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COMMUNAL ROOSTING OF COMMON RAVENS IN SOUTHWESTERN IDAHO

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ABSTRACT.—From 1983–1987, Common Ravens (*Corvus corax*) used thirteen communal roosts on a segment of electrical transmission line that runs 597 km from south-central Idaho to south-central Oregon. Up to 2103 ravens were counted at a single roost that spanned approximately six km of transmission line and 15 transmission towers. Most roosts were occupied between spring and autumn; one was occupied year-round. Peak numbers of ravens at most roosts and peak numbers of occupied roosts occurred during late summer and early autumn. Ravens concentrated on the highest portions of transmission towers, although more ravens roosted on the lower portions of towers when winds exceeded seven km/h. Ravens arrived at roosts earlier relative to sunset during summer than during spring or fall. Soon after fledging, juvenile and adult ravens left nesting areas and moved as far as 60 km to communal roosts. Some ravens used more than one communal roost during a year, moving between roosts up to 63 km apart. *Received 19 Feb. 1991, accepted 10 July 1991.*

Communal roosting is a prominent behavioral feature of the Corvidae (Goodwin 1976). Although roosting aggregations of up to several hundred Common Ravens (*Corvus corax*) have been observed throughout the northern hemisphere (Table 1), little is known about raven roosting behavior or roost site selection. Furthermore, there has been no published account of ravens roosting on power lines. In southwestern Idaho and southeastern Oregon, large concentrations of Common Ravens roosted on towers of Pacific Power's Malin to Midpoint 500-kV transmission line. This apparently unique situation provided an ideal opportunity to observe and document the roosting behavior of Common Ravens. Herein, we describe the temporal and spatial patterns of roost use and the behavior of ravens roosting on this transmission line.

STUDY AREA

The Malin to Midpoint 500-kV transmission line was constructed during 1980–1981 and runs 713 km (442 miles) from the Midpoint Substation, Jerome County, Idaho (line-mile 0) to the Malin Substation, Klamath County, Oregon (line-mile 442; Fig. 1). The line can be divided into two distinct segments separated by the Summer Lake Substation, Lake County, Oregon, located at line-mile 370. Fieldwork was limited to the area east of the Summer Lake Substation.

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TABLE 1

CHARACTERISTICS OF COMMUNAL ROOSTS OF COMMON RAVENS

Location	Peak count	Substrate	Season of use	Reference
California, USA	200	brushy canyon	autumn–winter	Cushing 1941
England, UK	120	crags	winter	Fergusson 1943
Iraq	100+	trees	winter	Hutson 1945
Wales, UK	70	trees	year–round	Cadman 1947
Scotland, UK	32	crags	not reported	Coombes 1948
Scotland, UK	276	not reported	not reported	Campbell 1956
England, UK	86	trees	winter–spring	Hurrell 1956
Michigan, USA	61	not reported	summer	Mahringer 1970
Virginia, USA	106	trees	winter	Lucid and Conner 1974
Alaska, USA	10	abandoned buildings	winter	Temple 1974
Alaska, USA	800–900	not reported	autumn–winter	Brown 1974
Alaska, USA	160	trees	spring–summer	Brown 1974
Oregon, USA	836	marsh vegetation	autumn–winter	Stiehl 1981
Scotland, UK	300+	oil tanks/cliffs	not reported	Ewins et al. 1986
Scotland, UK	300+	cliffs	summer	Ewins et al. 1986
Germany	620[a]	trees	year-round[b]	Sellin 1987

[a] Peak counts ranged from 40–620 ravens.
[b] Twelve roosts were occupied for periods up to six months during different seasons.

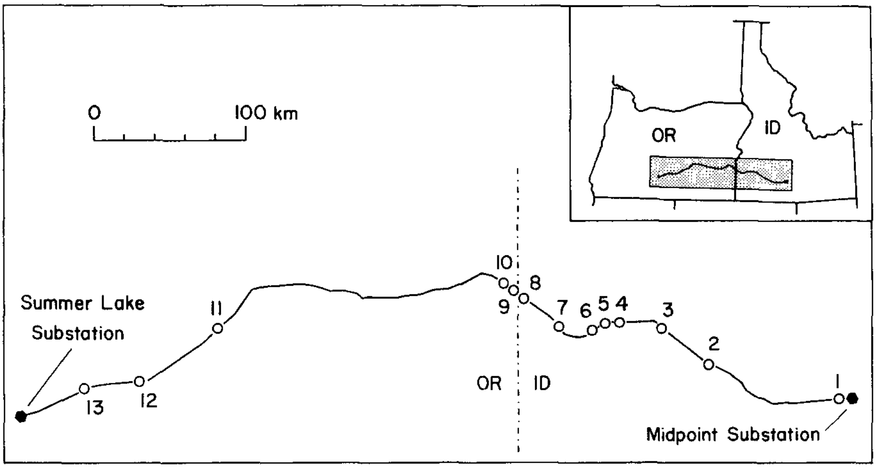

FIG. 1. Communal roosts of Common Ravens located on the Malin to Midpoint 500-kV transmission line, 1983–1987. Numbers refer to roosts described in Table 2.

