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ECOSYSTEM-LEVEL MANAGEMENT OF COMMON RAVENS ON THE POINT REYES NATIONAL SEASHORE

Report to Point Reyes National Seashore

by

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Executive Summary

(1) Herein, we report on movement and habitat use patterns, foraging and predatory behavior, and population size of Common Ravens on the Point Reyes Peninsula. We outfitted 13 adult ravens with backpack-mounted radio transmitters (Advanced Telemetry Systems, model 5955), and followed 9 birds throughout a study period lasting from February through July 1999.

(2) Common Ravens (*Corvus corax*) were concentrated at ranches at Point Reyes National Seashore (PRNS) and focused much of their foraging effort in those areas. Range size of non-breeding birds was larger than that of breeding birds.

(3) The most prevalent habitats associated with foraging were grazed grass, dunes, and cattle feeding areas. The most prevalent food items identified were small animals, including birds, rodents, and reptiles; calf carcasses and afterbirth; and grain.

(4) Preliminary results suggested that a few ravens specialized on Common Murre (*Uria aalge*) colonies, while many individuals visited Snowy Plover (*Charadrius alexandrinus*) nesting areas.

(5) We estimated the current population on Point Reyes and Tomales Point to be approximately 285 ravens. Christmas Bird Count data indicated that the winter raven population in the Point Reyes Count Circle increased slightly from 1970 to 1998, but showed no trend in the segments that include Point Reyes and Tomales Point from 1985 to 1998.

(6) The PRNS raven population is being subsidized by abundant food resources available at ranches.

(7) Controlling ravens' access to these resources may lead to a lower population level, thereby reducing their impact on vulnerable avian species.

(8) Conditioned Taste Aversion (CTA) would be difficult, with an unknown likelihood of protecting nesting Common Murres, and would probably be ineffective for protecting Snowy Plovers. Lethal control methods would probably provide a temporary solution or require intensive, ongoing efforts.

(9) Home range sizes, habitat use, and foraging ecology for this population in a human-structured landscape should be investigated further to provide more information on the factors affecting the raven population, and allow for quantitative analyses of those factors.

(10) Specific recommendations are to extend the study for another two years; review monitoring protocols; investigate, with ranchers, alternative methods for food delivery to cattle; and further evaluate the use of CTA at Point Reyes Lighthouse and possibly test this technique.

Introduction

Common Ravens are opportunistic nest predators on many bird species, and have the potential to adversely affect populations (Andren 1992, Gaston and Elliot 1996). The effect can be especially pronounced on vulnerable populations, where ravens may have a disproportionate, negative impact on reproductive success, survival, and population size (Littlefield 1995). In addition, ravens are adaptable birds, able to exploit a variety of food resources (Engle and Young 1989, Stiehl and Trautwein 1991). These traits allow ravens to thrive in human-structured environments (Engle and Young 1992, Marzluff et al. 1994). Raven populations in the Western U.S. are increasing (Sauer et al 1997) or being maintained at artificially high levels, which may be due primarily to their use of human refuse and habitats (Engle and Young 1992, Marzluff et al. 1994).

Concern over the impact of raven predation on Snowy Plover and Common Murre populations in the Point Reyes National Seashore prompted this study of raven ecology. The Pacific Coast Snowy Plover population is listed as a threatened species under the Endangered Species Act of 1973 (USFWS 1993). The Point Reyes population dropped from approximately 54 birds in 1987 to approximately 12 birds in 1995 and 1996 (Hickey and Page 1996). Common Murre populations of PRNS are in a depleted state due to by-catch in gill-net fisheries, chronic and catastrophic oil spills, and recent El Niño events (Page et al 1990, Takekawa et al. 1990, Ainley et al 1995, Nur et al. 1996). To address these concerns, we investigated movement patterns, habitat use, and foraging ecology of radio-tagged Common Ravens, monitored the effects of predation by Common Ravens on Common Murres and Snowy Plovers, and estimated Common Raven population size on the Point Reyes Peninsula. We report results from our first year of the study, discuss factors influencing the raven population, evaluate management options, and define future study needs in this report.

Methods

Trapping

Ravens were captured between 8 December 1998 and 12 August 1999 using a CODA Enterprises 86-6000 Netlauncher and M & M Fur Company Victor 1.5 Soft Catch Coil Spring traps. We measured the weight, culmen length, and wing chord of each bird. We checked birds for brood patches when caught during the breeding season (February – July), and used mouth color to age the birds (Kertuu 1973). Each bird was individually color banded and adult birds (not more than one of each pair) also received an Advanced Telemetry Systems (ATS) backpack-mounted radio transmitter (model 5955) weighing from 21.55 to 22.20 grams. We made transmitter harnesses from Teflon ribbon in the manner of Beuhler et. al. (1995). Electrical heat-shrink tubing was used to color code transmitter antennas with one or two colors to make identification of individual birds easier.

General Radio-Tracking Strategies

To obtain information on movement patterns, habitat use, foraging ecology, and behavior, we divided each day into 3 time periods: morning (first 4 hours of daylight), mid-day (all hours between morning and late day), and late day (last 4 hours of daylight). We sampled each bird over all time periods (i.e. one complete day) at least once a month to ensure a balanced sampling approach for each bird and to detect diurnal patterns of behavior and habitat associations. We

began tracking in February and continued through July 1999. We devoted one hour to finding each radio-tagged bird; if a bird was not found during this time, we moved onto the next bird. If a bird was found, we monitored its movement for two hours using an ATS Receiver (model R4000) coupled with ATS Magnetic Dipole and 4 Element YAGI antennas.

At five-minute intervals, during 2-hour focal observation periods, we recorded location, behavior, habitat type, nearest habitat type, viewing distance, and group size (all birds within 50 and 100 meter radii of the focal bird). We also recorded the time whenever a bird flew out of, or back into, view. Locations were plotted on 7.5 minute USGS topographic maps and recorded as UTM coordinates. All locations were confirmed visually; new locations were recorded when a bird moved at least 100 meters from the previous location. The same location was recorded if a bird didn't move at least 100 meters or flew away and returned to the same area during the five-minute period between observations. Flying locations were only recorded if a bird showed interest in a particular area by circling, patrolling, scanning, inspecting, swooping down, etc.

We report results pertaining to the following information:

(1) Home Ranges
To qualitatively evaluate the extent of each bird's home range, areas of high raven concentration, and overlap of raven territories, we mapped locations obtained during the 2-hour focal periods.

(2) Foraging Habitat and Food Resources
To identify foraging habitats and food resources, we expanded upon observations of foraging behavior obtained during the 2-hour focal periods. In addition to the information mentioned above, we recorded food item, method used to obtain food, foraging substrate, and foraging height above ground. To obtain a measure of foraging habitat use, we divided the number of foraging observations in each habitat type by the total number of foraging observations for each bird. We then pooled individuals to calculate the mean frequency of occurrence of each habitat type. To identify important food resources, we divided the number of times each food item was seen by the total number of observations in which food item was identified for each bird. Again, we pooled individuals to calculate the mean frequency of occurrence of each food type.

(3) Predation
Common Murres
To investigate the effects of Common Raven predation on Common Murre colonies, U.S. Fish and Wildlife Service personnel conducted 2-hour predation watches, beginning in April and continuing throughout the murre breeding season. All disturbance events by predators and non-predators were recorded, and were sub-divided into ground and air events. Ground events were further sub-divided into active (e.g. ground harassment, lunging, pulling, and predation) and non-active (e.g. scavenging abandoned eggs or standing near the edge of a sub-colony) events. Air events were further sub-divided into harassment (e.g. hovering or dive-bombing by a predator) and fly-over (e.g. causing head-bobbing or flushing of murres from rocks) events. Non-active and fly-over events were only recorded if they caused a disturbance. Predatory and scavenging (i.e. eating abandoned or dead eggs and chicks) events were recorded to obtain information on the frequency and type of predation and were sub-divided into the above categories for both Common Raven and Western Gull. Eggs and chicks were only included in predation rate

calculations when method of obtainment was known. Numbers of ravens and tagged ravens seen patrolling murre colonies were noted.

Snowy Plovers
Point Reyes Bird Observatory (PRBO) staff counted the number of ravens seen along the beaches during Snowy Plover censuses or nest monitoring; sightings of radio-tagged birds on beaches were also made. The duration of censuses was not standardized; data was collected opportunistically during the course of other field work.

