain conservation effort, annual migration counts at Hawk Mountain were telling Broun something about the numbers of raptors that were out there (as well as the numbers that he was protecting on site), and Broun had the foresight to realize that long-term counts would tell conservationists something about population change over time. On top of all that, Broun found hawkwatching enjoyable, and learned that inviting others to see the migration at Hawk Mountain could provide the Sanctuary with the opportunity to spread a conservation message to thousands of visitors annually (Broun 1949).

Shortly after Hawk Mountain was established, hawkwatching—both as conservation monitoring and as recreation—began to spread across North America (Chapter 3, Bildstein 2006), in much the same way that Audubon's *Christmas Bird Counts* had earlier in the 20th century (cf. Drennan 1981).

By the late 1950s, many in the hawkwatching community were calling for the establishment of a network of migration watchsites that could do continentally what Hawk Mountain Sanctuary and other sites were doing regionally (J. Taylor pers. comm.): monitor numbers of birds of prey and offer conservation assessments for individual species. The founding of the Hawk Migration Association of North America in 1975 and of HawkWatch International in 1986 set the intercontinental stage for this dream (Chapter 3, Harwood 1975). The creation of the Raptor Population Index (RPI) in 2003 put this dream into action, and the publication of *State of North America's Birds of Prey* summarizes the history and results of this effort as of early 2007.

Below, we offer our vision of the future of counting migrating raptors for conservation.

Challenges

Bird migration, in general, and the visible daytime movements of birds of prey in particular, have fascinated humanity for millennia (Brown and Amadon 1968, Bildstein 2006). This, together with the charismatic nature of raptors themselves, has created a longstanding interest in studies of their migrations. As a result, with the possible exceptions of waterfowl and shorebirds, we now know more about the long-distance movements of raptors than we do about any group of birds (Bildstein 2006). Given the history of sustained growth in hawkwatching and raptor-migration studies (Heintzelman 1975, 1986, 2004; Kerlinger 1989; Zalles and Bildstein 2000; Bildstein 2006) there is little reason to think that this will change anytime soon. Recent advances in technology, particularly in data entry and management, data analysis, and the rapid dissemination of results, together with improvements in field guides, optics, and outdoor clothing, suggest that monitoring the movements of raptors at migration watchsites will remain a popular and largely volunteer effort for some time into the future (Bildstein 1998a). That said, much remains to be done to improve our monitoring efforts.

Aspects of our work in need of improvement include (1) the geographic coverage of both autumn and spring watchsites, (2) the number of spring watchsites and an assessment of their value for population monitoring, (3) our statistical procedures for analyzing raptor counts at "mega-watchsites" along major migration corridors, and (4) our understanding of the dynamic migration–geography of raptors, including within-species differences in migration behavior and changes in the extent of migration and migration geography over time. We address each of these needs below.

The geography of watchsites.—RPI coverage of North America is uneven geographically. Eight of the 22 watchsites whose counts were analyzed and presented in this work are east of the Mississippi River and north of the Mason-Dixon Line. And, overall, most active watchsites in North America are in the northeastern United States (Table 1, Chapter 2). This is so because the first watchsites were in the Northeast and watchsite activity spread, geographically, from them. Although some of this historical bias will self-correct as more recently established southeastern and western watchsites accumulate sufficient numbers of count years for trend analysis, it is clear that additional watchsites are needed outside of northeastern North America.

The impact of limited watchsite coverage elsewhere in North America, perhaps, is best reflected by the fact that no watchsite in Canada or the United States now counts more than one or two percent of the total known migratory flights of Swainson's Hawks (*Buteo swainsoni*) and western populations of Turkey Vultures (*Cathartes aura meridionalis*), two species of common North American migrants whose populations all but evacuate the western United States and western Canada each autumn (England et al. 1997, Kirk and Mossman 1998, Chapter 2). Although these two species are counted by the hundreds of thousands to millions at watchsites in Mexico, Costa Rica, and Panama (Ruelas et al. 2000, Porras-Peñaranda et al. 2004, G. Angehr pers. comm., Chapter 7), the lack of significant migration monitoring in Canada and the United States compromises RPI's ability to detect changes in regional populations and, thereby, its ability to assess the regional conservation status of two of North America's more abundant long-distance migrants.

Although some workers have argued that Turkey Vultures and Swainson's Hawks do not concentrate along traditional flight lines north of Mexico—thereby making counting large numbers of migrants at watchsites north of the Rio Grande difficult, if not impossible—in truth, no one has systematically searched for flight lines of these two species in the American West. Migratory routes used by satellite-tracked Turkey Vultures and Swainson's Hawks would be one place to start gathering information for such a search, as would published anecdotal reports of large movements of these two species. The movements of many other western populations of raptors including Ospreys (*Pandion haliaetus*), Northern Harriers (*Circus cyaneus*), and Peregrine Falcons (*Falco peregrinus*), also are under-sampled in the region. And, unfortunately, western North America is not the only place with too few watchsites.

Notwithstanding activities at a critical watchsite at Curry Hammock State Park in the Florida Keys (Lott 2006, Chapter 7), season-long migration counts are generally lacking along the Atlantic Coast of eastern North America south of Kiptopeke, Virginia, as well as in the interior Southeast. Watchsites also are largely absent on the Pacific Coast south of the Golden Gate Raptor Observatory in northern California (Zalles and Bildstein 2000, Chapter 6).

If the RPI is to succeed in the long term, it must activate and maintain additional long-term autumn-migration watchsites outside of northeastern North America.

The number of spring watchsites.—Most watchsites are operated by volunteers whose interest in season-long counts is often driven by the potential for seeing large flights of migrants. Because of this, most RPI watchsites are along traditional migration corridors where large numbers of migrants regularly concentrate, and autumn watchsites far outnumber spring watchsites. The latter is true mainly because autumn migration occurs shortly after the breeding season when populations are at their peaks, whereas spring migration occurs after winter when populations are at their low points. Other factors that act to favor autumn versus spring counts include *delayed return migration* in some species (Bildstein 2006) and a less geographically concentrated return migration overall (cf. McCarty et al. 1999). In addition to all of this, many species of raptors engage in *loop migration*, which means that high-volume autumn watchsites often have disproportionately low spring counts. As a result, whereas 138 of all 188 active watchsites in North America operate in autumn, only 50 watchsites operate in spring (Table 1 in Chapter 2). As is true of migration watchsites in general, most spring count sites (72%) are east of the Mississippi River and north of the Mason-Dixon Line.

