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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,

[1]*Acopian Center for Conservation Learning, Hawk Mountain Sanctuary, 410 Summer Valley Road, Orwigsburg, Pennsylvania 17961, USA. E-mail: goodrich@hawkmtn.org; and*
[2]*HawkWatch International, 2240 South 900 East, Salt Lake City, Utah 84106, USA.*

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–C). 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).

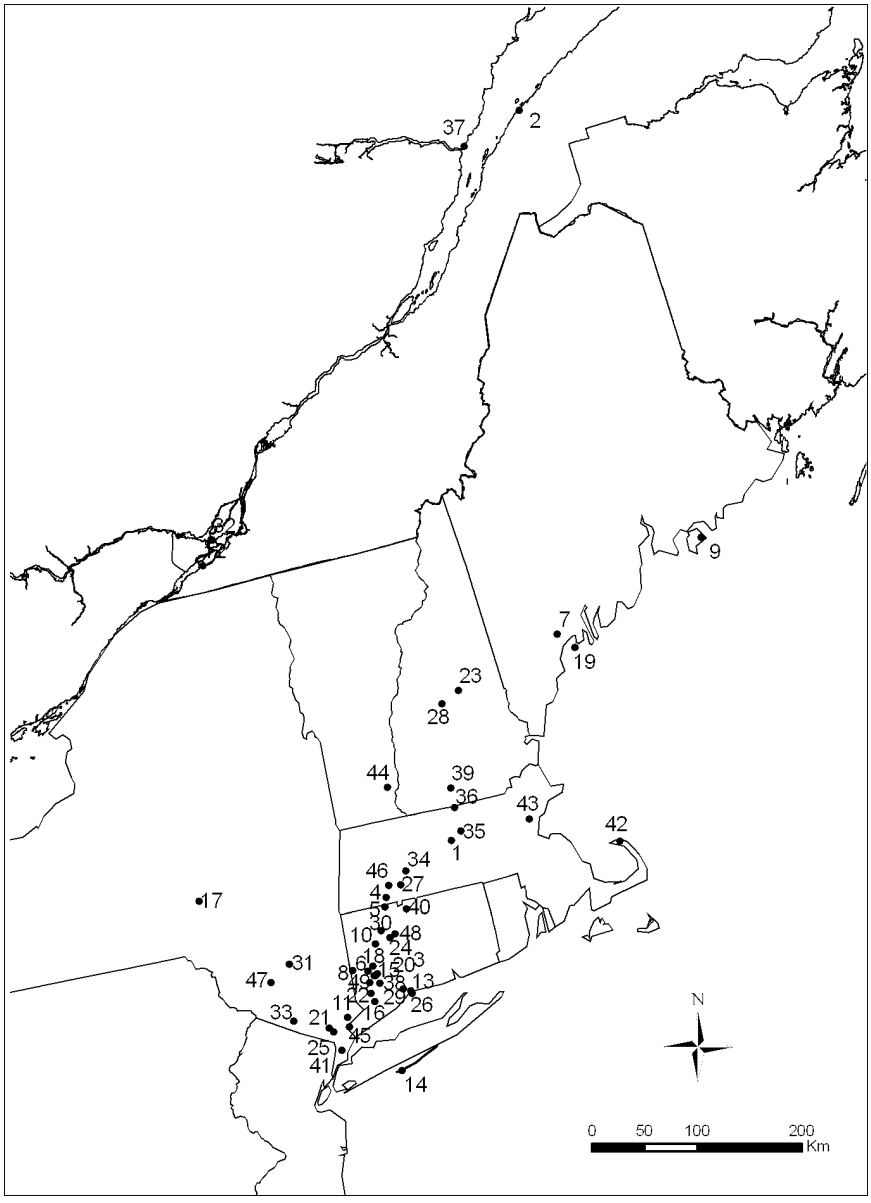

Fig. 1. (A) North American migration watchsites in the Eastern region of the continent (Atlantic corridor). Site numbers correspond to those listed by section in Table 1. *Figure 1 is continued on the following page.*