(4) Population Size
Christmas Bird Counts
Christmas Bird Count (CBC) data were obtained for the Point Reyes Count Circle, covering the period between 1970 and 1998. Count data were standardized as numbers per party hour by dividing the number of birds seen by the number of hours each team, or party, spent looking for birds in the area. Data was then log transformed (Ln), and regressions were performed to test for population trends. Data from segments of the CBC that include Point Reyes and Tomales Point (i.e. our study area) were separated and similar procedures were performed.

Roost Counts
We counted ravens and American Crows (*Corvus brachyrhynchos*) at a communal roost site at Home Bay once a week to obtain information on seasonal variation of roost attendance and raven population size. We used these counts, in conjunction with known territories, to estimate raven population size on the Point Reyes Peninsula. We began counts one hour before sunset and stayed until it was too dark to accurately count individual birds.

Road Surveys
PRNS personnel conducted road surveys along Sir Francis Drake Blvd., between the Pierce Point Wye and the Chimney Rocks Wye once a week from November 1996 to August 1999. Observers drove 35-45 mph from a standardized starting point. At the beginning of each survey, observers recorded survey route name, observer names, start time, date, visibility (good, fair, poor), wind speed, and odometer reading. Odometer reading, group size, perpendicular distance from the road, side of vehicle, flight direction, behavior, and comments were recorded each time ravens and crows were observed.

Results and Discussion

Trapping
We captured 15 adult ravens and 1 juvenile, and attached 13 transmitters between December 1998 and August 1999. We were able to follow 9 birds throughout the study period (February through July 1999). One of the tagged birds removed its antenna part way through the season, making tracking difficult if the bird was not in "line of sight". We were unable to follow one bird due to a defective transmitter. In addition, one transmitter was recovered from a dead bird, and one was found unattached with the harness intact. The last bird was caught late in the season (12 August) and was not included in this year's analyses.

Home Ranges

The importance of the ranches to ravens of PRNS was evident from the location data collected this year. Ravens concentrated at the ranches, focusing much of their foraging effort in those areas (Figure 1). Four tagged birds used the Mendosa and Nunes Ranches, while 5 tagged birds used the McClure Ranch (Figures 2 and 3).

There were also differences in the home ranges of breeding birds using the ranches versus those not using the ranches, and in home range size between breeding and non-breeding birds. Very localized movement patterns were seen in breeding birds that didn't spend much time at the ranches. For instance, one bird nested at Drake's Beach, and was rarely seen far from its nesting site (Figure 4). Another bird divided its time between the cliffs near the lighthouse and the Nunes and Mendosa ranches (Figure 5); this bird was probably a breeding bird (i.e. nesting was not confirmed, but the bird's behavior suggested breeding status).

In both cases, the home ranges of breeding birds were smaller than their non-breeding counterparts. For example, one non-breeding bird roosted at the communal roost site on Home Bay, and, from early February through April, foraged at the ranches on Point Reyes. From early May through July, the bird foraged at the ranches on Tomales Point, while still using the communal roost (Figure 6). The same bird was seen along the beach, between South Beach and Abbott's Lagoon. Another radio-tagged bird at the roost site foraged on ranches on Tomales Point from early February through April. That bird then disappeared from the peninsula and was tracked to a ranch north of Tomales, on the east-side of Tomales Bay, returning to Tomales Point in late May.

Foraging Habitats and Food Resources

Ravens spent most of their foraging time at ranches. Results are expressed as the mean frequency of use of each habitat type among 9 focal ravens ± SE. Grazed grass (0.312 ± 0.058) was the primary foraging habitat, followed by cattle feeding areas (fenced in areas with troughs; 0.138 ± 0.057), and plowed fields (0.036 ± 0.026). Some habitats were available on and off the ranches, including cypress, pine, and eucalyptus trees (0.065 ± 0.035); bare ground (0.048 ± 0.021); ungrazed grass (0.036 ± 0.013); and coastal scrub (0.013 ± 0.007). Ravens also spent time foraging in, or from, other human-designed habitats, including fence posts or telephone poles (0.071 ± .020); roads and parking areas (0.008 ± 0.004); mowed grass (0.005 ± 0.005); and human structures and picnic tables (0.005 ± 0.003). Other areas included, dune areas, including areas with iceplant, pickleweed, exotic dune grass, bare dunes, *and* native dune communities (0.151 ± 0.098); sandy and pebble beaches (0.041 ± 0.019); cliffs (0.065 ± 0.043); and sea stacks (0.006 ± 0.006). The substantial variability of foraging habitat use among individuals indicated that focal observations of more ravens are needed to detect clear patterns of habitat use, and more observation periods per individual are needed to adequately assess foraging variation within individuals. With additional data, we will also compare use of foraging areas with the relative availabilities of foraging habitat types. Beaches, cliffs, and sea stacks may be underrepresented in our sample due to the difficulty of tracking the birds in those areas.

Small animals, including birds, rodents, and reptiles, made up a large part of raven diets (0.311 ± 0.116; expressed as the mean frequency of occurrence among 9 focal ravens ± SE); followed by calf carcasses and afterbirth (0.262 ± 0.134); and grain (0.134 ± 0.080). Other human food

sources, including garbage, bread, and fruit, were also represented (0.087 ± 0.045). Food items making up smaller portions of the data will require more observations to distinguish statistically. These items included: terrestrial and marine invertebrates (0.067 ± 0.055); dung, probably including invertebrates and grain (0.050 ± 0.033); roadkill (0.056 ± 0.056); eggs (0.011 ± 0.011); Turkey Vulture regurgitations (0.011 ± 0.011); and meat from unknown sources (0.011 ± 0.011). Observations for each individual were pooled across observation periods, so no estimates of variability within individuals are available. Food items were difficult to identify, and smaller food items may be underrepresented in the above sample.

Predation

Common Murres

Preliminary results suggest that there are a few ravens specializing on the murre colonies. While it is difficult to be certain that the same birds are visiting colonies, there were generally only one or two birds near murres. We do not know whether other ravens were excluded by territorial individuals. However, large groups of ravens seen near the Lighthouse Visitor Center and at other places on the peninsula apparently were not involved in predatory attempts on murre colonies (Christine Hamilton, USFWS, pers. comm.).

One marked raven and/or her mate flushed murres from Wishbone Rock 3 times while entering or leaving their nest. One murre egg was laid on Wishbone Rock, but disappeared shortly thereafter; no further nesting attempts were made at this site. One or both of the pair also caused head-bobbing at Boulder Rock on one occasion, and caused a disturbance 8 times at Cone Rock. The pair was seen at the Cone Rock colony with their fledglings late in the season; murre eggs and chicks were taken by this pair, and the colony abandoned the site before the end of the breeding season. (Christine Hamilton, FWS, pers. comm.). Another marked bird (presumably breeding near the lighthouse) was seen once at Boulder Rock. Other radio-tagged ravens that were often seen at the nearby Nunes Ranch were not seen at the murre colonies.

Results from predation watches on murre colonies indicate that ravens cause 48% of all disturbances. Ravens cause 42% of ground disturbances and 84% of air disturbances; total air disturbances make up only 15% of all disturbances. Cone Rock received the highest number of total disturbances per hour (1.75) as well as the highest number of disturbances per hour by ravens (1.02; Table 1). It is difficult to assess the impact of disturbance, though it may keep murres from breeding in certain areas.

Data show that the overall predation rate on the colonies is 0.03 eggs and chicks per hour; ravens were responsible for all predation events during the 2-hour watches. The overall scavenging rate is 0.104 eggs and chicks per hour; ravens were responsible for 33% of all scavenging events, while Western Gulls were responsible for the remainder. Boulder Rock received the most predation per hour (0.06). The Elephant Seal Cove colonies received the most overall scavenging per hour (0.17), while Cone Rock received the most scavenging per hour by ravens (0.11; Table 2). A rough estimate of the number of eggs and chicks predated during the murre breeding season yields 35 eggs and chicks ([4 events/11 days = x events/96 days]). It is difficult to assess the impact of this egg and chick loss without data on the number of eggs laid at the colonies and the total number of eggs and chicks lost (including predation, abandonment, non-viable eggs, etc.).

