MIGRATION AND WINTER RANGES OF FERRUGINOUS HAWKS FROM WASHINGTON

JAMES W. WATSON AND D. JOHN PIERCE.
Washington Department of Fish and Wildlife,
600 Capitol Way N., Olympia, Wash. 98501.

Progress Report
January 2000

Suggested Citation:
Watson, J. W., and D. J. Pierce. 2000. Migration and winter ranges of ferruginous hawks from Washington. Annual Report. Washington Department of Fish and Wildlife, Olympia, Washington, USA.

Abstract: In the spring of 1999, a study was initiated to investigate the migration and winter ranges of ferruginous hawks (*Buteo regalis*) that breed in Washington state. We attached satellite PTT's (platform transmitter terminals) to 9 adults and 1 nestling to monitor their long-range movements. All but 1 adult migrated across the continental divide in early fall and most hawks became localized in northwestern Montana/southeastern Alberta. Adult hawks remained at initial destinations 4 to 10 weeks. Proximal cause of migration was a high population of Richardson's ground squirrels (*Spermophilus richardsoni*) along the northern Rocky Mountain front. Straight-line mean distance of migration to early fall destinations was 616 km. Hawks made at least 1 additional major movement prior to October. Three hawks migrated to the plains of North Dakota, Nebraska, and Oklahoma. Ground visits identified hawk locations in towns of black-tailed prairie dogs (*Cynomys ludovicianus*). Four adults migrated back across the continental divide to California. Ground visits identified these hawk locations in association with colonies of California ground squirrels (*S. beecheyi*). The juvenile hawk followed the same route of her mother, but moved back and forth along the migration path and covered at least 3,168 km in 69 days. We confirmed 1 adult mortality, possibly from gunshot, and another adult mortality was suspected. Satellite monitoring will continue through spring, 2000, with plans to deploy at least 4 additional PTTs.

The ferruginous hawk (*Buteo regalis*) is a large, solitary raptor of the arid lands of the central plains and Great Basin that extend northwest to the remaining shrubsteppe habitat of eastern Washington. The ecology of this hawk, more than any other Buteo, is dependent on the native prairie ecosystems that are becoming increasingly rare and fragmented largely due to conversion to agriculture. In Washington, the decline in shrubsteppe mammals such as black-tailed jackrabbits (*Lepus californicus*) and the Washington ground squirrel (*Spermophilus washingtoni*) have likely contributed to the listing of the ferruginous hawk as a state Threatened Species. Only 25% of the 200 ferruginous hawk nesting territories are occupied in most years in eastern Washington, and many of these have remained vacant for years.

Ferruginous hawk winter ecology, specifically winter movements, winter range philopatry, and prey relationships, are little studied. Studies of banded juvenile ferruginous hawks east of the continental divide have shown nearly all of these birds winter east of the Rocky Mountains throughout the central plains and into Mexico (Salt 1939, Harmata 1981, Gilmer et al. 1985, Schmutz and Fyfe 1987, Houston et al. 1998). Many of these hawks in the central plains feed on black-tailed prairie dogs (*Cynomys ludovicianus*), a species being reviewed for possible listing by the U.S. Fish and Wildlife Service. Recent analysis of all historic band records did not find evidence of distinct subpopulations of ferruginous hawks east and west of the Rocky Mountains (Gossett 1993).

In Washington, ferruginous hawks are absent from the state between September and February when their whereabouts are unknown. It is important to understand where these threatened birds go during fall and winter to identify their habitats and prey. The influence of prey abundance and distribution on breeding ferruginous hawks that results in sporadic breeding and possible nomadism (Woffinden and Murphy 1989) may similarly influence behavior of wintering ferruginous hawks. It is unknown if factors on wintering areas limit breeding populations by reducing individual survival and affecting breeding health (Schmutz 1984, Plumpton and Andersen 1997).

Satellite telemetry is a technology that allows long-range monitoring of raptors throughout the world (Brodeur et al. 1996, Kjellen et al. 1997, Ueta et al. 1998 Britten et al. 1999). Hawks instrumented with Platform Transmitter Terminals (PTTs) can be monitored regularly via satellites which retransmit the hawk's locations back to ground stations, where they can be downloaded by computer. In spring, 1999, we initiated a study to investigate the migration of ferruginous hawks from eastern Washington using satellite telemetry. We report here on the preliminary results of that investigation, with specific objectives to: 1) describe ferruginous hawk migration corridors and timing; 2) identify their winter ranges and key prey; and 3) identify their sources of winter mortality.