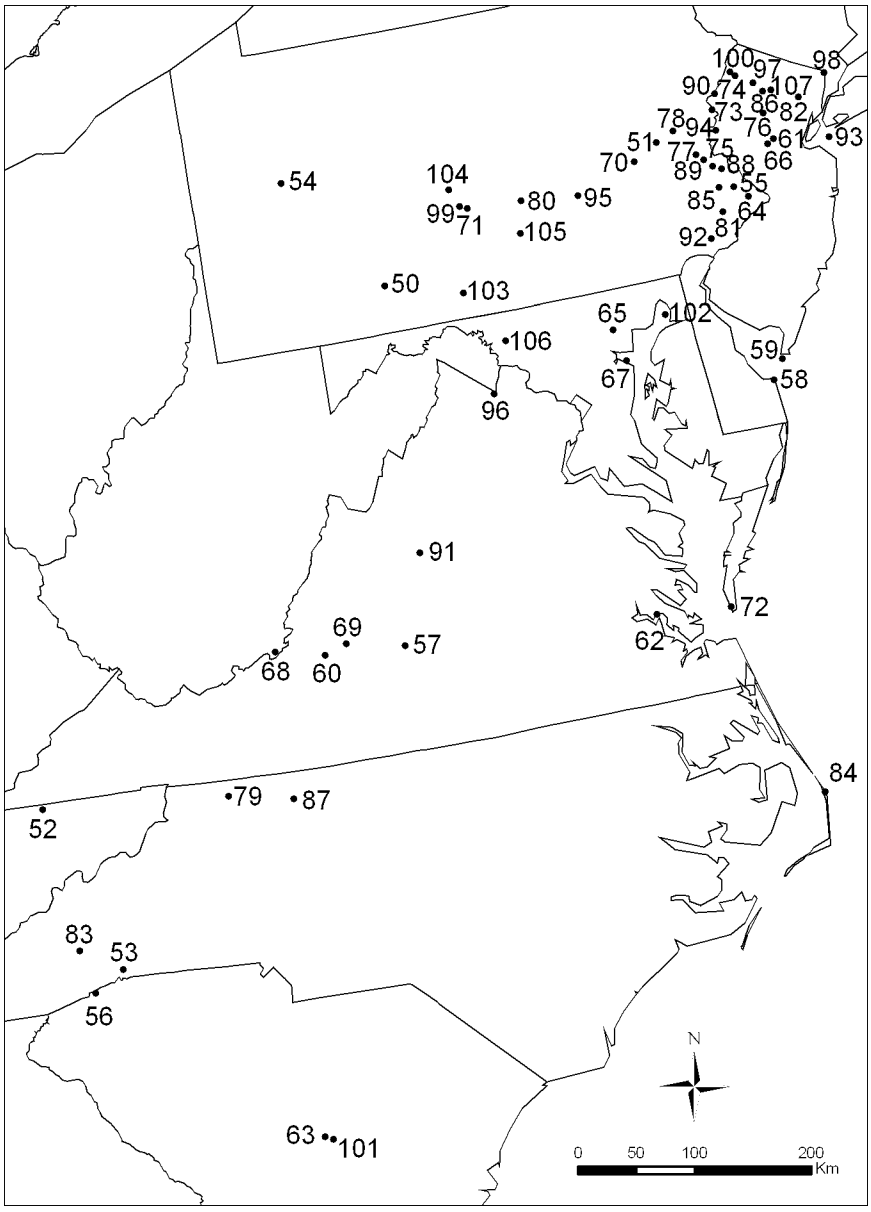

Fig. 1. (A) North American migration watchsites in the Eastern region of the continent (Appalachian corridor). Site numbers correspond to those listed by section in Table 1. *Figure 1 is continued on the following page.*

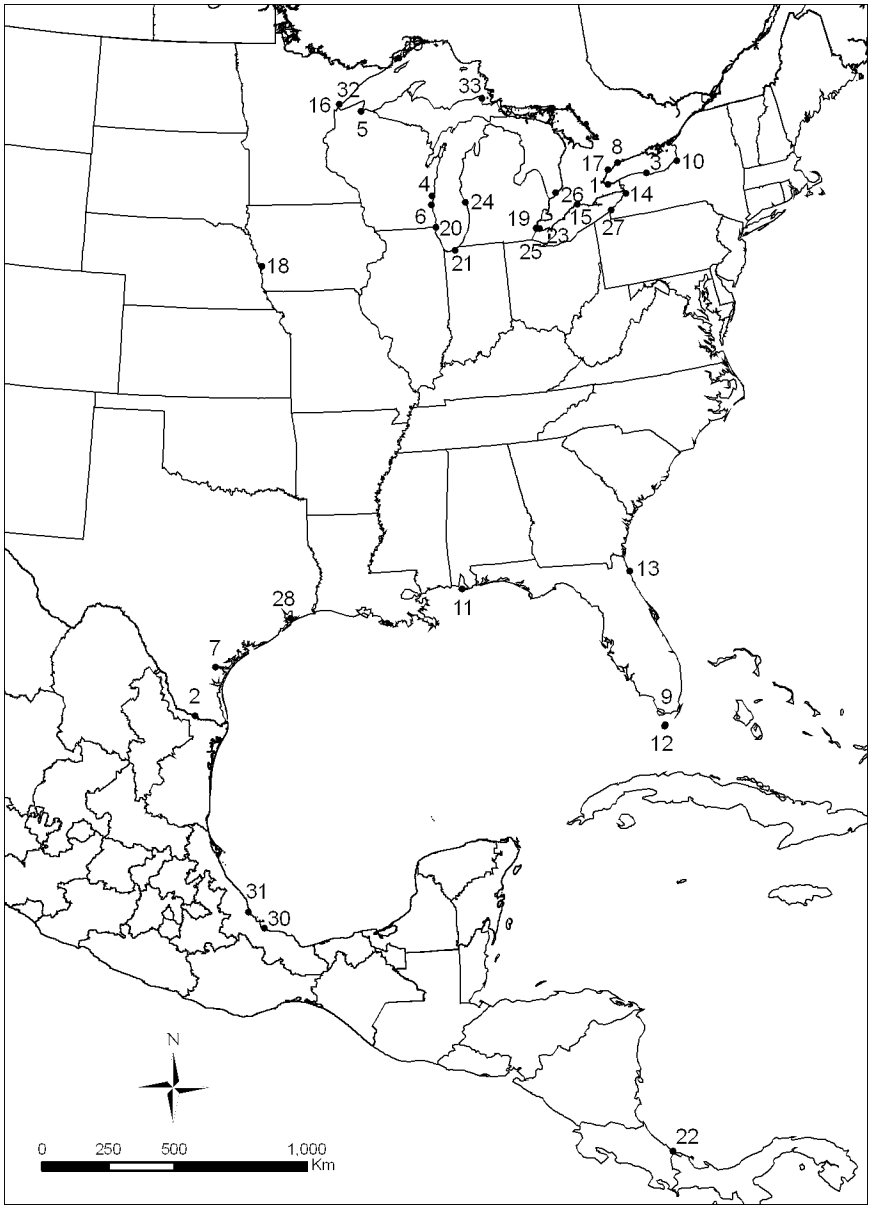

Fig. 1. (B) North American migration watchsites in the Central region of the continent. Site numbers correspond to those listed by section in Table 1 (Central region includes the Eastern and Western Great Lakes and Gulf Coast corridors). *Figure 1 is continued on the following page.*