The paucity of spring watchsites limits RPI's ability to assess the extent to which shifts in over-winter mortality versus changes in reproductive output affect counts at autumn watchsites, and as such limits our ability to focus conservation efforts where they are needed most.

If RPI is to succeed in the long term, it must activate and maintain additional spring watchsites throughout North America.

Statistical analysis of counts along major migration corridors.—RPI's current data analysis builds upon protocols that were developed to monitor population change in songbird migrants at Long Point Bird Observatory in southern Ontario based on spring counts there (Hussell 1981). The protocols (see Chapter 4) involve the calculation of geometric-mean daily counts, which serve to significantly reduce the influence of extremely high single-day counts. The use of this technique to monitor raptor population change is questionable at mega-watchsites along the intercontinental Mesoamerican Land Corridor, where day-to-day variation in passage rates of super-abundant, super-flocking species, including Turkey Vultures, Swainson's Hawks, and Broad-winged Hawks (*B. platypterus*) are often extreme (i.e., ranging from a few migrants on one day to hundreds of thousands of migrants on the next; Chapter 7). Although reducing the influence of occasional extreme outliers is appropriate for some species in some circumstances (Hussell 1981), it may not be so for super-flocking migrants along major migration corridors where single-day counts of as many as 800,000 birds can represent 50–60% of the total count for a season. An example of this occurred in 2001 at the Veracruz River of Raptors watchsite when 775,000 Broad-winged Hawks were counted on 28 September, and more than 360,000 were counted the next day, collectively representing 53% of the season's overall count. A similar situation occurred in 2001 at the Corpus Christi, Texas watchsite. As mentioned in Chapter

7, RPI currently is examining how best to assess population trends in such situations.

If RPI is to succeed in the long term, it must continue to develop and use the best possible statistical analyses and interpretive protocols.

Migration geography.—Until recently, most raptor-migration science has focused inwardly on the birds themselves, concentrating on descriptive natural history (e.g., Brown and Amadon 1968, Ferguson-Lees and Christie 2001) and flight mechanics (Kerlinger 1989) rather than on broader theoretical and ecological questions (Bildstein 1998b). Overall, relatively few studies in raptor-migration science have formulated hypotheses, tested predictions, and modified existing hypotheses based on findings (for notable exceptions see Kerlinger 1989). And indeed, much of the work on raptor migration is built upon *hypothesis compatibility* (*sensu* Templeton 2007), rather than upon *hypothesis testing*.

One unfortunate consequence of this approach is that many practitioners in the field still view the migration geography of birds, including raptors, as being fixed, all-but-immutably in place, despite a growing body of field and experimental evidence that suggests otherwise (Viverette et al. 1996, Berthold 1999, Bildstein 2006). The picture that is now emerging from the literature indicates that migration behavior in general, and migration geography in particular, are dynamic and flexible attributes of many species, and that both can shift quickly in response to changing ecological conditions. This, together with the fact that the overwhelming majority of North America's migratory raptors are *partial migrants* that exhibit geographic variability in migratory tendencies, leads us to conclude that changes in migration counts often can reflect changes in migratory behavior just as easily as they reflect changes in the sizes of source populations.

Thus we believe that watchsite counts alone are insufficient in assessing the conservation status of North America's birds of prey, and that additional continental survey data, including both *Breeding Bird Surveys* and Christmas Bird Counts, together with a better understanding of the current migration geography and migration behavior of North America's raptors, themselves, will be needed if RPI is to properly assess the population status of North America's birds of prey.

A case in point is global climate change. Many students of bird migration have concluded that continued global climate change is likely to hasten shifts in both migration behavior and population size in many species of migratory birds (Møller et al. 2006). A growing body of field evidence suggests that there is no reason to suppose raptors will be an exception in this regard (Bildstein 2006). With this in mind, we call for a broader and more scientific approach to the discipline of raptor-migration science (cf. Bildstein 1998b). Specifically, we recommend new studies that incorporate hypothesis testing and that use the new observational, experimental, and analytical tools now available to students in the field, so that we can better track and identify shifts in migration behavior as well as shifts in numbers.

If RPI is to succeed in the long term, it must begin to foster work that leads to a better understanding of the phenomenon of raptor migration, particularly the degree to which birds of prey shift their migratory movements and behavior in light of local, regional, and continental ecological change.

Opportunities

Important, new, and, as yet, largely underused tools in raptor-migration science include satellite tracking (Bildstein 2006, Meyburg and Fuller 2007), radar ornithology (Gauthreaux et al. 2001), stable isotopes (Hobson 2002, Lott and Smith 2006), and the use of data-loggers to monitor raptor physiology during flight (J. Mandel pers. comm., O. Bahat pers. comm.). Although these new techniques have limitations, taken together they offer complementary and potentially rich sources of information regarding the migrations of birds of prey that, together with counts of visible migrants at watchsites, can significantly improve our abilities to assess regional and continental population change. We discuss the potential benefits and limitations of each below.

Satellite tracking.—One of the most important new tools in raptor-migration science is satellite tracking (Meyburg and Fuller 2007). Developed in the early 1980s, satellite tracking employs platform transmitter terminals (PTTs) as small as 10 g that are capable of transmitting hundreds of locations annually. Although relatively expensive, tracking the migratory movements of raptors by satellite offers the holy grail of raptor migration: an ability to follow individual migrants on a daily or even hourly basis. Solar-powered PTTs, which can send signals for several years or more, allow researchers to follow the movements of individual birds on a series of outbound and return migrations. Recently developed PTTs equipped with GPS units provide location accuracy to within a few meters (Meyburg and Fuller 2007). As of early 2006, the migratory movements of at least 27 large-bodied birds of prey had been tracked by satellite (Bildstein 2006).

Initially designed to determine the geography of animal movements, satellite tracking also enables researchers to assess the flight speeds of birds during migration, the extent of nocturnal versus diurnal flight, the occurrence of stopover and night-time roosting behavior and the location of stopover and roost sites, and habitat use. One recent analysis even used satellite tracks to assess the navigational cues used by Peregrine Falcons moving between North and South America, and Western Honey Buzzards (*Pernis apivorus*) and Ospreys moving between Europe and Africa (Thorup et al. 2006). Because solar-powered satellite tracking units allow researchers to follow the movements of individuals across several years, satellite tracking allows researchers to assess the extent of inter-year flexibility in both temporal and spatial aspects of migration. Individuals tracked by satellite and outfitted with downloadable data loggers also can provide information on their physiological condition (e.g., core body temperature, heart rate, etc.) and flight mechanics (e.g., flapping rates) during their migrations (J. Mandel pers. comm, O. Bahat pers. comm.).

