Distribution and Abundance of Golden Eagles and Other Raptors in Campbell and Converse Counties, Wyoming

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by

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ABSTRACT.—Raptor surveys were conducted on a 14,554-km^2 study area in northeastern Wyoming between 1981 and 1989. Nesting sites for 202 golden eagle (*Aquila chrysaetos*) pairs, 119 ferruginous hawk (*Buteo regalis*) pairs, 108 red-tailed hawk (*B. jamaicensis*) pairs, 53 great horned owl (*Bubo virginianus*) pairs, 51 Swainson's hawk (*Buteo swainsoni*) pairs, and 21 prairie falcon (*Falco mexicanus*) pairs were identified. Limited numbers of nest sites of less frequently encountered raptors, including northern goshawks (*Accipiter gentilis*), northern harriers (*Circus cyaneus*), merlins (*Falco* sp.), short-eared owls (*Asio flammeus*), and burrowing owls (*Athene cunicularia*), were documented.

All available nesting habitat of golden eagles seemed to be saturated. Nesting densities were greatest along riparian areas and in the pine-dominated hills. Eighty-two percent of the occupied golden eagle nests were in trees. Reproductive performance of the eagle population varied widely over the 9-year period. Prey abundance and weather seemed to be the principal factors controlling reproductive success.

Red-tailed hawks and great horned owls occupied the same general habitats as did golden eagles. Ferruginous hawks were generally associated with scoria outcrops that were scattered throughout the central and southern portion of Campbell County. Swainson's hawks were primarily associated with trees surrounding abandoned and active ranch buildings. Prairie falcon nesting was limited to the few cliffs on the study area.

Twenty-two bald eagle (*Haliaeetus leucocephalus*) winter roosting areas, used by an estimated 108 birds, were found on the study area in 1983. Bald eagles constructed four nests, but did not remain on the study area during the breeding season. No occupied nest sites were found. Current land reclamation practices on the study area's 16 large coal surface mines seem to be maintaining, and, in some cases, benefiting certain resident raptor species.

Our report presents information on the distribution, abundance, and reproductive success of golden eagles (*Aquila chrysaetos*) and other raptors as they existed in northeastern Wyoming during the 1980's. The study area is in the heart of the Powder River Basin and is one of the richest energy-producing areas in the United States. Most of the area is in Campbell County, which has been referred to as the slumbering giant because of its vast amounts of coal and oil reserves, most of which remain undeveloped. The energy boom of the 1970's brought many changes to this part of Wyoming. Coal silos, oil pumpers, and power lines now break the skyline of open rangeland and natural horizons. Subdivisions, trailer parks, and the new town of Wright have become permanent features of the landscape.

As energy reserves continue to be developed, additional changes will come to northeastern Wyoming. It has been

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suggested that birds of prey are sensitive to human disturbance and may act as indicators of the health of an ecosystem or natural community. The value of resurveying previously censused raptor populations to determine changes in their status over time has been demonstrated by Henny et al. (1973), Belyea (1976), and Craighead and Mindell (1981). Nesting studies that include all resident raptor species are infrequently conducted, yet are important in understanding the ecology of population changes. Data presented in this publication will serve as a baseline for assessing future changes in raptor populations that nest in northeastern Wyoming.

The impetus for these raptor surveys was the need for better data on the number and location of raptor nest sites and roosts. The U.S. Fish and Wildlife Service, Bureau of Land Management, and U.S. Forest Service used these data to apply coal unsuitability criteria numbers 11–14 to land planning units where future coal development was being considered (Stewart et al. 1979). These agencies also needed nesting data to assure compliance with the Surface Mining Control and Reclamation Act of 1977, Endangered Species Act, Eagle Protection Act, and Migratory Bird Treaty Act during the leasing and development of Federal mineral resources.

We present results of a series of systematic raptor surveys initiated in 1981 and continuing in portions of the study area through 1989. Before beginning our surveys, limited raptor nesting data were collected by personnel from the Wyoming Game and Fish Department, coal companies, and environmental consultants. We have attempted to consolidate all of the existing nest data into this report. Although the basic objective of all survey work was simply to find nest sites and determine their status, we also examined nest site selection by several species in relation to habitat type.

Study Area

Location

The study area included all of Campbell County and the northern quarter of Converse County, Wyoming (Fig. 1). The area (14,554 km^2) was approximately 77 km wide and 200 km long. It was bounded on the north by the Wyoming–Montana border at 45° north latitude and on the south by 43°15′ north latitude; the area extended between 105°5′ and 106° west longitude.

Topography

The study area was situated within the eastern Powder River Basin, which is the largest intermountain basin in Wyoming. Elevations range from about 1,058 m in the northeast corner of the area to about 1,845 m in the southwest corner. Pumpkin Buttes are the highest and most significant escarpments in the area (Fig. 2). Smaller sandstone and scoria cliffs are in the northern portion of Campbell County. Much of the area is characterized by open rolling hills and plains dissected by widely separated drainage systems that flow primarily to the east, northeast, and north.

Climate

The climate of the area is semiarid, with cold winters and warm summers (Trewartha 1961). Precipitation averages about 35.6 cm per year. The average annual temperature is about 7° C. July is the warmest month, with daily maximum temperatures of 32° C or above. January, the coldest month, has frequent daily minima of −18° C or below (U.S. Department of Commerce 1974). The growing season averages 129 days (U.S. Department of the Interior 1979). Winds, which are a major cause of raptor nest destruction in the area, frequently reach speeds up to 64 km/h with occasional higher gusts. Winds are strongest during winter and spring (U.S. Department of Commerce 1974).

Vegetation

The area falls within Bailey's (1980) Great Plains Shortgrass Prairie Province. Most of the area is characterized by open big sagebrush (*Artemisia tridentata*)–grassland (*Agropyron* sp.) plains (Fig. 3). Deciduous trees, primarily plains cottonwoods (*Populus deltoides*) and willows (*Salix* spp.), occur along drainages and at springs where sufficient moisture exists. Ponderosa pines (*Pinus ponderosa*) are common in the Rochelle Hills along the eastern boundary of the study area, in the northern third of the area, and on the slopes around Pumpkin Buttes (Figs. 4 and 5). The composition of the vegetative cover types within the study area is shown in Table 1.

Prey Base

The study area supports a diversity of potential prey species for raptors. The most important and abundant species for golden eagles are white-tailed jackrabbits (*Lepus townsendii*; Fig. 6), cottontails (*Sylvilagus* sp.), black-tailed prairie dogs (*Cynomys ludovicianus*), thirteen-lined ground squirrels (*Spermophilus tridecemlineatus*; Fig. 7), sage grouse (*Centrocercus urophasianus*), and waterfowl. Pronghorn (*Antilocapra americana*), mule deer (*Odocoileus hemionus*), white-tailed deer (*O. virginianus*), and domestic sheep and cattle are readily eaten

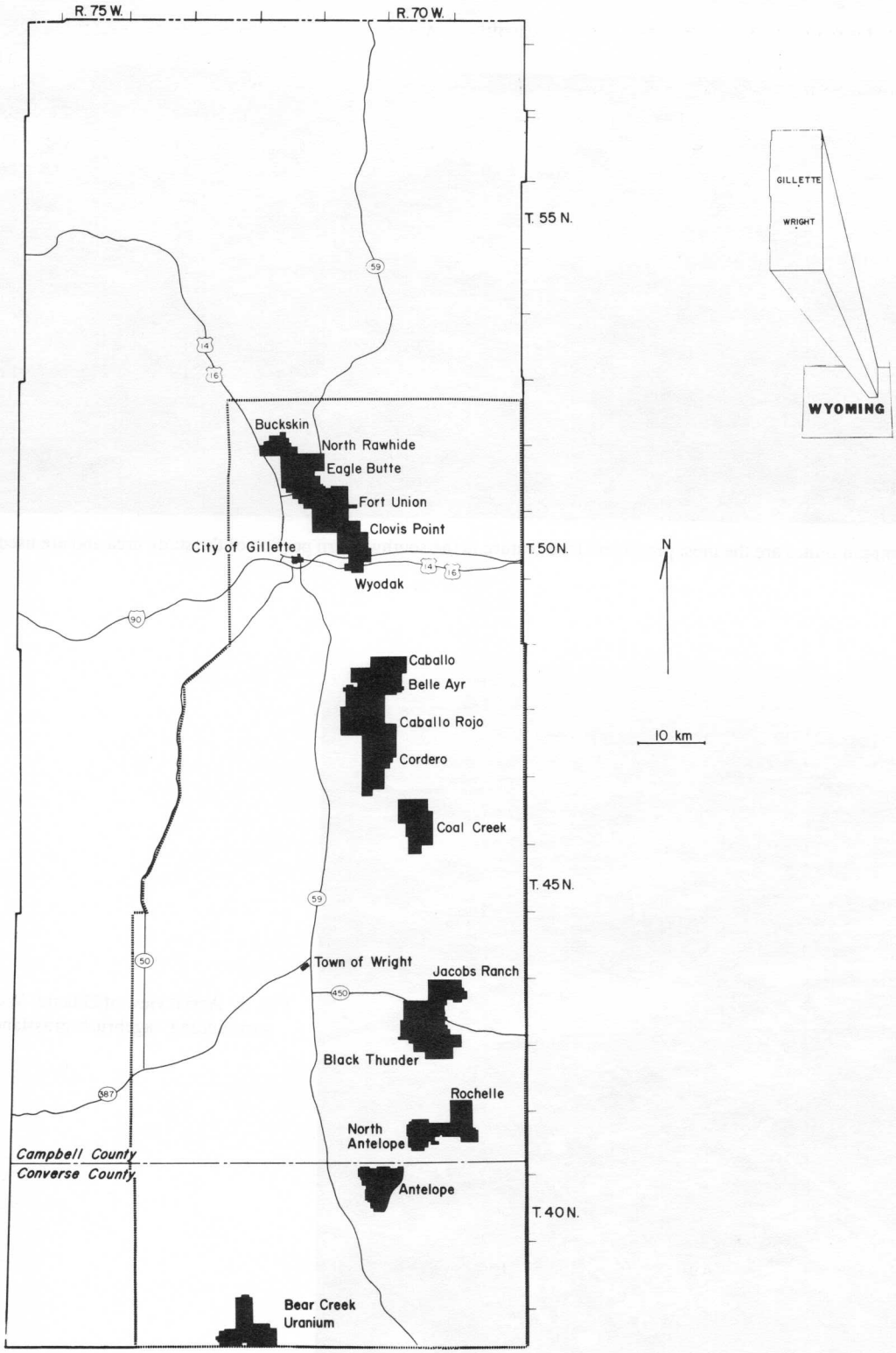


Fig. 1. Location of the study area in northeastern Wyoming. Black shading indicates the distribution of coal and uranium mining activity.

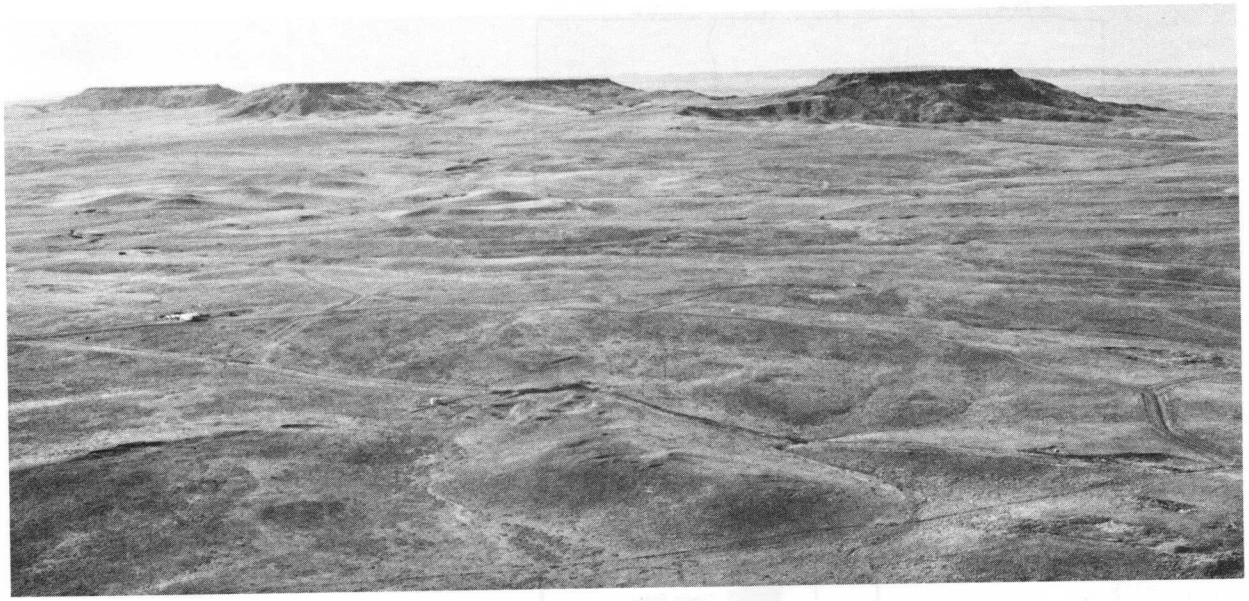


Fig. 2. Pumpkin Buttes are the most prominent land feature in the southwestern portion of the study area and are used by several raptor species.

