Breeding ecology of Canada geese on an irrigation reservoir in northwestern Montana

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BREEDING ECOLOGY OF CANADA GEESE ON AN IRRIGATION RESERVOIR IN NORTHWESTERN MONTANA

by

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Breeding ecology of Canada geese (Branta canadensis moffitti) was studied on Ninepipe National Wildlife Refuge during 1984 and 1985. The study was initiated in response to management concerns about declining productivity. Nest abandonment rates exceeded 20% on Ninepipe during the early 1980's, far higher than elsewhere in the Flathead Valley. Suspected causes included social conflicts among the geese, interspecific interactions with nesting ring-billed (Larus delawarensis) or California gulls (L. californicus), and fluctuating water levels. Of 167 nests established in 1984 and 1985, 18 (11%) were abandoned. Detailed behavioral observations totaling 730 hours were obtained on a subset of 69 nests, 5 of which eventually were abandoned. Social factors associated with crowding appeared to be the major cause of nest abandonment: virtually no abandonment occurred on single-nest islands, but multiple-nest islands showed elevated rates of nest abandonment. Furthermore, the abandonment rate declined by about half when 40 new nesting sites were provided. Observations of weak pair bonds and low clutch sizes suggested that young geese may have been mainly involved in nest abandonment. Nesting geese virtually ignored gulls, and vice versa: gulls, great blue herons, and double-crested cormorants had no detectable influence on nest abandonment by geese. Fluctuating water levels had no influence on nest abandonment, but were a major determinant of overall nest success.

Canada goose broods were monitored from pipping until fledging. Gosling survival, the impact of gang brood and creche formation on survival, and habitat use were examined. Average brood size in single broods remained stable through the rearing period around 4.2 goslings/brood. Regular counts of goslings during the period comprised an average of 55% of the goslings estimated to have hatched, but the best census indicated that at least 80% of the goslings survived to fledging. Sightings of broods were recorded daily and analyzed with a Harmonic Home Range Program. Brood locations corresponded with areas of mudflat exposure during low water periods but shifted to other areas during periods of high water. Brood use of shorelines was determined by establishing "goose dropping" transects. These transects showed an inverse relationship between use and distance from the reservoir edge.

ACKNOWLEDGEMENTS

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THESIS INTRODUCTION

Maintaining or improving the productivity of Western Canada geese (*Branta canadensis moffitti*) is important to waterfowl managers throughout the northwestern United States and Canada. Doing so successfully requires a thorough knowledge of the degree and causes of egg and gosling mortality. Managers in the Flathead Valley, Montana have monitored resident breeding populations for over 30 years, and concern about productivity increased when the breeding flock on Ninepipe National Wildlife Refuge exhibited a high rate of nest abandonment in relation to other breeding flocks in the Valley. Therefore, this study was initiated at Ninepipe NWR to:

1) Determine the causes of nest abandonment,
2) describe general nesting behavior, and
3) document general behavior and ecology during the broodrearing period including gosling survival, brood habitat use, and gang brooding behavior.

This thesis has been divided into two chapters. The first, entitled "Nesting ecology of Canada geese on an irrigation reservoir in northwestern Montana", will be submitted to the Murrelet, and the second, entitled "Brooding ecology of Canada geese on an irrigation reservoir in northwestern Montana", will be submitted to the Wildlife Society Bulletin.

NESTING ECOLOGY OF CANADA GEESE ON AN IRRIGATION RESERVOIR IN NORTHWESTERN MONTANA

INTRODUCTION

A flock of Western Canada geese (Branta canadensis moffitti) breeding in the Flathead Valley of Montana has been monitored since the 1950's (Geis 1956, Craighead and Stockstad 1964, and Mackey et. al. 1987). The birds traditionally nest on islands in Flathead Lake, Flathead River, and scattered irrigation reservoirs and potholes throughout the valley.

During the 1950's, Ninepipe Reservoir supported only 7 to 10 nesting pairs, or about 5% of the nesting population in the valley (Geis 1956); today up to 95 pairs nest annually on the reservoir, comprising about 25% of the valley population. Because Ninepipe now supports a substantial proportion of the valley nesting population, general nesting ecology of the geese was of interest, and concern developed when surveys at Ninepipe during the 1980's revealed a high rate of nest abandonment (>20%) in comparison with the rest of the Flathead Valley flock (<2%). Possible explanations included fluctuating water levels, competition with nesting gulls, and competition among nesting geese. The main objective of this study was to determine the cause of nest abandonment and to provide management recommendations that could improve productivity.

Funding for this project was provided by the National Bison Range (U. S. Fish and Wildlife Service) and the Montana Cooperative Wildlife Research Unit. Additional logistical support was obtained from the

Confederated Salish and Kootenai Tribes and the U. S. Bureau of Indian Affairs. Drs. C. L. Marcum and R. L. Hutto are gratefully acknowledged for their editorial review.

STUDY AREA AND METHODS

Ninepipe National Wildlife Refuge, a satellite of the National Bison Range, is located 83 km north of Missoula, Montana, on the Flathead Indian Reservation. The refuge was established in 1921, and encompasses a 677 ha irrigation reservoir and 158 ha of grasslands. Potholes and glacial soils characterize the area surrounding the reservoir, providing abundant habitat for waterfowl. Improving nesting habitat for waterfowl is the major wildlife management goal of refuge managers, but this goal must be met within constraints imposed by irrigation demands on the reservoir. The Flathead Irrigation Project, U. S. Bureau of Indian Affairs, has primary control of the water supplies to meet irrigation needs. To enhance nesting habitat, refuge managers constructed 42 islands during the 1960's and 1970's, installed 15 large round bales of grass hay during 1984, and built 25 small (7 m^2) rock islands during 1985. Most of the islands support goose nests, 5 support tree-nesting colonies of great blue herons (Ardea herodias) and double-crested cormorants (Phalacrocorax auritus), and 6 support nesting colonies of ring-billed gulls (Larus delawarensis) and California gulls (L. californicus). Upland habitat was burned in 1983 (10 ha), 1984 (40 ha), and 1985 (10 ha), to rejuvenate grasses and improve grazing opportunities for geese. One permit for grazing livestock was issued for the north shore of the reservoir during late spring 1985.

All islands on the reservoir were visited during late April and searched systematically for nests. The number of eggs, incubation stage, and distance to nearest neighboring nest were recorded. Eggs were then re-covered with down and nest location was mapped. During subsequent visits, nest fate was determined and the island was surveyed to document any new nest attempts. Water levels were monitored throughout the nesting season, and records of the daily water elevations were obtained form the Flathead Irrigation Project.

Behavioral observations were made during daylight hours, and rotated throughout the day to sample daily variations in activities. Activities recorded included the number and duration of incubation recesses by the female and the number of interactions. Interactions were classified as social (intraspecific) or interspecific conflicts, and as threats, chases, or fights. The duration and result of the conflict was noted as was individual involvement (male, female, or both). I estimated the distance from the nest to the interaction site and whether the female left the nest to participate. Finally, I noted the relationship of the intruder to the focal pair (i.e. whether the intruder was a neighbor nesting on the same island or not).

RESULTS

General Reproductive Performance and Habitat Conditions - 1984 vs 1985

Nesting effort dropped by 20 nests and nearly 100 eggs between 1984 and 1985, and nest success declined from 81% to 69% (Table 1). Clutch size in successful nests and egg success did not differ significantly between years. Water levels on Ninepipe were essentially ideal for nesting geese during 1984: all islands and all but one bale were separated form the mainland by > 5 m of water from March through June (Fig. 1). Conversely, water levels were so low during 1985 that 46% (32 of 69) islands and all surviving bales were attached to the mainland during most of the nest initiation period (Fig 1, Table 2). Nesting geese clearly avoided attached sites, nesting on 78% of the secure sites in 1985 but only 26% of the attached sites (Table 2). Of the 21 sites that were present in both years, but changed in security status, 71% (15/21) were used during 1984 when all were secure, but only 14% (3/21) were used during 1985 when all were attached. On islands that were secure both years (n=39), nest numbers remained essentially stable (57 in 1984 vs 51 in 1985), indicating that pairs excluded from attached sites were unable to "crowd" on to the remaining secure sites.

The major difference in success rates between years was associated with predation and flooding, as influenced by water levels (Fig. 2) All but one nest on attached sites were destroyed by either dogs (Canis familiaris) or coyotes (C. latrans). Only one nest was destroyed by birds, although common ravens (Corvus corax) and black-billed magpies (Pica pica) were common. Geese were clearly unable to "predict" fluctuating water levels and three nests were lost to flooding during 1985.

Abandonment varied little between years (13% and 11%), and was somewhat lower than expected from surveys in previous years. Abandoned

Table 1. General reproductive characteristics of Canada geese on Ninepipe Reservoir during 1984 and 1985.

	1984		1985
NESTS			
Successful[a]	69(81%)		46(69%)
Unsuccessful	16		21
Known fate	85		67
Unknown fate	9		7
Total	94		74
EGGS			
$\bar{X}$ clutch size $\pm$ s.d.			
successful nests	5.5±1.5		4.9±1.6
abandoned nests[b]		3.8±2.0	
Total	5.1±1.8		4.4±2.1
$\bar{X}$ number of eggs left in hatched nests	0.75±1.27		0.26±0.74

a. % successful = N hatching $\geq$ 1 egg/ N known fate nests
b. years combined because of small sample sizes.