Population assessments of many of the RPI results reported earlier in this work have been compromised by suspected changes in migration behavior, including migration short-stopping (Sharp-shinned Hawk [*Accipiter striatus*] accounts, Chapters 5 and 9), and route shifts (Chapters 6 and 9) in response to environmental changes such as climate amelioration (Viverette et al. 1996), increased numbers of bird feeders and, consequently, bird-feeder birds (Warkentin et al. 1990, Viverette et al. 1996), and regional droughts (Chapters 6 and 9). This indicates that understanding and describing the extent of migration dynamics will be critical to population monitoring. This is likely to become increasingly so, as such changes are likely to increase rather than decrease in the face of expanding human effects on both human-dominated and natural landscapes (Jetz et al. 2007).

The use of satellite tracking, including implementation of new systems employing GPS-logging, solar-powered "mini" tags for use on small, as well as, large raptors (Wikelski et al. 2007), together with other new tracking technologies such as cellular-telephone-based tracking units, can play an important role in helping RPI conservationists better understand ongoing changes in migration behavior, and in so doing help them more accurately interpret watchsite-count data.

Radar ornithology.—Developed for the military in the 1930s, radar uses radio waves to detect the range, direction of travel, and speed of moving objects in the air column. Systematic studies of raptor migration using radar date from the 1970s, when radar was used to detect migrants crossing the Strait of Gibraltar in southern Spain and migrants following the shorelines of the Great Lakes in southern Ontario, Canada (Bildstein 2006). Doppler weather-surveillance radar recently has been installed at 150 stations across the United States. Imagery from this array enables researchers to detect groups of raptor migrants up to 110 km away (Gauthreaux et al. 2001). Used only episodically to date, Doppler radar offers considerable potential for detecting large-scale movements of soaring migrants in the American West and elsewhere. Used in conjunction with on-the-ground counts of visible migrants to enumerate the migrants and identify them to species, Doppler radar could help RPI conservationists locate outbound and return flight lines of western Turkey Vultures and Swainson's Hawks, two relatively common migrants whose movements, for the most part, have yet to be sampled in large numbers north of the Rio Grande (see above), as well the flight lines of returning Broad-winged Hawks in eastern North America.

The use of radar ornithology can play an important role in determining where to site additional autumn watchsites outside of northeastern North America, as well as additional spring watchsites throughout North America.

Stable isotopes.—One potentially powerful technique for assessing the sources of raptors seen at watchsites uses geographic variation in relative occurrences of naturally occurring rare and common stable isotopes in the feathers of captured migrants to determine where the bird has come from (Hobson 2002, Lott and Smith 2006). Investigators already have used this technique to assess birth-place latitudes of young Cooper's Hawks (*A. cooperii*) migrating south through the Florida Keys (Meehan et al. 2001), as well as the origins of Sharp-shinned Hawks captured in eastern Nevada in autumn (Lott and Smith 2006). Although the technique remains in the early stages of development, and may be of limited use in certain circumstances, it offers a critical advantage over large-scale banding and trapping in being able to determine the origins of migrants seen at watchsites contemporaneously with counts collected there, something that banding and trapping data are not able to do in that they take many years to accumulate. Contemporaneous assessments of origins are likely to become increasingly important should migration behavior continue to change as anticipated.

The use of stable isotopes can play an important role in determining the geographic sources of raptors counted at watchsites.

Conclusions

Three factors drive the rate of success in conservation biology and monitoring: serendipity, advancing technology, and the appearance and acceptance of new ideas and paradigms (cf. Bildstein 1998b). All three of these factors are thriving in RPI. First, few other charismatic diurnal migrants line up at known locales as raptors do twice a year to have their populations checked by enthusiastic volunteers, and an underlying strength of RPI is its ability to take advantage of this serendipitous situation. Second, advancing technology in the form of satellite and GPS tracking, Doppler radar, and stable isotopes offer new opportunities for studying and understanding the geography of raptor migration. Third, a new appreciation for the dynamic nature and flexibility of raptor migration itself provides us with a new and useful paradigm for understanding the movement ecology of birds of prey.

These three factors, together with our recognition of areas in need of improvement (e.g., more watchsites outside of northeastern North America, more spring watchsites overall, improved statistical analyses, and more information on the geography of raptor migration), all but ensure success.

As we move to the next stage, we need to keep all of the above in mind as we work together with volunteer hawkwatchers and the greater conservation and scientific communities in ways that will strengthen our ability to provide increasingly accurate and timely conservation assessments of North America's birds of prey.

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12

Recommended Methods for Population Monitoring at Raptor-migration Watchsites

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Abstract.—We provide recommendations for the optimal operation of raptor-migration watchsites, with the goal of reducing and controlling for variation in counts from sources unrelated to population change. Each site must ensure consistency in the seasonal coverage period, length of the daily count period, the number and skill of observers, and the location of observation points. A written protocol must give clear instructions on what and how to count and what to record, so that different observers will collect data as consistently as possible. We outline the contents of a field protocol and emphasize the need to archive the specifics of the protocol in use each field season. Changes in protocols should be avoided, but if absolutely necessary, there are procedures for changeover, described herein, that allow data from both before and after a change to be pooled for analyses. Following the recommended procedures will greatly reduce the variation in counts that can bias annual indexes and resulting trends.

Every experienced hawk counter is well aware that numbers of migrating raptors recorded daily are affected by weather, number and skill of observers, and numerous other factors that affect detectability of birds, such as behavior and altitude of flying birds or volume of migration. When counts are made with the aim of tracking long-term changes in population

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levels, concern arises that daily count variability from these sources will interfere with detection of true changes in annual population size.

This chapter provides specific instruction to count organizers on means of reducing fluctuation in daily counts that is caused by variation in observation effort. Although directed primarily at hawk counters, this paper also provides important information to users of trend results, illustrating the issues of data quality and methodology that should be taken into account when considering the quality of trends from specific sites.