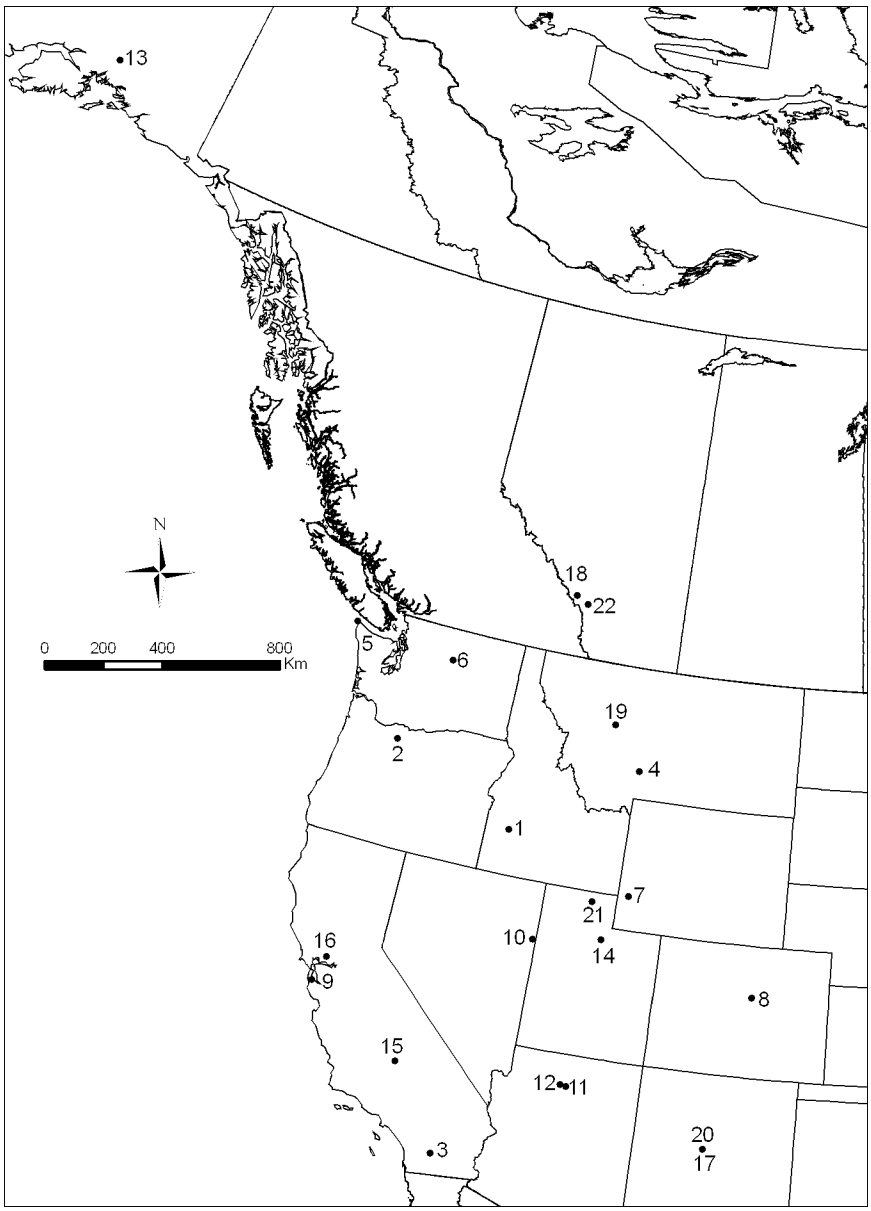

Fig. 1. (C) North American migration watchsites in the Western region of the continent. Site numbers correspond to those listed by section in Table 1 (the western region includes the Rocky Mountain, Intermountain, and Pacific Coast corridors).

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.

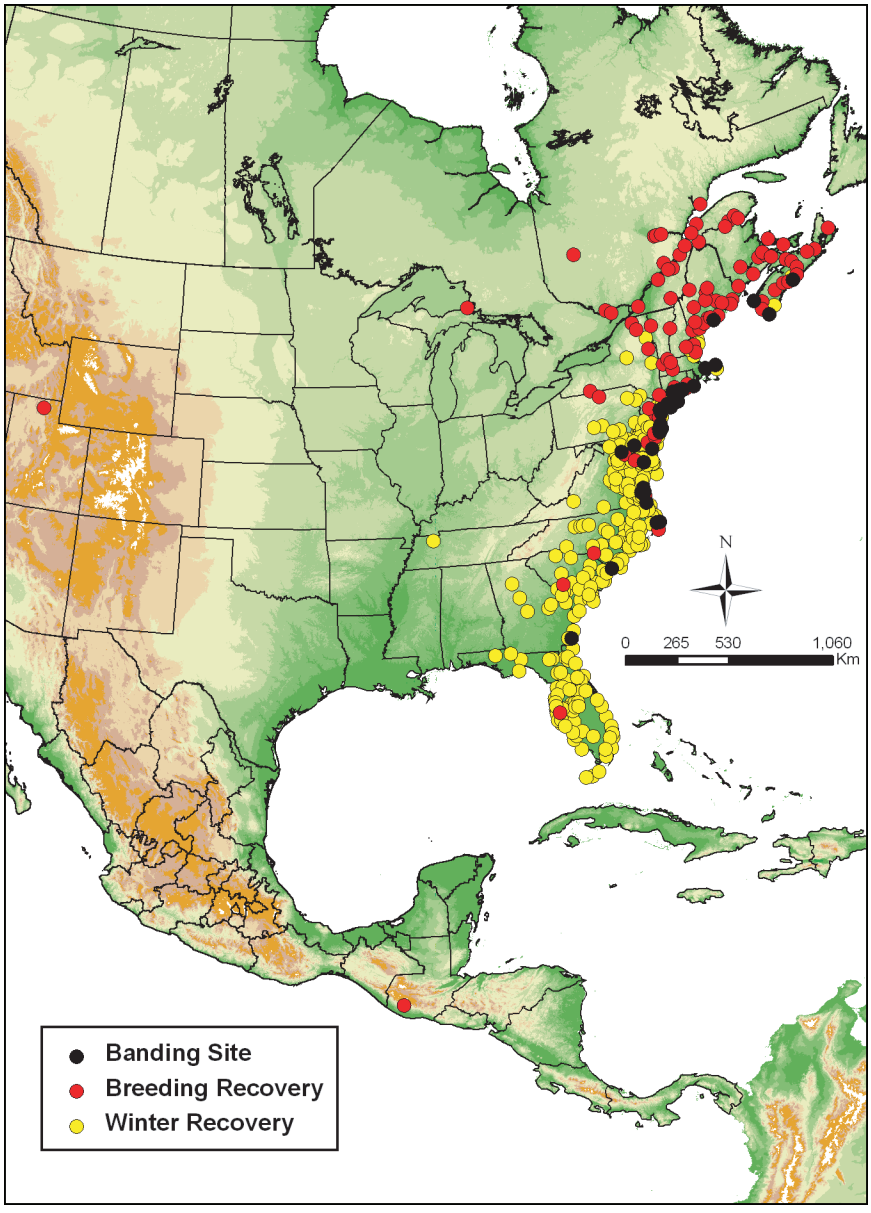

Fig. 2. (A) Breeding season and winter band recoveries of Sharp-shinned Hawks (*Accipiter striatus*) trapped during migration (1 September to 30 November) on the Atlantic Coast (red = breeding season: 15 May to 15 August; yellow = winter season: 15 December to 1 March; blue = banding sites). *Figure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