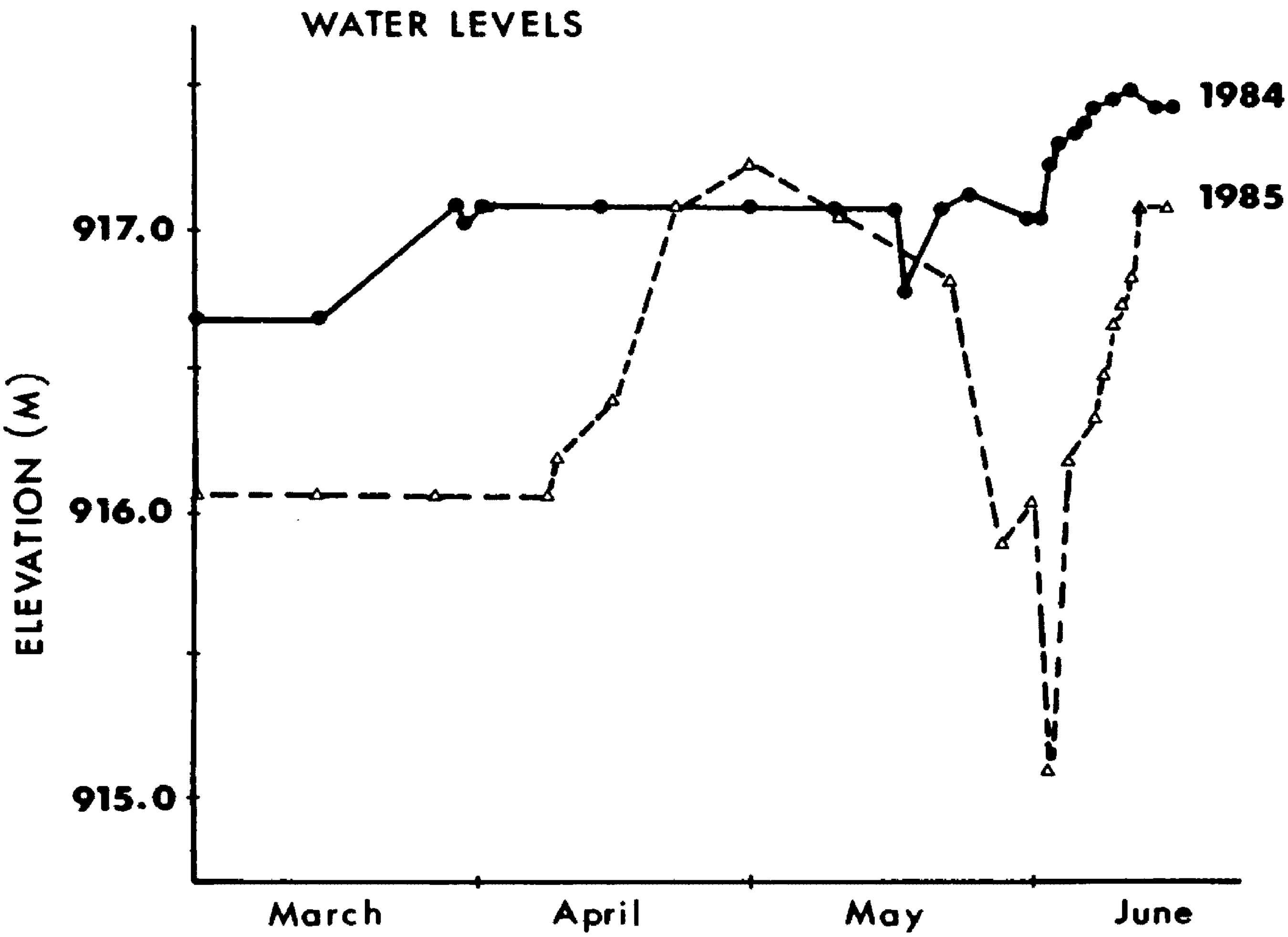

Fig. 1. Water levels in Ninepipe Reservoir during 1984 and 1985. About half of all nesting sites were secure at 916.0 m elevation, and all were secure at 916.5 m. Nest initiation peaked about 1 April.

Table 2. Availability and use (%) of nest sites relative to site security during 1984 and 1985. A site (island or bale) was considered secure when it was seperated from the mainland by > 5m of water on 1 April.

ISLANDS	1984	1985
# present	44	69
# used	35(80)	32(46)
# secure	44	37
# used (%)	35(80)	32(86)
HAYBALES		
# present	15	7
# used	11(73)	1(14)
# secure	14	0
# used (%)	11(73)	-
ALL SITES		
# present	59	76
# used (%)	46(78)	33(43)
# secure	59	37
# used (%)	46(78)	29(78)
# attached	0	39
# used (%)	-	10(26)

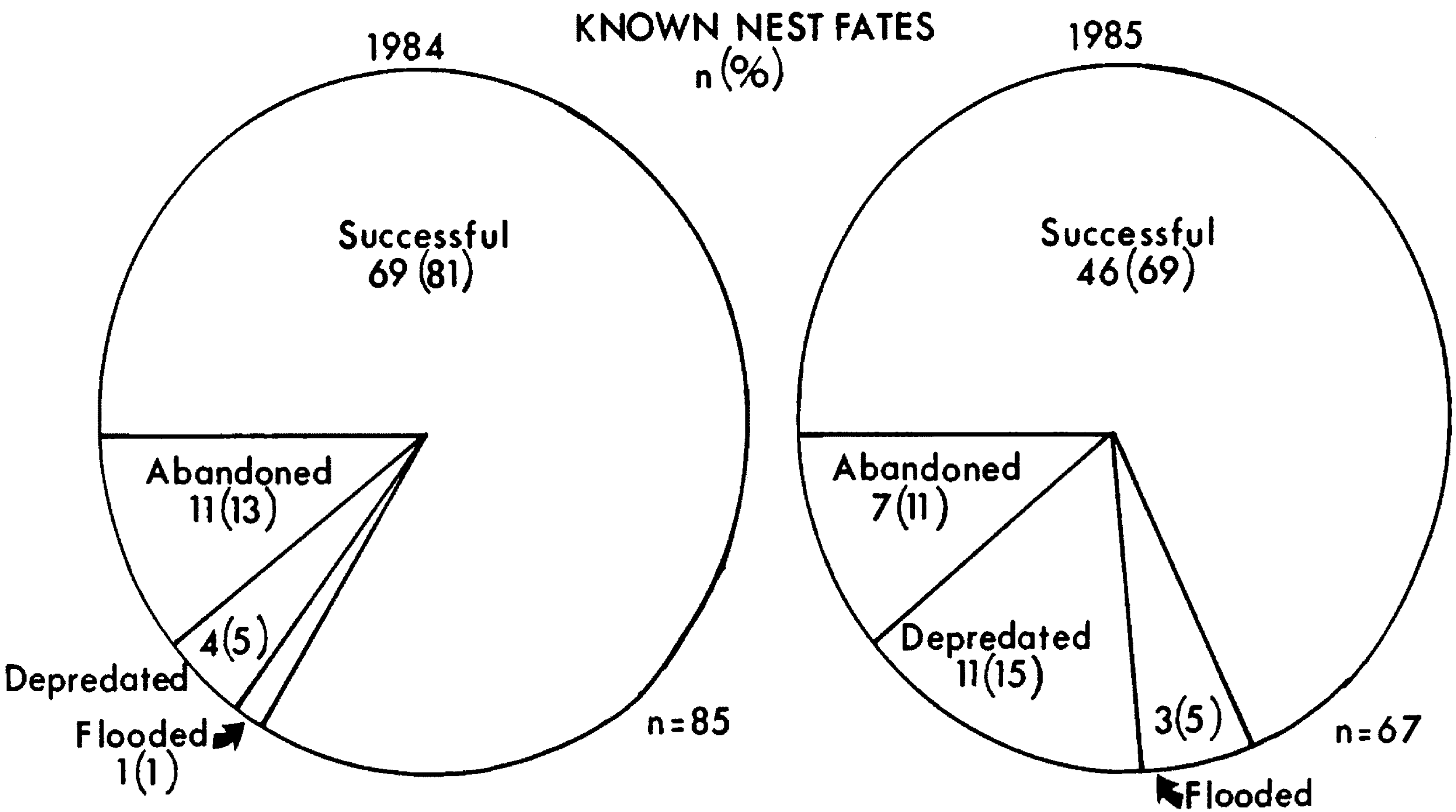

Fig. 2. Number (%) of Canada goose nests on Ninepipe Reservoir during 1984 (94 total/85 known fate) and 1985 (74 total/67 known fate).

nests had a characteristic unkempt appearance and significantly smaller clutch sizes than successful nests (3.8$\pm$ 2.0, n=18; vs 5.3$\pm$1.6, n=105; t=2.88, 21 d.f., $p<0.01$). Based on 730 hours of intensive observation on a subset of 69 nests, three possible causes of abandonment were considered: Fluctuating water levels, interspecific conflicts, and social conflicts among geese.

Fluctuating water levels appeared to have no affect on nest abandonment. Of the three intensively observed nests that were affected by falling water levels, one hatched and two were incubated normally until predation occurred. Similarly, the three nests affected by rising water levels were incubated normally until flooding occurred.

Interspecific conflicts with other nesting birds had no detectable affect on nest abandonment by geese: Geese virtually ignored nesting gulls, great blue herons and double-crested cormorants. Of 372 interactions recorded, only 17 (4.6%) involved interspecific intruders: Great blue herons 7 (1.9%), ducks 5 (1.3%), gulls 4 (1.1%), and magpies 1 (0.3%). Furthermore, nest abandonment rates by geese on the six islands that supported nesting colonies of approximately 500 gulls per island did not differ significantly from rates of those geese nesting on islands without gulls; this relationship was also true for great blue herons and double-crested cormorants (Fig. 3).

Mallards (*Anas platyrhynchos*) and geese were observed nesting simultaneously on one haybale and one 7m^2 rock island. The two nests on the haybale were successful but the two on the island succumbed to a fate unrelated to conflicts (i.e., structural failure of the island causing the destruction of the nests). Geese tolerated nesting mallards

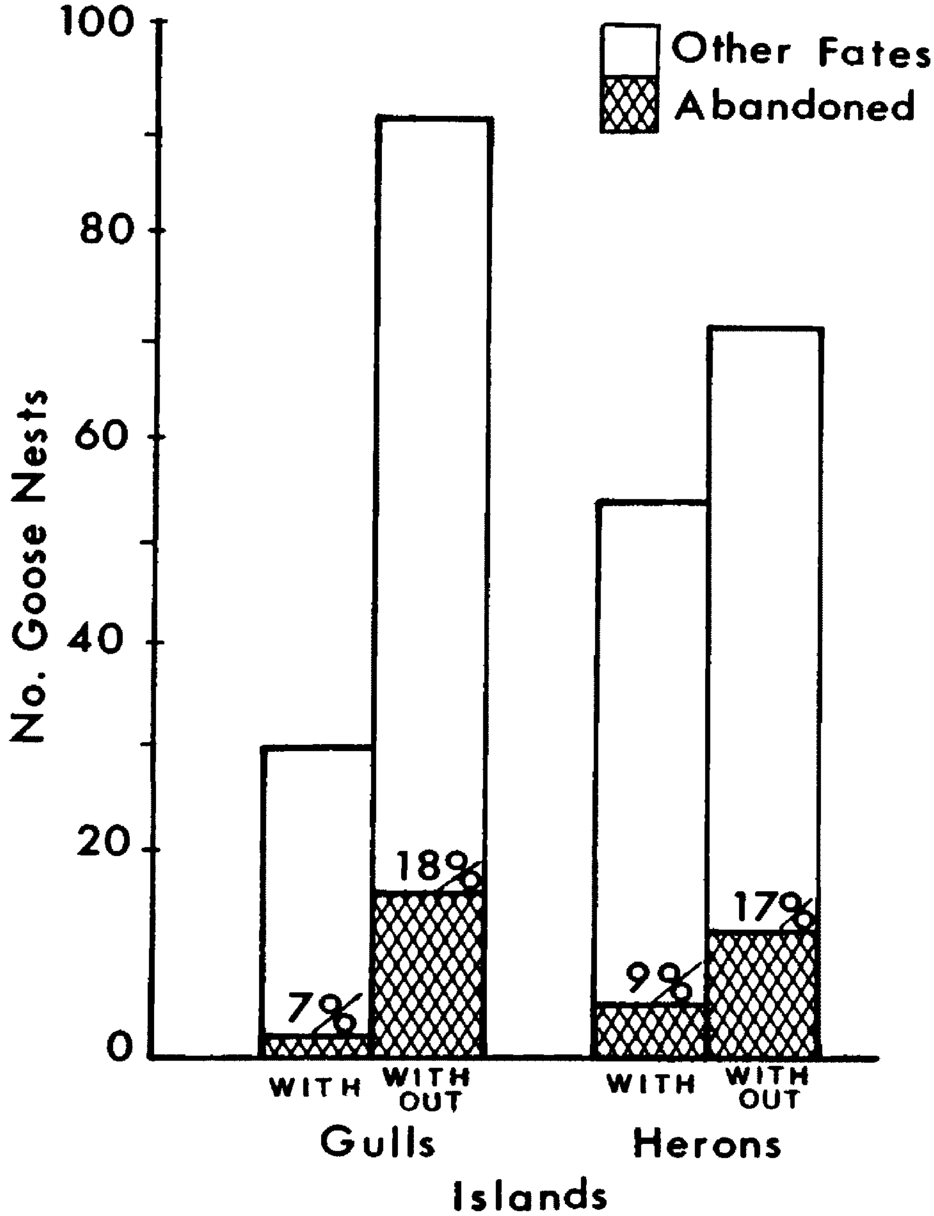

Fig. 3. Nest abandonment by Canada geese relative to the presence or absence of nesting gulls and great blue herons on Ninepipe Reservoir. Differences are not significant ($X^2 = 1.46$, 1 d.f., $p = 0.25$). Colonies of great blue herons usually included nesting double-crested cormorants.

at close quarters (<1m) very well and only one interaction was recorded during 25 hours of observation of these birds.