No amount of standardization in count effort can ensure that all migrants passing a site are observed, and hawk counts are only an index of true abundance. (For a detailed discussion of proportion of migrants counted, see Dunn 2005.) The assumption underlying trend analyses based on index counts is that count indexes fluctuate in parallel with true numbers. However, there is active debate in the bird-monitoring community about the validity of this assumption, and numerous count methods are being tested for estimating the proportion of birds available to be detected that are actually recorded (Thompson 2002). Estimating detectability is important for accurate comparisons of breeding-bird densities between habitats (e.g., Bibby and Buckland 1987). That said, at a site where detectability is not changing systematically over time, long-term trends based on index counts should not differ importantly in magnitude from those based on counts adjusted for detectability. Systematic change in detectability is less likely to be a problem in standardized counts of migrating raptors than in those of breeding birds, because migrants passing over a particular site are presumably little affected by habitat change on the ground. Nonetheless, continued research is needed, and the double-observer method (Nichols et al. 2000) is the most suitable approach for migrant raptor counts. In the meantime, it should be understood that all results of long-term trends in raptor migration to date are based on index counts and that most hawk-watch sites are operated by amateur enthusiasts who are likely to continue with index counts in the foreseeable future. Therefore, we concentrate here on recommendations that will minimize changes in detectability as a result of changes in watch effort.

A simple example of how change in effort can affect counts is given in Table 1, which shows hypothetical counts of a species at each of three nearby sites. Let us assume that sites A and B used the same methods in both years, whereas at site C, a tower was built between the two years to improve visibility. Sites A and B each detected a 10% decline in numbers between the two years, even though total numbers at the two sites were very different. At site C, however, numbers rose by 10%. Assuming that all three sites were sampling the same population, we are drawn to the conclusion that the change in methods at site C was the probable cause of the increase at that location.

Table 1. Hypothetical example illustrating the importance of consistency in counts.

Site	Count in year 1	Count in year 2	Percentage of change in numbers	Consistent count
A	200	180	–10	Yes
B	1000	900	–10	Yes
C	500	550	+10	No

The key to making index counts reliable is to count consistently at each site, both within and among years. Most organizers will want to maximize counts to maintain volunteer interest and enthusiasm, and the site and methods can be selected to afford that opportunity. What must be avoided are subsequent changes in procedures that alter the number of birds recorded independent of any change in actual numbers passing the site.

Consistency of counts within and among years requires each watchsite to set standards for the ways in which data are collected and to ensure adherence to those standards. That said, there is no need for standard methods to be exactly the same for every watchsite, and dates of coverage, length of daily watch period, etc., can be set as most appropriate for each location. As long as counts are conducted consistently within each site, the count index at all sites sampling the same population should change in parallel, even if observation protocols differ between sites.

Key elements of data collection that require consistency include timing of seasonal and daily coverage, timing and length of daily observations, observer numbers and skill, count locations, and details of count instructions. Each of these factors is discussed below.

Seasonal Coverage

For a species to be well monitored, observations should be taken across most of the migration period, not only during peak passage (Lewis and Gould 2000). For a species to qualify for analysis, counts should be made on a minimum of 75% of days during the species' migration "window" (the period during which 95% of migrants pass by that particular site). For species with migration windows of less than one month, we recommend covering at least 20 days (preferably more) within the migration window. These recommendations are based, in part, on studies modeling the effects of less intense coverage on statistical power for detection of population change (Thomas et al. 2004, Farmer et al. 2007).

Each watchsite should set the coverage period to include the migration windows of as many species as possible. Alternatively, watchsite personnel may decide to focus on one or more target species and limit coverage even though other species could be monitored at that site with additional effort. It is desirable that the same dates be covered each year, but this is not essential, provided that at least 75% of the migration windows of target species is covered.

Daily Count Period

A standardized daily counting period should be defined with a specified start time and number of hours of counting. The official Hawk Migration Association of North America count forms are printed for recording hourly counts, so it is simplest to set the official period to start and end on the hour. Start time should be specified as to time zone and standard versus daylight time (e.g., Eastern Daylight Savings Time, Mountain Standard Time).

It is recommended that the daily counts cover 8–9 h, with a minimum of 6 h. The start time and length of the daily count period should be set to maximize coverage of target species (i.e., targeting the times of day when peak movement occurs). However, consistency is more important than total proportional coverage. For example, if most counters can spend only 6 h at the site, the standard count period should not be 8 h, even if that would better cover the period of daily migration activity. Start time and length of count period may differ according to time of year (e.g., shorter count period in December when there is less daylight), but only so long as the same within-season changes in count length are followed consistently year after year. Counters may start before the official starting period and end later if they wish, so long as data collected during the standard period can be separated easily for analysis.

Counts should be continued through the entire standardized period even when few birds are present, and counters should not select days for counting based on expectation of large numbers. Because low counts can be boring for counters, it is important to stress in instructions that such counts are as important for detecting population trends as are "big flight days." If observers come only on days when good migratory movement is expected, the data cannot be used for monitoring population trends.

Instructions also should clarify the conditions under which a count may be suspended. Observer safety should be paramount (e.g., stop and take shelter during thunderstorms or vacate the site if wildfire smoke makes conditions unhealthy); observer comfort should be a secondary concern. Taking short breaks to shelter during heavy showers is fine, but intermittent showers, unfavorable migration conditions, high winds, etc., should not be cause for terminating observations prior to the end of the standard period. Decisions to skip an entire day should be based only on forecasts of hurricane-strength winds, steady rain, snow, or other factors that are unlikely to allow any periods of visibility or safe observation conditions. Whereas the target always should be to cover the full standard-length daily period, inevitably there will be times when counts are cut short or full days are missed. In such cases, the reason for lack of coverage should be recorded directly onto the daily report form. For instance, "rain-thunderstorm" might be written across 0900 through 1100 hours if a person was absent for those hours because of a thunderstorm. If an entire day is missed, a daily record sheet nonetheless should be completed, giving the date and the cause of there being no coverage, and it should be added to the collection of daily report forms for the season. This is, by far, the best means of ensuring that causes of gaps make it into the permanent database. There are various ways of treating missing data in trend analysis, and the method chosen depends on the cause of the gap.

Numbers of Observers

Having a single official counter can be acceptable and may be the only feasible option for many watchsites. That said, population trend analyses may be compromised when the same observer takes most of the counts in a given season. Most people feel instinctively that having a single person conducting all counts will reduce day-to-day variation and therefore be "good." However, observers vary in skill levels. When a single observer does all the counting in a single season and there are different single observers in different years, the "observer effect" cannot be separated from the "year effect," which is the signal of population change. If, for example, a particularly gifted counter collects most of the data in a given year, counts in that particular year will be higher, on average, than those in years with observers of more typical skill.