Our study area encompassed a 125-km segment of line (line-miles 83–160) located in southwestern Idaho and extreme southeastern Oregon (Fig. 1). The free-standing steel-lattice towers (Fig. 2) are 25–47 m high and spaced approximately 300–400 m apart. In Idaho, the power line follows the relatively flat, deep-soiled Snake River plain. At the Oregon border, the Snake River heads north while the line continues west into more rolling topography. The area is dominated by livestock-grazed shrubsteppe vegetation (West 1983) and agriculture. From 1978–1987, mean annual temperature averaged 10.1 ± 1.1°C, and annual precipitation averaged 36.4 ± 7.8 cm (U.S. Dept. of Commerce, unpubl. data). Each year, about two-thirds of the annual precipitation fell from October to March.

METHODS

Roost surveys.—From April 1984 to November 1988, we surveyed the study area once each month to locate new communal roosts and to identify reoccupancy of previously used roosts on the transmission line. We considered a "roost" to be a collection of one or more adjacent transmission towers each with a concentration of at least three ravens perched together after sunset or before sunrise. Family groups of ravens roosting on towers at or near their nest sites during the fledging period (late May to mid-July) were not considered communal roosts.

From April 1984 to September 1985, we surveyed the study area primarily from the air. From then on, we surveyed the line from the ground. Surveys were flown as late in the evening as possible without compromising either our safety or ability to see roosting ravens. Aerial surveys began approximately 10 min after sunset on clear nights and five min after sunset on overcast nights. Ground surveys were performed by an observer who drove maintenance roads adjacent to the line and examined insulators for accumulated raven feces (i.e., contamination). In addition, we obtained information on roost occupancy over the entire transmission line opportunistically from routine maintenance patrols and nest surveys (Steenhof et al. 1987).

Throughout the study, we interviewed residents living near the transmission line to de-

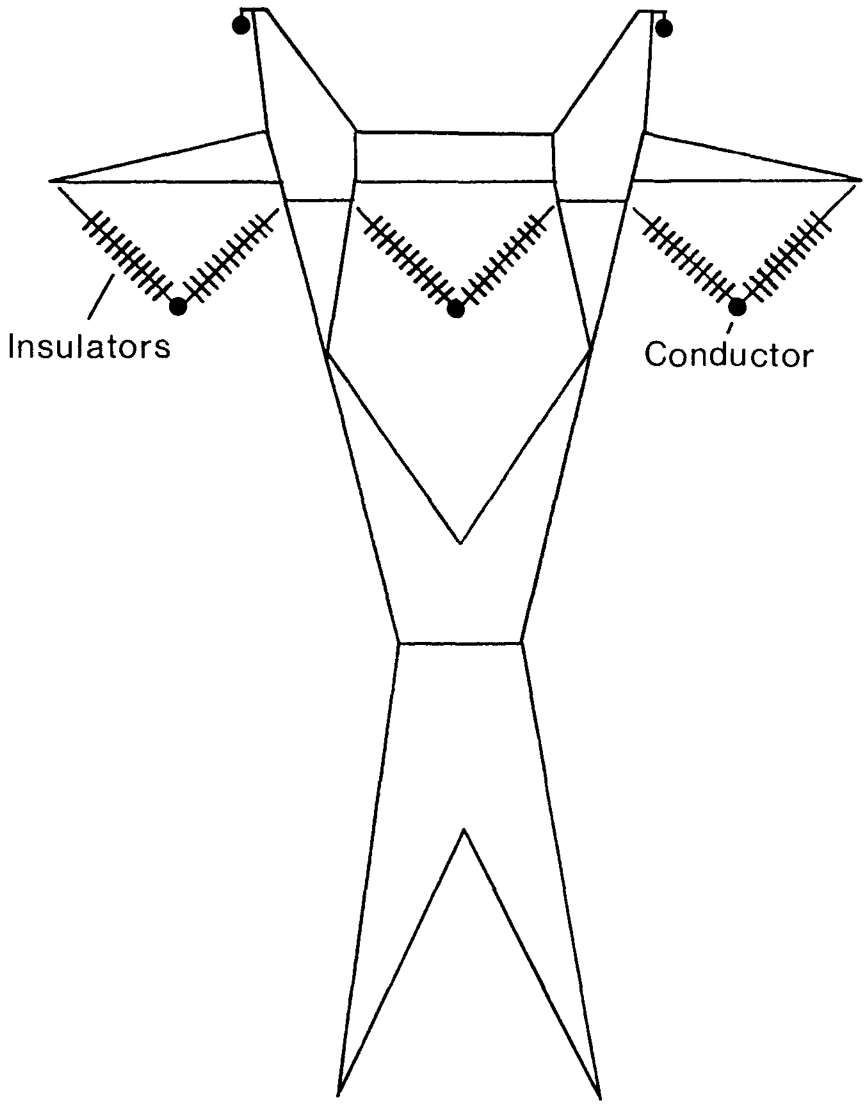

FIG. 2. Outline of a typical 500-kV transmission tower.