Rates of interaction were similar between geese on single-nest islands (0.50 interactions/nest/hr) and those on multiple-nest islands (0.59 interactions/nest/hr). Predictably, average defense distance from the nest was significantly shorter on multiple-nest islands (2.6 ± 2.5 m, n=209 vs. 9.9 ± 20.9m, n=127; Kolmogorov-Smirnov Z = 3.44, $p<0.01$).

Length of incubation recesses by females that abandoned nests tended to be longer than for successful females (37.9 ± 43.5min, n=15; vs 17.4 ± 13.8min, n=102; t = 1.81, p = 0.091). Islands (including bales) with only one goose nest had extremely low abandonment rates (1/55 = 1.8%), but islands with multiple (2+) nests exhibited significantly higher rates (15/98 = 15.3%; X^2 = 2.53, d.f.=1, $p<0.01$). This relationship was consistent between years (Fig. 4) and provided clear indication that social interaction between pairs was a primary factor influencing nest abandonment.

Harassment by dominant ganders was never documented as an immediate cause of abandonment, but one series of interactions was witnessed where an aggressive gander regularly chased a pair away from a nest site. During six hours of observation over three days, 20 interactions occurred (3.3/hr), or about six times the average. Rising water levels destroyed the nest site of the subordinate pair and terminated the interactions. When I examined the site it was not apparent that a nest had yet been established so this series was excluded from further analysis.

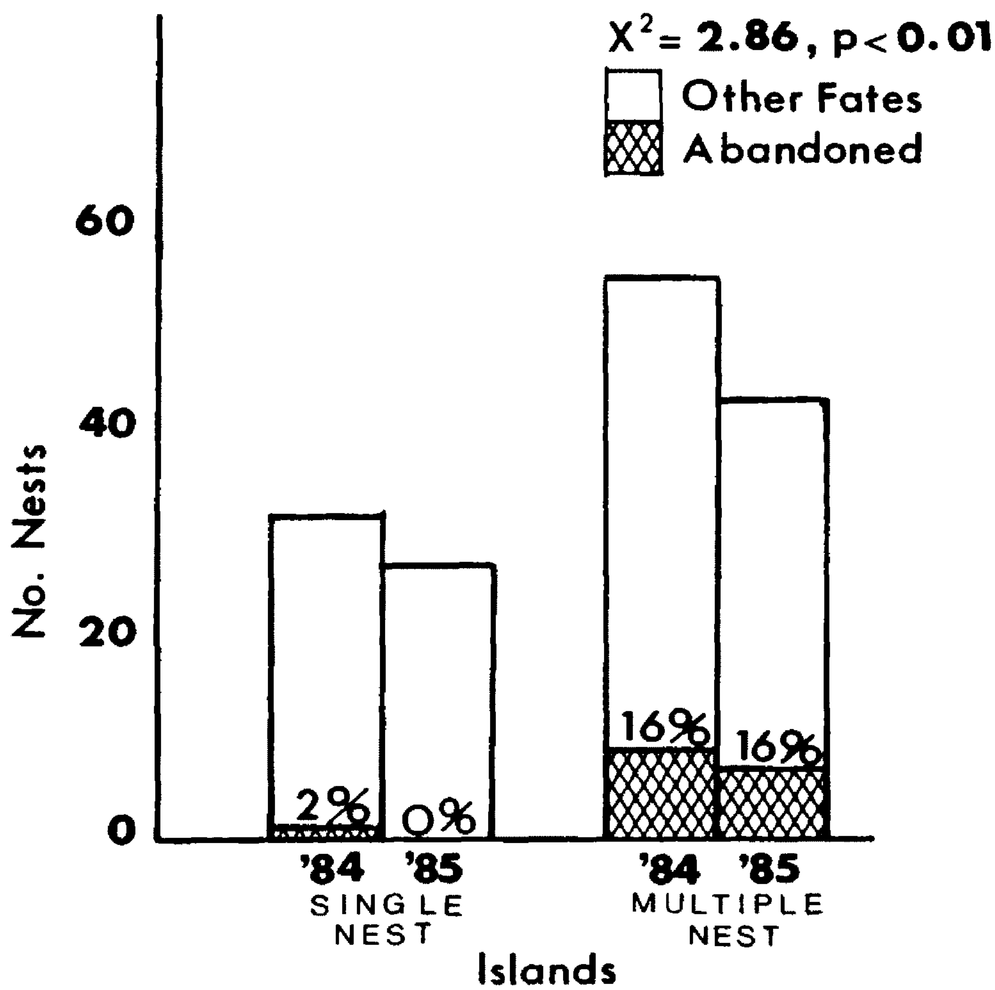

Fig. 4. Nest abandonment rates on islands with single nests versus those with multiple nests. Test for differences in probabilities on abandonment rates show significantly lower rates on single-nest islands; $X^2 = 2.86$, 1 d.f., $p<0.01$.

Island size was inversely related to the number of nests present and therefore to nest abandonment. Islands less than 500 m^2 usually supported only one nest and averaged 0.52 nests/100m^2. Average number of nests per island and the proportion of nests abandoned increased as island size increased (Fig. 5). The average island size for multiple-nest islands was 910 ± 427 m^2. Multiple-nest islands averaged 0.48 nests/100m^2, and the nearest neighbor distance was significantly shorter for abandoned nests than for successful nests (6.9 ± 3.3 m, n=15; vs 11.2 ± 10.2 m, n=65; t = 2.98, 70 d.f., $p<0.01$).

DISCUSSION AND MANAGEMENT IMPLICATIONS

The substantial decline in numbers of nests on Ninepipe with a decrease in number of secure nest sites caused by low water levels during 1985 suggest that secure nest sites are about saturated, and therefore displaced pairs could not "crowd" onto the remaining secure sites. Numbers of abandoned nests at Ninepipe declined from an average of 16 nests/yr in 1980 - 1983 (Ball, unpubl. data) to an average of 8 nests/yr during my study, concurrent with the development of new nesting sites. Most of these new sites are relatively small. They tend to support only one goose nest, and hence tend to have low abandonment rates. However, most of the new sites also are close to shore and consequently will be vulnerable to land-bridging unless water levels are near optimum. I predict that breeding populations and production on Ninepipe will increase proportionate to the number of secure nest sites and that abandonment rates eventually will rise somewhat. Nest success

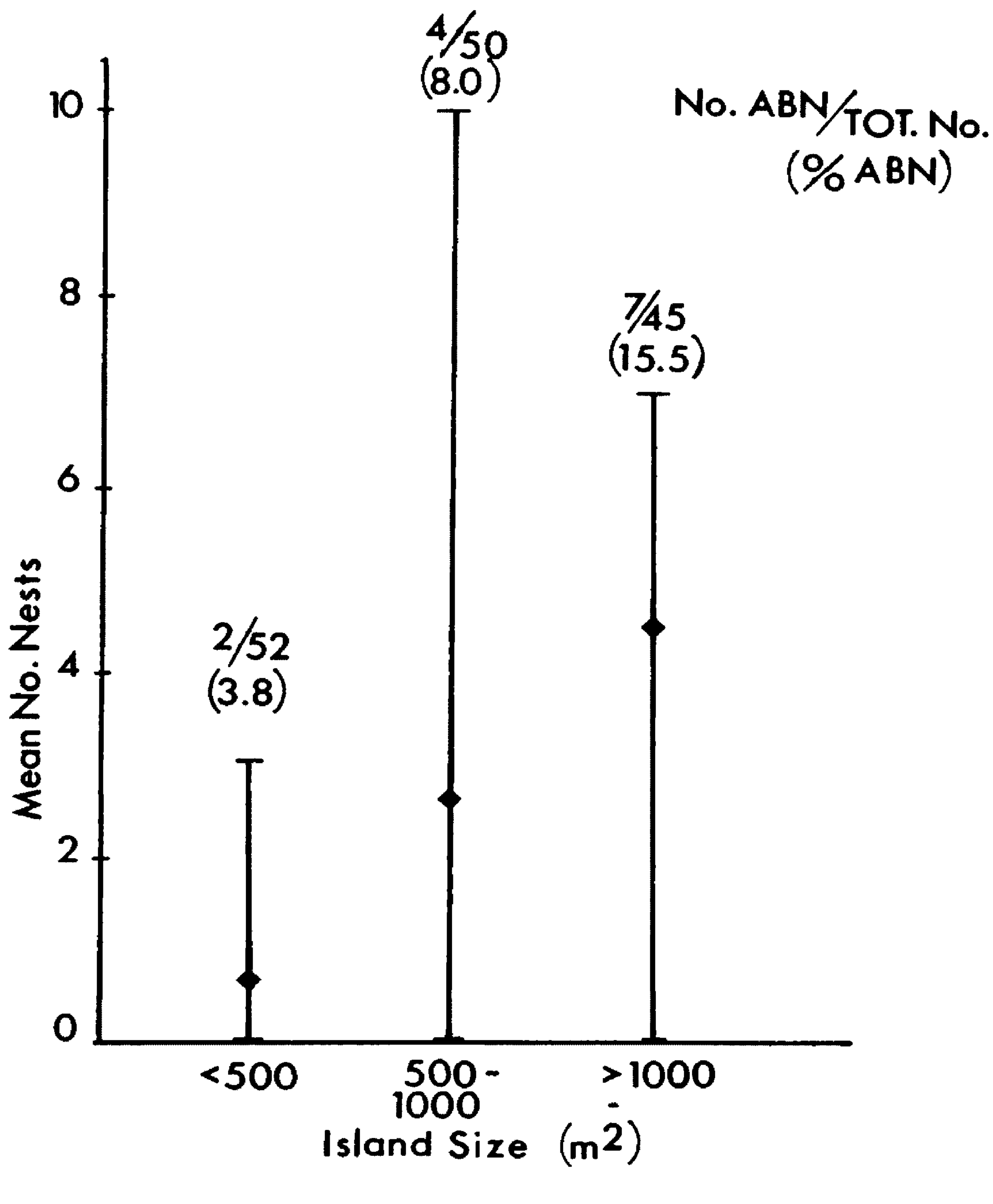

Fig. 5. Mean and range of goose nests relative to island size. Number abandoned/total number of nests and percent abandoned (%) are displayed above each size group.

rates on Ninepipe clearly depend primarily on water levels and have been high enough to allow the population to fill new breeding sites as they have been provided. Abandonment rates could be minimized by making any new nesting islands relatively small (10-20m^2). This approach would also be most efficient economically for goose production, but considerations of duck production and island security and durability also must be considered.

Nest abandonment by geese is not related to interspecific interactions on Ninepipe Reservoir, although the gull colonies do tend to devegetate islands. Geese are the heaviest and most aggressive species present and usually dominate or ignore most other species. Furthermore, potential interactions are minimized by vertical segregation from the tree-nesting species (great blue herons and double-crested cormorants) and temporal segregation from gulls, which are usually just beginning to incubate as geese are hatching nests.