Fig. 3. Aerial view of Gillette, Wyoming, and surrounding sagebrush-grassland habitat.

Fig. 4. The Powder River and associated "breaks" habitat in northwestern Campbell County.

Table 1. *Surface cover on raptor study area, Campbell and Converse Counties, Wyoming.*

Surface cover type	Dominant plant species	Area (km^2)	Percent composition
Shrubland and grassland	Big sage, wheat grasses	10,828	74.4
Ponderosa pine forest	Ponderosa pine	1,746	12.0
Cropland	Grain, alfalfa, cultivated grasses	1,543	10.6
Riparian	Cottonwood, willow	306	2.1
Water, roads, urban	—	131	0.9
Total		14,554	100.0

Fig. 5. Stands of ponderosa pine are common in northern and eastern Campbell County; note the large prairie dog town complex on the creek bottom.

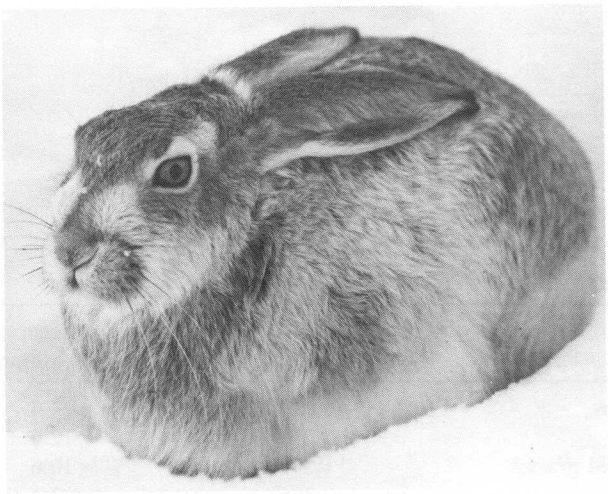


Fig. 6. White-tailed jackrabbits are widespread throughout the sagebrush-grassland habitat of northeastern Wyoming and are the most important prey species for golden eagles.

Fig. 7. Thirteen-lined ground squirrels are associated with agricultural land and disturbed areas.

when available as carrion, and some fawns and lambs are taken by eagles. All vertebrate species known to occur in the region are listed in the Final Environmental Statement for the development of coal resources in the eastern Powder River in Wyoming (U.S. Department of the Interior 1979b).

History of Land Use and Energy Development

Land use and energy resources in the Powder River Basin were determined by the geological history of northeastern Wyoming. A period of mountain building 65 million years ago, known as the Laramide orogeny, created the Rocky Mountains and their associated basins, including the Powder River Basin. During the next 25 million years, a tropical and subtropical climate existed in Wyoming, and northeastern Wyoming was covered by large semitropical forests that eventually gave rise to extensive deposits of coal. Intense erosion from the mountains followed, filling the basins with fine sediments. Basins also filled with volcanic ash as the result of volcanic activity. The entire interior of the continent was again uplifted about 5 million years ago, creating erosional conditions that began the excavation of the Powder River Basin. This erosion continues today.

Plains Indians occupied the rich grasslands of the Powder River Basin until they were driven from the area by the Army and advancing white settlement in the mid-1800's. As early as 1866, longhorn cattle were driven through the basin on their way to Montana, and by 1882 the Wyoming Stock Growers' Association reported cattle roundups from the Belle Fourche and Little Powder rivers and Black Thunder and Caballo creeks. The entire Powder River Basin was surveyed between 1881 and 1883, and sections and townships were marked. By 1888 a postal route was operating between Sundance and Buffalo, and in 1890 Edward Gillette surveyed for the Burlington Northern Railroad, which would be built within the year. The town of Gillette, named after the railroad surveyor, was a major shipping point for cattle. By the end of the 1890's, cattlemen were harvesting hay from the valleys, and some dry farming began. A dam was built on the Little Powder River in 1892, and irrigated farms were established there and along Rawhide Creek. Sheep were brought into the basin and have been an important part of the area's agriculture since 1920 (Fig. 8).

The presence of coal in the basin has always been an important part of its history. Throughout the area, the landscape is dotted with scoria, or burned rockhills, evidence of coal-crop fires that have been burning underground throughout recent geologic time. Indians and trappers who traveled through the country in the early 1800's mentioned the fires, and a major effort was made by the Civilian Conservation Corps in the 1930's to extinguish them. Settlers in the basin used the readily available coal to heat their houses, but it wasn't until 1909 that it was commercially mined. In 1924 strip-mining was begun at Wyo-Dak, just east of Gillette, and a power plant was built that continues to produce coal-fired power today. Production slowly increased from 33.5 tons in 1925

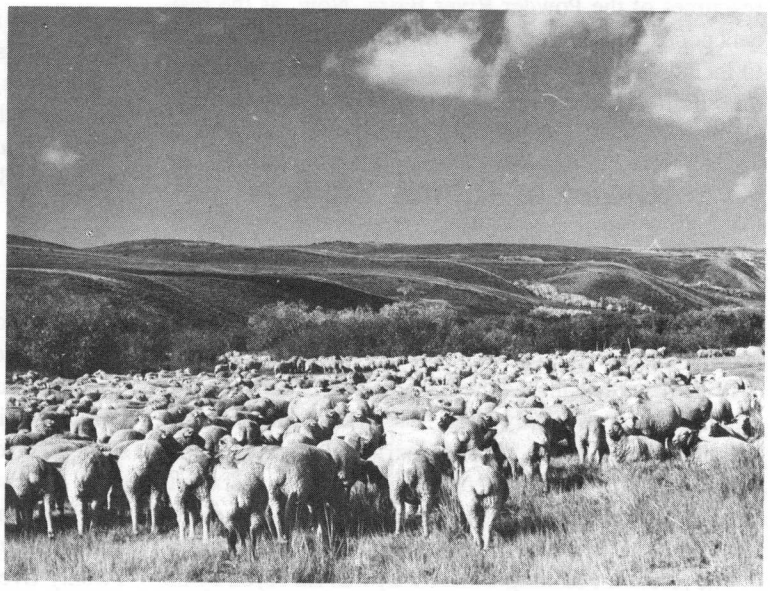


Fig. 8. Sheep grazing is one of the principal land use activities on the study area.

to 1.6 million tons in 1973. Since then, coal production in the Powder River Basin has increased dramatically with the establishment of the largest concentration of coal developments in the western United States (Fig. 1). In 1986 Campbell County coal production peaked at 113.9 million tons of coal, second only to the State of West Virginia (Jones 1986).

The first producing oil well in the Powder River Basin was dug 20 miles north of Gillette in 1941. The first commercial oil production occurred in 1948, but the first significant oil find occurred south of Gillette in 1956. Since the 1960's, oil and gas exploration and production have increased steadily.

Commercial grade uranium discoveries in Wyoming were made in the Pumpkin Buttes area in 1951, and the first commercial production took place in 1953. However, current market conditions for domestic uranium have led to the closing of all uranium mines in the Powder River Basin.

As land use in the Powder River Basin changed from subsistence hunting to agriculture and mining, growth in the human population has been substantial. In 1915 the population of Campbell County was 2,316. In 1940 it was 6,048, with a decrease to 5,861 in 1960. However, by 1970 it had risen to 12,957 (a 121% increase) and by 1980 the population had reached 24,367. The July 1988 census showed a resident population of 31,118 (Campbell County Economic Development Corporation, personal communication).

The change in land use in the 1800's from hunting to agricultural production and the subsequent growth in the human population has had profound effects on the wildlife resources of the Powder River Basin. Now, as the resident population continues to increase and land use enlarges to include mining and oil and gas production, the effect on wildlife resources must be carefully assessed.

History of Raptor Surveys

We divided the study area into three units with regard to the chronology, scope, and intensity of the raptor surveys (Fig. 9). The species surveyed, survey periods, and methods used differed in several respects (Table 2).

In 1981 we established the Eagle Research Area (ERA) within the larger study area. Most coal development activities occur in the ERA. Experimental golden eagle mitigation research and intensive monitoring of nest occupancy and productivity of all known pairs of golden eagles took place in this area between 1981 and 1985.

The Recluse Planning Unit (RPU) was surveyed by air and ground in 1981; all remaining portions of Campbell and Converse Counties in the study area were searched in 1982 using aerial surveys. The Wyoming Cooperative Fish and Wildlife Research Unit conducted a prairie falcon (*Falco mexicanus*) study in the Pumpkin Buttes area from 1982 to 1985 (Squires 1986).

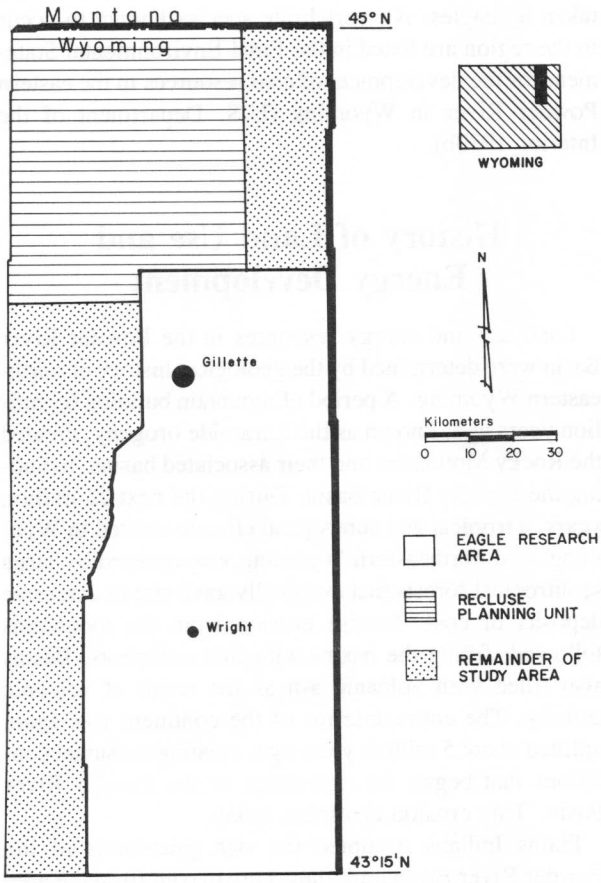


Fig. 9. Location of the three raptor survey units within the study area.

Methods

Surveys for nesting or roosting raptors were conducted primarily from a fixed-wing aircraft, a Bellanca Citabria or a Piper Super Cub, with one observer aboard. Rougher terrain, which is quite limited in the study area, was surveyed from a Bell Jet Ranger helicopter with two or three observers (Fig. 10). In addition to aerial surveys, the RPU was intensively ground searched by a team of four or five observers during the 1981 nesting season. Twenty-five hours of fixed-wing aircraft time and 31 h

Table 2. *Chronology of raptor surveys conducted in Campbell and Converse Counties during 1981–89.*

Area surveyed	Survey period	Species covered	Survey technique
Eagle Research Area	1981–89	Golden eagle	Airplane, foot surveys
	1981–85	Ferruginous hawk, Swainson's hawk	Airplane, foot surveys
Recluse Planning Unit	1981	Golden eagle, ferruginous hawk, Swainson's hawk, northern goshawk, prairie falcon, merlin	Airplane, foot surveys, helicopter
Remainder of Campbell and Converse Counties	1982	Golden eagle, ferruginous hawk, prairie falcon	Airplane

Fig. 10. A Bell Jet Ranger helicopter was used to survey rough topography in the northern portion of the study area. Cliff sites were important nesting areas for prairie falcons.

of helicopter time were spent surveying the area. Thirty man-weeks were spent surveying on the ground. In 1982, 36 h of flight time were used to survey the remainder of Campbell and Converse Counties.

Although all occupied nests were recorded, study emphasis was on the raptor species that are listed as Migratory Birds of High Federal Interest in the Powder River Coal Region. This list included golden eagles, ferruginous hawks (*Buteo regalis*), bald eagles (*Haliaeetus leucoephalus*), prairie falcons, merlins (*Falco columbarius*), and burrowing owls (*Athene cunicularia*).

Survey intensity varied among the three subunits of the study area. The most intensively studied area was the ERA, where we attempted to find all golden eagle nests and pairs (Fig. 9). Occupied nests of other species were recorded, but no attempt was made to completely inventory all species. From mid-February through July 1981, 88 h of flight time were used to survey the ERA. Flights were made during four periods of the golden eagle nesting cycle: (1) during courtship to determine which nests were occupied; (2) during egg laying to determine the number of breeding attempts and laying dates; (3) during the nestling period to estimate hatching success; and (4) just before fledging to determine productivity. This pattern of timing for the aerial surveys was repeated during the 1982 nesting season with flight time increased to 140 h to more precisely determine nesting chronology. In 1983, the courtship survey was dropped and survey time reduced to 61 h. In 1984 and 1985, aerial surveys were conducted only to determine nest occupancy and productivity, requiring 40 h of flight time in 1984 and 35 h in 1985. From 1986 through 1989, only productivity surveys were completed; approximately 15 h of flight time being expended each June. Because of the limited survey effort in these years, these data were used only to determine eagle productivity trends on the ERA.