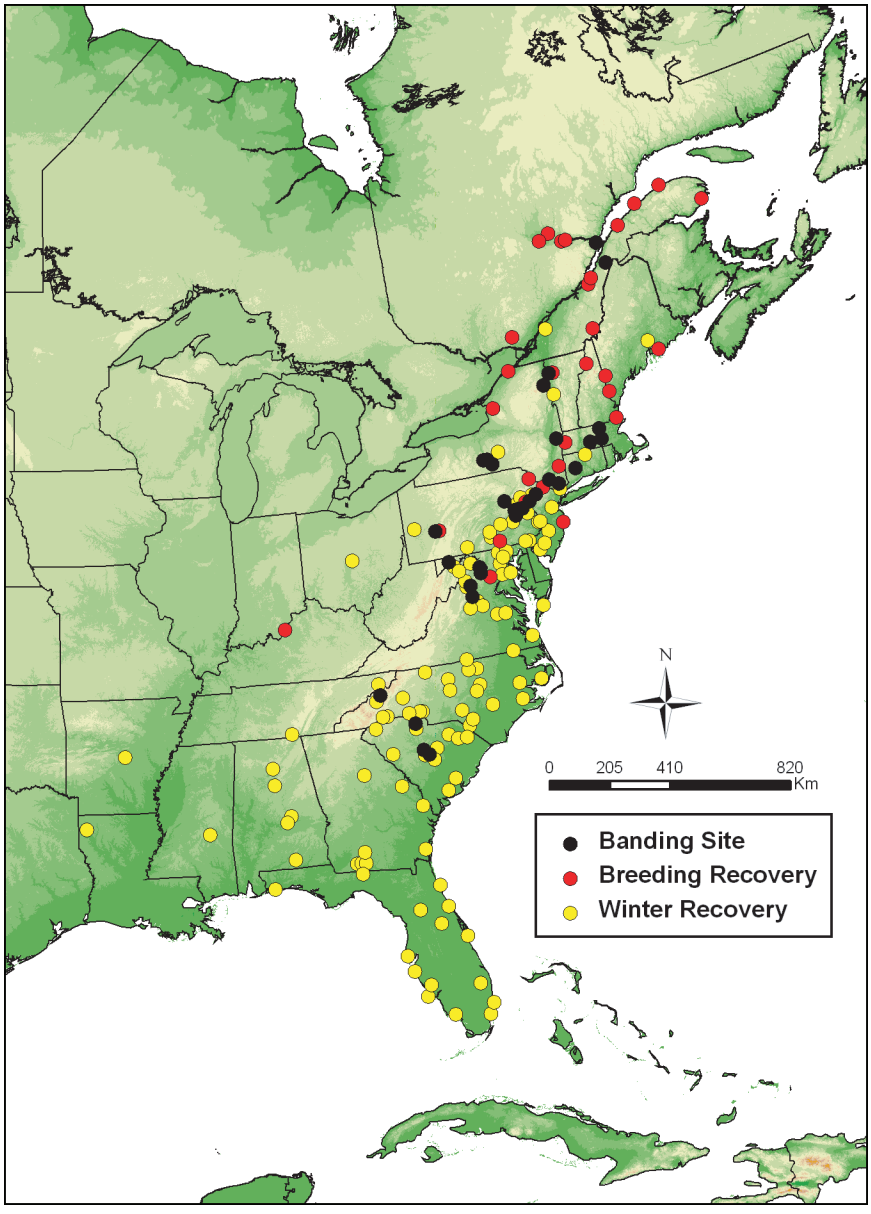

Fig. 2. (B) Breeding season and winter band recoveries of Sharp-shinned Hawks (*Accipiter striatus*) trapped during migration (1 September to 30 November) in the Appalachian Mountains (red = breeding season: 15 May to 15 August; yellow = winter season: 15 December to 1 March; blue = banding sites). *Figure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