My observations suggesting a link between weak pair bonds (inadequate defense by ganders) and eventual nest abandonment must be interpreted with caution because sample size of observed interactions by abandoning pairs was small. However, Cooper (1978:64) observed a similar relationship, and also documented relatively low fertility rates among eggs in abandoned nests (43% vs. 85% overall). If weak pair bonds did contribute to nest abandonment at Ninepipe, then the relatively high rates of abandonment on multiple-nest islands suggests either that pairs with weak bonds preferentially chose large islands, or that weakly bonded pairs also chose small islands but were successful there because such sites were more easily defended.

Age was also implicated in abandonment rates. Abandoned nests on Ninepipe had significantly smaller clutch sizes than successful nests. Brakhage (1965) and Geis (1956) believed that young geese (2-3 year olds) were more likely than older geese to abandon nests, and Raveling (1981) showed that young birds laid smaller clutches than older birds. In addition, Sherwood (1967) found that young females chose nest sites close to their natal area. Thus, the abandoned nests on Ninepipe may have represented young pairs with new and relatively weak bonds that were attempting to nest on their natal island. This scenario, however remains speculative without long-term studies involving individually identifiable birds.

The rates of nest abandonment I documented on Ninepipe are somewhat higher than those occurring elsewhere in the Flathead Valley (Mackey et. al 1985). Likewise, nests tend to be considerably more crowded on Ninepipe than elsewhere in the valley. Increasing abandonment with increasing nest density has been documented by Cooper (1978), Ewashuk and Boag (1972), and Nigus and Dinsmore (1980). Furthermore, I caution that the near absence of avian predation on goose nests at Ninepipe may mean that abandoned nests survive to be found and recognized at Ninepipe but destroyed by predators elsewhere in the Flathead Valley.

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ECOLOGY OF CANADA GOOSE BROODS ON AN IRRIGATION RESERVOIR IN NORTHWESTERN MONTANA

INTRODUCTION

The brood-rearing period of the Western Canada goose (Branta canadensis moffitti) has been difficult to document for wild populations. On Ninepipe National Wildlife Refuge, an excellent opportunity exists to observe, with accuracy and minimal disturbance, a wild population of geese during this time. This flock of 80-90 nesting pairs comprises about 25% of the entire breeding population of the Flathead Valley. Therefore, productivity of this flock is of considerable interest to local wildlife managers. The objectives of this study were to document gosling survival, the impact of gang brood and creche formation on survival, and habitat use of broods.

Funding for this project was provided by the National Bison Range (U. S. Fish and Wildlife Service) and the Montana Cooperative Wildlife Research Unit. Additional logistic support was obtained from the Confederated Salish and Kootenai Tribes and the Bureau of Indian Affairs. Editorial reviews were provided by Drs. R. L. Hutto and C. L. Marcum. Special thanks are extended to Dr. I. J. Ball for support in project design and editorial review.

STUDY AREA

Ninepipe National Wildlife Refuge, a satellite of the National Bison Range, is located 83 km north of Missoula, Montana, on the Flathead Indian Reservation. The refuge was established during 1921, and encompasses a 677 ha irrigation reservoir and 158 ha of grasslands. The major wildlife management goal is to provide habitat for nesting waterfowl, but this goal must be met within the constraints of irrigation demands. Surrounding areas provide numerous small wetlands, and cover for uplands nesters. To enhance nesting habitat on reservoir, refuge managers constructed 42 islands during the 1960's and 1970's, installed 15 round haybales during 1984, and built 25 small ($7m^2$) rock islands during 1985. Most of the islands support goose nests, five support tree-nesting colonies of great blue herons (*Ardea herodias*) and double-crested cormorants (*Phalacrocorax auritus*), and six support nesting colonies of ring-billed gulls (*Larus delawarensis*) and California gulls (*L. californicus*). Upland habitat was burned in 1983 (10 ha) 1984 (40 ha), and 1985 (10 ha), to rejuvenate grasses and improve grazing opportunities for geese. One permit for grazing livestock was issued for the north shore of the reservoir during late spring 1985.

METHODS

The refuge was searched for goose nests during late April of 1984 and 1985. Observations were made of the behavior of the adults and goslings during the period between hatching and leaving the nest. Once goslings left the nest, they usually were not identifiable from other broods, but survival was estimated by comparing the average number of goslings per brood at hatch to the average number of goslings per brood at fledging. Most brood observations were made from a vehicle with a 70x Questar telescope. Most of the reservoir was easily visible from a vehicle on the retaining dike and from vantage points along the south and north sides of the refuge. Broods were also observed when I was on foot or in a floating blind disguised as a muskrat house. Surveys were conducted three or more times weekly to determine brood size, age (Yocum and Harris 1965), location, general habitat category, activity, and creche size. Broods on Ninepipe Reservoir fell into two categories; those broods that appeared to originate from a single nest (henceforth 'single broods') and gang broods. A gang brood was defined as a single breeding pair with a brood of 10 goslings or more, or a brood containing goslings of mixed ages. I defined creches as groups of broods that moved, fed, and loafed together (Warhurst et al. 1983). Gosling and brood counts were conducted only when individual broods were clearly distinguishable from other broods. If brood mixing occurred I waited until the geese appeared undisturbed and families appeared to be the most differentiated.

Brood locations were analyzed using a harmonic home range program (Samuel et al. 1983). Primary areas of brood activity were delineated by core areas and 50% and 25% utilization volume contours.

General habitat categories were recorded at each brood observation, but specific habitat characteristics could not be observed without a great deal of disturbance to the geese. Consequently, transects similar to pellet transects used by researchers studying habitat use of deer, elk, and other ungulates (Neff 1968 and Rowland et al. 1984) were established to determine the distribution of goose droppings (henceforth 'pellets') in specific upland vegetation types. Preliminary observations indicated that broods seldom ventured more than 20-25 m from water, so transects were limited to 30 m in length, beginning at the water's edge and extending inland perpendicular to the shore. Each transect was divided into five, six meter segments. Within each segment two, one m^2 plots were selected at random, searched for goose pellets, and categorized according to vegetation type. The transects were established every 120 m along the reservoir perimeter (155 transects, 1550 m^2 plots). Because of the presence of non-breeding geese during the nesting period, use could not be solely attributable to adults with broods. However, only about 12 adults unaffiliated with broods remained on reservoir after the start of molt.

A small number of geese nesting on the refuge had been previously equipped with neck collars and radio transmitters for an ongoing study conducted by the Confederated Salish and Kootenai Tribes. Seven additional neck collars were placed on adult geese during the summer of 1984 to facilitate identification of nesting pairs. Individual brood movements were recorded for collared geese that produced broods and remained on the reservoir.

RESULTS

Leaving the Nest

General behavior at the beginning of brood-rearing was similar to that described by Brakhage (1965), Collias and Jahn (1959), and Kossack (1950). Goslings remained in the nest for several hours after hatching. They became more active as time passed and often made short exploratory trips around the immediate area of the nest. When the female left the nest, goslings either walked behind her to the water or jumped from elevated nest sites apparently in response to calls from the adults. Once away from the nest site, the brood was led into the emergent cover near shore and usually did not return to the nest. No observations were made of aggressive actions against goslings by gulls either on land or in the water.

Estimates of Gosling Production and Brood Sizes

During 1984, 309 eggs were known to hatch in 69 nests. During 1985, 211 eggs were known to hatch in 48 nests. Assuming that nest success was equal between known- and unknown-fate nests, I estimated 336 eggs hatched in 75 nests during 1984 and 233 eggs hatched in 53 nests during 1985.

Repeated brood surveys (n = 28) conducted from the ground in 1984 averaged 147, or 48% of the estimated total hatched. Peak gosling count from the ground was 200 (60%) and an aerial count was 178 (53%). However, 267 goslings (80%) were counted during a banding drive near fledging, indicating that preivous counts underestimated the total.

During 1985, repeated ground surveys (n = 20) averaged 139 goslings (60%), the peak ground count was 198 (85%), and the aerial count was 224 (96%).

Formation of Gang Broods and Creches

Single broods ranged from 1 to 9 goslings per brood and averaged 4.2 $\pm$ 2.1 (s.d.) goslings per brood. Gang broods began to appear about six days after the first broods hatched during 1984, and 14 days after the first broods hatched during 1985. The number of goslings per gang brood ranged from 12 to 30, incorporating an estimated 2.9 to 7.0 single broods per gang brood. During 1984 an estimated 36 (48%) single broods became incorporated into gang broods, and during 1985 an estimated 31 (58%) broods became incorporated into gang broods.

Both single broods and gang broods became members of creches. Creches were monitored only during 1985 and started to form about 14 days after the first broods hatched. They eventually contained 85% of the broods on the reservoir and averaged 3.5 broods per creche (range; 2 to 9 broods/creche). Creches appeared to remain stable in numbers. During 15 observations of a creche containing a color marked adult, the composition of the creche changed only three times when six additional goslings were counted.

Brood Size

The number of goslings per brood for single broods averaged 4.20 $\pm$ 0.49 goslings during 1984 and 4.08 $\pm$ 0.37 goslings during 1985, 4.20 ± 0.49 goslings during 1984 and 4.08 ± 0.37 goslings during 1985, and mean brood size did not decrease over time either years (Fig. 6).

The number of goslings per gang brood averaged 17.5 ± 5.3 goslings/brood during 1984 and 20.2 ± 8.3 goslings/brood during 1985. Again with no significant decline through time during either year (Fig. 7).

Brood Locations and Activity Centers

Major activity centers of broods shifted between 1984 and 1985 and also shifted between periods of low water and high water during 1985. The harmonic center of activity of broods during 1984 was along the retaining dike in the southwest corner of the reservoir (Fig. 8). In contrast, the harmonic center of activity during 1985 shifted from the south side during periods of high water (Fig. 9) to the southeastern side where vegetated mudflats were available during periods of low water (Fig. 10). At all times the majority of activity occurred along the south and west sides of the reservoir. Goose pellet densities coincided with observational data during 1984 and showed similar activity centers around the reservoir, but during 1985 pellet distribution and observations showed differing activity patterns in some areas (Fig. 11). This occurred because pellets could not be counted on the mudflats.