Acknowledgements: The Woodland Park Zoo, Grand Coulee Dam School District, and U.S. Fish and Wildlife Service (Partnerships for Wildlife) in cooperation with the Wildlife Research Division, and Cooperative Volunteer Program of the Washington Department of Fish and Wildlife (WDFW) provided primary financial support of the project. Battelle Pacific Northwest National Laboratories provided critical logistical help, coordinated by B. Tiller. M. Horowitz and J. Liguori provided trapping assistance, along with E. Rose, T. Aversa, and B. Barker of the Woodland Park Zoo. We thank G. Kuiper and G. Schmidt for coordinating the school project, and personnel of the Priest Rapids Hatchery for accommodations. The Woodland Park Zoo and Sarvey Wildlife Center provided great horned owls for use as lure birds. Long-distance monitoring of hawks could not have been accomplished without the assistance of several dedicated biologists and game agents. We especially thank Janet Linthicum, M. Smith, J. Pagel, C. Gill, G. Hunt, Hans Peters, and other associates of the Santa Cruz Predatory Bird Research Group; R. Stafford, D. Walker, and T. Young of the California Fish and Game Department; S. Fitton of the Bureau of Land Management; M. Glines of Montana Fish, Wildlife, and Parks; M. Crocker of the Oklahoma Fish and Game Department; S. Findholt Oregon Department of Fish, Wildlife and Parks; and Canadian biologists J. Schmutz, S. Houston, U. Banasch, and J. Allen. We thank A. Leary, P. Bartels, M. Fuller, J. Stofel, L. Schueck, and E. Yensen for technical assistance.

STUDY AREA AND METHODS

In May, 1999, we initiated ground surveys in south-central Washington to identify 15 active ferruginous hawk nests from territories that had been active in the previous 5 years (Wildlife Heritage Data Base, WDFW). Surveys were conducted primarily in Benton and Franklin Counties, where nests were most concentrated. Several territories were monitored on the Hanford Nuclear Reservation. Nesting ferruginous hawks on the Reservation have been the subject of 2 graduate projects, (Leary 1996, Jerman 1999). In addition, Battelle Northwest National Laboratories has maintained a thorough history of nesting ferruginous hawks on the Reservation (B. Tiller, pers. comm.), and was able to provide an aviary for housing great horned owls (*Bubo virginianus*), which we used as lures during trapping. For active ferruginous hawks nests that were located, we recorded the first day of incubation within 2 days, and rechecked nests on the estimated hatching day based on a 32-day incubation period (Palmer 1988). When young were about 14 days old we initiated efforts to trap adult hawks.

Trapping was conducted primarily with *dho-gaza* nets (Bloom et al. 1992). Nets (30-foot, 2 ply, black-colored, set on 3, 91 cm [36 in] poles) were arranged in a triangle with the lure bird, a great horned owl, tethered at the center. Nets were set to break away by attaching them with binder clips to tape tabs on net poles. Traps were set at dawn in full view of the adults, in the nearest level opening <100 m from the nest. To reduce stress on lure birds, we alternated birds every other trap day. We erected a portable blind <50 m from the trap set, and left 2 trappers in the blind, with a third exiting the blind in view of the birds and driving to a distant location. Trappers played a taped great horned owl vocalization once every 10 minutes from a portable hooting device (Wildlife Callers, Bellevue, Washington, USA). Radio communication alerted trappers about aggressive hawk behavior. When hawks were unresponsive to the owl lure, we placed an 20 cm x 40 cm dome-shaped bal-chatri, baited with 2 gerbils, in sight of the nest. We abandoned trapping efforts if hawks failed to respond after 45 min. We did not target a particular sex for capture.