The best way to address this problem is to have several observers who regularly rotate count duties (e.g., taking turns daily or every second or third day). That way, if any one observer drops out of the team in one year and is replaced by a new observer in the next, the overall impact on trend analysis will be negligible. Purposely introducing daily variation in observer skill will, in fact, ensure that annual abundance indexes are less influenced by "observer effect" and more representative of the population signal.

Another way to avoid confounding year effect with observer effect is to have two official counters working together (or three, if flight volume is normally high). This is the recommended option, as long as sufficient personnel are routinely available, for the following reasons:

- The average skills of two (or three) observers are more likely to be similar from year to year than the skills of individual observers.
- When two (or three) observers are present, one can be assigned to record data, which allows the primary observer(s) to work with less distraction. The extra observer(s) can call attention to birds that appear to have been missed, and can serve this function even if not

highly skilled. If the primary observer is of average skill, the second may be kept busier than with a highly skilled counter, but in both cases the total birds detected should be relatively similar, compared with solo counts by unassisted observers of different skill levels. Duties as primary counter should be regularly rotated, even if one observer (e.g., a paid employee) is present daily or is more skilled than other counters.

- Multiple counters offer the opportunity for estimating detectability using the double-observer method (Nichols et al. 2000).
- When two (or three) observers are present, there is more flexibility for taking short breaks, which increases comfort and promotes continued alertness throughout the entire count period.
- Adding an extra counter allows the count to be used for training and evaluating future principal counters.

Regardless of the number of official observers, that number should remain constant day to day and year to year. In theory, a variable can be added to analyses to take account of the effect of extra observers on number of birds detected, but the statistical model would treat the number of observers present as uncorrelated with number of migrants, and that is almost never the case. Instead, more people typically come to nonremote watchsites on days and under weather conditions when good flights are expected. That correlation introduces a bias that cannot be addressed at the analysis stage.

For this reason, visitors to the site should be discouraged from contributing to the official count (although this may be difficult to control). Having some volunteers on hand to talk with visitors can be very helpful, and can also fulfill public-education goals. Physical separation of the official lookout from visitor traffic also can be helpful. Visitor numbers per hour should be recorded whenever possible.

Observer Skill

The observers responsible for bird identification should be able to identify essentially all raptors (in all plumages) that pass by close enough for a good look, and some target proportion of more distant birds. Standards should be high enough to ensure that identifications are accurate and that the proportion identified is high enough to provide a good sample, but not so high as to exclude all but the most exceptional observers. We recommend, as a rule of thumb, that observers be able to identify to species at least 90% of migrating raptors at the site on any given day. As noted in the previous section, counts will be more consistent if exceptionally skilled observers share or rotate duties with other observers. When possible, watchsites should provide training opportunities to ensure a good supply of future counters. Allowable optical equipment and its use also should be standardized. Typically, hawk watches call for use of binoculars with ≤10× magnification for scanning and most identification, whereas telescopes should be used only to verify identification of and count individuals that already have been detected. Watchsites also should strive for consistency in the quality of optical equipment used.

What to Record

Instructions should stress that every raptor detected should be reported, even if it is not identified. There are techniques for including unidentified individuals in analyses, and if they are not reported, volume of migration will be underestimated. Daily report forms should include options for reporting numbers of unidentified falcons, accipiters, buteos, eagles, kites, vultures, and raptors, as appropriate for the site.

Observers should be given clear guidelines for excluding from counts birds that are not migrating past the site (local residents, or migrants that are milling around rather than moving past steadily). One way to do this is to tally only those individuals moving past some fixed reference point along the direction of expected migratory flow. At watchsites where large numbers of migrants may turn back after appearing to move past the site (as occurs at some sites at the edge of water barriers), it may be best to make counts of birds moving past the reference point in the direction opposite to the main migratory flow. Although hourly counts recorded on official data sheets may be the difference between these two figures, field tallies of the original numbers passing in each direction should also be retained. These data are interesting in themselves for research purposes, and analysts looking at population trends may wish to treat the data differently than has been recorded in hourly totals. If this is done, there should be a separate, dated tally sheet, designed for easy and unambiguous recording of the numbers going in each direction each hour.

Age and sex of raptors can be determined in some species, and such data are valuable for interpreting population trends and for research. Because age and sex classes may differ in timing of migration, samples should be taken at regular intervals throughout the season. In some circumstances, every individual of a species may be aged and sexed. For species that are more difficult to identify or more abundant, instructions might call for age, sex, or both to be recorded only during special, short-term counts, such as for 10 min each hour, or for one particular hour of the day or day of the week. These special tallies should be conducted on a regular schedule throughout the season (e.g., daily or every second day).

When numbers of migrants are too high for exact counts, clear instructions should be given to counters on how to record estimated numbers, such as counting small groups of estimated size instead of individuals (e.g., count groups of about 5 or 10). Hand-held tally devices help in rapidly counting large numbers. When an estimation is very inexact, observers keeping field notes should not record the lowest possible number (e.g., "100+") but should record the probable range (100–150). When tallies are added to produce the official hourly total, use the middle point of each probable range (e.g., 125 for a range of 100–150, or 300 for a range of 100–500).

At some watchsites, regular passage of diurnal migrants other than raptors—such as waterbirds, various small birds (e.g., hummingbirds, jays, finches, swallows) or even dragonflies and butterflies—may occur. Some of these species may be regular and abundant enough for trend analysis. If organizers want these data collected, they should select species that can be easily identified and counted without distracting from raptor counts, provide instructions to observers, and add the species to the field data sheets. Better yet, recruit additional observers to count non-raptor migrants.

It greatly aids analysts if daily weather variables are recorded at the site and are included as part of the database. Important weather variables include wind speed and direction, precipitation type and duration, cloud cover, visibility, barometric pressure, and temperature. Daily report forms should provide for entry of the required data. Instructions should indicate when measurements should be taken (e.g., many sites do this at the start of each hour) and should clearly specify equipment and procedures to be used.

Watchsite Location

The locations of most watchsites are selected because they are accessible and are known to have good raptor flights. That said, it will be easier to sustain observations over many years if other factors also are considered before a watchsite is established. The recommended minimum duration for contributing to trend analysis is 10 years (Hussell and Ralph 2005). Assurance of long-term access by counters is an important attribute, and count organizers should negotiate long-term access agreements with public and private landowners. Sites that are relatively close to populated areas and readily accessible to counters will be more likely to have a steady supply of volunteer personnel, which contributes to sustainability. Remote sites may be needed to ensure adequate regional sampling of migrant populations, but it is more likely that personnel will have to be hired and accommodations provided to ensure long-term coverage.