Of the birds equipped with neck collars, one reared a brood during 1984 and four reared broods during 1985. The 1984 family used a series of potholes adjacent to the reservoir as their major activity center (4 ha) with occasional trips onto the reservoir itself. The entire area of activity for the brood was 21 ha in size. Only one family during 1985

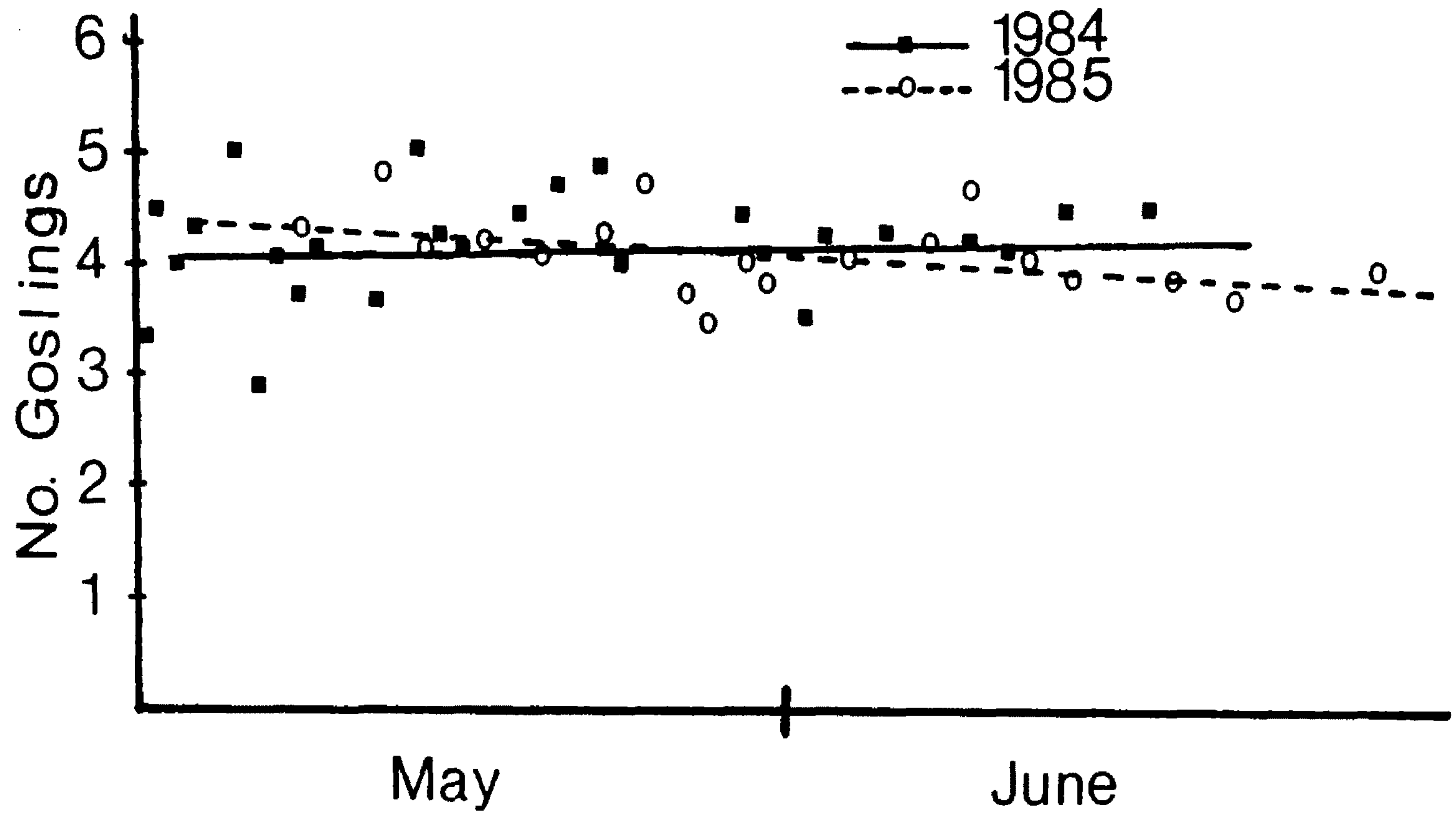

Fig. 6. Average size of single broods during 1984 ($\bar{x}$ = 4.20 ± 0.49, n = 26, slope = 0.007, r = 0.83) and 1985 ($\bar{x}$ = 4.08 ± 0.37, n = 20, slope = -0.009, r = 0.85).

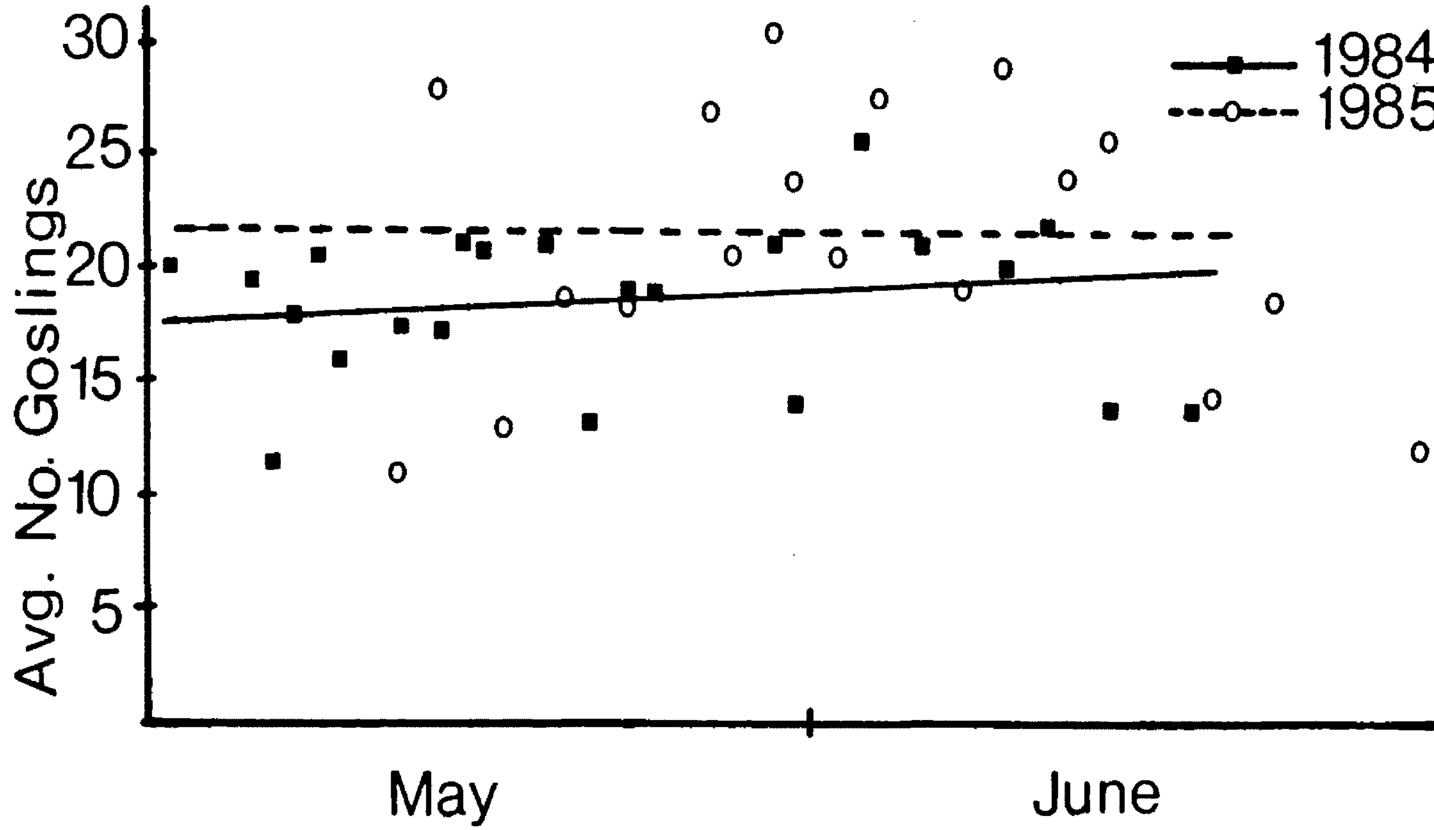

Fig. 7. Average size of gang broods observed during 1984 ($\bar{x}$ = 17.5 ± 5.3, n = 22, slope = 0.023, r = 0.85) and 1985 ($\bar{x}$ = 20.2 ± 8.3, n = 18, slope = -0.019, r = 0.85).

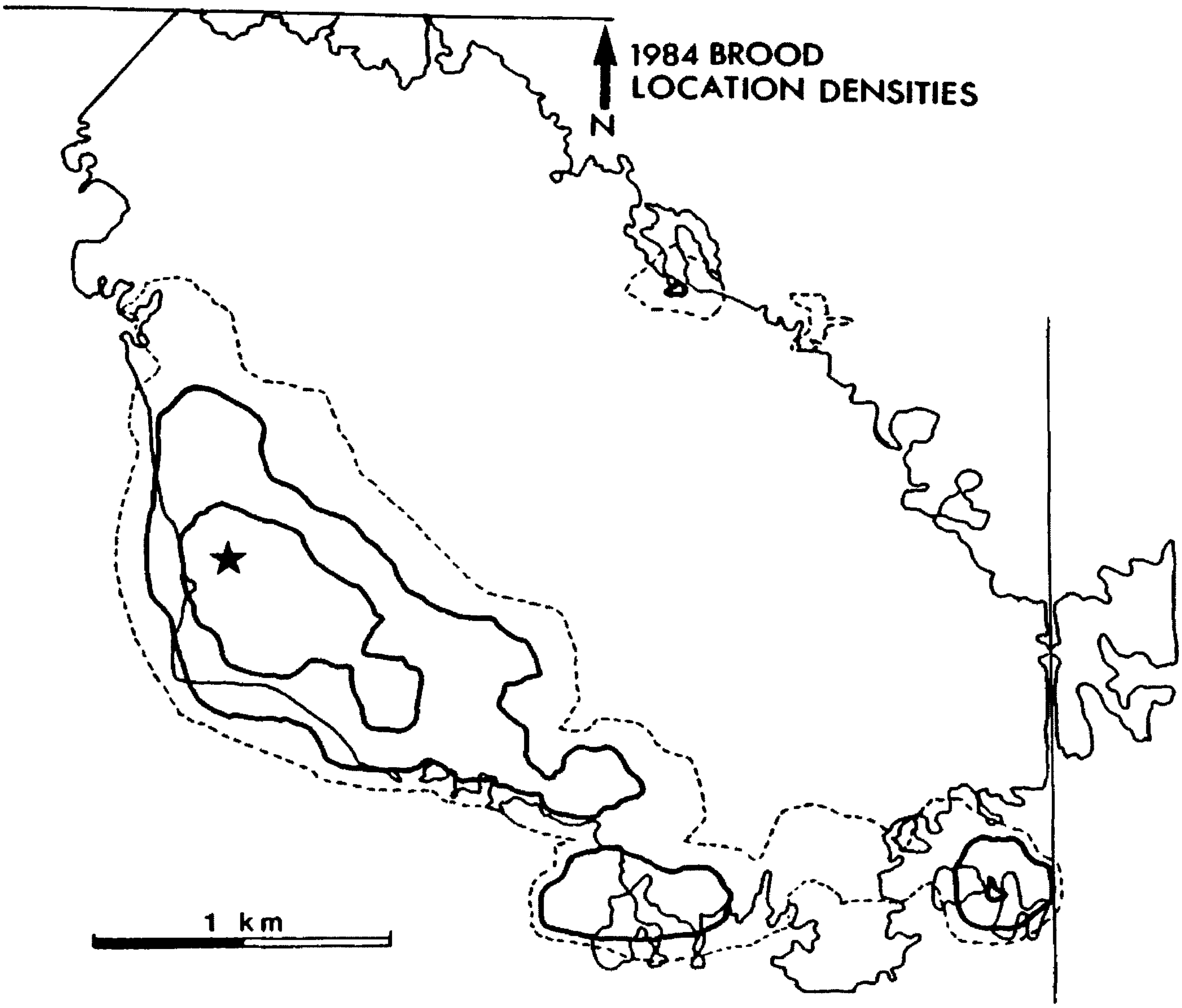

Fig. 8. Primary areas of brood activity on Ninepipe Reservoir during 1984. The * signifies the harmonic center of activity. The two heavy solid lines enclose 50% and 25% of the utilization volume, and contain 70% and 26% of the observations. The dotted line encloses the core area of activity, which contains 64% of the utilization volume, 84% of the brood locations, and 24% of the total area used. n = 545.