Snowy Plovers

Raven predation (clutches lost to ravens / total failed clutches) on Snowy Plover eggs increased from 38 % in 1986 to 65 % in 1989 and decreased to 39 % in 1995 (Hickey et al. 1995). In 1996, PRNS and PRBO initiated a project to protect nesting Snowy Plovers from ravens and other predators. In brief, exclosures were put up around Snowy Plover nests after second eggs were laid (Hickey and Page 1996). Exclosures are made of 2 x 4 inch mesh fencing and are covered with parallel rows of nylon twine; they are designed to exclude predators, while allowing Snowy Plovers access to the nests (White and Allen 1997). Ravens took 2-3 eggs that year, before exclosures were put up (Hickey and Page 1996). Exclosures were put up after the first egg was laid from mid-season in 1997 to 1999. In 1997, ravens took 2 to 6 eggs before exclosures were constructed (White and Hickey 1997). In 1998 and 1999, ravens predated no nests (White and Ruhlen 1998, Ruhlen and White 1999). It is not possible to calculate a predation rate on Snowy Plover nests now that exclosures are being constructed.

Observations indicate that groups of ravens occasionally visit the beaches. In 1999, the median number of ravens seen during Snowy Plover nest monitoring and censuses between North Beach and Lighthouse Beach was 4 (n=7, range: 1-10; most were congregated on Lighthouse Beach). A median of 3 (n=15, range: 2-11) ravens were seen between Abbott's Lagoon and Kehoe Beach, 2 (n=20, range: 1-7) were seen between North Beach and Abbott's Lagoon, 2 (n=18, range: 1-13) were seen on Limantour Beach, and 1 (n=5, range: 1-3) was seen on Drake's Beach. The number of ravens seen during Snowy Plover censuses or nest monitoring remained about the same from 1998 to 1999 (Figure 7; PRBO unpublished data). The difference between the number of birds seen between North Beach and Abbott's Lagoon was due to one large group, on one day, at Abbott's Lagoon. The duration of censuses was not standardized, and data was collected opportunistically during the course of other fieldwork; the comparison of sites above is based on the best information available, but may not accurately reflect relative numbers of ravens along beaches.

One radio-tagged bird was seen at Lighthouse Beach (nesting at Mendosa Ranch), and four radio-tagged birds were seen between North Beach and Abbott's Lagoon (one unknown breeding status, one non-breeder, one nesting at Indian Beach, and one nesting at Abbott's Lagoon). No radio-tagged birds were seen between Abbott's Lagoon and Kehoe Beach or on Limantour Beach.

Ravens seen on the beaches were often flying and scanning along the beach, probing in the sand for mole crabs, or feeding on bird (gull, loon, and guillemot) carcasses. Snowy Plovers acted nervously or flushed from their nests when ravens flew over. In one case, ravens were watching as a plover began scraping (PRBO unpublished data).

Population Size

Christmas Bird Count Data

The number of ravens recorded during the Point Reyes Christmas Bird Counts fluctuated substantially from 1970 to 1998. Much of the variation can likely be attributed to observer effort and weather. Count circle totals (median=339, n=29) ranged from 121 in 1978 to 656 in 1979. Counts from segments of the circle covering the study area (i.e. Point Reyes and Tomales Point) also fluctuated from 1985 to 1998 (all years for which segment date was available; median=213, n=14), ranging from 105 in 1986 to 316 in 1990 (Figure 8).

Ravens per party hour increased slightly in the total count circle from 1970 to 1998 (b=0.0225, t=2.41, p=0.023); no significant trends were evident in the segments covering Point Reyes and Tomales Point (b=0.0053, t=0.199, p=0.845). More ravens (2-3 per party hour) were seen on Point Reyes and Tomales Point than in the count circle as a whole (1-2 per party hour; Figure 9). Segments do not include the Point Reyes headlands, and some birds may have been counted at both a communal roost site in one segment and in another segment in some years. The numbers seen during Christmas Bird Counts are similar to numbers recorded in 1999 roost counts.

Roost Count Data

Ravens invariably flew into a communal roost at Home Bay from the west and northwest (i.e. from the direction of Point Reyes and Tomales Point). Raven numbers at the roost increased from 136 in late January to 259 at the beginning of March. Raven numbers dropped steadily throughout the remainder of the season, reaching 0 at the beginning of June. The ravens have not returned to the site, and appear to be roosting along Inverness Ridge. Ravens are continuing to forage on Point Reyes and Tomales Point during the day. American Crow numbers increased from 36 in late January to 116 in early February. Crow numbers showed more fluctuation, dropping to 21 in late February, increasing to 100 in mid-March and dropping to 2 by early June (Figure 10). Crows forage on Tomales Point during the day, rarely visiting outer Point Reyes. Many crows also forage along the Inverness shoreline.

Large numbers of ravens historically roosted at the Home Bay site. A count of 454 ravens was made at the same site on 24 June 1980; crows were also heard at that time (D. Shuford, unpublished data). The higher number of ravens in 1980 may reflect seasonal increases in the number of juveniles using the site late in the nesting season. At the same time this year, birds had stopped using the site for unknown reasons. It is likely that the majority of the Point Reyes population consists of non-breeders that roost at the communal site and forage at the ranches during the day. Non-breeding, radio-tagged birds used the roost site, while no breeding, radio-tagged birds were seen there.

Road Survey Data

The median number of ravens seen during road surveys between the Pierce Point Wye and the Chimney Rocks Wye was 13 (n=12, range: 0-52) in 1999. Most of the birds were seen near cattle troughs or in fields near ranches. The median number of ravens was 26 (n=5, range: 3-47) in 1996, 7 (n=18, range: 1-53) in 1997, 10 (n=8, range: 0-23) in 1998, and 13 (n=12, range: 0-52) in 1999. It should be noted that the road surveys cover only half of the study area, and larger groups were occasionally seen during focal observation periods. A maximum of 75 birds was seen within a radius of 50 meters from a focal bird, and a maximum of 100 birds was seen within a radius of 100 meters from a focal bird.

Population Estimate

Based on roost counts and known nests we estimate the raven population on Point Reyes and Tomales Point to be approximately 285 birds (peak roost count early in the nesting season + [(13 nests) x 2 birds/nest]). Roost count data may or may not include birds that cross Tomales Bay to forage or roost on the peninsula; early morning observations indicate that there is some movement to and from the east side of Tomales Bay. Our estimate of the number of territories is minimal, as efforts did not include extensive nest searching throughout the entire PRNS area.

The Christmas Bird Count total of 293 in 1998 supports a population estimate of this magnitude (roughly 300 birds).

Conclusions and Recommendations

Common Ravens of PRNS exist in a human-structured and dominated ecosystem. Long-term solutions for minimizing the predation pressure ravens exert on sensitive species such as Snowy Plovers and Common Murres may require changes in land-use practices. Ranching, while an important component of the PRNS ecosystem, provides an artificial source of food for both breeding and non-breeding ravens. Available data showed no significant trend in the raven population on the Point Reyes Peninsula, which suggests that the population has had a stable, abundant food resource available for a long period of time.

Preventing ravens' access to food resources at ranches may be the most viable and lasting way to reduce numbers of ravens. Methods for preventing ravens' access to calf carcasses and grain would help to achieve that goal, and should be investigated. Controlling access to grain would also benefit the ranchers by limiting the amount of grain lost to ravens. Methods for educating the public to prevent access to picnic lunches should also be investigated.

Other options for reducing the impact of ravens on sensitive species include controlled taste aversion (CTA; Avery et al. 1995) and lethal control. CTA was utilized in southern California in an effort to protect Least Tern colonies and appeared to be a viable option in that case (Avery et al. 1995). The technique involves providing eggs or prey that have been treated with a toxic substance that causes severe illness and subsequently blocks further selection of the prey. Although Avery et al. (1995) found that a prolonged period of conditioning was required, using several baited nests, and that treated eggs must be placed in nesting areas, these conditions may not be necessary. Nicolaus and Lee (1999) provided evidence that CTA can be achieved by a single treatment, causing long-term behavioral changes through medullary processes rather than cerebral, cognitive processes. CTA is most likely to succeed if conditioned ravens are territorial, excluding other ravens from the colony. (Nicolaus 1987, Avery et al. 1995).