termine if ravens had been roosting in the vicinity of the transmission-line roosts before the line was constructed.

Roost observations.—In 1983, we observed one raven roost (Pleasant Valley Road) once a month to monitor temporal trends in the numbers of ravens there (Steenhof 1983). Then from 1984–1987, we observed selected raven roosts in the study area one to three evenings/

week to further describe raven roosting behavior, use of towers, and temporal trends in raven numbers (Young and Engel 1988).

Roost observations were made from a vehicle parked at a good vantage point usually at least 400 m from the nearest occupied roost tower. Observations began by 10 min before sunset and continued until it was too dark to count ravens accurately (usually 30 min after sunset). Every 10 min, an observer recorded the number of ravens perched on each of 10 tower sections of every occupied roost tower (Fig. 2). Each evening, the maximum number of ravens counted during a single 10-min interval was considered the total count for that roost. Percent cloud cover, wind velocity, and presence of precipitation were also recorded during each roost observation. Wind velocity was measured with a hand-held anemometer. In addition, during 1984–1986 and 1988, exact times of first arrival were recorded during roost observations. "Time of first arrival" was defined as the time after which at least one raven was present continuously on a roost tower.

Two all-night observations were made at the Initial Point Roost in June 1984 to determine whether ravens moved among towers during the night. A night scope (U.S. Army, AN-TVS4) was used to make these observations.

From April 1984 to November 1988, we simultaneously observed all occupied roosts on the transmission line east of the Summer Lake Substation once each month to monitor temporal trends in the number of ravens roosting on the line at one time. Other raven roosts (off the line) found in the study area were also observed during these "simultaneous" counts to obtain an estimate of the trends in the total number of ravens roosting communally in the study area. Procedures for these "simultaneous" counts were the same as those described above, with at least one observer stationed at each roost.

Observing marked ravens.—During May and June 1984, we wing-marked 71 nestling ravens from nests on 500-kV transmission towers and 59 from nests on natural substrates to determine when and how far juvenile ravens traveled from their nests to join communal roosts (Young and Engel 1988). Color and position of markers denoted whether nestlings were from 500-kV transmission tower or natural-substrate nests. Each marker bore a single digit; numbers in combination identified the specific nest from which individual ravens came.

During 1985–1987, we captured, transmitter-equipped, and radio-tracked 33 ravens as part of a study of their movements and habitat use (Young and Engel 1988). Twenty-four ravens (16 adults, seven subadults, one juvenile) were trapped at feeding areas near roosts, and nine were hand-captured as fledglings (ca 35–40 days old) at their nests. Transmitter-equipped ravens were tracked during four randomly selected days each week. One raven was tracked on each observation day from the time it left its roost in the morning until it returned to its roost in the evening. In addition, roost locations of transmitter-equipped ravens were determined one to four nights per week to document movements of ravens among roosts. Roost locations were determined by an observer with a hand-held antenna who checked each roost in the study area between one hour after sunset and one hour before sunrise.

Data analysis.—We used one-way analyses-of-variance (ANOVA) to test for differences in the percentage of ravens roosting on upper tower sections among roosts. Tower sections were grouped into "upper" and "lower" sections, located above and below the tower insulators, respectively (Fig. 2). If a significant difference was found, Tukey's Honestly Significant Difference (Tukey HSD) tests were used to determine between which roosts significant differences existed. Individual tower-nights were the sample units for tower-use analyses. Data collected from the Wilson Creek Roost after 1984 were excluded from tower-use analyses, because perch-deterrent devices were installed on towers at this roost in 1985 as part of another study (Young and Engel 1988). Only nights with no wind (<1 km/h) were included in these analyses, because wind appeared to influence the vertical distribution of ravens among tower sections (Young and Engel 1988). Due to small sample sizes, inter-roost comparisons of tower use could be made only among the Initial Point, Marsing Dump, and Marsing Southwest roosts.