At many sites, flights can be observed from multiple lookouts, and it is important to fix the official lookout location once it has been selected, even though more birds may be seen on certain days from a different viewing site. To promote long-term consistency of counts, factors to consider in selecting an official watchsite should include the following:

- The field of vision should be such that growth of vegetation near the viewing point will not obscure the view over time. Building an observation tower when the watchsite is established can help reduce this concern.
- It should be possible to control visitors from distracting official counters and to avoid extra people contributing to the count. An observation tower or platform for official counters may be useful for this purpose.
- The site should have adequate room for safe and comfortable seating for observers.

Number of Official Lookouts at a Given Watchsite

Some watchsites have several observation points from which counts could be made. There are two sets of circumstances in which multiple lookouts can be used as part of the standard protocol.

One involves the case in which the birds counted at each lookout are fairly certain to be different individuals. Assuming that sufficient personnel are available, each lookout can be operated as an independent watchsite, with each following its own standardized protocols (which can differ between lookouts) for daily coverage. Data from these sites can be analyzed separately or combined for a pooled, multiple-site analysis. The data from each site are equally valuable for trend analysis, regardless of relative numbers of migrants detected. If there are not enough personnel to cover both sites according to recommended standard protocols, one of the lookouts should be selected as the site of the official count, and any secondary lookout should be staffed as an optional extra when there are personnel available. Data collected at optionally-covered secondary lookouts will be unsuitable for trend analysis. Personnel should understand this, and staffing of secondary lookouts must not diminish coverage at the official vantage point.

A second circumstance involving multiple lookouts occurs when a significant proportion of the birds counted at each of two observation points is likely to be seen from both points. In this case, double-counting should be minimized by establishing a dividing line, with personnel at each point recording only those birds on their side of the line. The task is made easier by choosing a line marked by physical features visible from both observation points. Once established, the line should not be altered. If desired, counters can communicate by radio to discuss who should count individual birds close to the dividing line. This technique, if used, must be part of the standard protocol of the watchsite and must not be used intermittently.

At several existing watchsites, one of two observation points is used on each count day, the choice of which point to use depending on weather (mainly wind direction). This is not a recommended procedure, and counts from such sites may be unacceptable for analysis of long-term trends.

Whenever there are sufficient personnel to staff more than one observation point, consideration should be given to setting up a new, more distant site, rather than adding another site close by. Doing so will contribute more to understanding of regional population change.

Field Protocols

A key factor in ensuring consistency is to have a carefully written protocol with complete instructions on how the counts are to be conducted at the particular site. It is best to keep this separate from other materials that are provided to counters. For example, if trapping and banding takes place at the station, there should be a separate protocol for each aspect of the operation (see Ralph et al. 2004 for recommendations on running a trapping operation for the purpose of population monitoring). Similarly, detailed information on identification tips (species, age, sex, morphs) and other general information on hawk watching unrelated to the specific site, and procedures for observer training, should be put in separate documents. Separating materials will help focus the attention of the reader on the important aspects of the topic at hand (i.e., maintaining consistency of methods at a particular watchsite), rather than on other items of importance (e.g., personal safety, how to band trapped raptors, etc.).

The overarching goal is to have a document that can be given to a qualified hawk counter who has never visited the site, with instructions complete enough to ensure that, without further guidance, that person can conduct counts consistent with all previous work.

A good protocol document should contain the following elements:

- A brief statement of the purpose of the watchsite, emphasizing the need to adhere to standards laid out in the manual to ensure that the counts can be used for trend analysis.
- Location (including precise geographic coordinates and photographs) and instructions for getting to the site.
- A map of the watchsite (with indication of scale and direction of north) showing the exact location of the official lookout(s) and identifying common landmarks and distances to those landmarks used in quantifying visibility or communicating among observers about the location of migrants.
- Details regarding dates of operation.

- Start and end time of the standard daily count period (specifying time zone and daylight or standard time), and instructions for reporting time (with all details) on each daily report form (e.g., 9 a.m. EDT, or 0900 EDT).
- Instructions for recording data collected outside of standard periods.
- Number and required skill of observers.
- Instructions and schedules for rotating observers.
- What species should be counted (including non-raptors), and guidelines for dealing with probable nonmigrating individuals.
- When and for which species to record age, sex, and color morphs.
- If useful as an aid to observers, brief descriptions of standard flight lines and behavioral patterns of migrants passing through the site, emphasizing variations in relation to different wind and other weather conditions (place in separate document or in an appendix if lengthy).
- Instructions on recording estimated numbers (place in a separate document or in an appendix if lengthy).
- Instructions for filling in all data forms, with quick reference keys to all codes used.
- Instructions for collecting and recording ancillary data, such as weather variables, rare-species reports, height of migration, etc.
- Guidelines for interrupting or ending counts before the standard period is completed, for determining when it is acceptable to skip complete days of observation, and how to report gaps (regardless of length or cause) on daily report forms.
- Required and allowed equipment, including that used for recording weather.
- Instructions on how to reduce visitor impacts on counts.

In an appendix or separate document, add brief miscellaneous instructions, such as where to park at the site, location of nearest restrooms, emergency numbers, what personal items to bring, where to get data forms and what to do with them after the count, duties of observers with respect to site-maintenance, and general safety and injury procedures. Each year, a copy of the field protocol should be labeled with the year and safely stored as a record of the way the operation was run that year. Any changes to protocols or instructions (see below) should be added immediately to the written document, not only to keep observers abreast of change, but also to ensure that there is a complete annual record as to how the station was operated. Analysts working with decades-old data usually have no other way to learn how the counts were conducted. Data on changes at the site, such as periodic dated photographs showing the view in 360º from the lookout(s), are also helpful to analysts.

Changes to Protocols

On occasion, there may be a good reason or an unavoidable need to change the protocol; for example, if the lookout has become untenable and must be moved, if a tower is needed to reduce visitor interference, or if there is a need to increase or decrease the number of people working together on official counts. Such changes can seriously compromise the value of the data set for long-term monitoring, effectively ending one data series and starting a new one.