Captured hawks were weighed, banded with USFWS tarsal bands, and measured (i.e., wing chord, wingspread, hallux length, beak depth, and foot pad). Hawks were sexed based on differences in nest attentiveness (e.g., females most attentive) and food provisioning activity (e.g., males primary foragers), and confirmed by size dimorphism of body measurements (Appendix, Table 1). We banded nestling hawks at accessible nests when young were 30 to 40 days old. We also telemetered 1 female nestling at a nest where the adult female was also captured. This allowed for an adult-to-juvenile comparison of migration patterns and timing. Hawks were outfitted with 30-g PTTs from *Microwave Telemetry, Inc.* PTTs were programmed to test the utility of different duty cycles: 4 units were programmed for 8 hr on/96 hr off with an expected life of 407 days; 4 units were programmed for 8 hr on/48 hr/off for 168 days, and then 8 hr on/192 hr off for the remaining 183 days; and 2 units were programmed for 8 hr on/192 hr off for an expected life of 783 days. Five-gram VHF transmitters from *Advanced Telemetry Systems, Inc.* were piggy-backed to PTTs for local monitoring of hawks prior to migration. VHF transmitters had an expected life of 60 days and were programmed for 12 hr on/ 12 hr off. PTTs were attached with "X-attachment" backpacks (Buehler et al. 1995) using 7-mm wide teflon ribbon. Hawks were released at capture locations <1 hr following capture.

Because the 3 NOAA satellites that retrieved data orbited the earth approximately every 2 hours at the latitude of the study area, a potential of 12, but most often 3 or 4 locations were obtained during each transmission period. Each location was coded by the ARGOS system into one these of seven classes (Service Argos, Inc. 1994) based on the quality of the data received: location class 3 accurate <150 m; 2<350 m; 1<1000 m; 0>1000 m (i.e. no more accurate than 1000 m); A (no accuracy); B (no accuracy); Z (invalidated location).

After deployment of PTTs in May through June, we monitored activities of telemetered hawks on their territories during 6-hr observational periods to record their local hawk movements and foraging activity. We alternated observations between birds, but because VHF transmitters functioned sporadically we were able to obtain consistent observations on only a few birds. In August, after hawks migrated from territories, we initiated ground visits and contacts with local biologists to obtain information on potential prey, habitat, and known ferruginous hawk use of the area where telemetered hawks became localized. For most hawks, biologists were able to

make ground visits to search for the hawk, make a photo record of the site, assess habitat and prey, and investigate possible mortality if necessary.

RESULTS

Trapping Summary and PTT Status

We monitored 36 ferruginous hawk territories in spring, 1999. We trapped at 15 territories and captured 9 adult ferruginous hawks, including 4 females and 5 males. At 5 of 6 territories where hawks were not captured they displayed a total lack of aggressiveness toward the lure. All but 1 hawk was captured using the *dho-gaza* set. We initially used 2 parallel nets spaced 3 m apart, rather than a triangular set, but on the first trap attempt hawks flew between nets and struck the lure owl. We incidentally captured an American kestrel (*Falco sparverius*) and prairie falcon (*Falco mexicanus*) that were banded and released. Two female hawks, at the May Junction and WPPSS territories (Table 1), were already banded when captured. The former bird was banded as an adult 6 years previously on an adjacent nesting territory (A. Leary, pers. comm.), and the latter bird was banded as a juvenile in the vicinity of the Hanford Nuclear Reservation 11 years before our study (Bird Banding Lab, Laurel MD).

As of 1 December, 1999, 8 of the 10 PTTs winters were transmitting, at least 6-months post-deployment (Table 1). Hawk 15185 was a confirmed mortality in November. The carcass was heavily scavenged on recovery, but pellet-sized holes and associated bruising in the breast bone and keel suggested possible shooting mortality. Hawk 15217 was a suspected mortality based on stationary signals and low temperature readings from the PTT sensor. No carcass was located after several ground searches (M. Glines, pers. comm.). This hawk was observed to have a serious leg injury just prior to dispersal, as evidenced by 1 leg that remained unretracted during flight. Only 1 of 2 young fledged from this nest and we suspect the second, fully-feathered young, starved, based on a lack of prey deliveries observed at the nest and assessment of its carcass.

Fall Dispersal and Migration

We observed hawks on territories for a combined 24 days prior to their dispersal. Female hawks at 3 of 4 territories did not provision food for young. Differences in late-season nest attentiveness were reflected in dispersal times relative to nesting phenology. Adult females dispersed from a maximum of 1 to 19 days after their last young fledged, and adult males from 17 to 40 days (Table 2). One female hawk (PTT 15184), with 3 feathered young, dispersed 160 km northeast of her territory for 2 days and returned to the territory for 8 days before she migrated. This hawk, and another female (PTT 15185) migrated from 1 to 6 days after the last young fledged.

Table 1. Status of 10 PTTs deployed on adult ferruginous hawks captured on breeding territories in eastern Washington, as of 1 December, 1999.