We used two-way ANOVA to examine the effects of wind velocity and the presence of precipitation on the percentage of ravens roosting on upper tower sections. Wind velocities were grouped into three categories for analysis: no wind, moderate winds (>0 km/h and <8 km/h), and high winds (≥8 km/h). If we found a significant wind effect and no significant interaction between wind and precipitation effects, we then used one-way ANOVA followed by Tukey HSD tests to locate between which wind velocities significant differences existed.

We used two-way ANOVA to test for month and cloud cover effects on times of first arrival. Percent cloud cover was grouped into three categories for analyses: clear skies (≤20% cloud cover), partly cloudy (>20% and <80% cloud cover), and overcast (≥80% cloud cover). If we found a significant month or cloud cover effect and no significant interaction between month and cloud cover effects, we then used one-way ANOVA followed by Tukey HSD tests to locate between which months or amounts of cloud cover significant differences existed. Individual roost-nights served as the sample units for these analyses.

All percentages were arcsine transformed (Zar 1974) before analysis. Statistical tests were evaluated at the 0.05 level of significance.

RESULTS

Use of roosts.—Large concentrations of roosting ravens were first observed on the transmission line in 1982, less than one year after the line was constructed. From 1983–1987, we located 13 communal raven roosts on the line, eight of which were within our study area (Fig. 1). Distances between adjacent transmission-line roosts in the study area averaged 12.4 km, ranging from 0.8 (Initial Point to Swan Falls Road) to 25.4 km (Wilson Creek to Marsing Dump). Five roosts (i.e., Initial Point, Swan Falls Road, Wilson Creek, Marsing Dump, and Marsing Southwest) were considered "major" roosts based on the relatively high numbers of ravens involved and the length of time each roost was occupied (Table 2). All major roosts we found were located on the transmission line in our study area during the first year surveys were made; no new major roosts developed on the line after 1984.

Interviews with local residents in the study area indicated that each of the major roosts was situated in an area where ravens roosted communally before the line was constructed; these earlier roosts occurred on rock outcrops, scattered clumps of low trees, and smaller transmission lines.

Ravens in the study area did not roost exclusively on the 500-kV transmission towers. Four communal roosts were found within 10 km of the transmission line by following transmitter-equipped ravens; three were on a 138-kV distribution line, and one was on the ground in mixed shrub-grass rangeland. Ravens also roosted occasionally on the ground adjacent to occupied transmission-line roosts.

The largest roosts on the transmission line were located within our study area. Maximum numbers of ravens counted at seven of the eight transmission-line roosts in the study area exceeded 500, whereas no more than 150 ravens were counted at the other transmission-line roosts (Table 2). The highest count at a single roost (Initial Point) was 2103 on 22 July 1984. Relative sizes of the major transmission-line roosts were consistent from year to year. Each year, numbers of ravens were highest at the Initial Point Roost, followed by Marsing Southwest, Marsing Dump, and then the Wilson Creek or Swan Falls Road roosts.

From year to year, use of the transmission line by roosting ravens was highest in the late summer to early autumn and lowest during winter. Total numbers of ravens roosting on the line during simultaneous counts ranged from zero to 2121, with numbers being highest in July–September and lowest in January–March (Fig. 3). Peak numbers of ravens at most transmission-line roosts (10) occurred generally during late summer and early autumn, although peak numbers occurred during spring or autumn at Swan Falls Road and Wilson Creek and during autumn and winter at Marsing Southwest (Table 2). Peak numbers of both roosting ravens and occupied roosts tended to coincide. Between zero and six transmission-line roosts were occupied on a single night, with the highest number of roosts occupied during July–September and the lowest during November–February.

Annual roost occupancy from 1983–1987 ranged from one to five years; five roost sites (Midpoint, Hot Springs, Ditto Creek, Alkali Creek, and Moon Reservoir) were occupied briefly (≤2 months) and during only one year (Table 2). Almost all transmission-line roosts (12) were occupied only between spring and autumn, but the Marsing Southwest Roost was occupied throughout the year. The length of time that individual roosts were occupied during a year ranged from one (e.g., Midpoint and Ditto Creek roosts) to 12 months (Marsing Southwest). The length of time each major roost was used was relatively consistent among years, although length of use of one major roost (Swan Falls Road) declined during the study.

Use of towers.—Within roosts, both numbers of towers used and numbers of ravens per tower varied considerably among nights. The number of towers used simultaneously at a roost ranged from one to 15 (Initial Point Roost), spanning up to six km of line. Numbers of ravens roosting on a single tower ranged from three to over 700. At each roost, ravens tended to concentrate on the centrally located towers within a span of occupied roost towers. However, ravens were never observed roosting on towers supporting nests occupied by ravens during the breeding season, even if the nest tower was located within a span of occupied roost towers.