It may not be feasible to employ this technique in PRNS, however, where large numbers of ravens may visit Snowy Plover nesting beaches (i.e. many ravens would have to be subjected to CTA for the technique to be effective). Similarly, lethal control of ravens would most likely be a temporary solution or would require intensive, ongoing efforts. The raven population on the peninsula is large (i.e. many birds would have to be culled), and there are source populations in the surrounding areas (i.e. other birds would move into available habitat). Additionally, lethal control may be unpopular and present difficult public relations issues. Therefore, current efforts to protect Snowy Plover nests from predation by constructing exclosures is the best interim management option.

Only a few ravens frequent murre colonies. Although accessibility and disturbance issues make the task of placing treated eggs in murre colonies difficult, CTA may be possible to achieve by baiting ravens on nearby rocks. We emphasize that the likelihood that CTA could successfully protect the murre colonies from raven predation is unknown. However, removing ravens from the vicinity of the murre colonies could invite larger numbers of non-territorial ravens to feed in

the (undefended) colony (Nicolaus 1987), and ongoing removal efforts would be difficult or ineffective.

A single year of study cannot adequately address basic aspects of local raven ecology. Home range sizes, habitat use, and foraging ecology should be investigated further. Continued monitoring of radio-tagged birds will allow for quantitative analysis of home range size. Habitat preferences should be further investigated by combining home range data with vegetation maps. It is then possible to use focal observation data to estimate the time spent in each habitat relative to its availability, thus providing a measure of each habitat's relative importance to ravens. Continued investigations of foraging ecology, including habitats used for foraging, food items, and predatory behavior, would provide more information about possible impacts on other species, as well as factors that may affect the raven population of PRNS.

Information on preferred natural habitat areas could be crucial in future management of PRNS, especially in predicting the effects of managing raven use of ranches. Continuing this research would also provide information that could be used to predict the effects of prescribed fires on the distribution and abundance of ravens. Because ravens in PRNS are part of a population that operates on a larger spatial scale, we encourage collaboration and expansion of this work into neighboring areas in the region.

Specific Recommendations
(1) Extend the study for another two years.
(2) Review monitoring protocols.
(3) Investigate, with ranchers, alternative methods for food delivery to cattle.
(4) Further evaluate the use of CTA at Point Reyes Lighthouse and possibly test this technique.

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Table 1. Rates of disturbance (disturbances per hour) obtained from 2-hour predation watches of Common Murre colonies at the Point Reyes Headlands in 1999.

Sub-colony	All Disturbances[1]				Common Raven Disturbances			
	ground		air		ground		air	
	active	non-active	harass	fly-over	active	non-active	harass	fly-over
Boulder Rock	15/29=0.52	9/29=0.31	1/29=0.03	0	12/29=0.41	5/29=0.17	1/29=0.03	0
Elephant Seal Cove	25/35=0.71	6/35=0.17	4/35=0.11	5/35=0.14	3/35=0.09	0	4/35=0.11	5/35=0.14
Cone Rock	22/28.5=0.77	22/28.5=0.77	0	6/28.5=0.21	20/28.5=0.70	6/28.5=0.21	0	3/28.5=0.11
Lighthouse Rock	26/35=0.74	19/35=0.54	1/35=0.03	1/35=0.03	3/35=0.09	1/35=0.03	0	1/35=0.03
Aalge Ledge	26/35=0.74	0	8/35=0.23	5/35=0.14	22/35=0.63	0	7/35=0.20	5/35=0.14
Face Rock	6/26=0.23	1/26=0.04	0	0	0	0	0	0
Wishbone Point	0	3/26=0.12	0	0	0	3/26=0.12	0	0
All sub-colonies	120/153.5=0.78	60/153.5=0.39	14/153.5=0.09	17/153.5=0.11	60/153.5=0.39	15/153.5=0.10	12/153.5=0.08	14/153.5=0.09

[1]includes disturbances by predators and non-predators

Table 2. Rates of predation and scavenging (events per hour) by two predators obtained from 2-hour predation watches of Common Murre colonies at the Point Reyes Headlands in 1999.

Sub-colony	Predation Rate				Scavenging Rate			
	Common Raven		Western Gull		Common Raven		Western Gull	
	eggs	chicks	eggs	chicks	eggs	chicks	eggs	chicks
Boulder Rock	1/29=0.03	1/29=0.03	0	0	1/29=0.03	0	3/29=0.10	0
Elephant Seal Cove	1/35=0.03	0	0	0	0	0	6/35=0.17	0
Cone Rock	0	1/28.5=0.04	0	0	2/28.5=0.07	1/28.5=0.04	1/28.5=0.04	0
Lighthouse Rock	0	0	0	0	0	0	2/35=0.06	0
Aalge Ledge	0	0	0	0	0	0	0	0
Face Rock	0	0	0	0	0	0	0	0
Wishbone Point	0	0	0	0	0	0	0	0
All sub-colonies	2/153.5=0.01	2/153.5=0.01	0	0	3/153.5=0.02	1/153.5=0.01	12/153.5=0.08	0

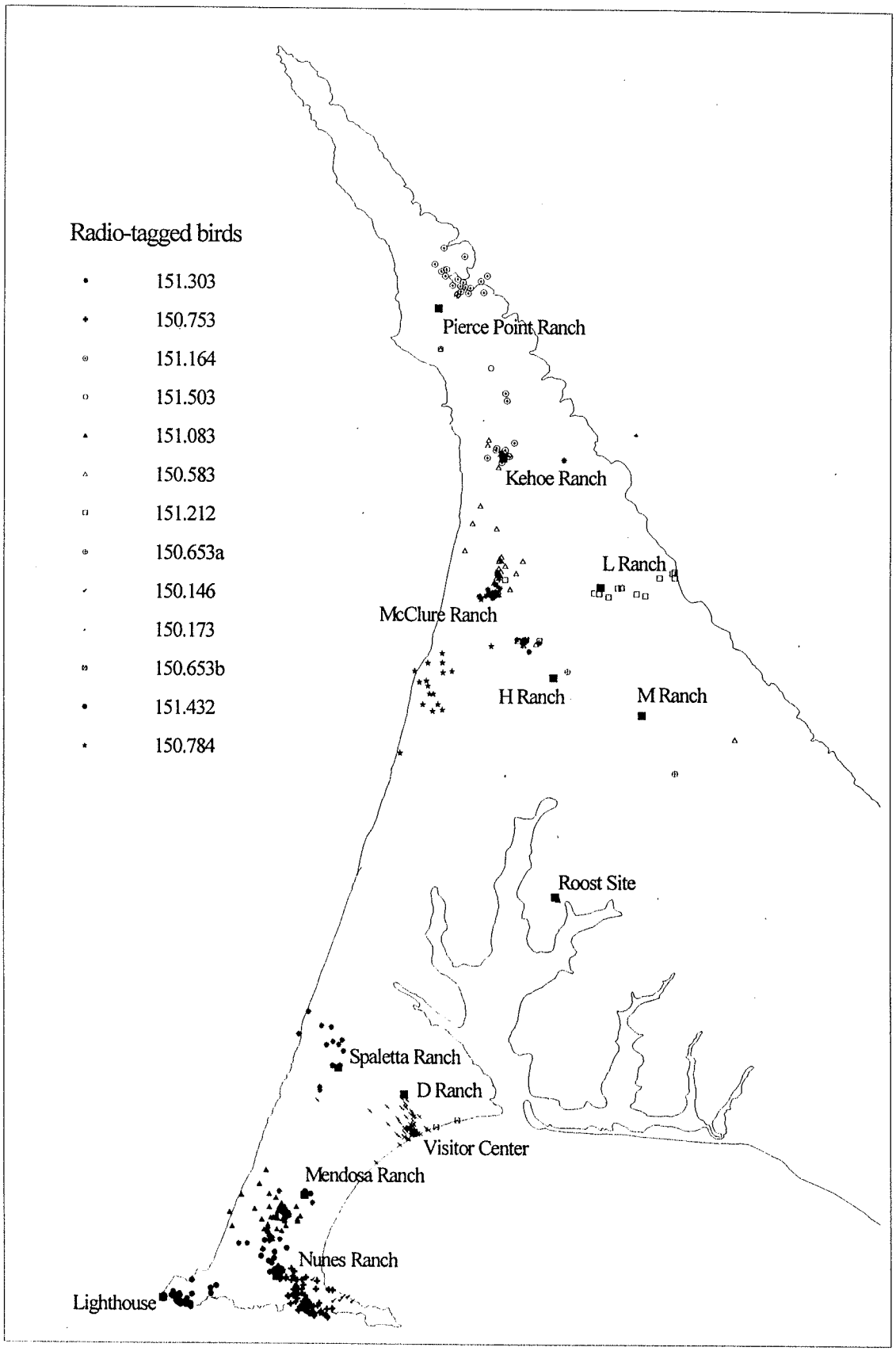

Figure 1. Distribution of radio-tagged Common Ravens on the Point Reyes Peninsula.