All nests were plotted on the largest scale U.S. Geological Survey topographic maps available (1:62,500 or 1:24,000 scale) and the locations identified by Universal Transverse Mercator coordinates. Nest substrate was recorded for each nest; nest condition, contents, and presence of adult birds were recorded each time a nest was observed. Many golden eagle nests were located by initially observing a pair of adults, and then searching the surrounding area for nests. Breeding pairs of eagles were especially conspicuous early in the breeding season on cold or calm clear days when they could often be seen perching together from more than a mile away. Eagle nesting density was calculated by dividing the highest known number of occupied territories into the acreage of the entire study area. On the ERA, the distance from each occupied nest to the nearest adjacent occupied nest was calculated and these distances were summed and averaged. To determine whether nest substrate influenced nest-spacing, distance to closest occupied nests within each substrate type was also calculated. Reproductive terminology definitions used in this report are the same as those in *Fish and Wildlife Technical Report* 26, "Nesting Ecology of Golden Eagles and Other Raptors in Southeastern Montana and Northern Wyoming."

During 1981 and 1982 golden eagle courtship surveys, we observed a substantial number of bald eagles using two previously documented winter roosts. Those sightings led us to conduct bald eagle winter roost surveys on the ERA in early 1983. That year, counts were conducted from a fixed-wing airplane on 18 and 19 January and 3 and 4 February. Each morning was cool and calm, and counts of known roosts were made during the first hour of daylight; searches for additional roosts were conducted for the next 2 h. All cottonwood and ponderosa pine areas on the ERA were searched. Flight time spent specifically searching for and counting bald eagles totaled 12.4 h. Several additional roosts were discovered during golden eagle surveys in 1983. A single count of the largest roosts was also made on 27 March 1985.

Results

Golden Eagles

Density and Distribution

The number of occupied eagle territories found on the ERA varied from 85 (1981) to 140 (1983). The progressive increase in the number of territories between 1981 and 1983 is believed to be a result of increased survey effort, greater familiarity with the study area, and possibly a small population increase. The decline in the number of documented territories after 1983 may have reflected reduced survey effort rather than a population decline. This conclusion is supported by a stable sample population of 36 eagle pairs that were consistently monitored over the 9-year period. Without exception, all of the territories determined to be occupied in 1981 were occupied each year through 1989. Therefore, we believe that approximately 140 pairs (the maximum number found in 1983) occupied the study area from 1981 to 1989. All suitable habitat on the ERA seemed to be saturated with breeding eagles. Minor fluctuations in population density most likely resulted from changes in available nest sites. For example, the loss of an isolated nest tree in an open grassland area could result in the displacement of a breeding pair.

The 140 occupied nests were distributed over the study area (Fig. 11) with an average of 4.3 km (1.6–11.3 km;

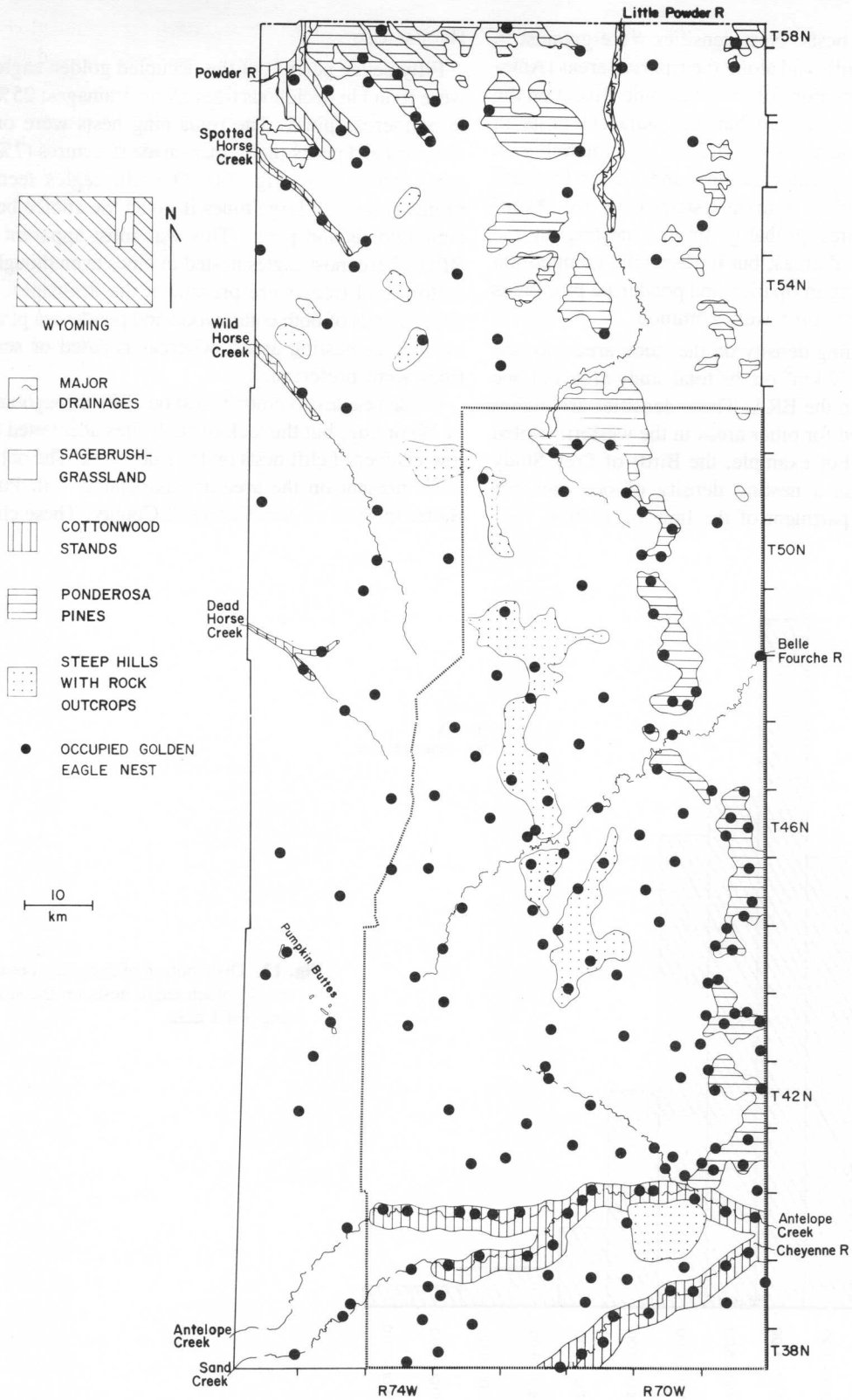


Fig. 11. Distribution of major vegetation types and occupied golden eagle nests on the study area during 1981–85.

Fig. 12) between nests. Nest densities were greatest in the pine-covered hills and along the riparian areas (Antelope Creek and Dry Fork of the Cheyenne River) on the study area. Mean distance between adjacent nests in sagebrush-grassland areas was 5.2 km as compared with 3.4 km for nests in ponderosa pine, and 3.1 km for nests in cottonwood stands in riparian systems (Fig. 13). Availability of nest sites probably limited nesting in the sagebrush-grassland areas, but intraspecific competition may regulate nesting in riparian and ponderosa pine areas where suitable structures were common.

Minimum breeding density on the study area was one breeding pair per 72 km^2 on the total study area and one pair per 51 km^2 on the ERA. These densities are higher than those reported for other areas in the western United States (Table 3). For example, the Birds of Prey Study Area in Idaho has a nesting density of one pair per 99 km^2 (U.S. Department of the Interior 1979a).

Habitat Use

Fifty-seven percent of the occupied golden eagle nests were found in deciduous trees along drainages; 25% were in ponderosa pines. The remaining nests were on rock outcrops and peaks (8%), man-made structures (7%), and creek banks (3%; Fig. 14). Overall, eagles seemed to prefer nesting in large pines if given the choice between cottonwoods and pines. This was most apparent in the RPU where most eagles nested in pines even though large cottonwood trees were present in the drainages. Large dense stands of both cottonwood and ponderosa pine were avoided as nesting areas, whereas isolated or scattered trees were preferred.

Golden eagles commonly nest on cliffs throughout much of Wyoming, but the lack of such sites accounted for the low number of cliff nests on the study area. The only large cliffs present on the area are associated with Pumpkin Buttes in southwestern Campbell County. These cliffs are

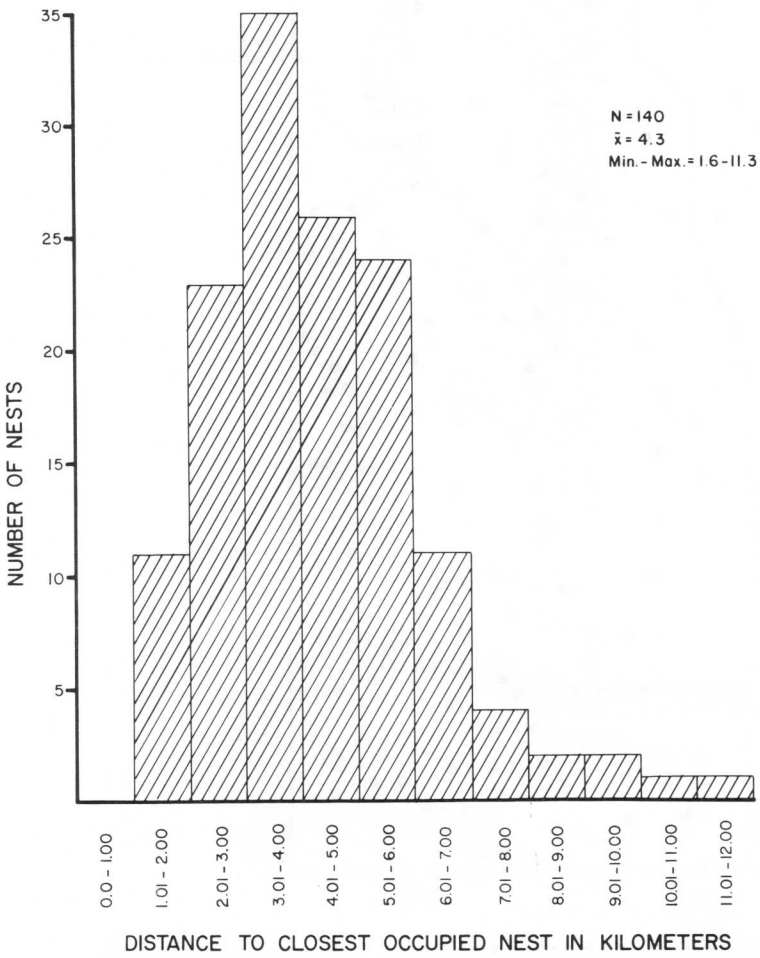


Fig. 12. Distribution of distances between occupied golden eagle nests on the study area using 1983 data.