Overall, 92% of the ravens observed roosting on transmission towers

TABLE 2

USE OF COMMUNAL ROOSTS BY COMMON RAVENS ON THE MALIN TO MIDPOINT 500-KV TRANSMISSION LINE, 1983–1987

Roost (line-miles)	Periods of occupancy		No. of ravens		
	Year	Months[b]	$\bar{x}$ (SD)	Max. (month)	N
1.[a] Midpoint (2)	1986	Oct.	—[c]	—[c]	—[c]
2. Hot Springs (61)	1985	May–June	22 (0)	22 (June)	1
3. Ditto Creek (85–86)	1986	Sept.	42 (0)	42 (Sept.)	1
4. Pleasant Valley (101–103)	1983	Feb.–Sept.	181 (247)	620 (July)	5
	1984	July–Aug.	77 (95)	144 (Aug.)	2
5. Initial Point (106–113)	1984	Apr.–Sept.	835 (398)	2103 (July)	63
	1985	Mar.–July	460 (269)	1075 (July)	58
	1986	Apr.–Nov.	532 (441)	1226 (Aug.)	8
	1987	May–Dec.	571 (390)	1339 (Aug.)	36
6. Swan Falls (114–117)	1984	Apr.–Oct.	110 (133)	359 (Oct.)	165
	1985	Aug.–Sept.	379 (126)	543 (Aug.)	11
	1986	Mar.–May, July–Sept.	175 (202)	540 (Mar.)	6
	1987	Mar., June, Aug.	13 (8)	27 (Mar.)	9
7. Wilson Creek (131–132)	1984	Apr.–Oct.	245 (135)	559 (Oct.)	11
	1985	Mar.–Aug.	123 (85)	298 (May)	42
	1986	Mar.–Oct.	66 (40)	137 (Apr.)	31
	1987	Mar.–May, July–Dec.	115 (118)	334 (Sept.)	26
8. Marsing Dump (148–150)	1984	Aug.–Sept.	427 (264)	613 (Aug.)	2
	1985	Jan.–May, July–Oct.	284 (253)	945 (Oct.)	49
	1986	Jan., Mar.–Dec.	299 (198)	621 (Nov.)	11
	1987	Jan.–Dec.	233 (164)	543 (Oct.)	43
9. Marsing Southwest (153–156)	1984	Apr.–Dec.	311 (188)	690 (Dec.)	17
	1985	Jan.–May, July–Oct.	284 (253)	945 (Oct.)	49
	1986	Jan., Mar.–Dec.	299 (198)	621 (Nov.)	11
	1987	Jan.–Dec.	233 (164)	543 (Oct.)	43

TABLE 2
CONTINUED

Roost (line-miles)	Periods of occupancy		No. of ravens		
	Year	Months[b]	$\bar{x}$ (SD)	Max. (month)	N
10. Alkali Creek (160)	1985	Nov.	701 (0)	701 (Nov.)	1
11. Moon Reservoir (283–284)	1986	Aug.	136 (0)	136 (Aug.)	1
12. Wagontire (321–322)	1984	June–Oct.	101 (58)	148 (July)	4
	1985	July	37 (0)	37 (June)	1
13. Christmas Valley (342)	1984	July	63 (0)	63 (July)	1
	1985	July	12 (0)	12 (July)	1

[a] Numbers refer to locations on Figure 1.
[b] Systematic surveys did not begin until April 1984 and covered only line-miles 83–160.
[c] Occupancy of this roost was identified through ground surveys.