Territory	WDFW Occ. no.[a]	Sex	PTT ID	Band no.	Cycle[b]	Date deployed	Status
Route 2	273	M	15226	877-62665	8/48, 8/192	5/27/99	Functioning
WPPSS	132	F	15227	1207-25044	8/48, 8/192	5/29/99	Functioning
Webber Can.	301	F	15185	608-41259	8/96	5/30/99	Confirmed mortality, 11/15
May Junction	184	F	15184	1207-35127	8/96	6/2/99	Functioning
Beck 1	285	F	15216	608-41260	8/96	6/3/99	Functioning
FFTFN	135	M	15218	877-62667	8/48, 8/192	6/4/99	Functioning
Chandler B.	64	M	15217	877-62668	8/48, 8/192	6/7/99	Suspected mortality, 8/24
Sulfur Lake E.	194	M	15186	877-62669	8/96	6/12/99	Functioning
Kahlotus W.	129	M	15228	877-62670	8/192	6/14/99	Functioning
Webber Can.	301	F[c]	10372	608-41265	8/192	6/14/99	Functioning

[a]Washington Department of Fish and Wildlife Heritage Data Base Occurrence Number.
[b]Duty cycle of the PTT in hours on/hours off; PTTs with 2 duty cycles functioned for 168 days in the first cycle, and 183 days in the second cycle.
[c]Largest nestling hawk from the brood of 4 young.

Table 2. Latest fledging dates of young and times of adult dispersal of ferruginous hawks telemetered in eastern Washington, 1999.

Territory	No. young	Last Fledging date	Adult dispersal date[a]	Comment
Route 2	2	6/25	7/18-7/17	both young died 1-2 days post-fledging[b]
WPPSS	2	6/14	7/1-7/2	
Webber Can.	4	6/27	6/27-7/2	
May Junction	3	6/28	6/28-6/29	
Beck 1	3	6/19	6/30-7/4	
FFTFN	1	6/18	7/27-7/28	
Chandler B.	2	6/30	7/22	1 feathered young died in nest prior to fledging
Sulfur Lake E.	4	6/25	7/11-7/13	
Kahlotus W.	4	6/14	7/12-7/18	
Webber Can.	n/a	6/18	7/27-8/3	largest juvenile of brood

[a]Range of days on which hawks dispersed. Exact dispersal dates of most telemetered hawks were not determined because PTTs transmitted at least every other day.

[b] Young died from unknown cause and collision with powerline.