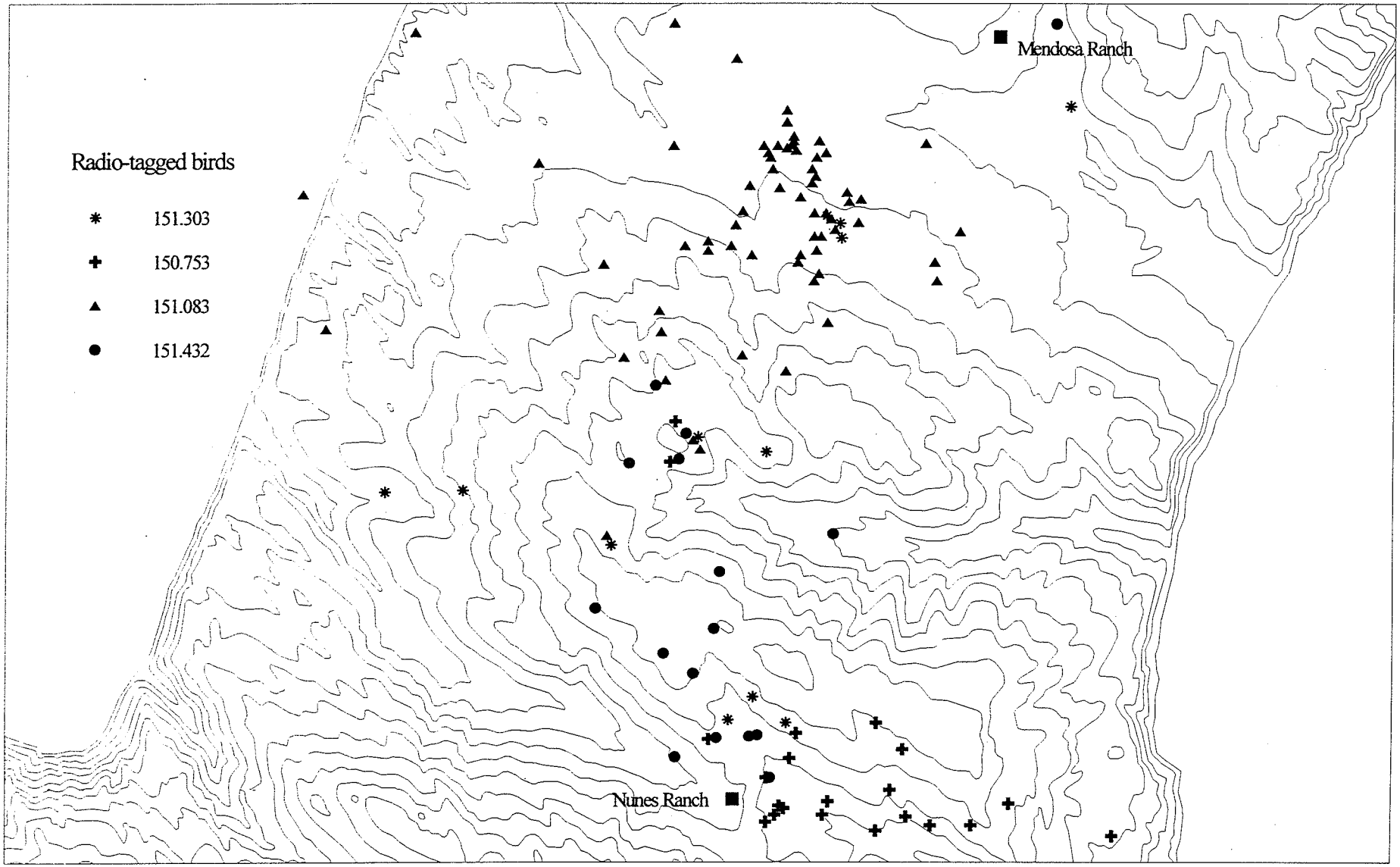

Figure 2. Use of the Nunes and Mendosa Ranches by radio-tagged Common Ravens.

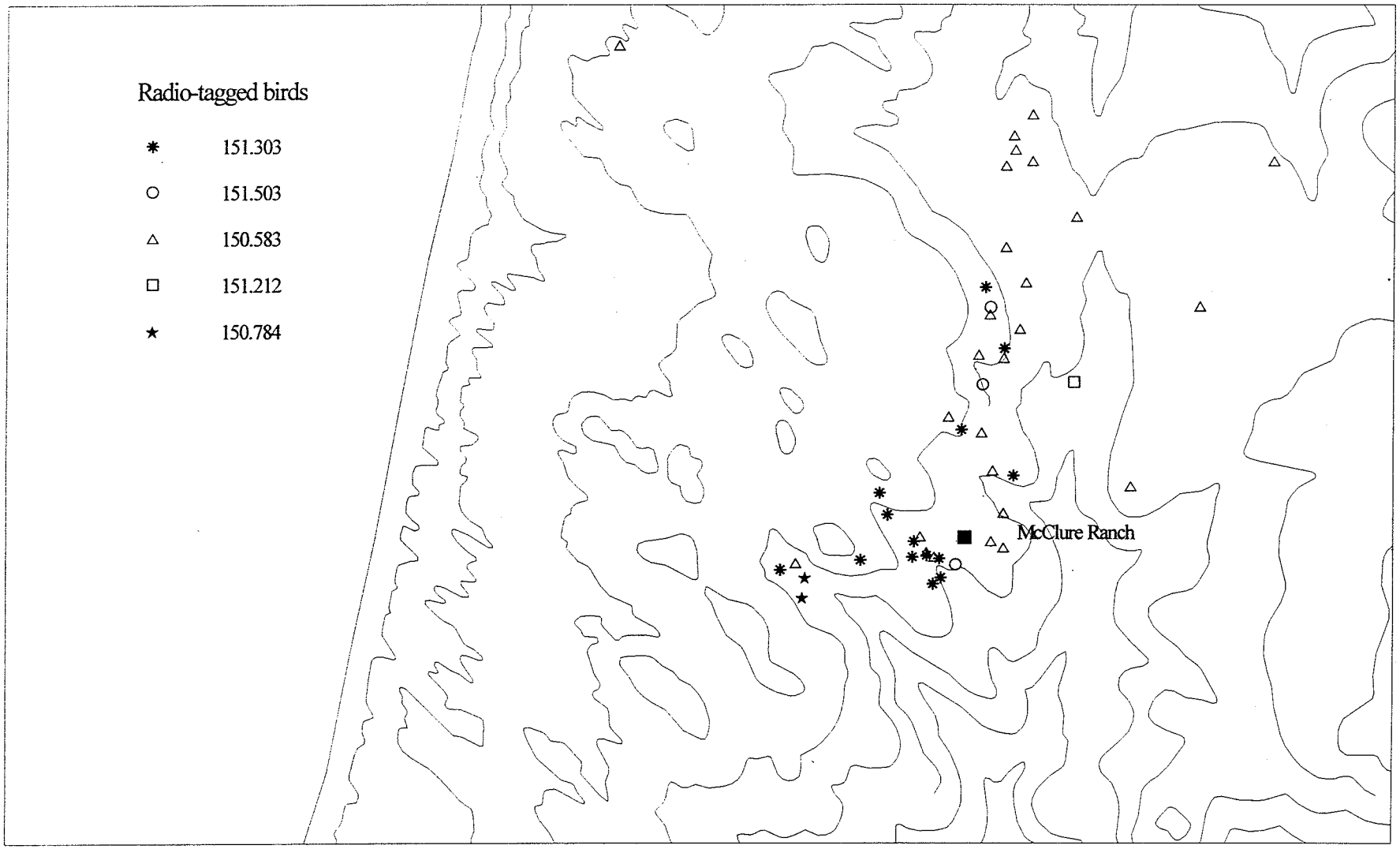

Figure 3. Use of the McClure Ranch by radio-tagged Common Ravens.