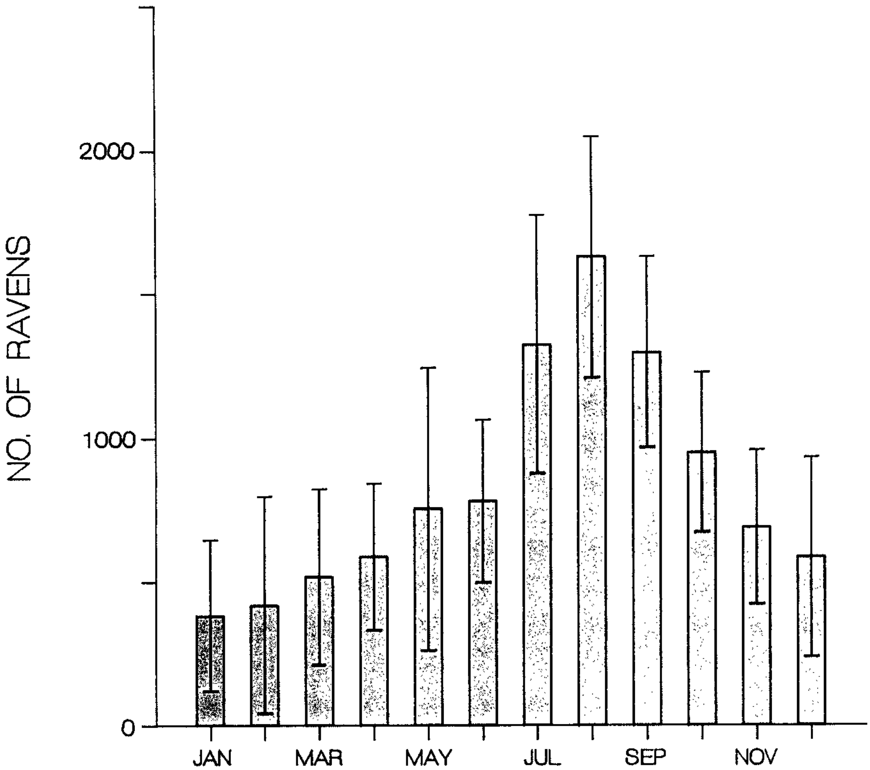

FIG. 3. Mean numbers of Common Ravens counted on the transmission line during monthly simultaneous observations, April 1984–November 1988.

roosted on upper tower sections above insulators. The percentage of ravens roosting on upper tower sections did not differ significantly between nights with and without precipitation (two-way ANOVA, $F = 1.87$, df = 1, 1403, $P = 0.17$); however, the percentage of ravens on upper tower sections did differ significantly among nights with different wind velocities (two-way ANOVA, $F = 47.11$, df = 2, 1403, $P < 0.01$). A significantly higher percentage of ravens roosted on upper tower sections during nights with no to moderate wind (95% and 92%, respectively) than during nights with stronger winds (77%; one-way ANOVA, $F = 54.66$, df = 2, 1406, $P < 0.01$; Tukey HSD Ps < 0.01).

Although the percentage of ravens roosting above insulators on windless nights differed significantly among roosts (one-way ANOVA, $F = 6.43$, df = 2, 608, $P < 0.01$), the majority (>93%) of ravens at each roost used upper tower sections. During evenings with no wind, the percentage of ravens roosting above insulators was significantly higher at the Marsing Southwest Roost (97%) than at the Initial Point Roost (94%; Tukey HSD $P < 0.05$).

Roosting behavior.—Ravens gathered at staging areas before roosting, converging from a variety of foraging areas. Staging areas were almost always open and sparsely vegetated. Some staging areas were located at the bases of roost towers; others were several km away. Ravens usually flew from staging areas to roost towers singly, in pairs, or in small groups (<10 individuals). However, the entire staging aggregation sometimes flew to the roost simultaneously.

Ravens began to roost on towers between one hour before and 35 min after sunset and usually continued to land on towers until dark. Maximum counts were almost always obtained during the last count interval. Mean time of first arrival on towers was 13 ± 22 min before sunset (N = 347 roost-nights). Times of arrival did not differ significantly among clear, partly cloudy, and overcast evenings (two-way ANOVA, $F = 2.50$, df = 2, 302, $P = 0.08$); however, arrival times did differ significantly among months (April–October; two-way ANOVA, $F = 5.01$, df = 6, 302, $P < 0.01$; Fig. 4). Times of first arrival tended to be earlier with respect to sunset during the summer months than during other times of year; arrival times were significantly earlier relative to sunset during June and July than during all other months (one-way ANOVA, $F = 10.01$, df = 6, 316, $P < 0.01$; Tukey HSD Ps < 0.05).

Ravens exchanged positions repeatedly on roost towers before settling down approximately one hour after sunset. No nocturnal movement was observed during two all-night observations. Ravens usually began to leave roost towers before dawn. Transmitter-equipped ravens were observed leaving roosts in total darkness as early as 45 min before sunrise. Ravens often gathered at staging areas immediately, but sometimes they flew directly to foraging areas. Occasionally, large numbers of ravens were also observed on roost towers during the day.

Roosting ravens occasionally shared towers with raptors, including Red-tailed Hawks (*Buteo jamaicensis*), Ferruginous Hawks (*B. regalis*), and Prairie Falcons (*Falco mexicanus*). Raptors almost always roosted on lower tower sections below ravens. Ravens usually ignored Golden Eagles (*Aquila chrysaetos*) perched beneath them on lower tower sections; however, when an eagle perched on an upper tower section of an occupied roost tower, ravens often harassed the eagle, rising repeatedly from the tower as a group to mob it. Ravens usually settled down by dark, and they were never observed roosting within 4–5 m of an eagle on an upper tower section.