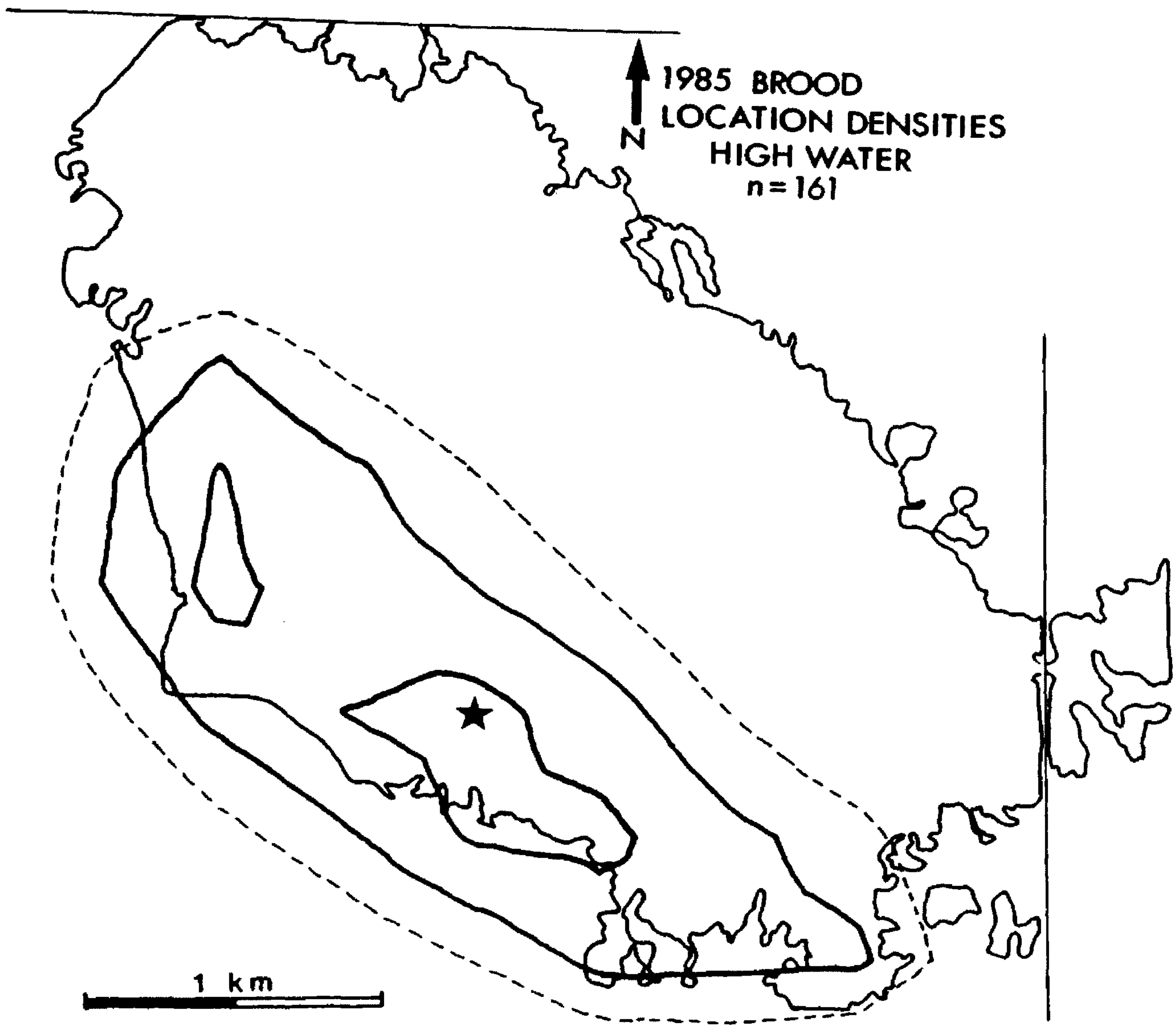

Fig. 9. Primary areas of brood activity on Ninepipe Reservoir during high water levels in 1985. The * signifies the harmonic center of activity. The two heavy solid lines enclose 50% and 25% of the utilization volume, and contain 81% and 58% of the observations. The dotted line encloses the core area of activity, which contains 64% of the utilization volume, 89% of the brood locations, and 33% of the total area used. n = 161.

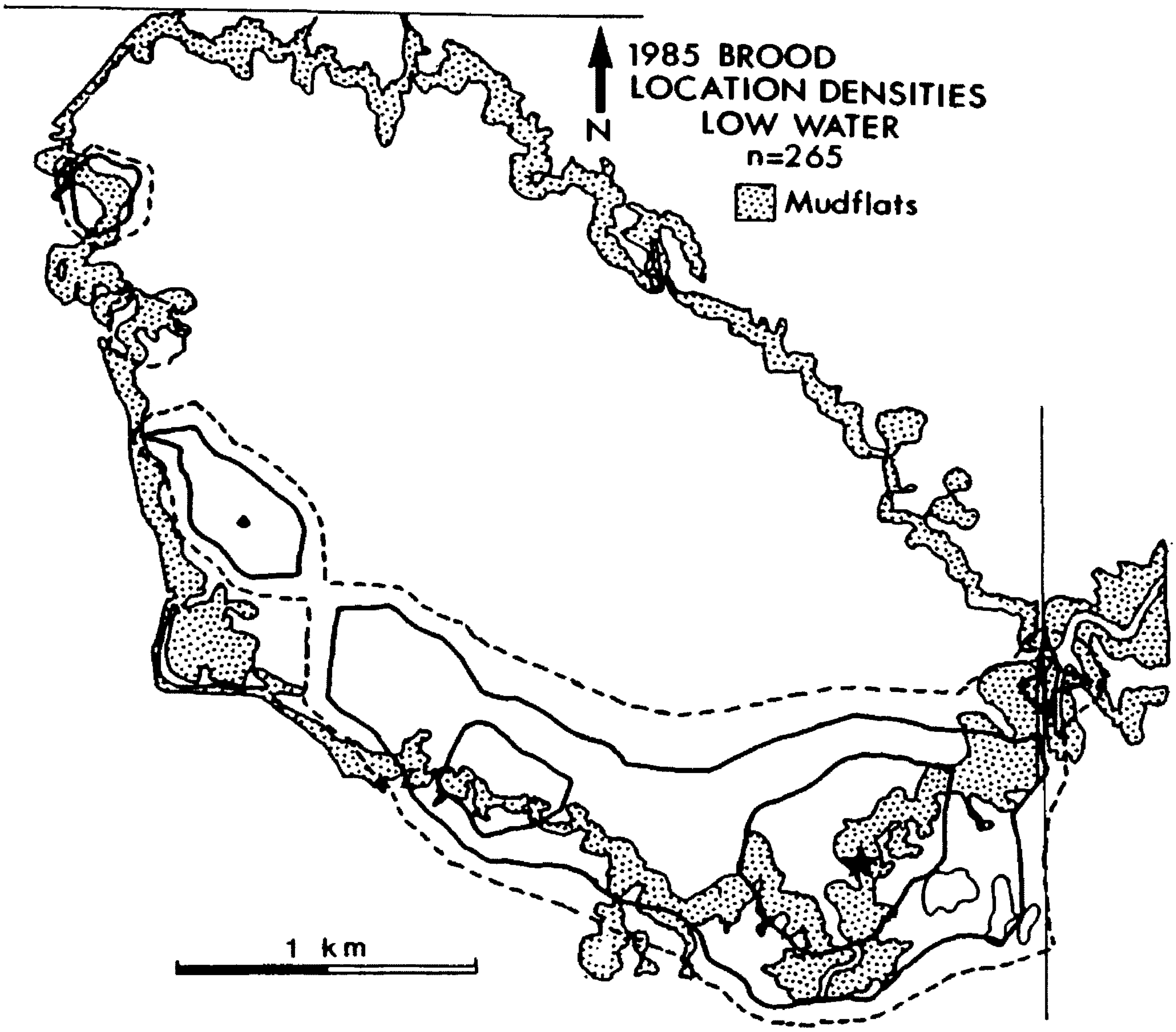

Fig. 10. Primary areas of brood activity on Ninepipe Reservoir during low water levels in 1985. The * signifies the harmonic center of activity. The two heavy solid lines enclose 50% and 25% of the utilization volume, and contain 79% and 43% of the observations. The dotted line encloses the core area of activity, which contains 58% of the utilization volume, 87% of the brood locations, and 26% of the total area used. n = 265.

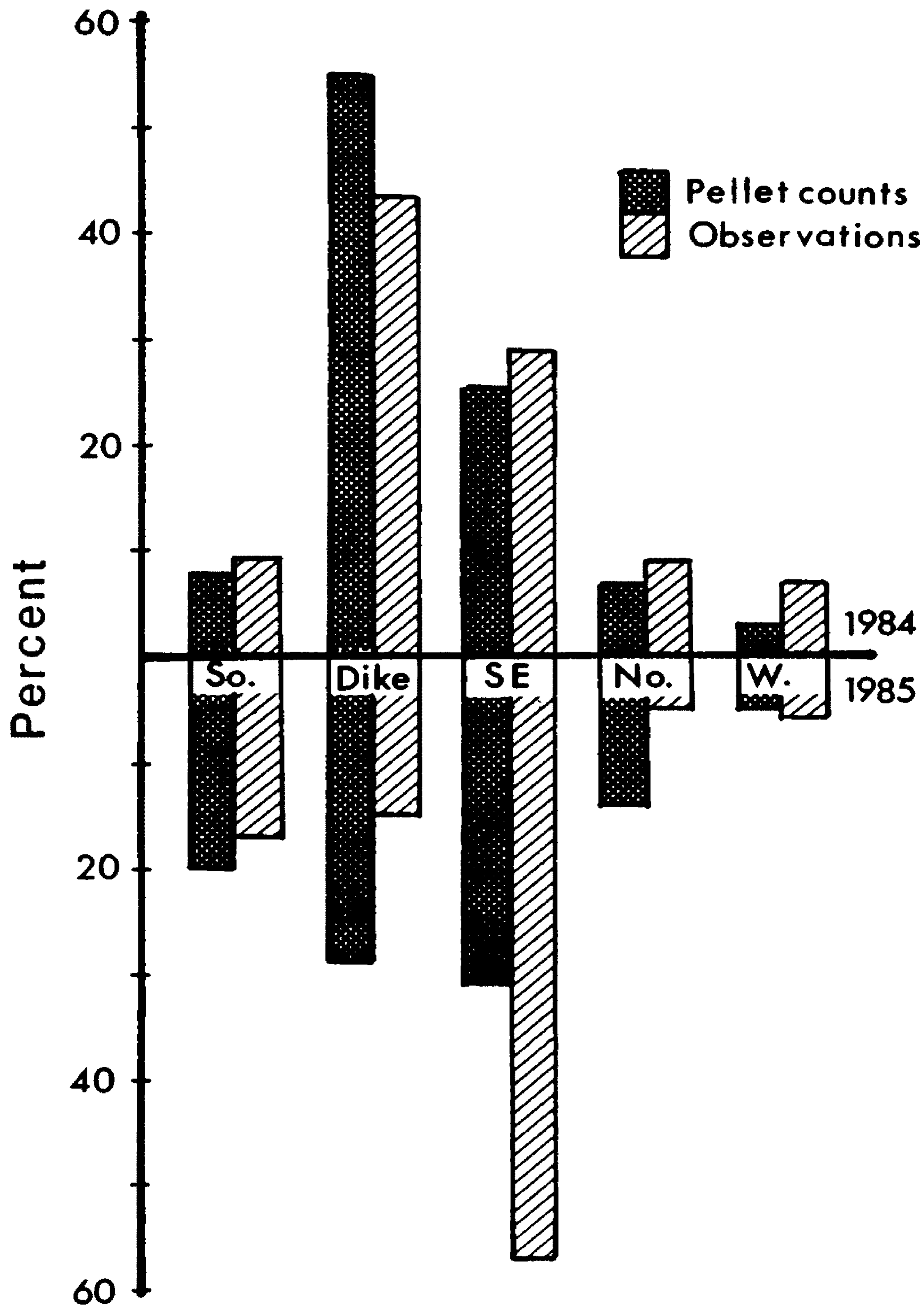

Fig. 11. Comparison of pellet counts and observations on five areas of the refuge. So = south side of the reservoir, Dike = retaining dike, SE = southeast side of the reservoir, No = north side of the reservoir, and W = west side of the reservoir.

was relocated often enough so that home range could be calculated. They were more mobile than the brood monitored during 1984, with an area of activity encompassing 49 ha along the west side of the reservoir (Fig. 12).