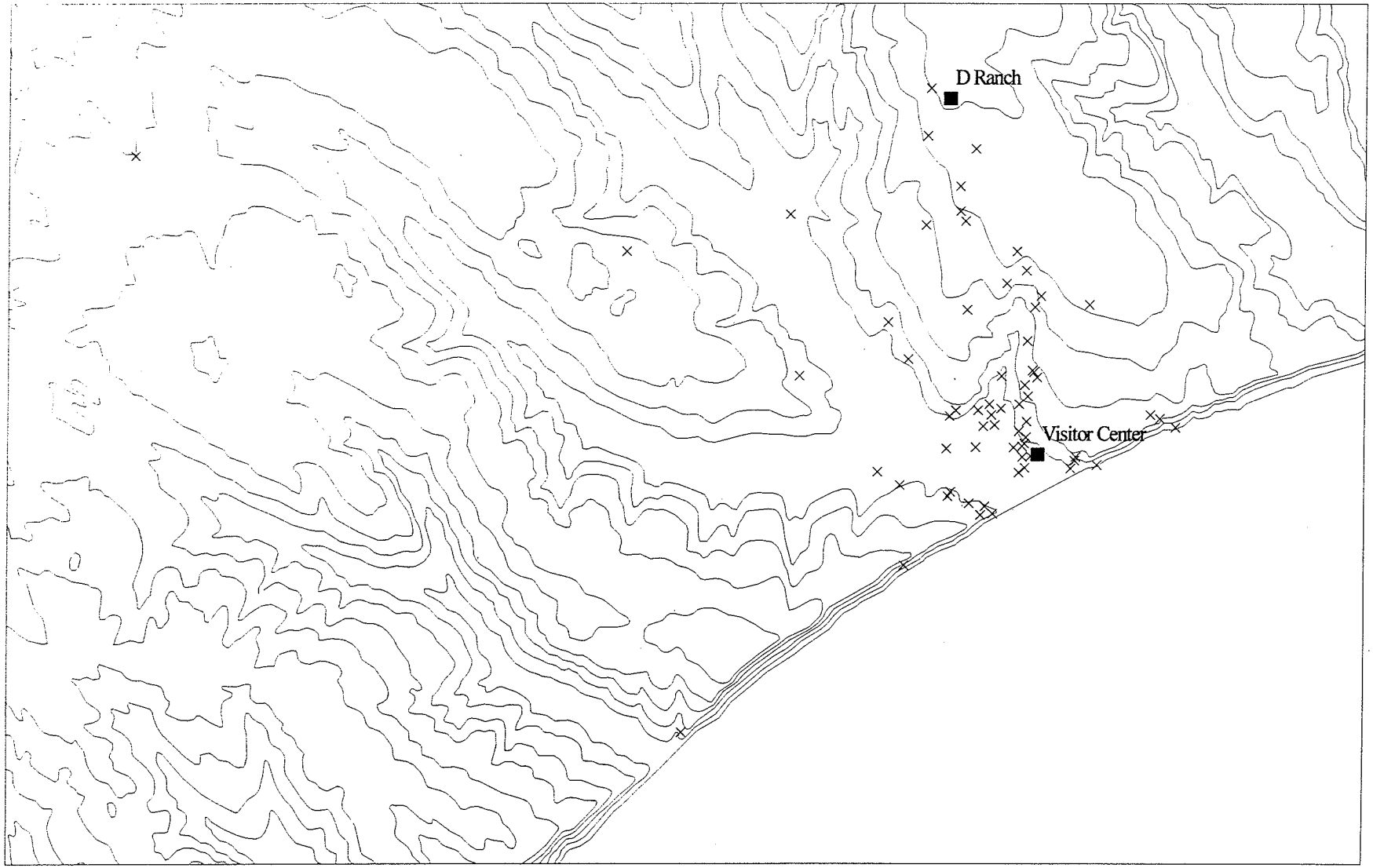

Figure 4. Movement patterns of a breeding, radio-tagged bird; this bird nested near the Visitor Center and was rarely seen far from its nesting site.

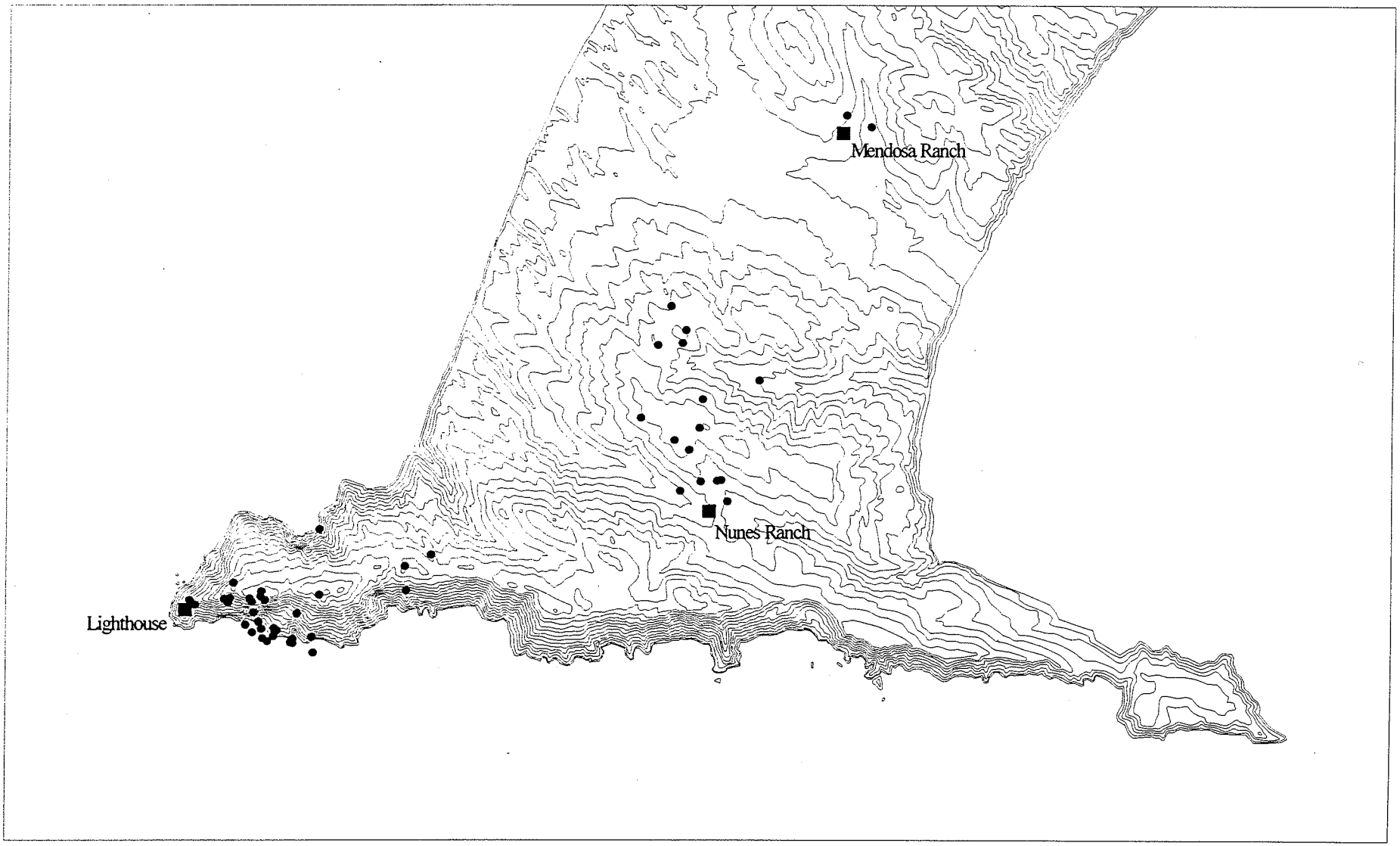

Figure 5. Ranch use by a breeding bird; this bird was presumed to be nesting near the lighthouse, but spent much of its time at the Nunes and Mendosa ranches.