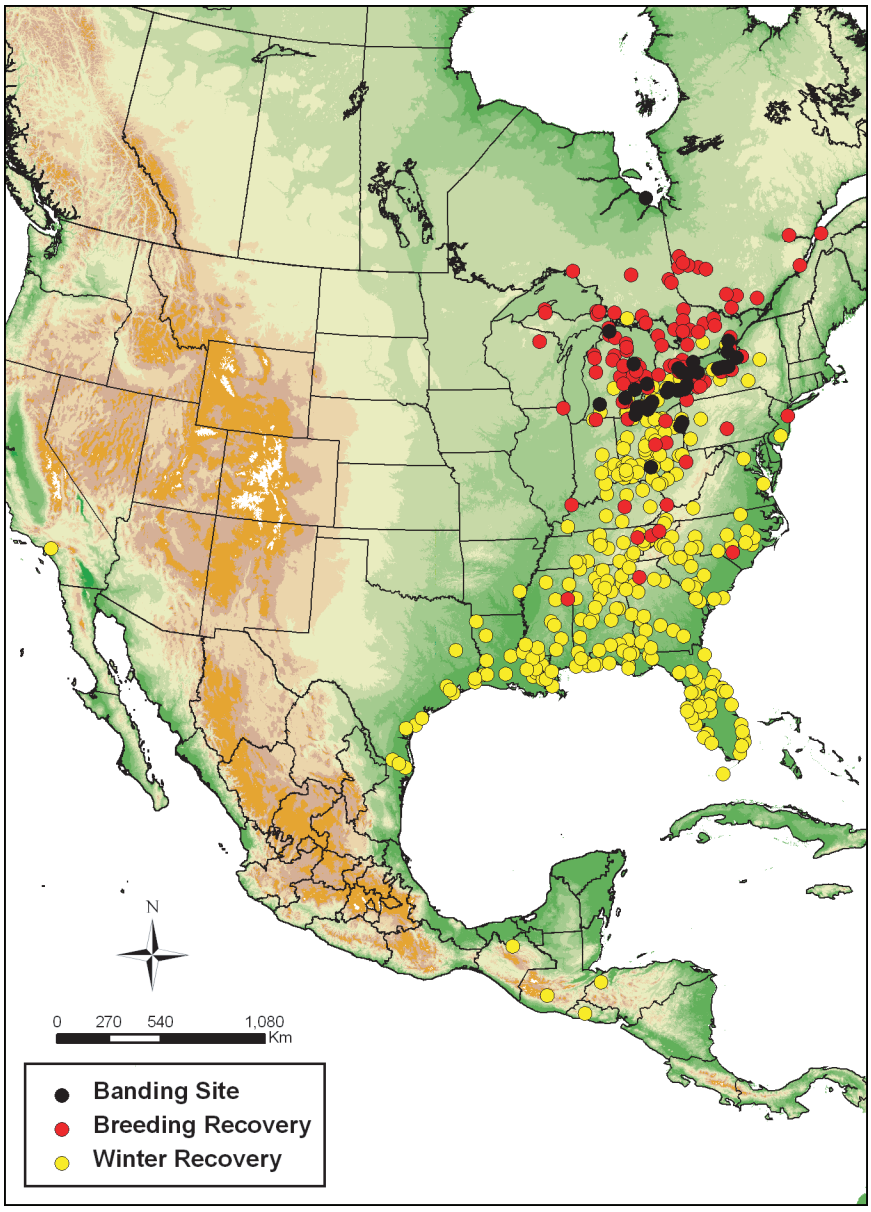

Fig. 2. (C) Breeding season and winter band recoveries of Sharp-shinned Hawks (*Accipiter striatus*) trapped during migration (1 September to 30 November) around the eastern Great Lakes (red = breeding season: 15 May to 15 August; yellow = winter season: 15 December to 1 March; blue = banding sites).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

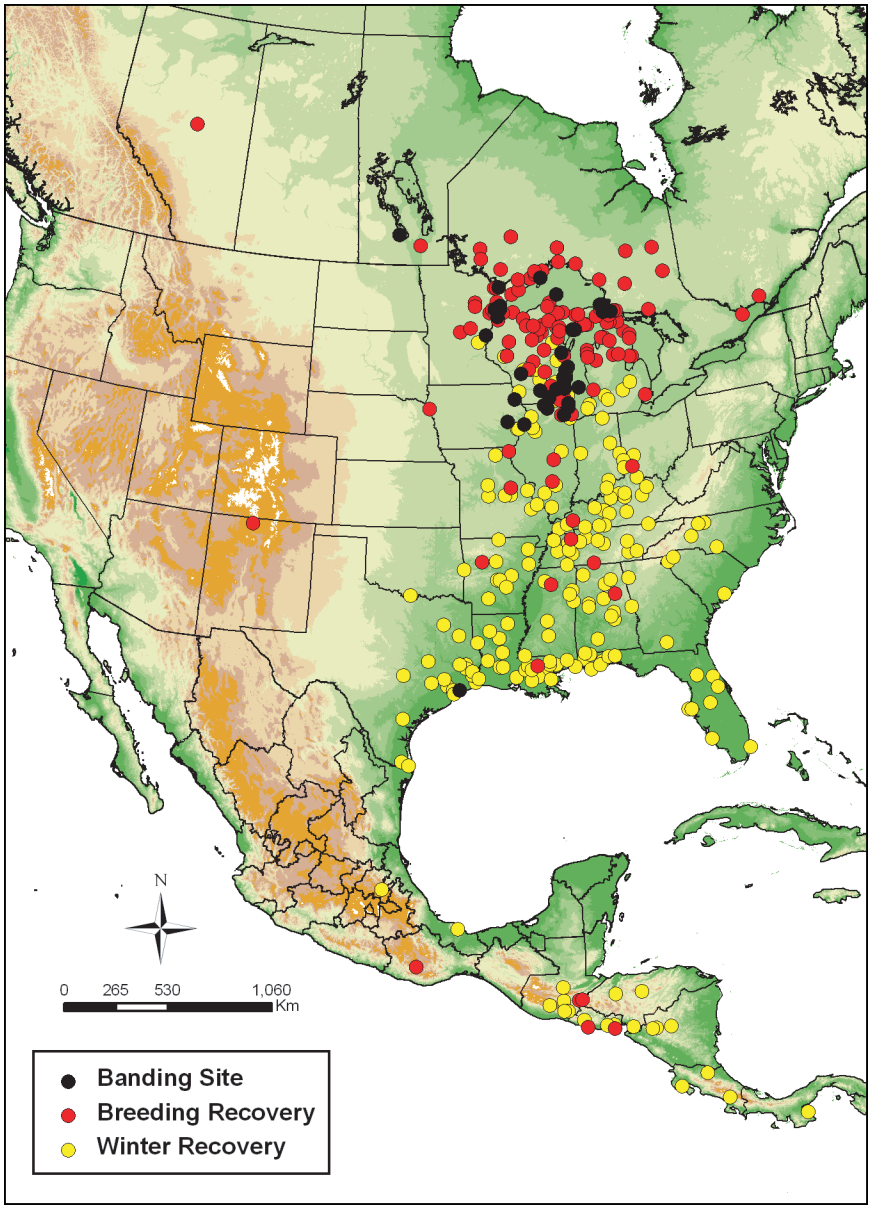

Fig. 2. (D) Breeding season and winter band recoveries of Sharp-shinned Hawks (*Accipiter striatus*) trapped during migration (1 September to 30 November) around the western Great Lakes (red = breeding season: 15 May to 15 August; yellow = winter season: 15 December to 1 March; blue = banding sites).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