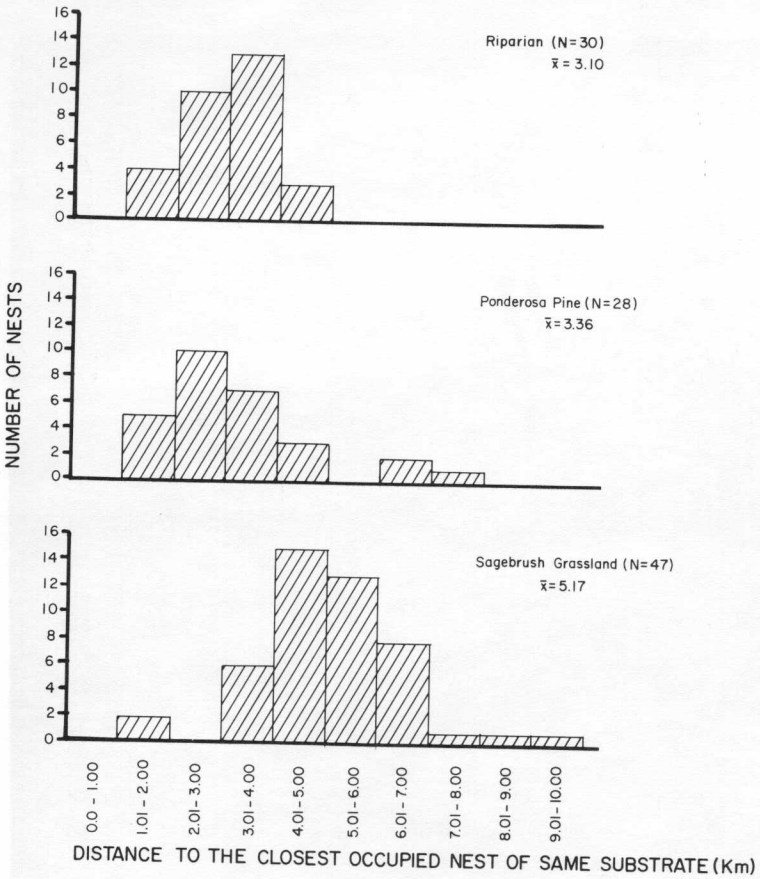
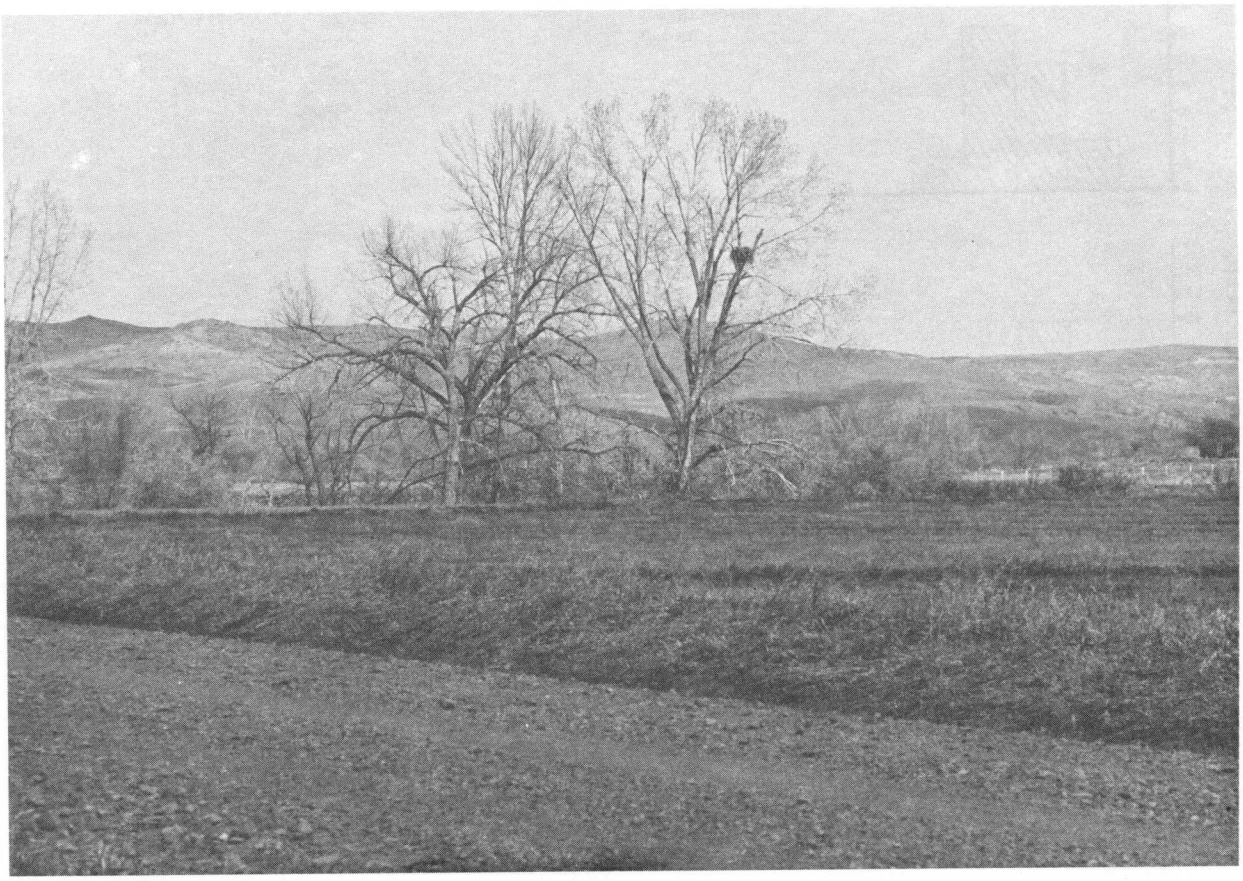


Fig. 13. A comparison of the spatial relations between occupied golden eagle nests in three vegetation types; nests on steep hills were included in the sagebrush-grassland type.

Table 3. *Golden eagle nesting densities compared for various regions.*

Source	Location	Size of area (km^2)	Habitat description	Number of pairs	km^2 per pair
Lockhart et al. (1980)[a]	Southern Wyoming	622	Sagebrush-rimrock	15	39
Watson (1957)	Scotland	570	Moorland	14	41
Phillips et al. (1984)	Northern Wyoming and southeastern Montana	648	Sagebrush-grassland	16	41
This study	Northeastern Wyoming Eagle Research Area	7,115	Sagebrush-grassland with scattered ponderosa pine and cottonwoods	140	51
	Total study area	14,554	Sagebrush-grassland with scattered ponderosa pine and cottonwoods	202	72
Kochert (1972)	Southwestern Idaho	3,694	Sagebrush-cliffs	56	66
Dixon (1937)	Southern California	2,520	Mountain foothills	27	93
Camenzind (1968)	West-central Utah	1,399	Shrubland-rimrock	14	100
USDI (1979a)	Snake River Birds of Prey Study Area	3,388	Sagebrush-large canyons	34	99
Edwards (1969)	Western Utah	2,858	Sagebrush	24	119
Reynolds (1969)	South-central Montana	3,263	Mountain foothills	23	142
Olendorff (1975)	Northeastern Colorado	2,598	Shortgrass prairie	12	217
Page and Seibert (1973)	Northeastern Nevada	22,083	Sagebrush-cliffs	88	251

[a]J. M. Lockhart, D. W. Heath, and C. L. Belitsky, Denver Wildlife Research Center, unpublished report.



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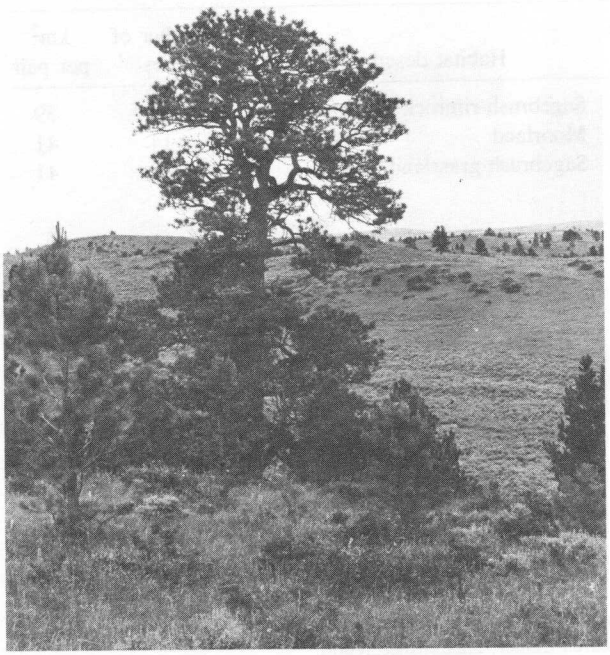

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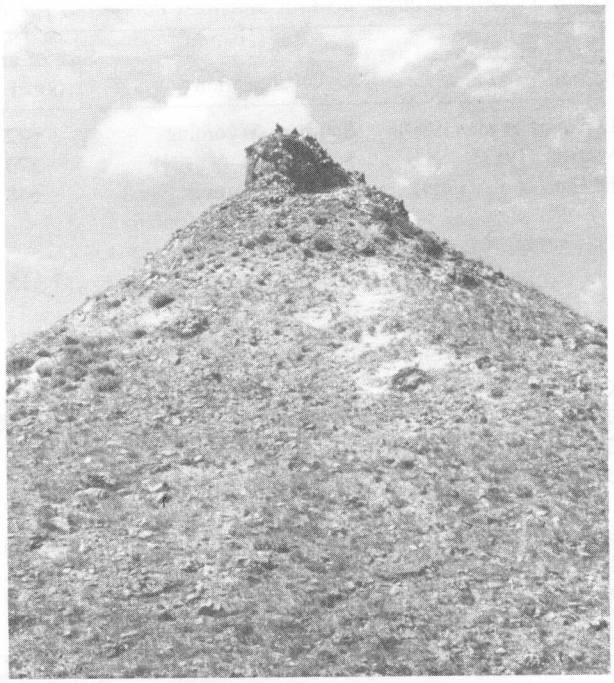

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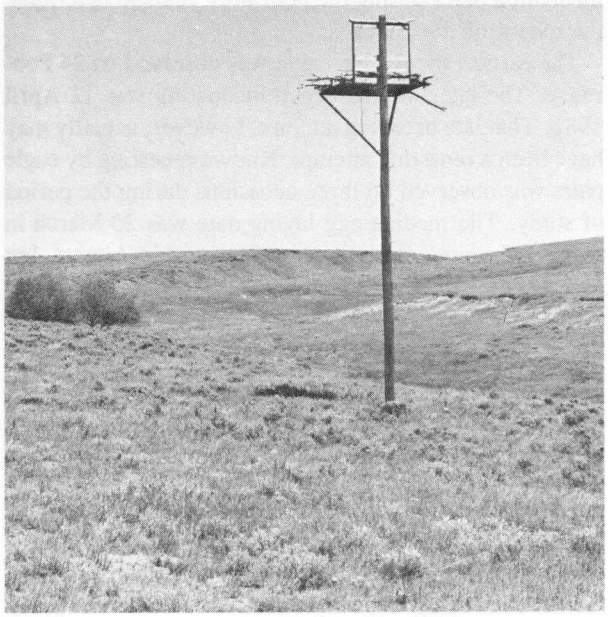
Fig. 14. Six typical nesting situations for golden eagles on the study area: (*a*) cottonwoods, (*b*) ponderosa pine, (*c*) rock outcrop



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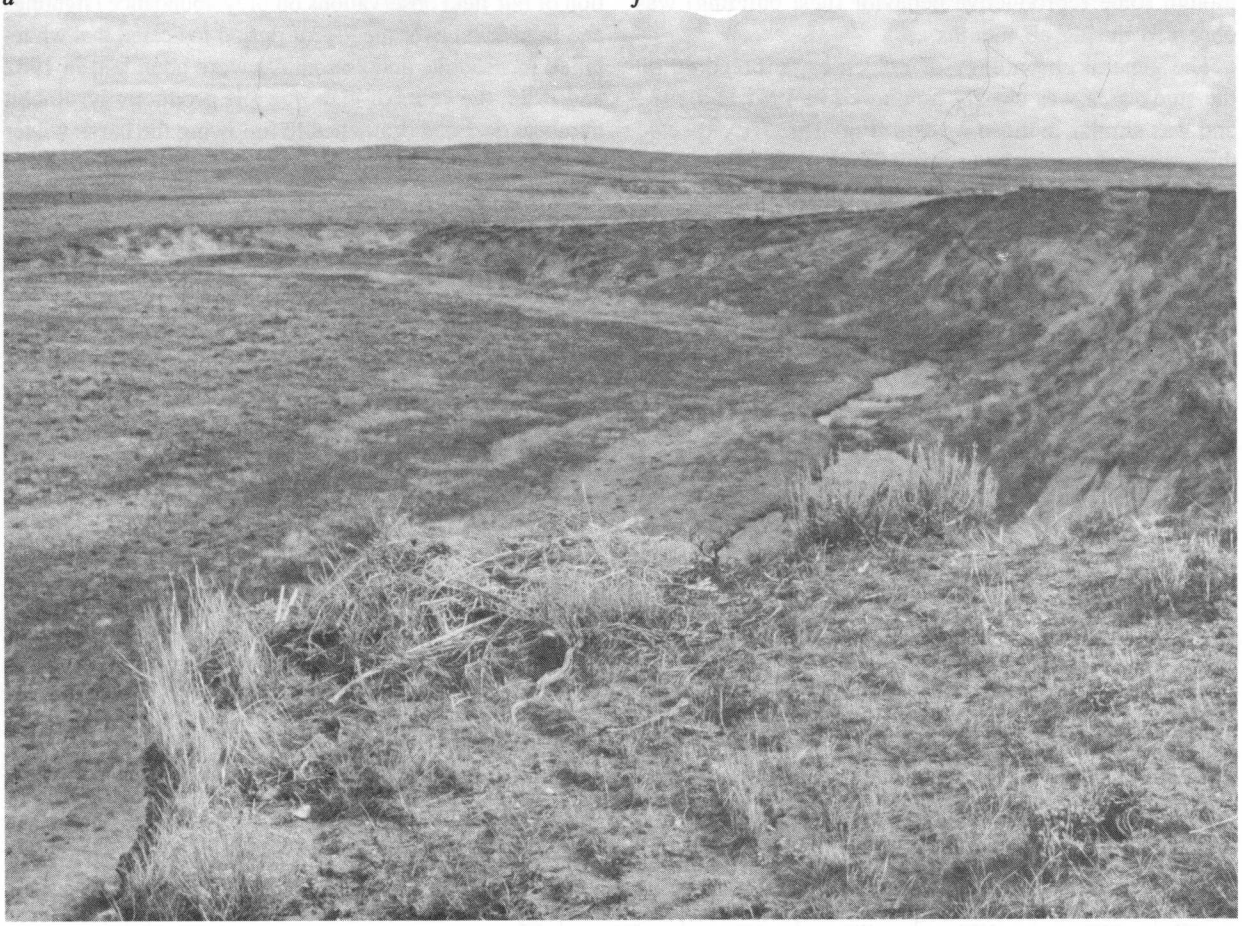

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on hilltop, (*d*) artificial nesting platform, (*e*) creek bank, and (*f*) sandstone cliff.

regularly used by nesting eagles. Smaller sandstone cliffs that occur on the RPU are occasionally used as nest sites. Scoria outcrops on the treeless hills that bisect the ERA were also used. Rock outcrops are found in the Rochelle Hills and in the northern portion of Campbell County, but eagles generally nest in large pines in those areas.