Ravens in the study area did not always roost communally. Transmitter-

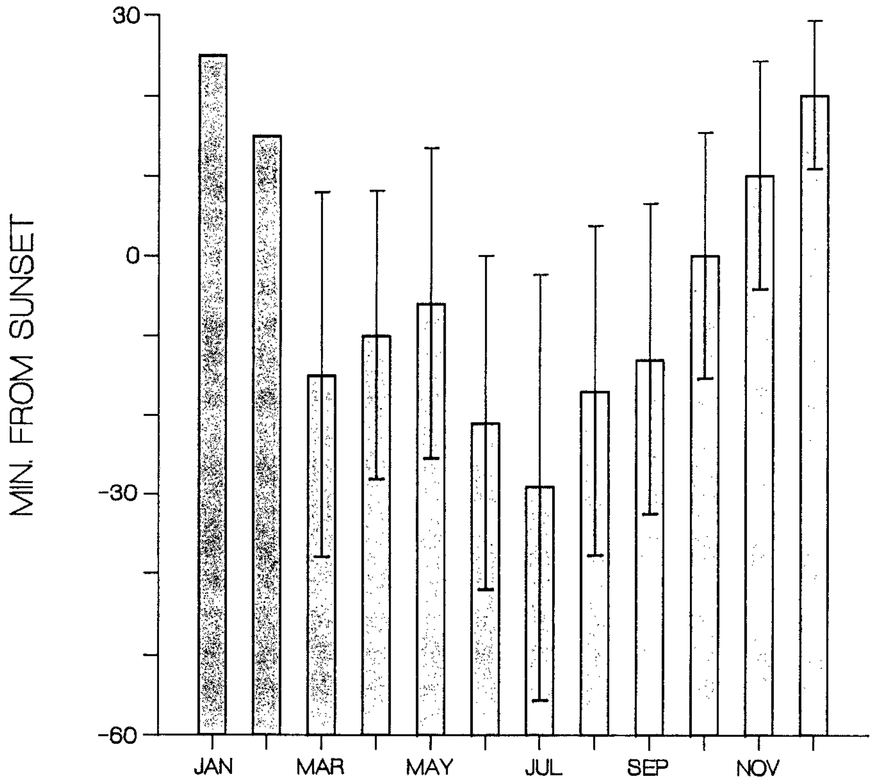

FIG. 4. Mean monthly times of arrival of Common Ravens to communal roosts, April 1984–December 1986 and January–November 1988.

equipped breeding ravens usually roosted at their nest sites during the breeding season and occasionally roosted at their nest sites during other times of year. In addition, one subadult transmitter-equipped raven was observed roosting alone on the ground in a cornfield approximately one km from the nearest communal roost.

Movements of ravens among roosts.—Numbers of roost locations obtained for 32 transmitter-equipped ravens ranged from two to 163 (insufficient data were collected for one transmitter-equipped raven). Twenty transmitter-equipped ravens used more than one roost during the periods they were tracked. Individual ravens were observed using from one to six different roosts. The maximum number of movements observed between roosts was exhibited by one raven that changed roosts 19 times over a period of 209 days. Conversely, the longest period an individual raven was observed using a single roost was 209 days at the Marsing Southwest

Roost. In general, the number of times a transmitter-equipped raven moved to other roosts increased with the length of time it was tracked; of the 11 ravens that were not observed changing roosts, nine were tracked for a relatively short period of time (≤ 3 months), and four were tracked during winter when only one roost (Marsing Southwest) was occupied. However, among those birds for which roost locations were obtained at least once per week, one raven used two roosts in a period of two days, and another used only one roost over 120 days.

Movements of ravens occurred between all transmission-line roosts in the study area, including those up to 63 km apart (Initial Point to Marsing Southwest). Frequency of movements between roosts was not related entirely to the distance between roosts. Movements of ravens among transmission-line roosts were most frequent between the Initial Point and Marsing Southwest roosts (nine movements), followed by movements between the Initial Point and Swan Falls Road roosts (six movements).

Incorporation of juvenile ravens.—We made 85 sightings of wing-marked (but not transmitter-equipped) juvenile ravens within 400 m of a communal roost. Forty-five (53%) sightings were of ravens from transmission-tower nests, and 22 (26%) were of ravens from natural-substrate nests (18 sightings were not identified). During 1984, the year these ravens were marked, we began seeing wing-marked fledglings at the Initial Point Roost in early July; three of these sightings were of fledglings from a natural-substrate nest approximately 24 km away from the roost.

We obtained more detailed information on incorporation of fledgling ravens into communal roosts from the five transmitter-equipped fledgling ravens. Dates of incorporation occurred from eight to 41 days after transmitter attachment ($\bar{x} = 23 \pm 12$ days), when the ravens were between 43 and 81 days old. Four of the juvenile ravens first joined roosts on the 500-kV transmission line; however, one juvenile first joined a roost on a nearby 138-kV distribution line. Notably, this raven was the only transmitter-equipped juvenile from a natural-substrate nest. Juvenile ravens did not always first join the roost closest to their nests. One juvenile initially joined a roost 50 km from its nest, and another raven joined one 60 km away. In contrast, juvenile ravens from two nests within the Initial Point Roost first joined that roost.