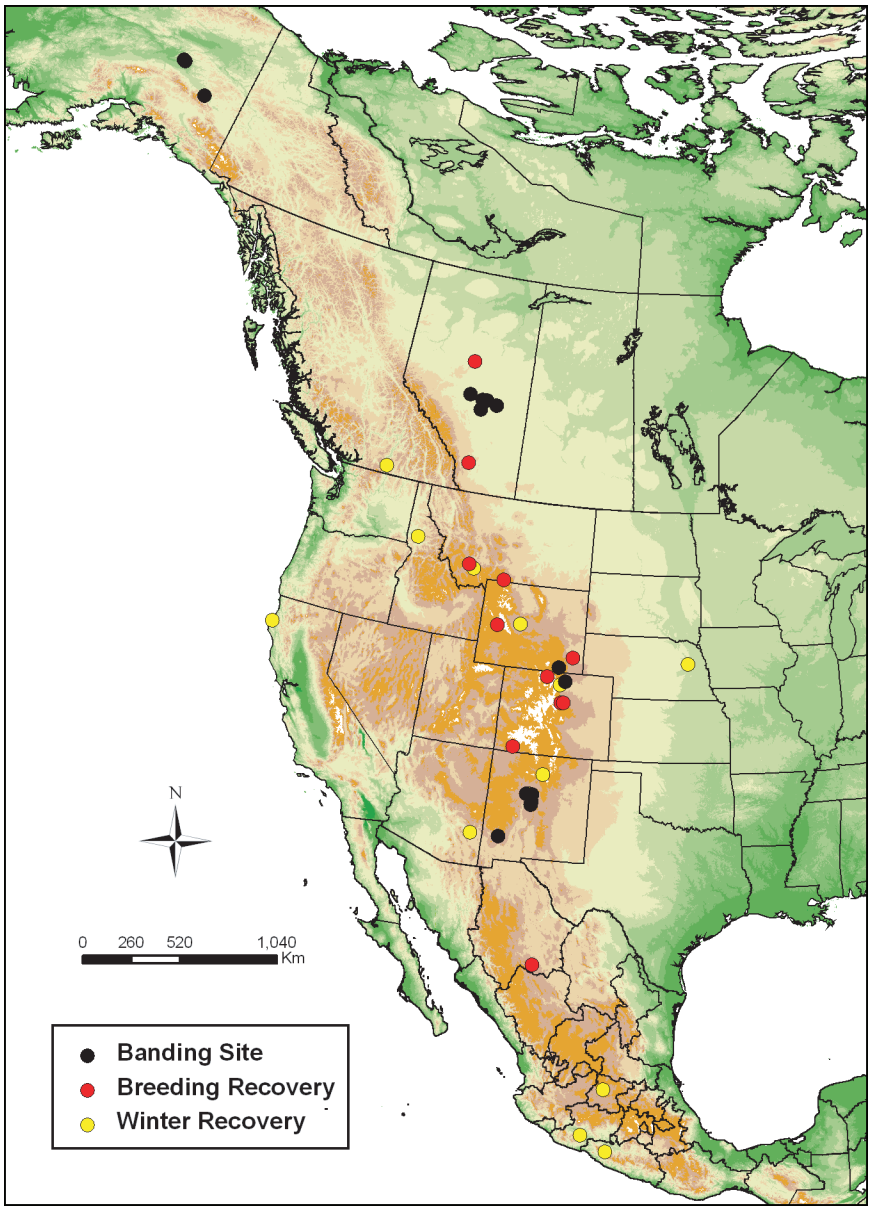

Fig. 2. (E) Breeding season and winter band recoveries of Sharp-shinned Hawks (*Accipiter striatus*) trapped during migration (1 September to 30 November) in the Rocky Mountains (red = breeding season: 15 May to 15 August; yellow = winter season: 15 December to 1 March; blue = banding sites). *Figure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

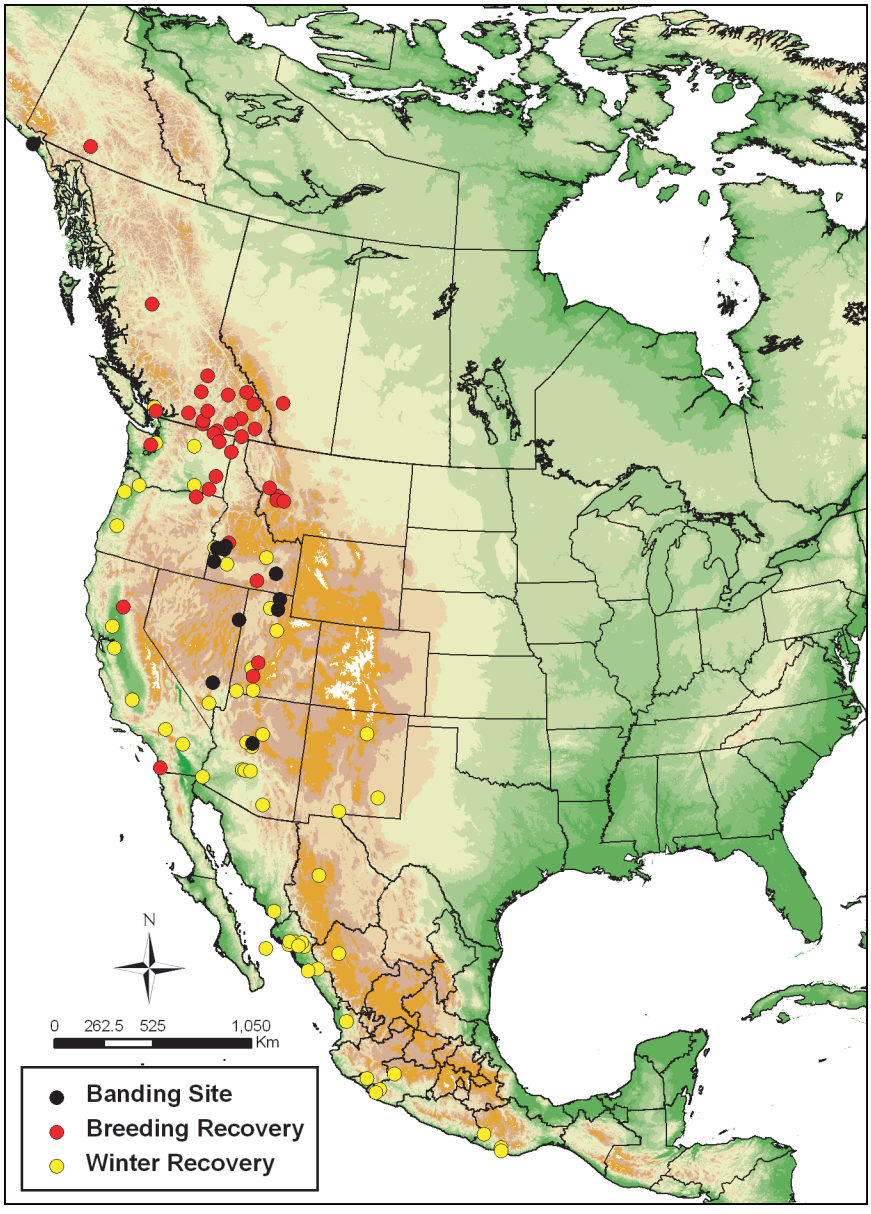

Fig. 2. (F) Breeding season and winter band recoveries of Sharp-shinned Hawks (*Accipiter striatus*) trapped during migration (1 September to 30 November) in the Intermountain West (red = breeding season: 15 May to 15 August; yellow = winter season: 15 December to 1 March; blue = banding sites). *Figure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