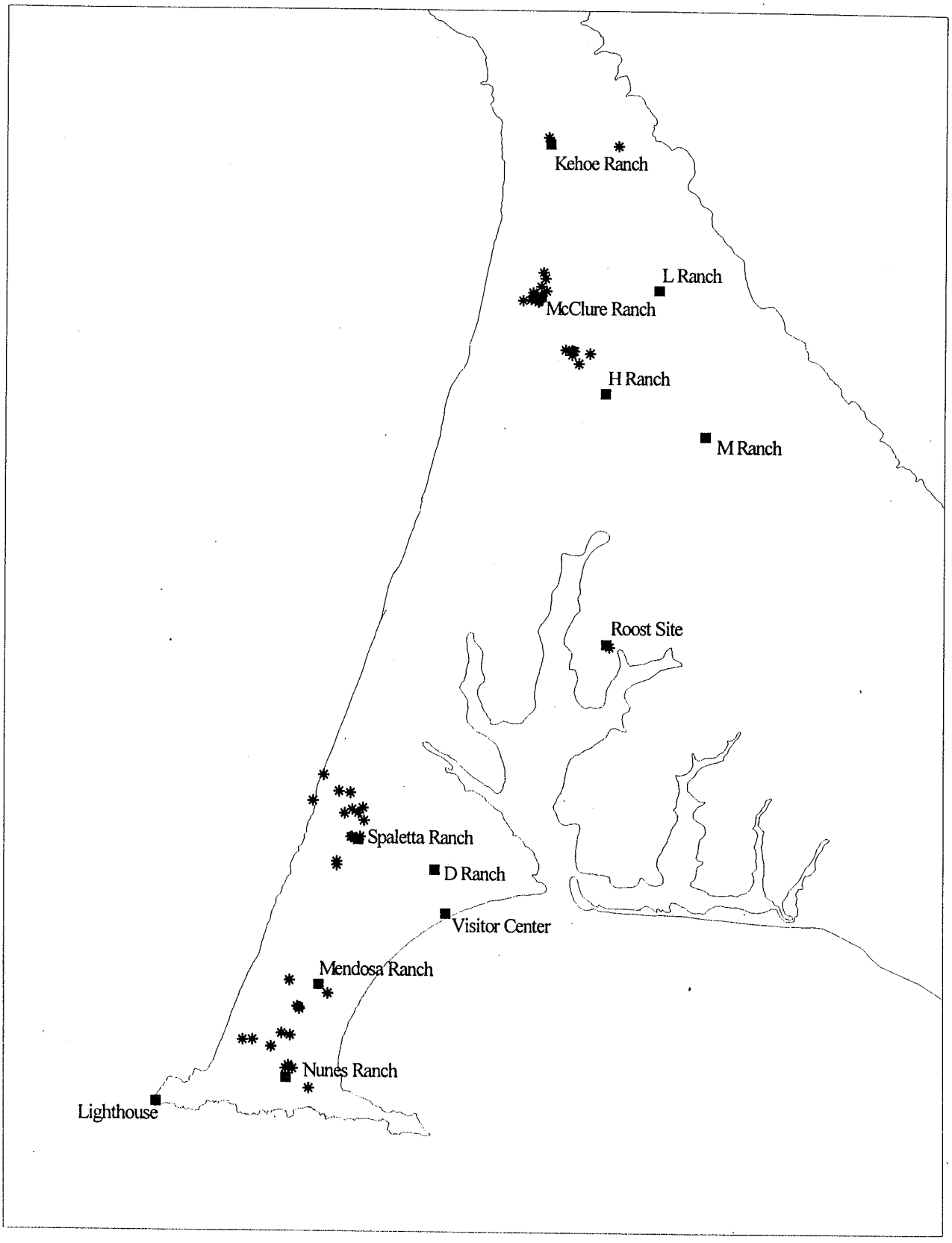

Figure 6. Movement patterns of a non-breeding, radio-tagged bird; this bird roosted at a communal roost site, foraged on the Nunes and Mendosa ranches early in the season, and foraged on the McClure and H ranches later in the season.

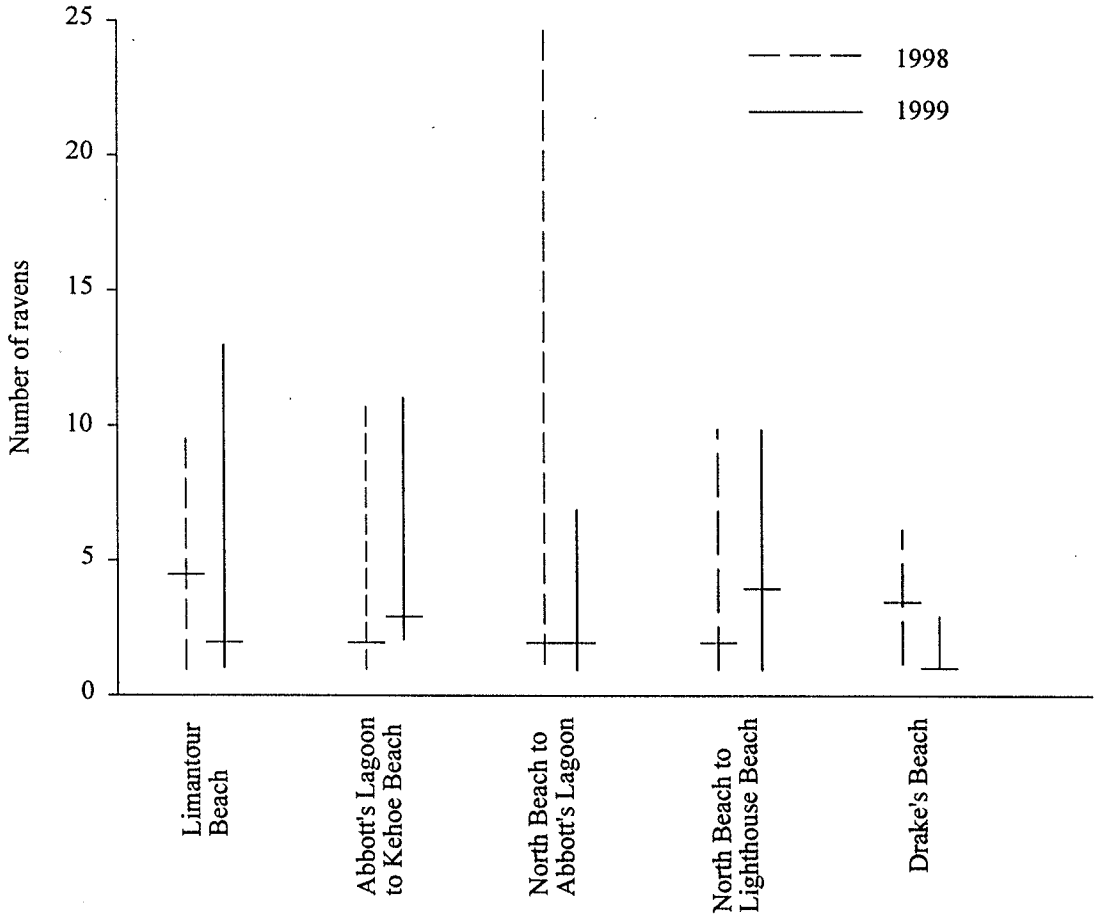

Figure 7. Number of ravens seen along sections of beaches during Snowy Plover censuses and nest monitoring in 1998 and 1999. Vertical lines indicate range; cross-hatches indicate median.