Man-made nesting structures used by eagles on the study area included windmills, a military observation tower, and nesting platforms constructed at coal mines. The loss of nest trees during coal surface-mining operations made these structures important to specific pairs of eagles in the study area.

Reproduction

Breeding golden eagles in Campbell and Converse Counties are nonmigratory and remain on their territories throughout the year. An influx of nonbreeding migratory eagles was noted in fall, but these birds departed as the breeding season arrived. The breeding season extends from approximately mid-February to mid-August, although some reproductive behavior (nest building) was observed during all months.

The general chronology of golden eagle breeding on the study area was closely monitored in 1981 and 1982 and was similar in those 2 years (Fig. 15). We expected the nesting chronology to remain the same throughout the study but noted that egg laying was delayed about a week to 10 days during 1985 and 1986. We believe that this delay was due to lower prey densities in these years. Newton (1979) gives evidence of delayed egg laying in several raptor species in poor prey years. Therefore, Fig. 15 should be regarded as the nesting chronology during good prey years. We did not collect enough data on incubation dates during the poor prey years to determine the extent of the changes.

The earliest incubating eagle was observed on 24 February. The latest a bird began incubating was 12 April 1982. That late breeding attempt, however, actually may have been a renesting attempt. Known renesting by eagle pairs was observed on three occasions during the period of study. The median egg laying date was 20 March in 1982. All young were on the wing by mid-August, but parental care of some fledged birds was observed to the end of the calendar year.

Reproductive success of the eagle production on the ERA varied considerably over the 9-year period. The number of young fledged on the area ranged from an observed high of 163 in 1983 to an observed low of 30 in 1986 (Fig. 16). All reproductive variables used to measure productivity show that 1983 was a good year for golden eagles in northeastern Wyoming (Tables 4 and 5). Prey abundance and weather seem to be the principal factors controlling eagle reproductive success. Interpretation of our field observations on prey abundance (sightings and road-kills) over the 9-year period indicated that white-tailed jackrabbits and cottontails were abundant in 1982 and 1983, the years of highest eagle productivity. Rabbit numbers declined dramatically following the harsh winter of 1983–84 and the April 1984 blizzard. Populations of these prey species remained depressed through 1986; they began to recover in 1987. Eagle reproduction was greatly reduced during the years prey populations were depressed.

A comparison of eagle productivity by nest substrate is shown in Table 6. The average number of young per

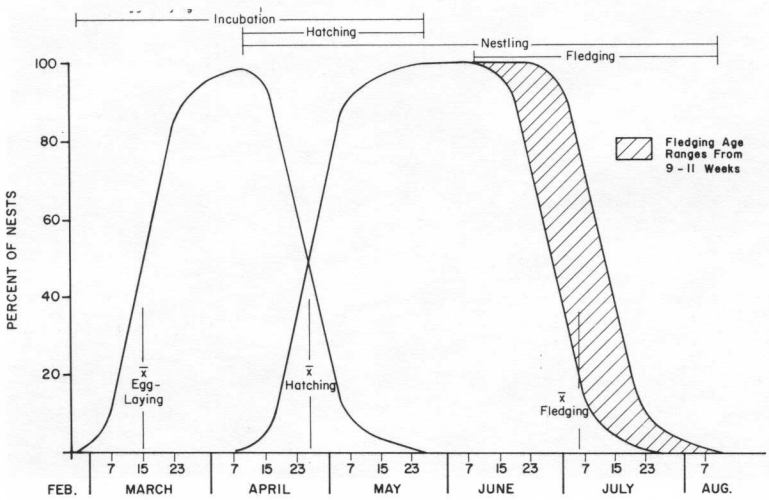

Fig. 15. Golden eagle nesting chronology in 1981 and 1982. Graph was constructed from incubation dates for 86 nests and using an incubation period of 42 days.

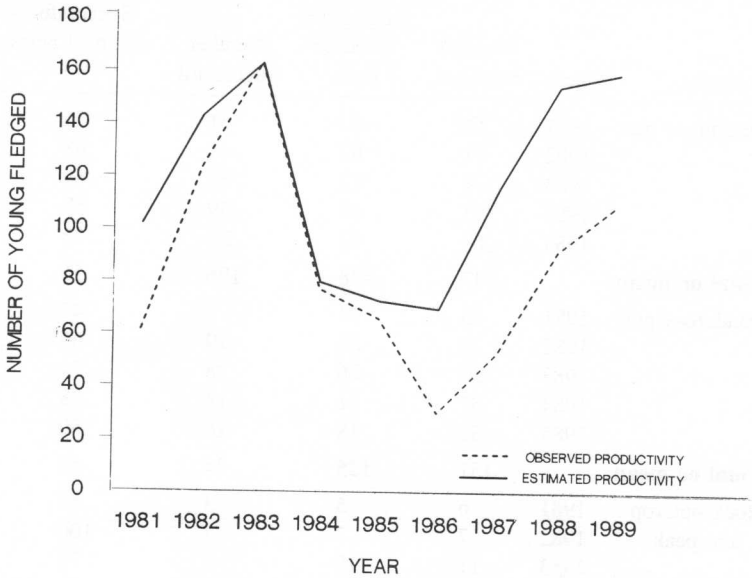

Fig. 16. Trends in golden eagle reproductive success by year on the Eagle Research Area, Wyoming. Estimates of the number of young fledged per year were based on the number of young per occupied nest and a stable population of 140 eagle pairs.

Table 4. *A yearly comparison of golden eagle reproductive success on the Eagle Research Area, Wyoming, 1981–85.*

	Year						
	1981	1982	1983	1984	1985	Total	$\bar{x}$
Number of occupied nests	85	120	140	134	127	606	121
Number of breeding pairs	77	106	130	110	63	486	97
Number of successful nests	46[a]	81[b]	99[a]	58	47	331	66
Successful occupied nests (%)	55	68	71	43	37	—	55
Number of young fledged	61	123	163	77	66	490	97
Young per occupied nest	0.73	1.02	1.16	0.57	0.52	—	0.81
Young per breeding pair	0.81	1.16	1.25	0.70	1.06	—	1.01
Young per successful nest	1.33	1.52	1.65	1.33	1.40	—	1.48

[a]Two nests in 1981 and one in 1983 with unknown success were not included in productivity calculations.
[b]Two nests that failed during incubation but were not counted as successful.

Table 5. *Frequency of golden eagle nests from which 0, 1, 2, or 3 young fledged on the Eagle Research Area, Wyoming, 1981–85.*

Year	Number of occupied nests	Number of nests with			
		0 young	1 young	2 young	3 young
1981	83[a]	37	31	15	0
1982	118[b]	39[c]	43	32	4
1983	139[d]	40	37	60	2
1984	134	76	40	17	1
1985	127	80	28	19	0
5-year total	601	272	179	143	7

[a]Two occupied nests with unknown success are not included.
[b]Two nests that contained two young from which one young was removed, are not included.
[c]Two nesting pairs that failed, but later adopted and fledged one young each, are counted as fledging 0.
[d]One occupied nest with unknown success is not not included.

Table 6. *Golden eagle reproductive success on the Eagle Research Area, Wyoming, by nesting substrate used, 1981–85.*

Substrate	Year	Nests: Number occupied	Nests: Number of breeding pairs	Nests: Number successful	Successful occupied nests (%)	Number of young fledged	Young/ occupied nest	Young/ breeding pair	Young/ successful nest
Deciduous tree	1981	56[a]	50[a]	31	55	43	0.77	0.88	1.39
	1982	71	62	48	68	68	0.96	1.10	1.42
	1983	78	72	54	69	86	1.10	1.19	1.59
	1984	73	61	39	53	49	0.67	0.80	1.26
	1985	69	33	24	35	33	0.48	1.00	1.38
Total or mean		347	278	196	56	279	0.80	1.00	1.42
Ponderosa pine	1981	15	14	7	47	8	0.53	0.57	1.14
	1982	29	26	19	66	32	1.10	1.23	1.68
	1983	38	36	28	74	47	1.24	1.31	1.68
	1984	37	31	14	38	19	0.51	0.61	1.36
	1985	32	18	16	50	22	0.69	1.22	1.38
Total or mean		151	125	84	56	128	0.85	1.02	1.52
Rock outcrop and peak	1981	6	5	3	50	3	0.50	0.60	1.00
	1982	7	7	7	100	12	1.71	1.71	1.71
	1983	11	10	8	73	15	1.36	1.50	1.88
	1984	11	8	0	0	0	0	0	0
	1985	11	4	2	18	2	0.18	0.50	1.00
Total or mean		46	34	20	43	32	0.70	0.94	1.60
Man-made	1981	5	6[a]	3	60	3	0.60	0.50	1.00
	1982	9	8	5	56	9[b]	0.78	0.88	1.40
	1983	10	10	8	80	13	1.30	1.30	1.63
	1984	10	8	3	30	6	0.60	0.75	2.00
	1985	10	6	4	40	7	0.70	1.17	1.75
Total or mean		44	38	23	52	38	0.86	1.00	1.65
Creek bank	1981	3	2	2	67	4	1.33	2.00	2.00
	1982	4	3	2	50	2	0.50	0.67	1.00
	1983	3	2	1	33	2	0.67	1.00	2.00
	1984	3	2	2	67	3	1.00	1.50	1.50
	1985	5	2	1	20	2	0.40	1.00	2.00
Total or mean		18	11	8	44	13	0.72	1.18	1.63

[a] Includes one unsuccessful nesting attempt.
[b] Includes two young fostered in nests that failed during incubation.

successful nest was highest (1.7) for birds nesting on man-made structures and lowest for those nesting in deciduous trees (1.4). Our field observations also indicated that nest losses are less for eagles being raised on platforms because these nest sites are more secure and less apt to be destroyed by wind. In terms of the number of young fledged into the population, and in direct proportion to nesting habitat used, deciduous trees produced the most eagles (57%), followed by ponderosa pines (25%; Fig. 17).

Specific portions of the ERA consistently fledged more eagles than other parts of the study area (Fig. 18). We believe these geographic differences in productivity can be attributed to a more reliable food supply in certain areas. Many of the nest sites in the southern one-third of the study area along Antelope Creek and the Cheyenne River are associated with large black-tailed prairie dog towns that supplied resident eagles with a stable food source for 8–10 months of the year.

Red-tailed Hawks

We observed 108 occupied red-tailed hawk (*Buteo jamaicensis*) nests during the study. Red-tailed hawks

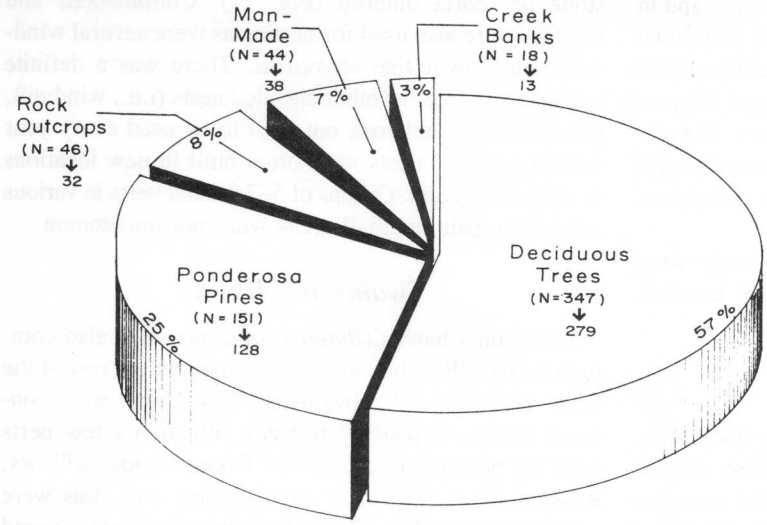

Fig. 17. Pie chart showing percent young produced from each nesting substrate on the Eagle Research Area, Wyoming, 1981–85.

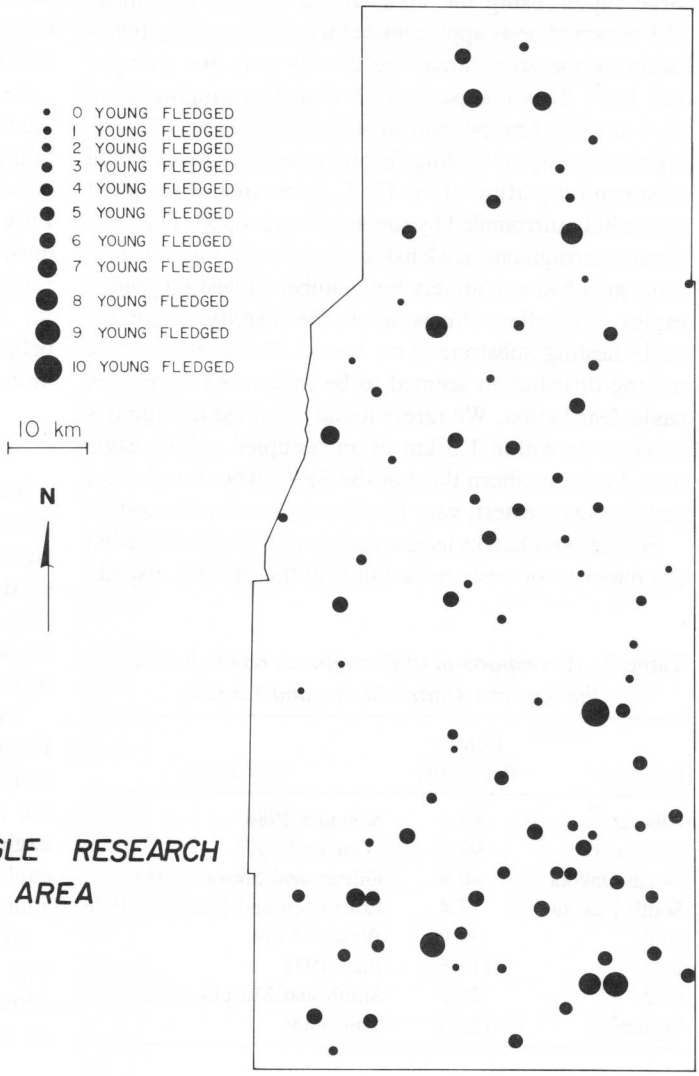

Fig. 18. Distribution of golden eagle productivity on the Eagle Research Area, Wyoming, 1981–85.

nested in a wide variety of habitats throughout the study area, but were most common along riparian areas and in ponderosa pines. Unlike ferruginous hawks, red-tailed hawk distribution did not seem to be affected by golden eagle distribution. Red-tailed hawks often nested in proximity to occupied eagle nests (within 0.3 km). Cottonwoods and ponderosa pines were the most commonly used nest substrates, but a few pairs used willows and power line crossarms.