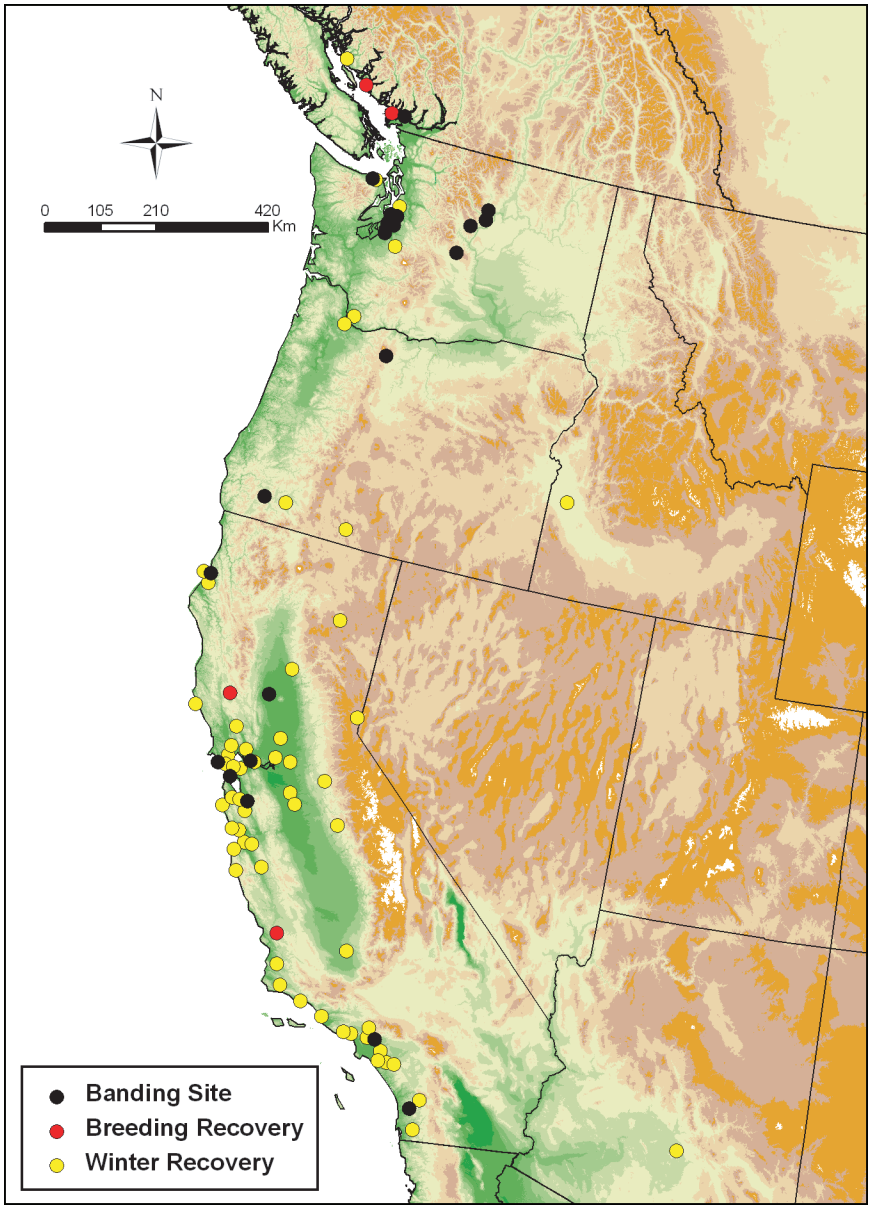

Fig. 2. (G) Breeding season and winter band recoveries of Sharp-shinned Hawks (*Accipiter striatus*) trapped during migration (1 September to 30 November) on the Pacific Coast (red = breeding season: 15 May to 15 August; yellow = winter season: 15 December to 1 March; blue = banding sites).