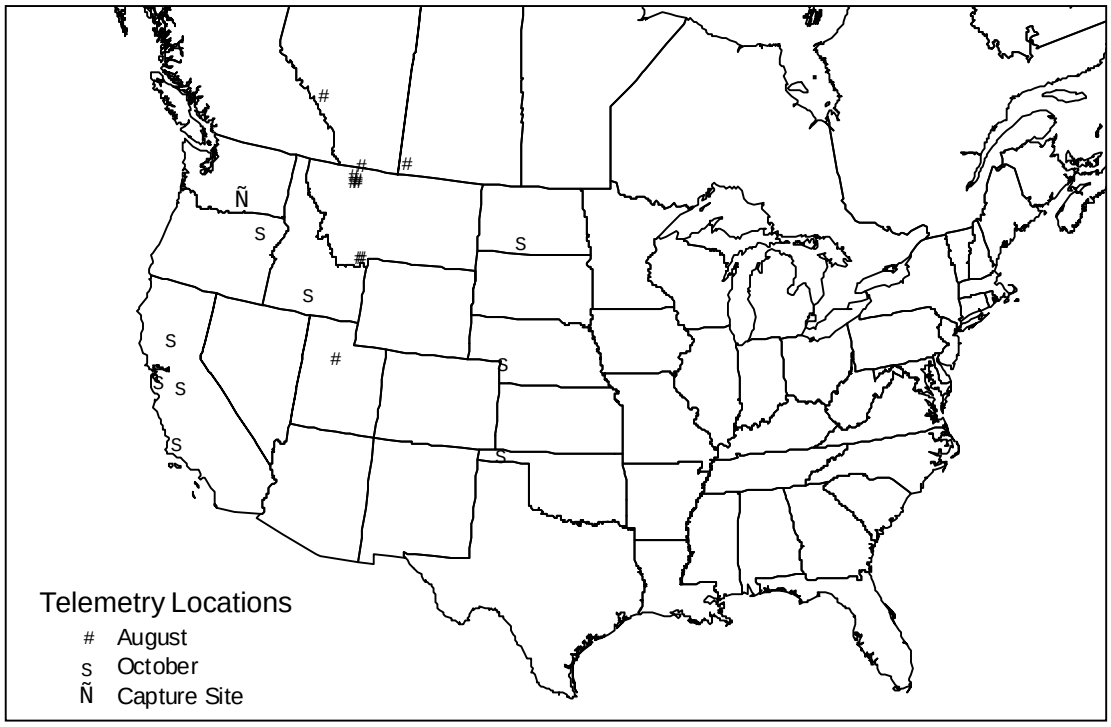

Fig. 1. Fall locations of ferruginous hawks trapped on breeding territories in southcentral Washington, 1999.

Initial migration was primarily easterly, with the exception of 1 bird that migrated north, and another that migrated southeast (Fig. 1). By August, the 4 adult females became localized <40 km from Browning, Montana, and the juvenile female became localized 425 km to the south near Ennis, Montana. Males localized in southern Alberta (2), southwest Saskatchewan, southwest Montana, and northern Utah. Straight-line mean distance from nest territories to early fall destinations was 616 km (range = 525 km to 927 km). Because PTTs did not transmit daily we could not determine the exact rate of travel, but 5 adult hawks arrived at destinations in <6 days, and the remaining adults in <15 days. Minimum rates of travel for adults based on straight-line flight was 40 to 106 km/day but we suspect most hawks migrated at least at the latter rate. The juvenile hawk arrived at the fall destination in 18 to 25 days.

Because 6 hawks moved to the eastern front range of the northern Rocky Mountains we suspected a common attraction of hawks to this area. Observations in Montana and southern Alberta, in the areas where telemetered hawks were located, found ferruginous hawks feeding on Richardson's ground squirrels (*Spermophilus richardsoni*) which were ubiquitous along fencerows and highways. During casual counts along about 80 km of highway in the vicinity of telemetered hawks in northwest Montana (Browning, Montana to Cardston, Alberta) we counted an average of 1 ferruginous hawk/km. Similar roadside counts along about 40 km of highway in southwest Montana (south of Ennis, Montana) yielded an average of 2 ferruginous hawks/km. Local ranchers indicated 1999 had a wet spring that provided good forage for ground squirrels. As a result, there were high populations of Richardson's ground squirrels along the northern Rocky Mountain front and east through the Cypress Hills of Saskatchewan (W. Harris, pers. comm.) where 1 study bird was located. An exception was 1 hawk that became localized in alpine meadows northeast of Banff National Park. Columbian ground squirrels (*S. columbianus*) were the most likely prey for the 46 days he remained in the area (J. Allen, pers. comm.). We were unable to determine prey associations of hawk 15218 in northern Utah.

Between 7 August and 7 October all hawks made at least 1 additional major movement. By October, 3 hawks had relocated to the central and northern plains of North Dakota, Nebraska, and Oklahoma (Fig. 1). These hawk locations were associated with black-tailed prairie dog towns (*Cynomys ludovicianus*) (D. Thompson, M. Crocker, W. Cornatzer, pers. comm.). Ferruginous hawks were seen in these areas although expiration of VHF transmitters prevented visual confirmation of telemetered hawks. The remaining adult hawks relocated to northeast Oregon and central California by late fall (Fig. 1). California ground squirrels (*S. beecheyi*) were the most common potential prey at telemetered hawk locations in California, and were very abundant at most locations (M. Smith, J. Pagel, C. Gill, B. Stafford, D. Walker, G. Hunt, pers. comm.). The juvenile hawk flight path was similar to that of her mother (Montana through southcentral Idaho, to central California) but they were not synchronized. The juvenile moved back and forth along this flight path before arriving in southcentral Idaho where she remained in early October (Fig. 1). She flew southwest from Montana to Nevada in mid-August, northeast to Idaho in late August, southwest to central California in mid-September, and northeast back to Idaho in late September. Total direct distance covered by the juvenile hawk was 3,168 km in a maximum 70 days (10 July through 17 September; average 45 km/day).