To ensure that pre- and post-change data can be combined as a single, long-term data set, it is essential that the old and new protocols be used on alternate days (or, better yet, run simultaneously) for at least one and preferably for two or three seasons. If the two protocols are run simultaneously, great care must be taken to ensure that the data are collected independently by the two procedures (i.e., each protocol should be run as though the other were not being done, and without communication among personnel involved in each). Each count form must have a notation on which protocol was used for collecting the data recorded there. Using this phase-in procedure allows the effect of the protocol change to be modeled in analyses, which allows the population signal to be separated from the effect of the change in methods.

Field Forms

In addition to having instructions in a written protocol, it is important that data forms be unambiguous, so that observers will not vary in what they record. This is yet another factor that contributes to consistency in the data set. Keys to codes used for recording weather or other extra data, estimated numbers, etc., should be printed on the forms or on a weather-proof page for posting at the field site.

Conclusions

No watchsite can run a program that will be perfectly free of variation in effort and observer skill. However, it is quite feasible to collect data in a standardized, consistent manner that will greatly increase the value of the data for tracking population change and contributing to research and conservation objectives. Doing so can enhance the satisfaction of participants, whose pleasure comes not only from observing raptor migration, but from knowing that their extensive time commitment and careful recording has produced data that can be put to good use.

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Glossary

***Accipiter*.**—A genus of ~50 largely forest-dwelling species of diurnal raptors, most of which have short, rounded wings and long tails.

Age-structured population.—A population in which birth and death rates vary as functions of the age of the individual.

Altitudinal migration.—Occurs when migrants shuttle between high-altitude breeding areas and low-altitude wintering areas.

Apparently secure.—Uncommon but not rare; some cause for long-term concern due to declines or other factors (www.natureserve.org).

Bird Conservation Region (BCR).—Ecologically distinct regions in North America having similar bird communities, habitats, and resource-management issues. BCRs were developed by a team comprising members from the United States, Mexico, and Canada at the first international North American Bird Conservation Initiative (NABCI) workshop held in Puebla, Mexico, in 1998 (for details, see www.nabci-us.org).

BCR (Bird Conservation Region) species of concern.—Species that, without additional conservation actions, are likely to become candidates for listing under the U.S. Endangered Species Act.

Breeding Bird Survey (BBS).—A continent-wide, breeding-bird population monitoring system developed and administered by the U.S. Geological Survey Patuxent Wildlife Research Center in Laurel, Maryland. The North American Breeding Bird Survey (BBS) began in 1966 when ~600 surveys were conducted in the United States and Canada east of the Mississippi River. Today there are ~3,700 active BBS routes in the continental United States and Canada, of which ~2,900 are surveyed annually. Survey routes are 24.5 miles (92.2 km) long with 50 stops at 0.5-mile intervals. A 3-min point count is conducted at each stop, during which the observer records all birds heard or seen within 0.25 mile of the stop. Routes are randomly located to sample habitats that are representative of the entire region. Other requirements, such as consistent methodology and observer expertise, visiting the same stops each year, and conducting surveys under suitable weather conditions, are necessary to produce comparable data over time. A large sample size (number of routes) is needed to average local variations and reduce the effects of sampling error. The density of BBS routes varies considerably across the continent, reflecting regional densities of skilled birders.

Broad front migration.—Dispersed migration in which individual migrants travel with little if any deviation from their preferred directions (i.e., are largely unaffected by geographic features such as mountain ranges and coastlines). Compare with *narrow front migration*.

Broad frontal migrant.—A raptor that engages in *broad front* migration.

Buteo.—A genus of 28 species of largely open-habitat diurnal raptors with long, broad wings and short tails.

Catchment area.—The geographic area from which migrants at a watchsite are migrating. Different watchsites draw migrants from different catchment areas.

Chain migration.—Occurs when migratory populations that breed at high latitudes migrate approximately the same distance as those that breed at lower latitudes, thereby maintaining their latitudinal relationship between seasons. Compare with *leap-frog migration*.

Christmas Bird Count (CBC).—A winter monitoring program for birds in North America, administered by the National Audubon Society. Each CBC consists of a "count circle," 15 miles (24 km) in diameter, within which teams of observers count birds on a single day between December 14th and January 5th each year. The CBC began on Christmas Day 1900, when ornithologist Frank Chapman proposed the count as a new holiday tradition.

Coefficient of variation.—A measure of the variation within a population calculated as the standard deviation of the population expressed as the percentage of the mean.

Complete migrant.—A species or population in which at least 90% of all individuals regularly migrate. A species or population, not an individual, characteristic. Compare with *irruptive migrant* and *partial migrant.*

Confidence interval (CI).—A range of values set to include the parameter being estimated a given percentage (usually 95%) of the time.

Count population.—The number of birds potentially countable at a watchsite.

Critically imperiled.—At very high risk of extinction due to extreme rarity, very steep population declines, or other factors (www.natureserve.org).

Delayed return migration.—Occurs when juvenile raptors remain on their wintering grounds during their entire second and, in some instances, third year before returning to the breeding grounds in their third or fourth year. Delayed return migration often occurs in species with delayed maturation. The phenomenon is believed to save subadults the expense of migration and to eliminate competition with adults during the breeding season.

Differential migration.—Age- or sex-related differences in one or more aspects of migration behavior, including direction or speed of travel, distance traveled, and timing of departure, etc.

Diurnal.—Active primarily during daylight hours.

Diversion line.—A geographic or topographic feature, including mountain ranges, bodies of water, and deserts, that causes migrants to alter their course to avoid the feature, and in so doing concentrates them. Compare with *leading line*.

DDT (dichlorodiphenyltrichloroethane).—A synthetic organochlorine insecticide, once widely used in agriculture and human-disease control. A persistent, broad-spectrum compound often termed a "miracle" pesticide, DDT came into widespread use in the late 1940s. DDT was banned in many countries, including Canada and the United States, in the early 1970s when it was found to be a contaminant in human body tissue and in many ecosystems globally. DDT negatively affects the reproductive success of birds, including raptors, by disrupting a female's ability to produce sufficient eggshell material for her eggs. See also http://www.atsdr.cdc.gov/tfacts35.html

Endangered.—In danger of extinction throughout all or a significant portion of the species' range (U.S. Fish and Wildlife Service).

Extirpated.—Eliminated from a portion of its range.

Falco.—A genus of 37 diurnal raptors with long, pointed wings and long tails.

Geometric mean.—Smaller than or equal to the arithmetic mean, the geometric mean is calculated as the *n*th root of product of *n* members of the data set. The geometric mean equals the arithmetic mean only when all values in the data set are equal.