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

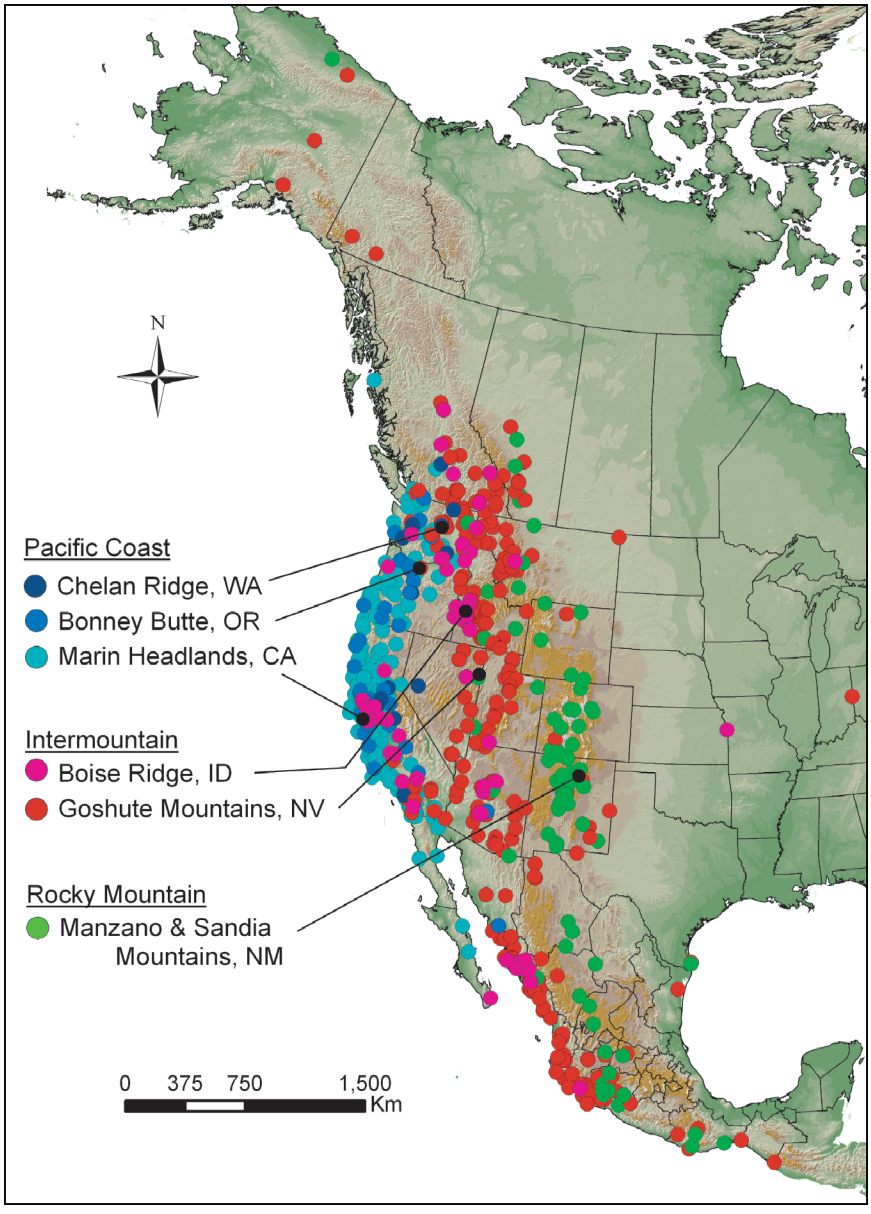

Fig. 3. Combined-species (primarily Sharp-shinned Hawks [*Accipiter striatus*], Cooper's Hawks [*A. cooperii*], Red-tailed Hawks [*Buteo jamaicensis*], and American Kestrels [*Falco sparverius*]) band-recovery patterns for six western raptor migration banding stations (1980–2006).

(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

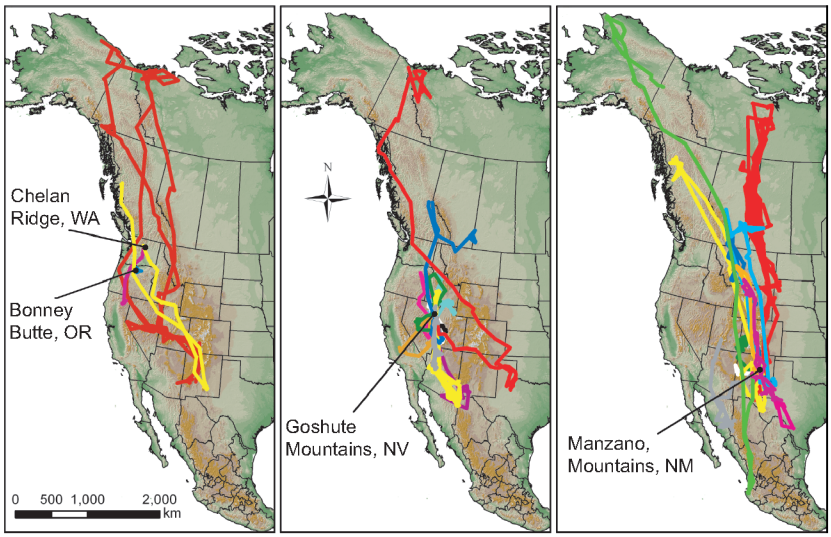

Fig. 4. Movements of immature and subadult Golden Eagles (*Aquila chrysaetos*) as determined by satellite tracking of birds outfitted at autumn migration-banding sites in Washington (n = 2), Oregon (n = 2), Nevada (n = 13), and New Mexico (n = 12) between 1999 and 2006. On each map, tracks of different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

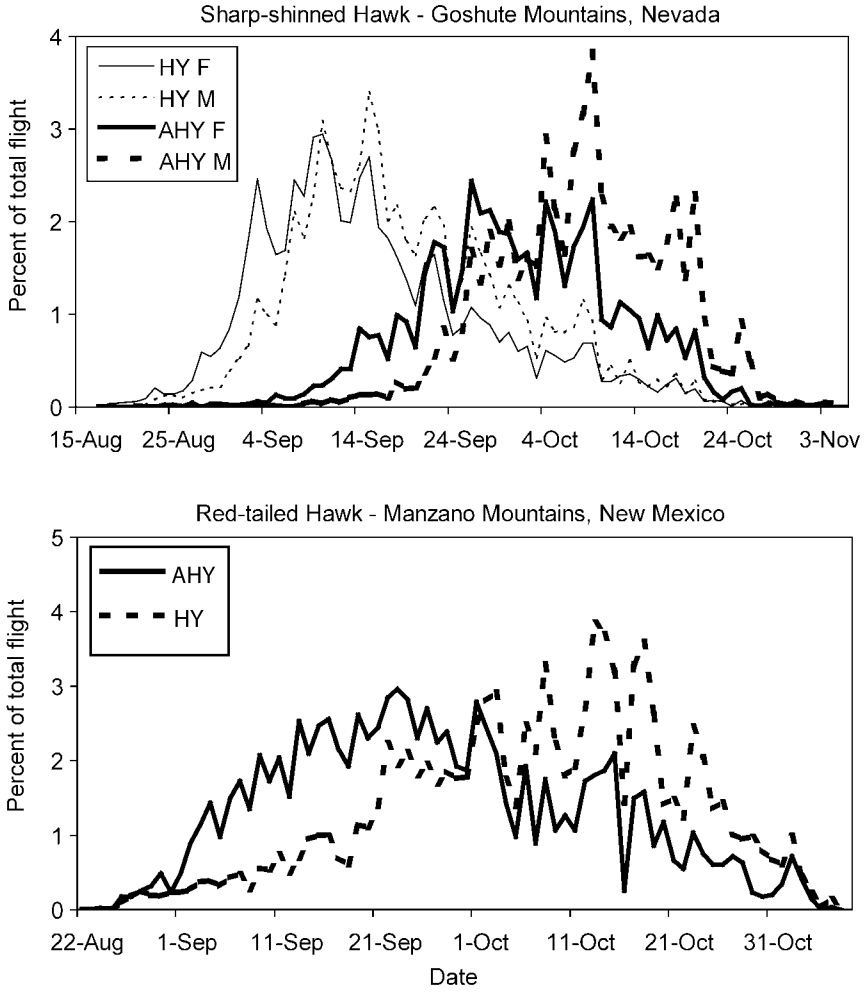

Fig. 5. Age-specific autumn passage patterns for Sharp-shinned Hawks (*Accipiter striatus*) in the Goshute Mountains, Nevada (based on aggregate capture data for 1990–2006), and for Red-tailed Hawks (*Buteo jamaicensis*) in the Manzano Mountains, New Mexico (based on aggregate count data for 1985–2006). 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 overwater 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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