Red-tailed hawks were migratory on the study area. Most arrived in mid- to late March and left in late fall. However, a few wintered on the area.

Ferruginous Hawks

Ferruginous hawks nested throughout the study area. One hundred and nineteen occupied nests were plotted during the study, making them the second most common large raptor using the area. If we assume that those 119 occupied nests approximated the total breeding population on the study area, the density was one pair per 122 km^2. This compares with densities ranging from 17.4 to 116.6 km^2 per pair in other studies (Table 7). The highest density of nesting ferruginous hawks was in the west-central portion of the ERA, in an area of scattered scoria hills surrounded by sagebrush-grassland (Fig. 19). Typical ferruginous hawk habitat is shown in Fig. 20. This same area had a relatively low number of nesting golden eagles. We believe this is due to the scarcity of suitable eagle nesting substrate (i.e., trees). Ferruginous hawk nesting distribution seemed to be influenced by golden eagle distribution. We rarely found occupied ferruginous hawk nests within 1.5 km of an occupied golden eagle nest. In the southern third of the ERA, where eagle nest density was greatest, very few ferruginous hawks nested.

Ferruginous hawks used a variety of nest substrates but the majority of nests were built on the ground, usually on a fairly prominent rock, eroded creek bank, or sandstone or scoria outcrop (Fig. 21). Cottonwoods and willows were also used for nesting as were several windmills and power line crossarms. There was a definite tendency for trees or other elevated nests (i.e., windmill, power line, or tall rock outcrop) to be used every year whereas ground nests were often built in new locations in successive years. Groups of 5–7 ground nests in various states of repair in small areas were not uncommon.

Table 7. *A comparison of ferruginous hawk densities in the western United States and Canada.*

Location	Density (km^2/pair)	Reference
Alberta	69.1	Schmutz 1984
Colorado	99.9	Olendorff 1973
North Dakota	40.4	Gilmer and Stewart 1983
South Dakota	17.4	Lokemoen and Duebbert 1976
Utah	39.9	Weston 1969
Utah	116.6	Platt 1971
Utah	20.7	Smith and Murphy 1973
Wyoming	122.0	This study

Swainson's Hawks

Swainson's hawks (*Buteo swainsoni*) were also common on the ERA, but were uncommon on the rest of the study area (Fig. 19). Swainson's hawk nests were confined almost exclusively to trees, although a few nests were on power line crossarms. Cottonwoods, willows, Russian-olives (*Elaegnus angustifolia*), and elms were used for nesting (Fig. 22). Old windbreaks planted around both abandoned and active ranch houses were used extensively for nesting by Swainson's hawks.

Swainson's hawks arrived on the study area approximately the first week of April and began nest construction almost immediately. Adults were incubating by the end of May, and young fledged around the middle of July. Fifty-one occupied Swainson's hawk nests were found during the study. However, because leaf-out was occurring during nest construction, and there was a tendency for Swainson's hawk nests to blow down easily, we believe that they were more common than the number of nests we found indicates.

Prairie Falcons

Nesting prairie falcons were not common on the study area because of the scarcity of cliffs. Where suitable nest sites existed, primarily Pumpkin Buttes and a few small sandstone cliffs in the northern portion of the study area (Fig. 23), prairie falcons did nest. We believe that the 21 occupied nest sites recorded is a nearly complete count of the number of breeding pairs on the study area.

The number of sites occupied by prairie falcons on Pumpkin Buttes varied from five to seven between 1982 and 1985 (Squires 1986). The cliffs on Pumpkin Buttes are the largest escarpments on the study area. Golden eagles also nested on these cliffs, but prairie falcons and eagles did not nest on the same cliffs in other parts of the study area.

In addition to the prairie falcon nests indicated on Fig. 19, an occupied nest was reported by H. Postovit (Powder River Eagle Studies, personal communication) on a coal mine highwall in 1986.

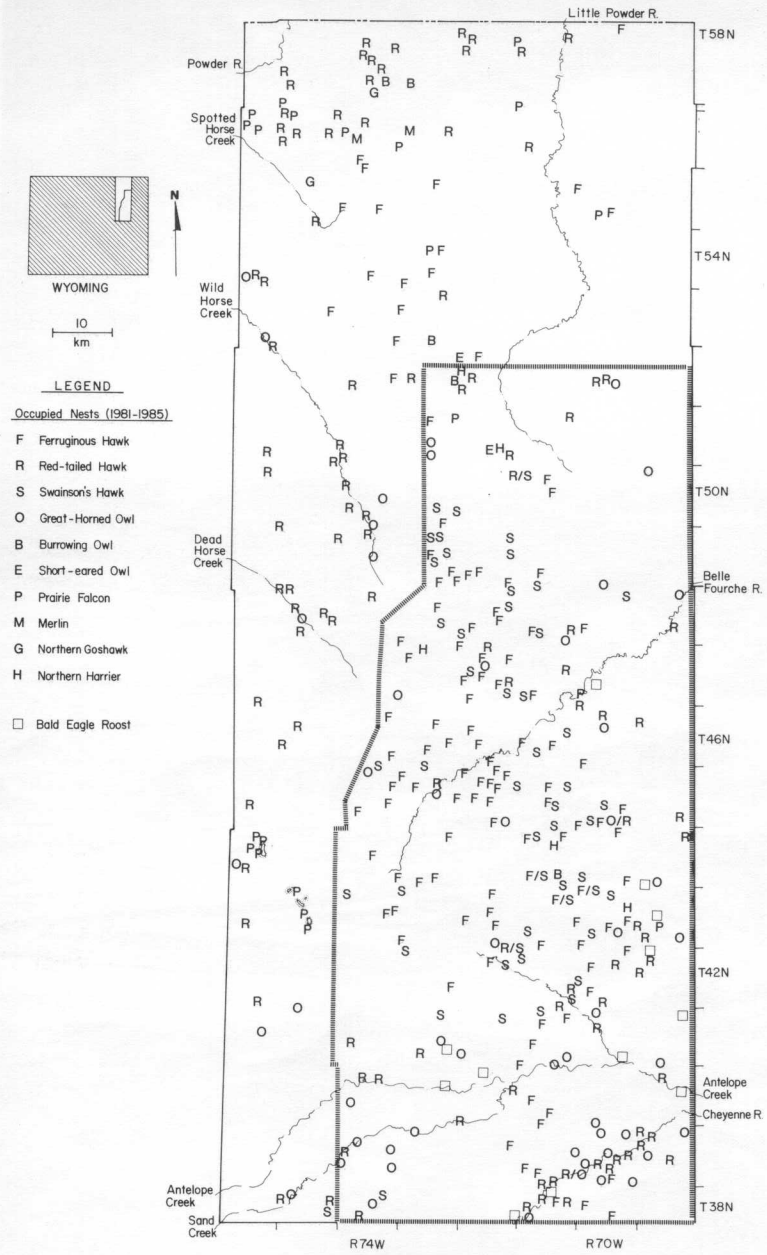

Fig. 19. Location of bald eagle winter roosts and other occupied raptor nests on the study area. Eagle Research Area is shown within the heavy border.

Although prairie falcons were not common as nesting birds on the study area, many were seen on the area in late summer and early fall, coinciding with the dispersal and migration period of the prairie falcon breeding cycle. Most of these birds disappeared by late fall and very few falcons were seen on the area during winter. Prairie falcons were commonly observed during spring migration, but few were seen during the breeding season.

Great Horned Owls

Great horned owls (*Bubo virginianus*) nested throughout the study area in a variety of sites. In addition to using the old nests of golden eagles, ferruginous hawks, red-tailed hawks, and Swainson's hawks, owl nests were in rock crevices, on coal mine silos, and on an abandoned haul truck. Fifty-three occupied great horned owl nests were recorded.

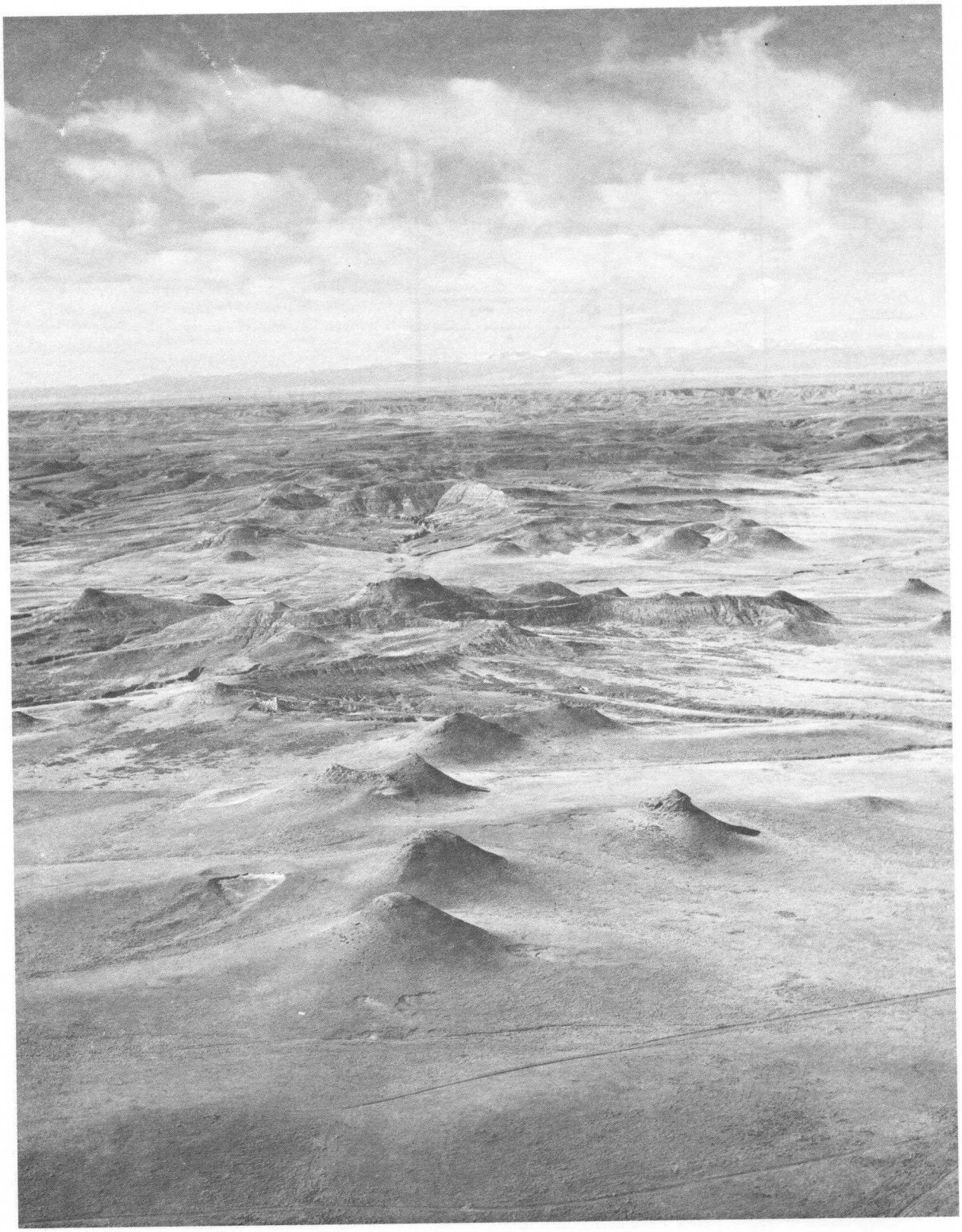

Fig. 20. Typical ferruginous hawk-nesting habitat north of Gillette, Wyoming.

Fig. 21. Ferruginous hawk nest on rock outcrop.

Fig. 22. Small trees (mostly elms) are typical nesting sites for Swainson's hawks.