DISCUSSION

Three main aspects of the roosting behavior of ravens we observed were similar to those exhibited by many other communally roosting species. First, most communally roosting birds studied use the same roost sites year after year (Eiserer 1984). Although five roost sites on the transmission line were occupied for less than two months and during only one year, most roost sites on the line were used during successive years. Intermingling of birds among local communal roosts such as we observed is also common (Caccamise et al. 1983).

Second, seasonal fluctuations in numbers of birds at a communal roost are typical (Eiserer 1984). Similar to ravens in our study, roosting flocks of European Starlings (*Sturnus vulgaris*) and Common Grackles (*Quiscalus quiscula*) increased through early summer, peaking in mid-August and then declining through fall (Caccamise et al. 1983). The seasonal changes in numbers of ravens at the communal roosts we observed likely reflect changes in both the proportion of the local population using communal roosts and in the size of the local raven population. The summer increase in ravens at communal roosts was probably due to an influx of nesting birds and their newly fledged young; peak numbers of roosting ravens coincided with the post-fledging period, and all marked juvenile ravens joined communal roosts during this time. On the other hand, autumnal declines in overall numbers of ravens using communal roosts may have been due to dispersal of some birds out of the study area, with those remaining shifting to the Marsing Southwest Roost for the winter. All (six) transmitter-equipped ravens that remained in the study area until winter moved to the Marsing Southwest Roost when this roost was increasing in size and other roosts were being evacuated.

Third, roost approaches typically tend to occur at higher light intensities than do roost departures (Eiserer 1984). Ravens may leave roosts at lower light intensities than they enter them simply to take advantage of early morning foraging opportunities (Counsilman 1974) or because of an immediate need for food upon waking (Seibert 1951). Although cloud cover does not appear to influence roosting time in some birds (Young 1971), the lack of relationship we found between cloud cover and roosting time may have been due to our method of measurement. Illumination level may influence the timing of initial movements of ravens toward their roosts more than it influences the timing of arrival at the roost, as observed in starlings (Davis and Lussenhop 1970). Seasonal differences in the timing of roosting flights have also been observed in other species where, similar to ravens in this study, roosting times were earliest during summer (Davis 1955, Meanley 1965, Gyllin and Kallander 1976); however, the reasons for these differences remain unclear (Eiserer 1984).

There are, however, three unique aspects of the raven roosts on the Malin to Midpoint transmission line. First, these are the largest known roosts of Common Ravens in the world (Table 1). Before this study, the largest reported roosts included one of up to 800–900 ravens near Fairbanks, Alaska (Brown 1974) and another in the Harney Basin, Oregon, where a peak of 836 ravens was recorded (Stiehl 1981). The peak count of 2103 ravens recorded at the Initial Point Roost is more than twice the number of ravens observed at either of the other roosts.

The relatively large sizes of the raven roosts we observed were likely due to locally abundant food sources and nest sites for ravens. In our study area, foods associated with agriculture comprise a large part of the diet of ravens year-round and are abundant throughout the year (Engel and Young 1989). Furthermore, cliffs of the Snake River Canyon, numerous buttes and rock outcrops, and the transmission towers together provide abundant nest sites for ravens in our study area. As many as 128 raven pairs nest in the Snake River Canyon (USDI 1979), and in 1987, 35 pairs of ravens nested on the 500-kV transmission-line towers in our study area (Steenhof et al. 1987).

The second unique aspect of the transmission-line roosts is that they involve man-made structures, whereas most raven roosts reported in the literature occurred on natural substrates (Table 1). Ewins et al.'s (1986) report of ravens roosting on oil storage tanks, and Temple's (1974) observations of ravens roosting in abandoned buildings, are the only previously published records of Common Ravens roosting on man-made structures. Although ravens did not roost exclusively on transmission towers during our study, towers appeared to present an attractive alternative to other roost sites. Ravens roosting on transmission towers may be less susceptible to predation than those roosting closer to the ground or in trees and rock outcrops. In addition, the transmission towers may provide safe roosting sites that are also in closer proximity to local food sources than alternative sites.

Lastly, the roosts we observed were used predominately during spring to autumn, and one was occupied year-round. Most raven roosts reported in the literature were occupied in autumn and winter, excluding a spring/summer roost of up to 160 ravens in Alaska (Brown 1974) and a summer roost of up to 61 ravens in Michigan (Mahringer 1970; Table 1). Furthermore, only two previously reported raven roosts (Cadman 1947, Sellin 1987) were occupied year-round. The perennial food supply provided by agricultural activities in our area may have facilitated the year-round occupation of the Marsing Southwest Roost.

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