DISCUSSION

Preliminary results suggest that prey, specifically colonial rodents, were the proximal cause of ferruginous hawk migration from Washington in the early fall. Migration of female hawks, which did little food provisioning for young, was immediately after young fledged at 2 territories, and for all females was prior to the time when juveniles attained independence. Female flight destinations in early fall were remarkably similar, and to an area in northern Montana and southern Alberta with a large resident hawk population. The size of the breeding population of ferruginous hawks in southern Alberta has been correlated to abundance of Richardson's ground squirrels, the primary prey (Schmutz and Hungle 1989). Similarly, population abundance of ferruginous hawks in the Cypress Hills area of southwest Saskatchewan, where hawk 15228 resided in early fall, is closely related to abundance of Richardson's ground squirrels (Houston and Bechard 1984). Further, ferruginous hawks in southern Alberta migrate south from their breeding range when Richardson's ground squirrels enter estivation (Schmutz et al. 1979, Schmutz and Fyfe 1987). Washington hawks, especially females, joined this population as soon as their nesting duties ended in early fall, took advantage of the feeding opportunities, and then migrated a second time at a time when the last ground squirrels enter estivation. Most telemetered hawks then migrated to the Great Plains or California, where black-tailed prairie dog towns and colonies of California ground squirrel colonies were located, respectively. Black-tailed prairie dogs are important to the ecology of wintering ferruginous hawks throughout the central plains (Cully 1991, Allison et al. 1995, Plumpton and Andersen 1997). California ground squirrels are unique among the *Spermophilus* because they are available to raptors throughout the fall and winter. They rarely, if ever, estivate throughout the year (E. Yensen, pers. comm., Evans and Holdenried 1943).

All but 1 telemetered hawk crossed the continental divide, demonstrating the divide was no barrier to hawks migrating eastward from Washington, and some of these hawks joined the Alberta/Saskatchewan/North Dakota population of migrant ferruginous hawks in late fall when they disperse southward across the Great Plains to Mexico (Salt 1939, Gilmer et al. 1985, Schmutz and Fyfe 1987, Houston et al. 1998). Other telemetered hawks migrated back across the continental divide to California. Ferruginous hawks banded in the northern plains, especially nestlings, rarely migrate to California (Salt 1939, Gilmer et al. 1985, Schmutz and Fyfe 1987, Houston et al. 1998). Only 4.1% of 435 recoveries of ferruginous hawks banded east of the continental divide were recovered west of the divide (Gossett 1993). Our preliminary sample, albeit small, suggests that Washington hawks make an important contribution to wintering ferruginous hawk populations in California, and Washington hawks may migrate west across the divide at a higher rate than resident eastern populations.

Early fall use of parkland by hawk 15226, and specifically alpine meadows, was unexpected and unusual for this species (Schmutz et al. 1980). No ferruginous hawks have been sighted in Banff National Park since 1974 (H. Dempsey, pers. comm.).

Telemetered hawks will continue to be monitored as they return to territories in spring, 2000. We plan to monitor adult recruitment at the 2 nests where adult mortality occurred. We hope to deploy at least 4 additional PTTs on adult or juvenile hawks to further compare migration patterns, to better understand philopatry to wintering areas, and to determine fall and winter

mortality factors. We've established a web page that features the study (http://www.wa.gov/wdfw/wlm/research), as has the Woodland Park Zoo (http://www.zoo.org/). The Grand Coulee Dam School District has prepared a video of the study which can be downloaded from the internet (http://www.gcdsd.wednet.edu).

LITERATURE CITED

Allison, P. S., A. W. Leary, and M. J. Bechard. 1995. Observations of wintering ferruginous hawks (*Buteo regalis*) feeding on prairie dogs (*Cynomys ludovicianus*) in the Texas panhandle. The Journal of Science 47:235-237.

Bloom, P. H., J. L. Henckel, E. H. Henckel, J. K. Schmutz, B. Woodbridge, J. R. Bryan, R. L. Anderson, P. J. Detrich, T. L. Maechtle, J. O McKinley, M.D. McCrary, K. Titus, and P. F. Schempf. 1992. The *dho-gaza* with great horned owl lure: an analysis of its effectiveness in capturing raptors. Journal of Raptor Research 26:167-178.

Britten, M. W., P. L. Kennedy, and S. Ambrose. 1999. Performance and accuracy evaluation of small satellite transmitters. Journal of Wildlife Management 63:1349-1358.

Brodeur, S., R. Decarie, D. M. Bird, and M. Fuller. 1996. Complete migration cycle of golden eagles breeding in northern Quebec. Condor 98:293-299.

Buehler, D. A., J. D. Fraser, M. R. Fuller, L. S. McAllister, and J. K. D. Seeger. 1995. Captive and field-tested radiotransmitter attachments for bald eagles. Journal of Field Ornithology 66:173-320.