Habitat Use

Habitat use shifted dramatically between 1984 and 1985. Concentrated use by broods shifted from upland grasslands during 1984 to vegetated mudflats during 1985 (Fig. 13). Lower water levels during 1985 made mudflats vegetated with spike sedge (*Eleocharis* sp.), pepperwort (*Marsilea vestita*), and smartweed (*Polygonum* sp.) available to broods. Among 106 observations of feeding broods 60% (n = 89) were seen on vegetated mudflats, while only 11% were on uplands (n = 17). Pellet transects also showed a decline of upland use during 1985; 2195 pellets were counted on upland transects during 1984, but only 631 pellets were counted on the same transects during 1985.

Although overall use of uplands was relatively low during 1985, the pattern of habitat use in relation to availability remained consistent between years (Fig. 14). Gravel and roadside areas were used significantly more than expected (based on proportionate availability) but reed canarygrass (*Phalaris arundinacea*) and other emergent vegetation was used significantly less than expected. Use of Kentucky bluegrass (*Poa pratensis*) and other upland grasses and forbs was approximately equal to availability. Use in relation to distance from water followed the same pattern during each year. Use decreased as distance from water increased, except for the first 6 m closest to

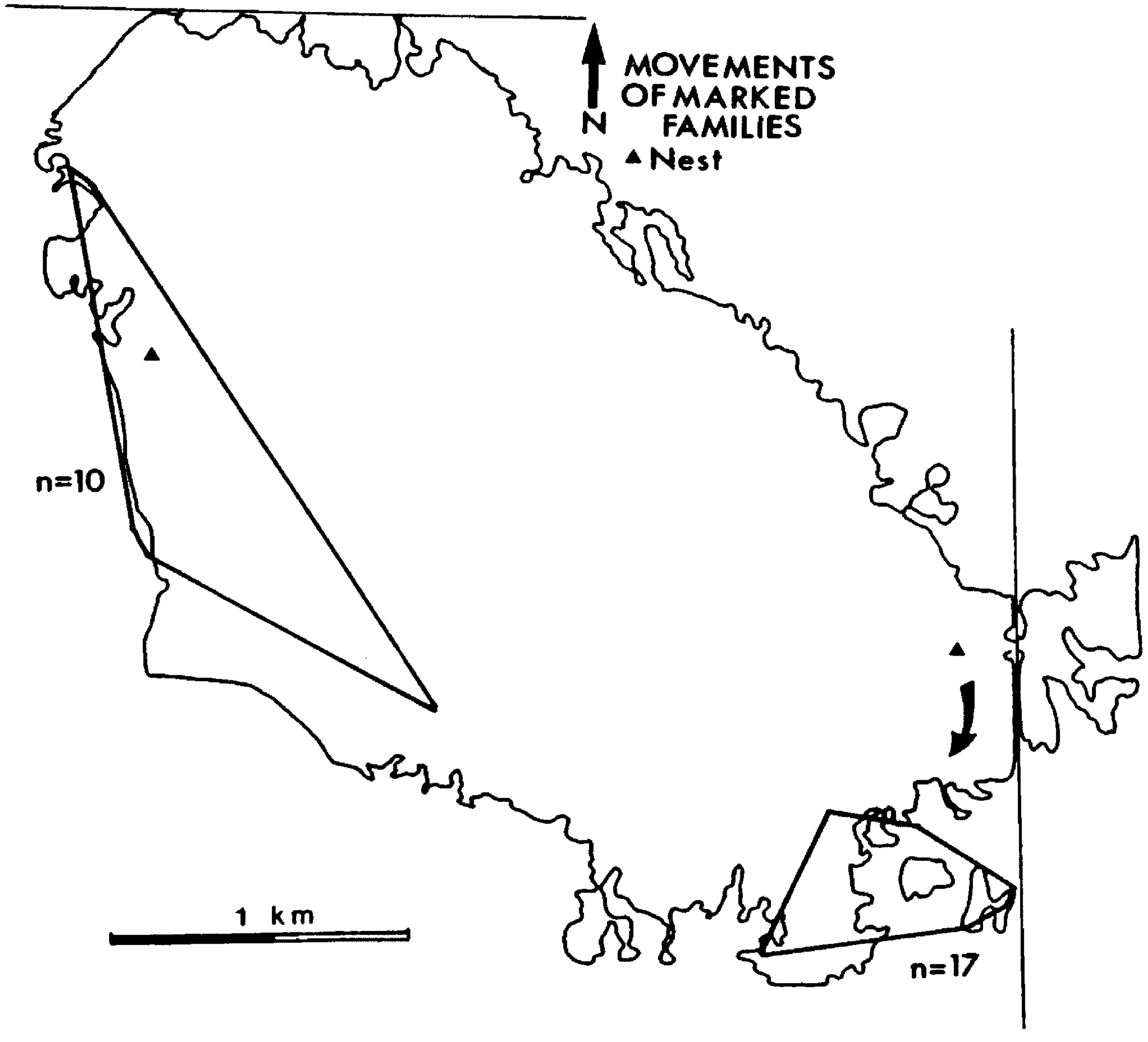

Fig. 12. Movements of marked geese with broods as indicated by minimum area polygons (Mohr 1947). Nests sites marked by (▲).

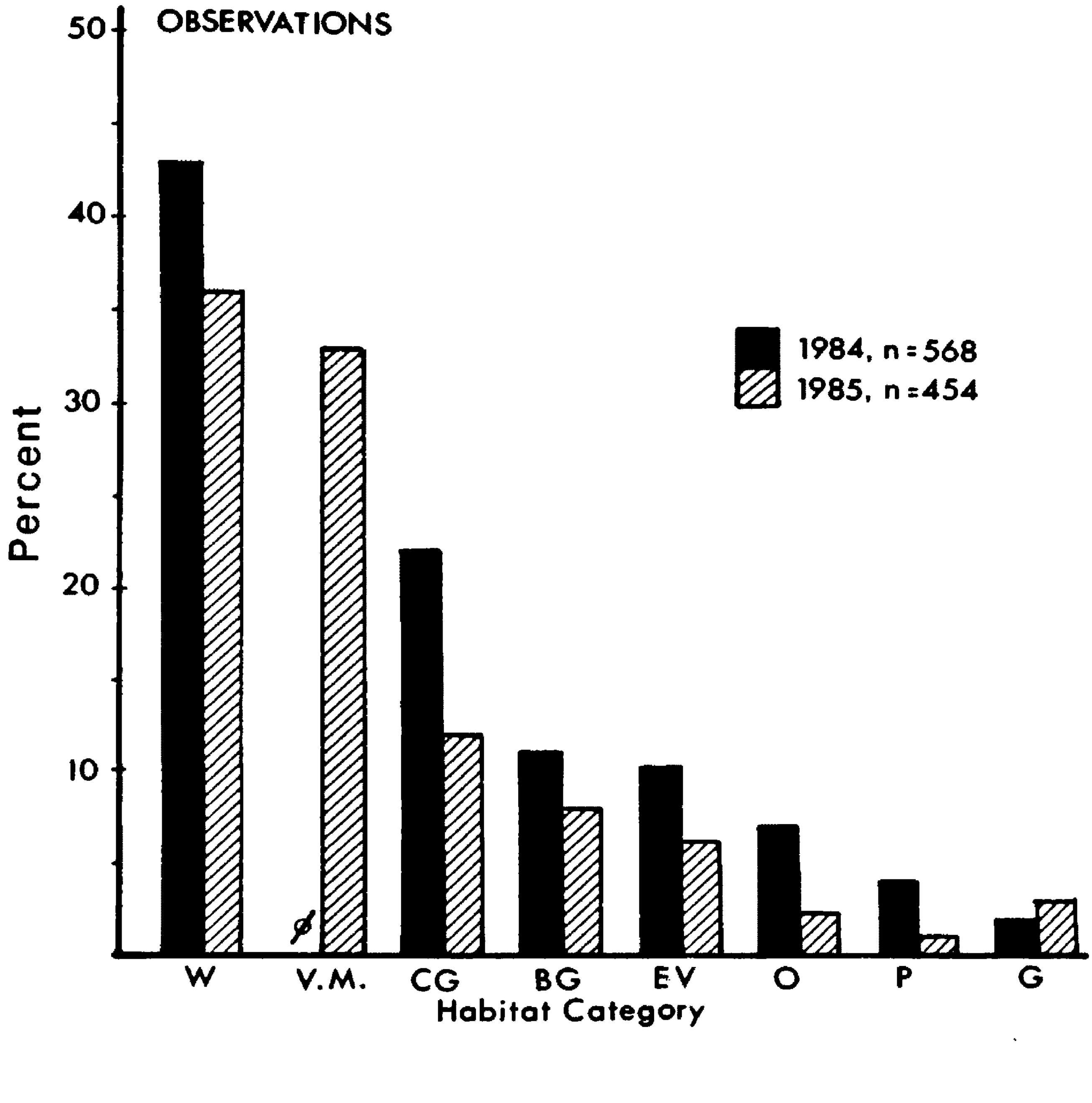

Fig. 13. Habitat characteristics at observed brood use sites. W = water, VM = vegetated mudflat, CG = reed canarygrass, BG = Kentucky bluegrass, EV = emergent vegetation, O = other grasses, P = potholes, and G = gravel.