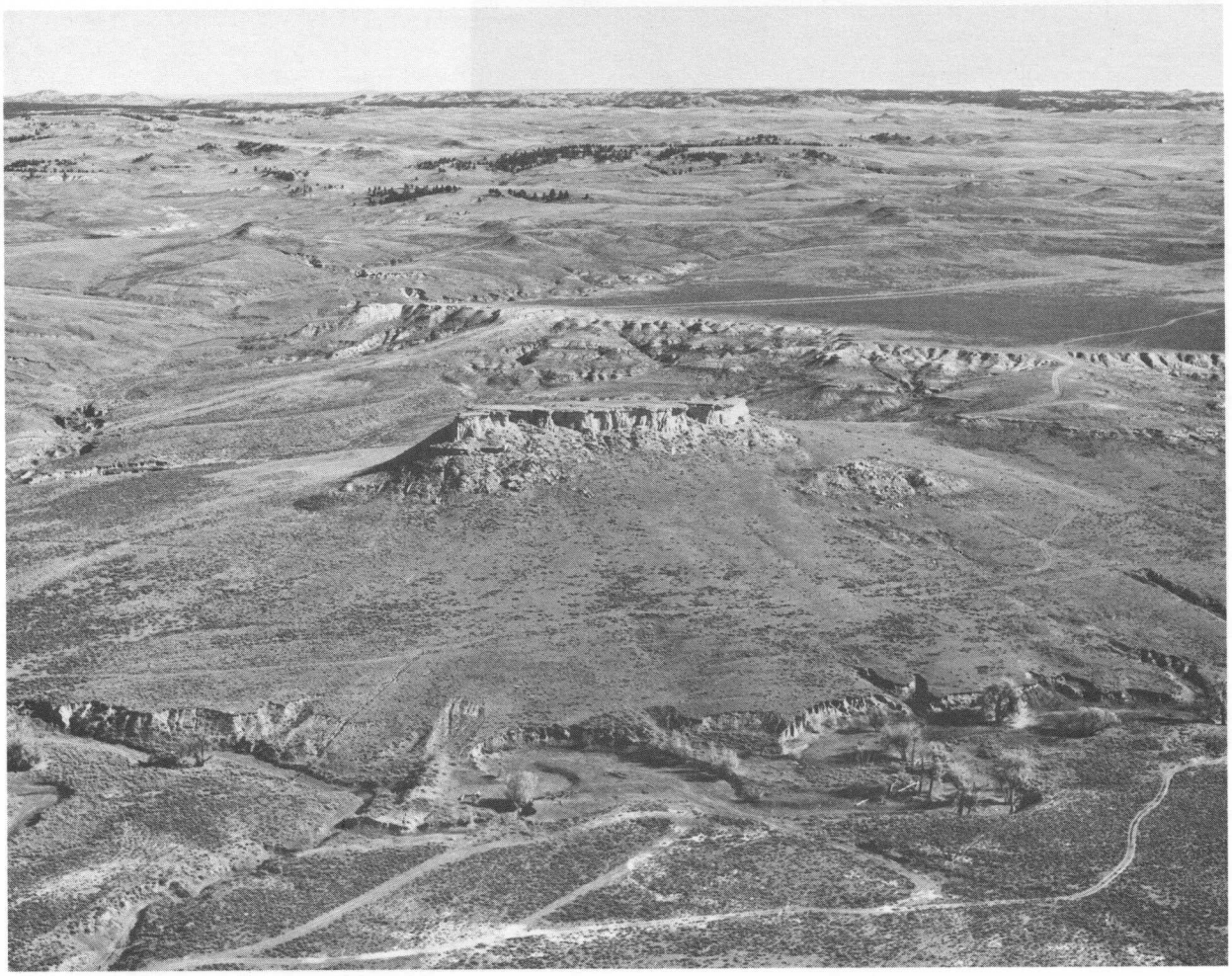

Fig. 23. Isolated sandstone cliffs are used by prairie falcons and golden eagles in the northern part of Campbell County.

We noted that when rabbits were scarce in 1985 (see section on golden eagle reproduction), no occupied great horned owl nests were observed that year during the late March–early April aerial golden eagle surveys.

Other Raptors

There was no systematic search for northern goshawk (*Accipiter gentilis*), northern harrier (*Circus cyaneus*), merlin, American kestrel (*Falco sparverius*), short-eared owl (*Asio flammeus*), or burrowing owl nesting sites. However, nests of all these species were encountered during the course of other field activities. Their distribution (except for kestrels) is shown in Fig. 19. Kestrels were commonly encountered throughout the study area. Nesting pairs were most abundant in the pine hills of northern Campbell County and along the cottonwood drainages in the southern part of the study area. Northern harriers were observed occasionally during the breeding season, but only two nesting sites were located. Both were in dense planted grassland, one on a mine reclamation area and one along a railroad right-of-way. Two nesting sites each of northern goshawks and merlins were found while surveying the RPU. The goshawk nests were in large ponderosa pines; the merlin nests were found in old black-billed magpie (*Pica pica*) nests in smaller pine trees. The number of short-eared owls seen on the study area fluctuated dramatically. They were most abundant during 1983 when we observed large numbers of voles (*Microtus* spp.) in grassy areas. Although many owls were seen in 1983, only two nests were found; one on a reclaimed grassland and one in a subirrigated meadow. Five burrowing owl nest sites were found. Two were on the RPU and three on the ERA. Three nesting sites were associated

with black-tailed prairie dog towns and the other two were in old badger (*Taxidea taxus*) holes.

Bald Eagles

Winter use of the study area by bald eagles has been documented since at least 1979. Since then, two bald eagle winter roosts in ponderosa pines near the eastern edge of the ERA have been checked regularly by Wyoming Game and Fish Department personnel. During our study an additional 10 roosting areas, 6 in cottonwood stands and 4 in ponderosa pines, were located (Fig. 19). The number of bald eagles counted at roosts varied from 1 to 22, and averaged 9.8 eagles per roost in 1983 (Table 8). An additional ponderosa pine roost, just off the southeast corner of the ERA in the Miller Hills, contained an additional 17 bald eagles. If we assume that there was little or no movement of bald eagles between roosts and between survey dates, then at least 108 bald eagles were in the study area between 18 January and 4 February 1983. This number compares surprisingly well with the estimate of 95 bald eagles using the area in the 1978–79 winter (Wyoming Game and Fish Department 1979). A study by Powder River Eagle Studies (U.S. Forest Service, Douglas, Wyoming, unpublished report) indicated that the number of bald eagles counted at some of these roosts varied dramatically during winter, and during 1984 the greatest number of bald eagles was counted in late February.

Although no recorded breeding attempts have been observed on the ERA, bald eagles constructed at least four nests during the study period. Each of those was built in cottonwood trees, and all were close to roosts. One of those nests was subsequently used by red-tailed hawks, but bald eagles tended that nest the following winter. The habitat on the ERA is not typical bald eagle breeding habitat, and the closest known occupied bald eagle nest is approximately 47 km to the southeast. With the repeated nest building activity on the area, we believe that bald eagles may attempt nesting on the ERA in the near future.

No systematic observations were made to determine food habits of the wintering bald eagles, but carrion (pronghorn, deer, sheep, and cattle) probably were the major source of winter food. A study of cast pellets by Hayden (1984) at the northernmost roost on the ERA during 1979–81 found that pronghorn, white-tailed jackrabbit, and domestic sheep accounted for 95%, by weight, of all pellets counted. Bald eagles were also observed hunting in the prairie dog towns along Antelope Creek.

Land Use and the Future of Raptor Populations

Distribution of nesting raptors and their use of the particular portions of the study area seemed to be associated with the habitat diversity. Riparian areas having large cottonwoods surrounded by upland sagebrush-grassland with prominent rock outcrops provided nesting and roosting sites for many large raptors. Cottonwood trees provided the most important substrate for nesting raptors, while the adjoining sagebrush-grassland areas supported

Table 8. *Location and numbers of bald eagles observed in and near roosts on the Eagle Research Area, Wyoming. All roosts were counted during the 1983 survey with the exception of Black Thunder.*

			In roost		Near roost[a]		
Name of roost	Location	Date	Adult	Immature	Adult	Immature	Total
Belle Fourche	T47N, R70W, secs 21, 27	3 February	14	2			16
Black Thunder	Discovered in 1985; no count data available						
Keeline	T43N, R69W, secs 10, 15, 16	18 January	20	2			22
School Creek	T42N, R69W, secs 4, 5	18 January	3	3			6
Keyton Creek	T41N, R69W, sec 1	4 February	12	3			15
Antelope Creek	T41N, R70W, sec 25	4 February			1		1
Antelope Creek East	T40N, R69W, sec 13	4 February	7	5			12
Antelope Creek West	T40N, R73W, secs 12, 13	19 January	2	4			6
North Bates Creek	T41N, R73W, secs 24, 25	18 January	8	1			9
South Bates Creek	T40N, R72W, sec 3	19 January	5				5
Cheyenne North	T38N, R71W, sec 3	19 January	7	1	2		10
Cheyenne South	T38N, R71W, secs 18, 19	19 January	4	1	1		6
Total							108

[a] Bald eagles observed within 1 km of roost during survey.

the necessary prey base to feed this complex of raptors. The Betty Reservoir 15′ quadrangle (58,016 ha) in the southwest portion of the ERA exemplified how five raptor species used one area of diverse habitat (Fig. 24). This location contained the nesting sites of 33 golden eagle pairs, 7 ferruginous hawk pairs, 3 red-tailed hawk pairs, and 2 great horned owl pairs. During winter months four bald eagle roosts were also identified there.

Mining (Fig. 25) and oil and gas development (Fig. 26) have had, and will continue to have, an effect on raptor habitat in the study area. In addition, agriculture has affected portions of the area in the past. Farming and grazing practices on the area have benefited some species and have been detrimental to others. Windbreaks planted around homesteads and clearing of sagebrush are beneficial and have probably led to an increase in the number of breeding Swainson's hawks on the area. Most of the windbreaks around abandoned homesteads are used by some raptor species. However, heavy grazing by domestic livestock seems to be slowly removing these windbreaks and eliminating cottonwood regeneration along riparian areas. If this trend continues, we expect a decline in the number of tree-nesting raptor species. Although Bureau of Land Management and U.S. Forest Service management plans provide for protection and rehabilitation of riparian areas under their control, much of the study area is private surface ownership over which Federal land management agencies have little influence.

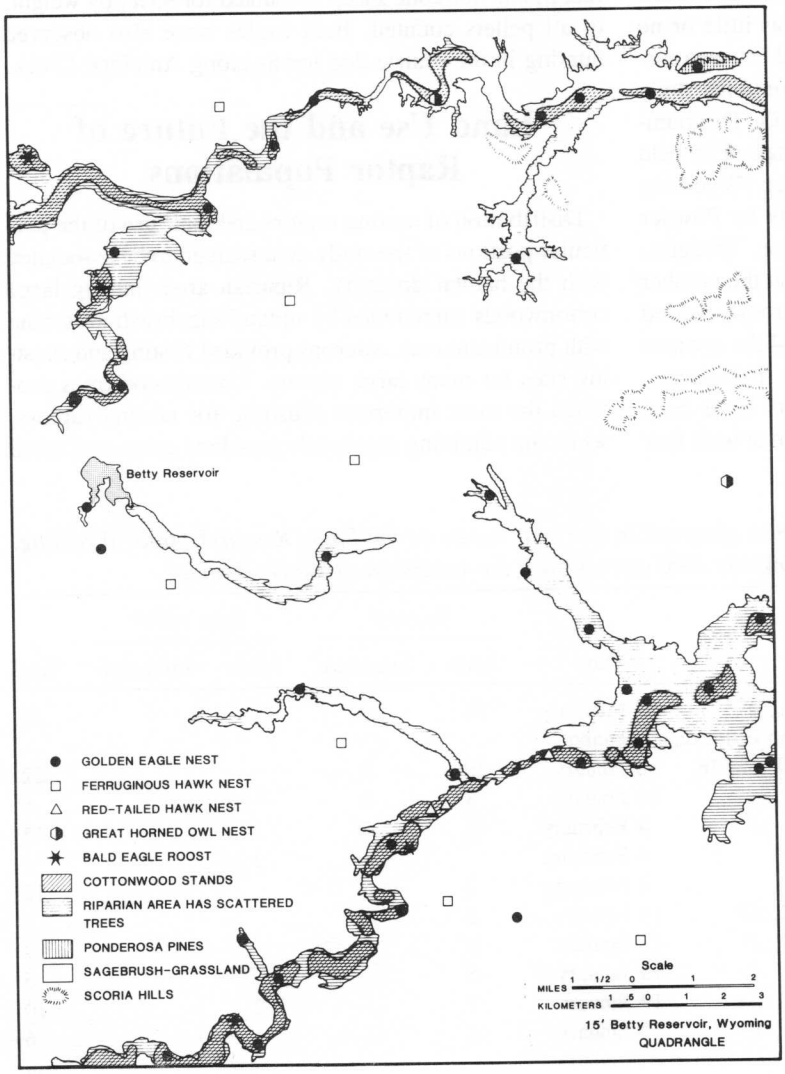

Fig. 24. Vegetative composition of the Betty Reservoir 15′ minute quadrangle map showing the typical spatial distribution and nesting habitat use patterns for four prairie-nesting raptors.