Cully, J. F. 1990. Response of raptors to reduction of a Gunnison's prairie dog population by plague. American Midland Naturalist 125:140-149.

Evans, F. C., and R. Holdenried. 1943. A population study of the Beechey ground squirrel in central California. Journal of Mammalogy 24:231-260.

Gossett, D. N. 1993. Studies of ferruginous hawk biology: recoveries of banded ferruginous hawks from presumed eastern and western subpopulations; morphological and genetic differences of presumed subpopulations of ferruginous hawks; and sex determination of nestling ferruginous hawks. Thesis. Boise State University, Idaho.

Gilmer, D. S., D. L. Evans, P. M. Konrad, and R. E. Steward. 1985. Recoveries of ferruginous hawks banded in south-central North Dakota. Journal of Field Ornithology 56:184-187.

Harmata, A. R. 1981. Recoveries of ferruginous hawks banded in Colorado. North American Bird Bander 6:144-147.

Houston, C. S., and M. J. Bechard. 1984. Decline of the ferruginous hawk in Saskatchewan. American Birds 38:166-170.

_____, W. C. Harris, and A. Schmidt. 1998. Ferruginous hawk banding in Saskatchewan. Blue Jay 56:92-94.

Jerman, A. L. 1999. Juvenile ferruginous hawk movements and flight skill development during the post-fledging dependency period in south-central Washington. Thesis. Boise State University, Idaho.

Kjellen, N., M. Hake, and T. Alerstam. 1997. Strategies of two ospreys *Pandion haliaetus* migrating between Sweden and tropical Africa as revealed by satellite tracking. Journal of Avian Biology 28:15-23.

Leary, A. W. 1996. Home ranges, core use areas, and dietary habits of ferruginous hawks in southcentral Washington. Thesis. Boise State University, Idaho.

Palmer, R. S. 1988. Ferruginous hawk. Pages 135-151 *in* R. S. Palmer, editor. Handbook of North American birds. Vol. 5, part 2. Yale Univ. Press, New Haven, Connecticut.

Plumpton, D. L., and D. E. Andersen. 1997. Habitat use and time budgeting by wintering ferruginous hawks. Condor 99:888-893.

Salt, R. 1939. Notes on recoveries of banded ferruginous rough-legged hawks (*Buteo regalis*). Bird Banding 10:80-84.

Schmutz, J. K. 1984. Ferruginous and Swainson's hawk abundance and distribution in relation to land use in southeastern Alberta. Journal of Wildlife Management 48:1180-1187.

_____, S. M. Schmutz, and D. A. Boag. 1980. Coexistence of three species of hawks (*Buteo* spp.) in the prairie-parkland ecotone. Canadian Journal of Zoology 58:1075-1089.

_____, and R. W. Fyfe. 1987. Migration and mortality of Alberta ferruginous hawks. Condor 89:169-174.

_____, and D. J. Hungle. 1989. Populations of ferruginous and Swainson's hawks increase in synchrony with ground squirrels. Canadian Journal of Zoology 67:2596-2601.

Schmutz, S. M., D. A. Boag, and J. K. Schmutz. 1979. Causes of unequal sex ratio in Richardson's ground squirrels. Canadian Journal of Zoology. 57:1849-1855.

Service Argos, Inc. 1994. Animal Tracking. Argos Newsletter No. 48. Landover, Maryland, USA.

Ueta, M., F. Sato, E. G. Lobkov, and N. Mita. 1998. Migration routes of white-tailed sea eagles *Haliaeetus albicilla* in northeastern Asia. Ibis 140:684-686.

Woffinden, N. D., and J. R. Murphy. 1989. Decline of a ferruginous hawks population: a 20-year summary. Journal of Wildlife Management 53:1127-1132.

Appendix. Table 1. Mean (± SE) of body measurements of 4 adult female and 5 adult male ferruginous hawks captured in southcentral Washington, 1999.

Characteristic	Female	Male
weight (g)	1584.0 (46.4)	1021.5 (14.9)[a]
wing chord (mm)	458.3 (7.3)	428.2 (5.8)
hallux (mm)	33.8 (0.2)	26.9 (1.3)
beak (mm)	23.1 (0.4)	20.1 (1.6)
footpad (mm)	69.4 (4.4)	69.0 (0.6)
wingspread	1295.0 (69.8)	1163.0 (22.3)[a]

[a]4 hawks were sampled.