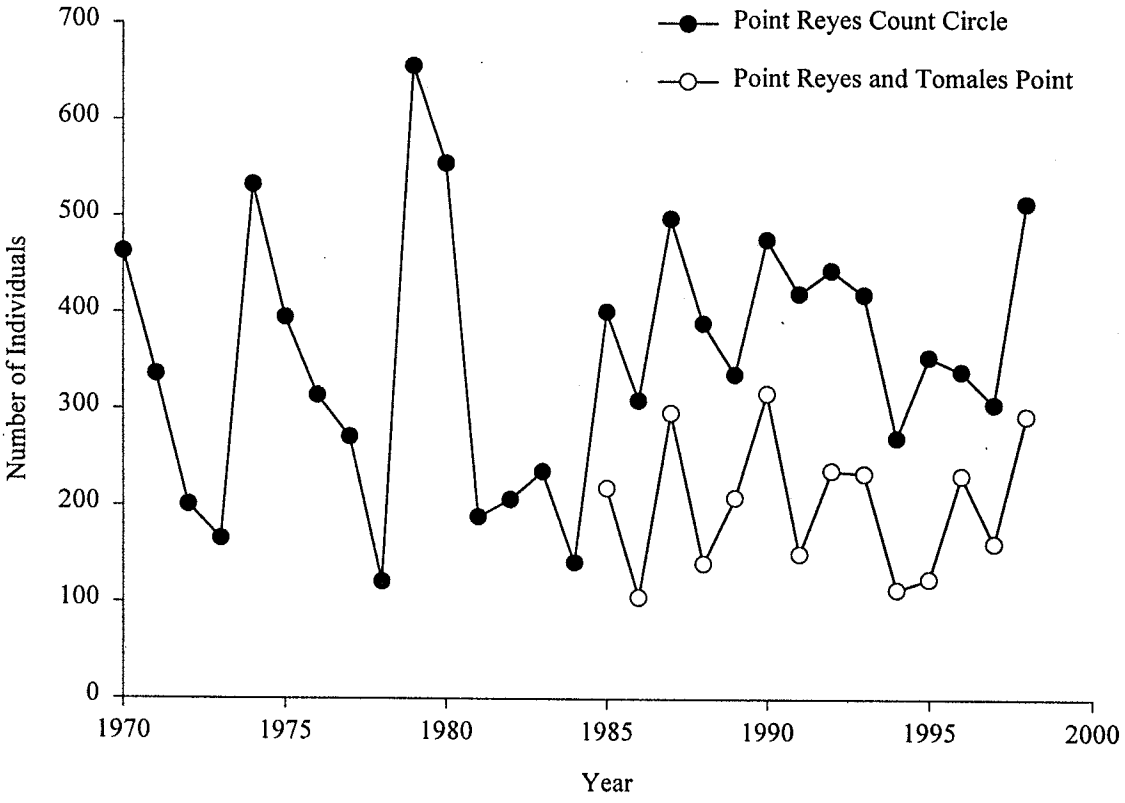

Figure 8. Number of Common Ravens counted during annual Christmas Bird Counts. Solid circles denote Point Reyes Count Circle totals; open circles denote segments covering Tomales Point and Point Reyes.

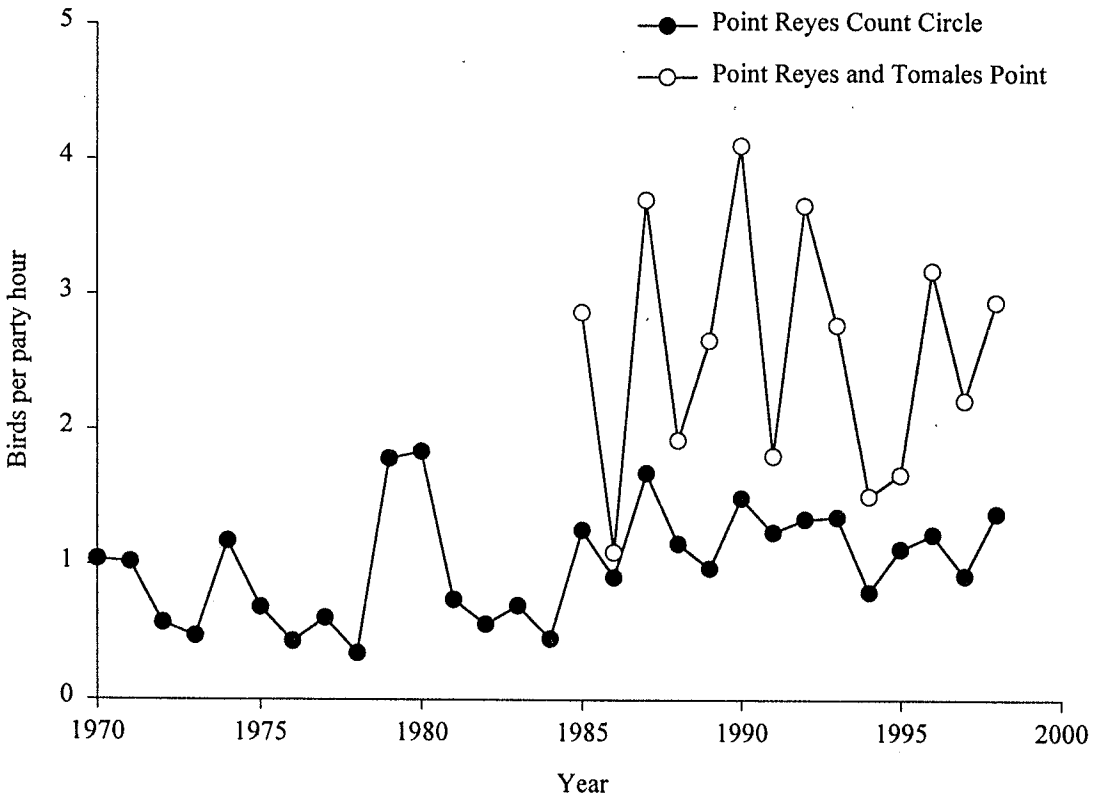

Figure 9. Number of Common Ravens seen per party hour during Christmas Bird Counts from 1970 to 1998. Solid circles denote Point Reyes Count Circle totals; open circles denote segments covering Tomales Point and Point Reyes.

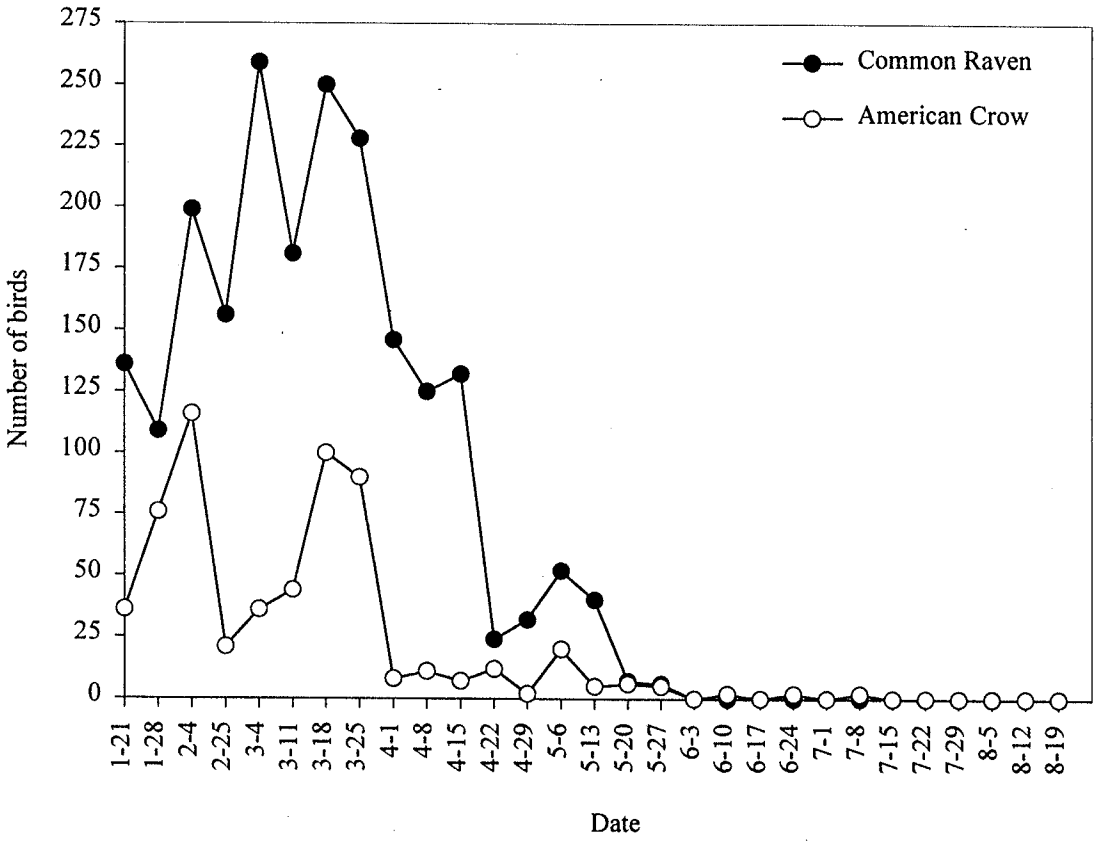

Figure 10. Common Raven and American Crow counts taken at a communal roost site in Point Reyes National Seashore in 1999.