Hypothesis compatibility.—A process in which a favored, *a priori*, hypothesis is made compatible with available evidence, often with the use of additional, *ad hoc*, assumptions. Inferior to *hypothesis testing*.

Hypothesis testing.—A process in which two or more alternative hypotheses (i.e., working explanations) are "tested" via a series of observable predictions associated with each hypothesis.

Imperiled.—At high risk of extinction due to very restricted range, very few geographic populations, steep declines, or other factors (www.natureserve.org).

Irruptive migrant.—Species or populations in which the extent of migratory movement varies annually, typically due to among-year shifts in prey abundance, and whose migrations are less regular than those of *partial migrant* and *complete migrant*.

Leading line.—Geographic or topographic features, including mountain ranges and river systems, that intersect the principal axis of migration of a region, and that attract and channel migrants, thereby concentrating them during their migrations. Compare with *diversion line*.

Leap-frog migration.—Occurs when migratory populations that breed at high latitudes migrate substantially farther and "leap over" non-migratory and, sometimes, migratory populations that breed at lower latitudes, thereby reversing their latitudinal relationships between seasons. Compare with *chain migration*.

Local migrant.—A species in which most populations, except those at the latitudinal periphery of the range, do not migrate.

Long-distance migrant.—A species in which at least 20% of all individuals regularly migrate >1,500 miles (2,400 km).

Loop migration.—Occurs when outbound and return migrations differ longitudinally with latitude. In the northern hemisphere, loop migration typically produces clockwise movements, with returning migrants traveling west of where they had traveled south during outbound migration. Loop or "elliptical" migration often results from greater wind drift during the early stages of outbound and return migration, coupled with greater compensatory movements later in the journey.

Mean.—A measure of the central location of a data set, computed by summing values in the data set and dividing them by the number of values. Compare with *median*.

Median.—A measure of the central location of a data set, computed as the value in an ordered array from smallest to largest, that splits the data set into two equal groups. Compare with *mean*.

Migrating population.—The portion of the *monitored population* that migrates past the count site on a particular day. The migrating population is not a constant proportion of the monitored population (i.e., the number of hawks from the monitored population that moves past the count site on any given day is not constant, because migration proceeds in uneven pulses in response to weather conditions and seasonal phenology).

Migration.—Directed movements from one location to another, recurring seasonally and alternating in direction.

Migration count.—The total number of raptors counted at a watchsite seasonally. Typically recorded hourly within each day. The migration count is the subset of individuals from the *count population* that actually is detected and recorded.

Migration flyway (or corridor).—Pathways of travel along which raptors concentrate while migrating.

Monitored population.—The (usually unknown) portion of the *total population* of the species that normally (i.e., every year) migrates past the count site. The population of interest at migration watchsites.

Narrow front migration.—Migration in which initially dispersed migrants deviate from their initial directions, via either *leading lines* or *diversion lines*, or both, thereby geographically concentrating their movements.

Nomadic.—A roaming or wandering lifestyle. In birds, refers to species that move widely and episodically across their ranges in response to changing conditions.

Obligate soaring migrant.—Species that soar in flocks while migrating to conserve energy and, therefore, complete their journeys energetically more efficiently than if they had not soared.

Partial migrant.—Species or populations in which fewer than 90% of all individuals regularly migrate, whereas others do not. A species or population, not an individual, characteristic. Compare with *complete migrant* and *irruptive migrant*.

Population trend.—Geometric rate of change in a population over a defined period.

Principal axis of migration.—A straight compass heading or rhumb line between a bird's breeding and wintering areas. The principal axis of migration is the shortest route between breeding and winter areas only when those areas fall along a direct north–south axis. In all other cases a "great-circle route," in which a series of different regional principal axes of migration occurs, is the shortest path.

Raptor migration count.—A location (i.e., raptor migration watchsite) at which visible migrants are regularly and systematically counted and recorded.

Regionally complete migrant.—Species that are complete migrants in part of their range and partial migrants elsewhere. Examples include Golden Eagle and Merlin in eastern North America.

Regional monitored population.—A regional population that is monitored at several, closely spaced watchsites.

Secure.—Common; widespread and abundant (www.natureserve.org).

Short stopping.—A phenomenon, first described in migratory waterfowl, that occurs when migrants shorten the lengths of their outbound movements to take advantage of newly available wintering areas that are closer to their breeding grounds than their traditional wintering areas.

Slope soaring.—Soaring in updrafts created when horizontal winds strike and are deflected over mountains and mountain ridges.

Statistically significant.—A population *trend* is considered statistically significant if there is a high level of confidence that the size of the population has changed. *P*-values associated with trend estimates report the probability of statistical significance (i.e., that the trend is not zero). The smaller the *P*-value, the greater the likelihood of statistical significance. For example, $P \leq 0.001$ means the chance that the true annual trend equals 0% is <0.1%. Therefore, our confidence in the trend is very high. Ecologists typically describe any result where $P \leq 0.05$ as statistically significant, but other levels (for example 0.10 or 0.01) are sometimes chosen, depending on the question being asked. In the raptor conservation status reports, any trend for which $P \leq 0.05$ is considered to be statistically significant.

Thermal.—A pocket of warm, rising air created by the differential heating of the earth's surface.

Thermal corridor, flyway, or pathway.—Migration routes that provide predictable thermals for soaring migrants.

Threatened.—Likely to become an endangered species within the foreseeable future throughout all or a significant portion of the species' range (U.S. Fish and Wildlife Service).

Total population.—The raptor population whose changes in size we wish to quantify.

Trajectory.—The pattern of change in population size over time.

Transect.—A series of two or more watchsites arranged perpendicular (or near perpendicular) to the principal axis of migration in a region used to assess the magnitude of migration there.

Trans-equatorial migrant.—Long-distance migrants at least 20% of whose populations migrate across the equator.

Trend.—The *geometric mean* rate of population change over the period of interest expressed as percentage change per year. If the trend in an index is linear, the geometric mean rate of change can be estimated by fitting a linear regression to the logarithm of the annual index.

Vulnerable.—At moderate risk of extinction due to a restricted range, relatively few geographic populations, recent and widespread declines, or other factors (www.natureserve.org).

West Nile virus.—A recently established virus that infects and can kill birds, including raptors, that has been linked to declines in some populations of birds. See http://www.cdc.gov/ncidod/dvbid/westnile/index.htm for additional details.

Wind drift.—Occurs when migrants encountering cross winds are pushed off of their intended course even while maintaining the same heading.