Fig. 25. Arco's Black Thunder mine is the largest producing coal surface mine in the western United States; note the reclaimed land (in foreground of photo), which was specifically designed to accommodate raptor habitat needs.

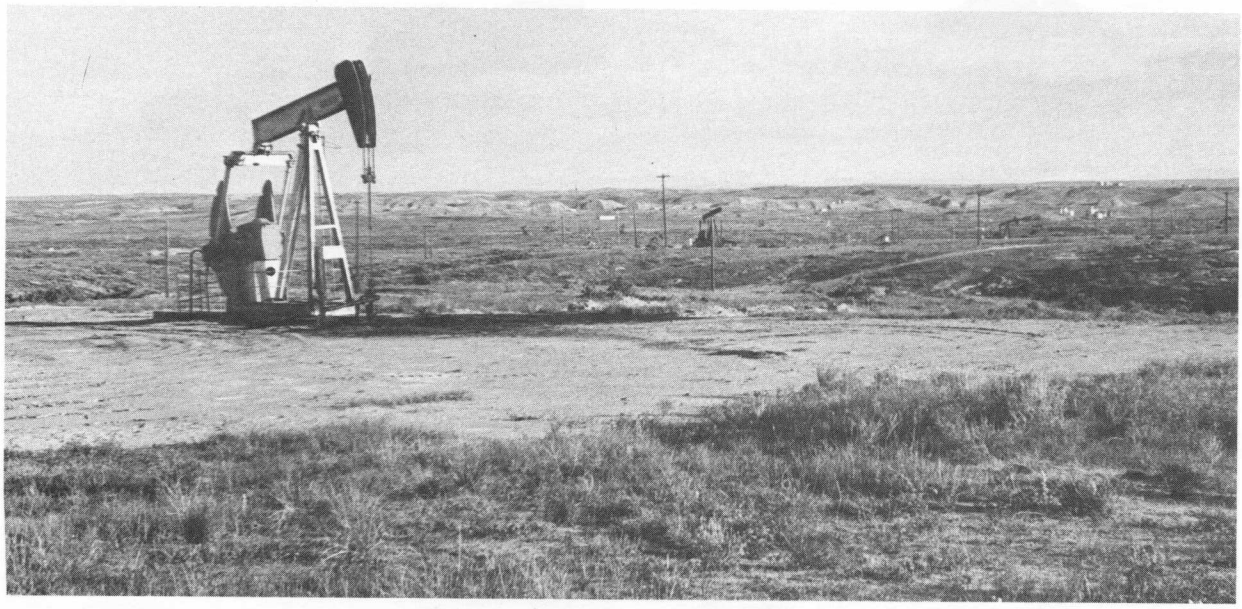

Fig. 26. New and expanding oil fields cause some loss of raptor hunting habitat. Human disturbance and power lines associated with oil development can pose threats to certain raptor species.

The Surface Mining Control and Reclamation Act of 1977 includes many provisions to prevent or mitigate the effects of surface mining on raptor populations. Raptor baseline surveys are required and protective measures are incorporated into mine plans before any disturbance takes place. In some instances, specific raptor habitat needs have been incorporated into mine reclamation plans (Fig. 27).

Buffer zones around nest sites were one of the first measures used to protect nesting raptors. An area around each known nest site was prohibited from surface use or disturbance. The protected area has varied from a radius of 0.4 to 1.6 km, depending on the species or land management agency involved. More recently, buffer zones have been established based on site investigations of the topography and knowledge of the nesting species' tolerance to disturbance. Buffer zones have also been defined on a temporal basis, that is, activity within the nest site buffer zone has been restricted only during the breeding season and during the use period for winter roosts.

When disturbance of a nest site is unavoidable, mechanical techniques (Fig. 28) have been used to construct nesting platforms (Fig. 14d) and to move breeding pairs to more secure nesting areas (Postovit et al. 1982; Phillips and Beske 1984; Fala et al. 1985).

Other measures that have been used to protect raptors include requiring that all power lines be constructed to specifications that reduce raptor electrocution hazards, planting trees to provide nest sites, constructing rockpiles to provide nest sites and prey cover areas, and leaving mine highwalls to provide cliff habitat for nesting sites and cover (Postovit and Postovit 1987). A study in the area has suggested that small mammal populations and biomass on reclaimed areas equal or exceed those in native habitats (Hingtgen and Clark 1984). Thus, it seems that mining, when accompanied by surface reclamation, will not destroy the prey base on which some raptors depend.

Current raptor protection measures seem to be adequately protecting the raptor resource, satisfying legal requirements of land and wildlife management agencies, yet allowing development of energy resources. When raptor conflicts arise, two alternatives are available to resolve problems; the resident pair can be relocated, or an application can be made for a permit to take the

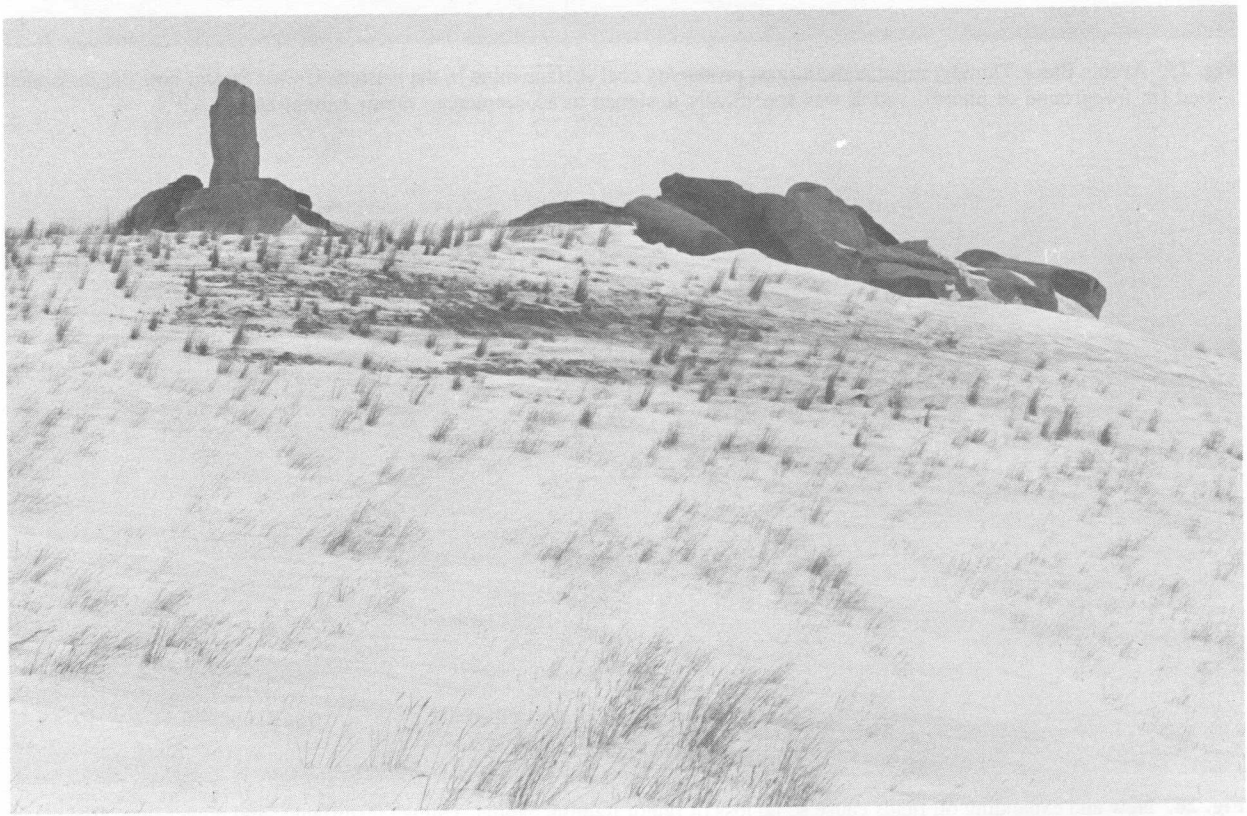

Fig. 27. Rock outcrops on reclaimed sites can serve as nest substrates and perches for many raptor species.

Fig. 28. A crane lifts golden eagle nest to truck for transportation to new location. Relocation of nesting sites has been a successful mitigation technique.

conflict nest (Ruos and Phillips 1982). A take permit, however, still requires development of a mitigation plan to provide for future use of the area by raptors.

Coal surface-mining operations had disturbed 6,979 ha of land on the ERA by December 1985. By December 1986, 1,189 ha (17%) had been reclaimed (Tessman 1987). Thus far, most of the mining activity on the ERA has occurred in sagebrush-grassland areas where few raptors nest. The total land area disturbed is approximately 1% of the ERA. Although parts of individual raptor territories have been altered, the net effect on nesting densities has probably been negligible. Most raptors continue to use mining areas throughout the coal removal and reclamation process.

Development and expansion of communities such as Wright, Wyoming (Fig. 29), have caused permanent losses of wildlife habitat. As with mining, most of these losses have been in sagebrush-grassland habitat where few raptors nest. The planting of trees along roadways and adjacent to towns may mitigate the habitat loss by encouraging raptors such as Swainson's hawks to use these areas.

The future of raptor populations in northeastern Wyoming will depend on the wise use of land by the public and private sector. We hope the information contained in this report will assist land managers in evaluating the effects of future energy development and other land use practices on raptors.

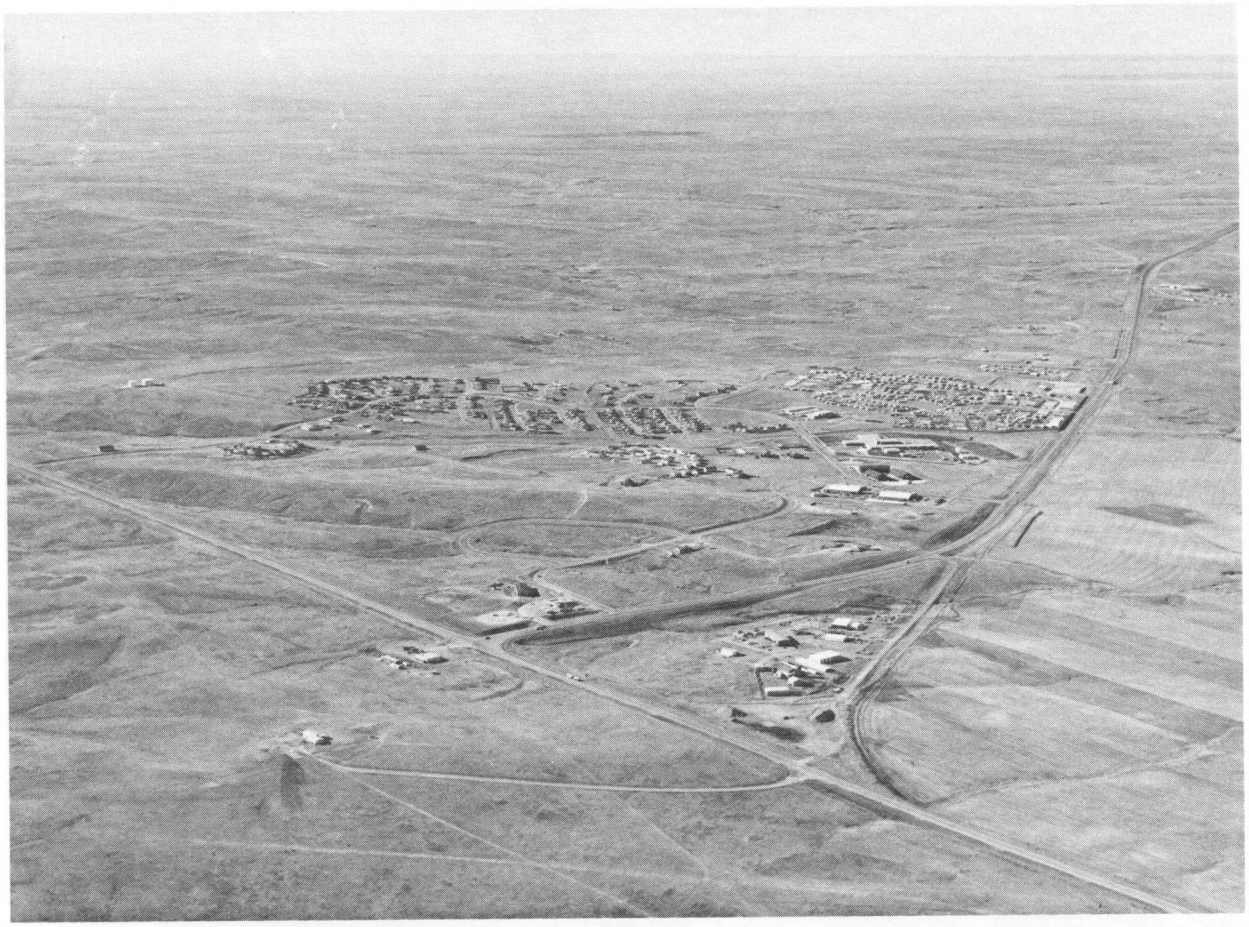

Fig. 29. New towns such as Wright, Wyoming, in southern Campbell County have permanently changed habitat on the study area.

Acknowledgments

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