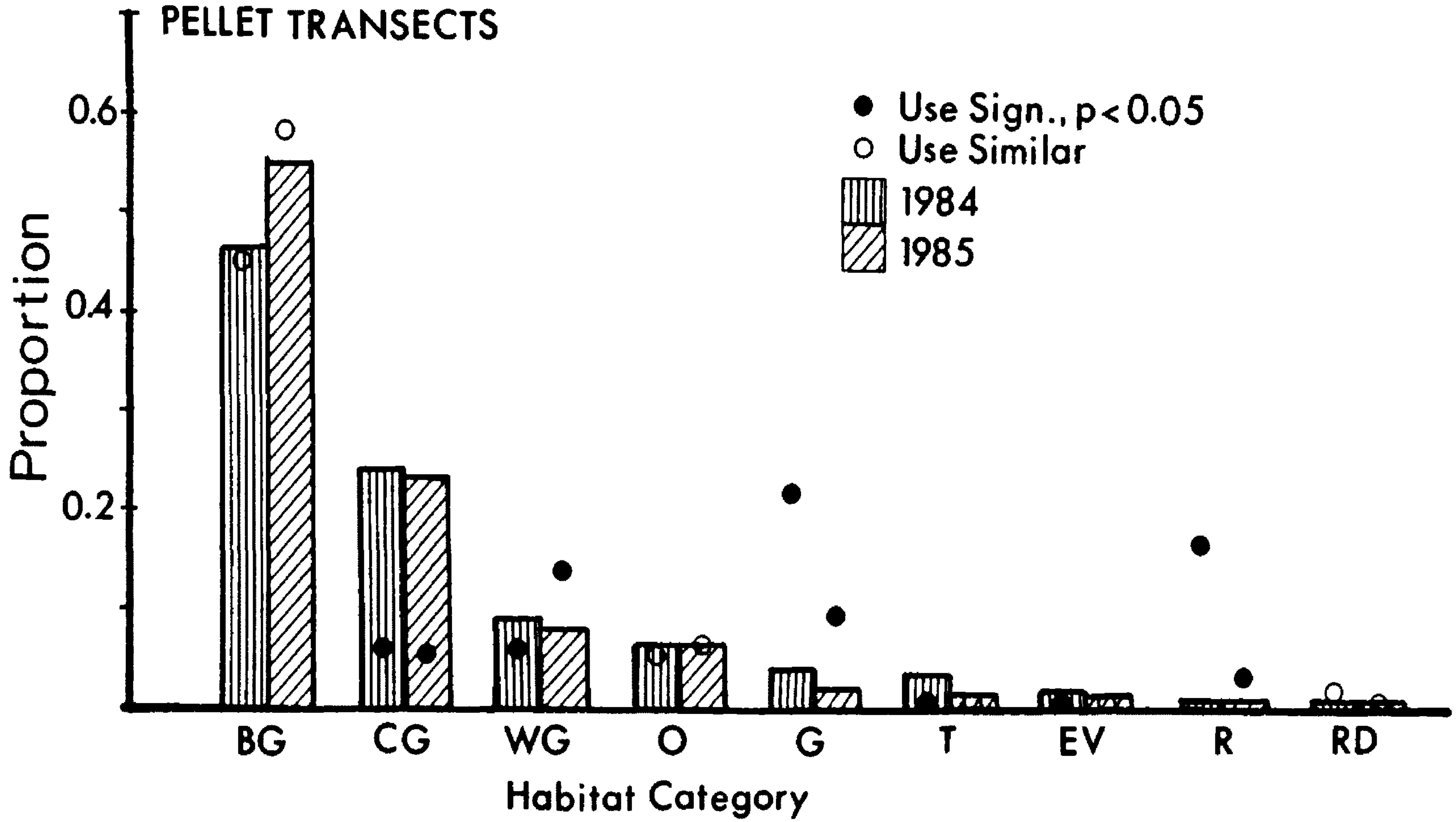

Fig. 14. Brood use of habitat categories relative to availability. BG = Kentucky bluegrass, CG = reed canarygrass, WG = wheatgrass, O = open water, G = gravel, T = thistle, EV = emergent vegetation, R = roadside with sparse vegetation, RD = rock dike.

shore. In the 0-6 m category, use was equal to availability for plots in reed canarygrass (Fig. 15), but greater than availability for plots with other dominant vegetation types (Fig. 16).

Habitat Manipulation

Brood use was expected to increase on uplands that were burned. However, observation of brood use on the uplands burned during 1985 was the same as during 1984 (6% during 1984, n = 34 vs 6% during 1985, n = 29). An indication that use may have increased on the burned area during 1985 was a proportional increase of pellets in relation to the other areas of the reservoir (20% of total pellets recorded during 1985 vs 8% during 1984).

Brood use was also expected to be higher in the area that was grazed during 1985. The grazed area had fewer observations (6% during 1984, n = 38 vs 4% during 1985, n = 19) which coincided with fewer pellets (161 during 1984 vs 91 during 1985) counted. However, the pellet count was proportionally higher during 1985 (7% during 1984 vs 12% during 1985).

DISCUSSION

Leaving the Nest

The abundance of gulls on Ninepipe was considered a potential threat to the survival of newly-hatched goslings. However, gulls were not observed to attack goslings on their nesting islands or in the

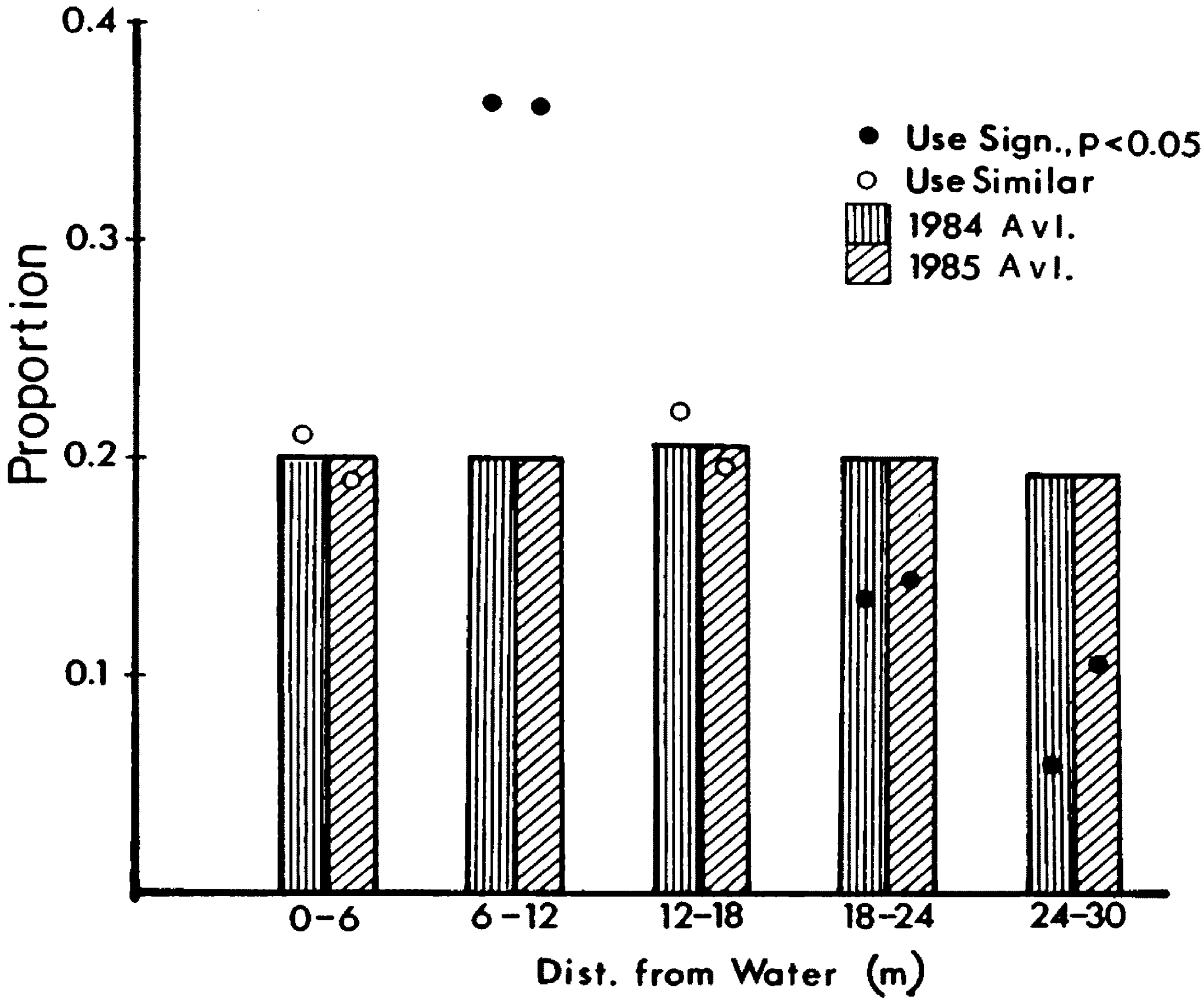

Fig. 15. Availability and brood use of areas at varying distance from water. Use is based on the density of goose pellets in m^2 plots.

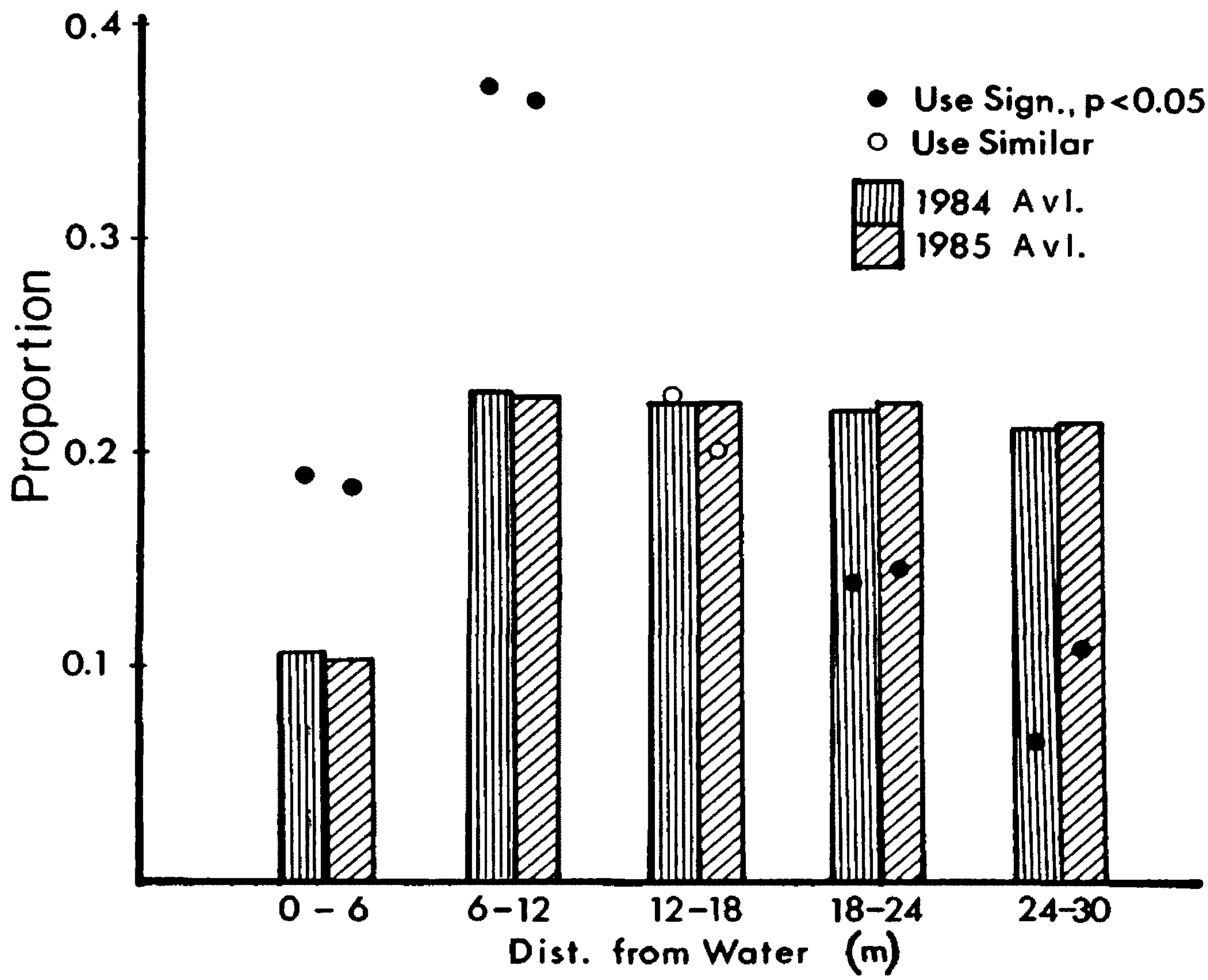

Fig. 16. Availability and brood use of areas at varying distance from water. Plots dominated by reed canarygrass are excluded. Use is based on the density of goose pellets in m^2 plots.

water. Gulls may have been reluctant to confront a protective adult goose. Odin (1957) observed no gosling mortality from California gull predation in Utah and felt that the large size and aggressive nature of the adult geese probably dissuaded any predatory attempts by gulls.

Estimates of Gosling Production and Brood Sizes

Gosling production and brood size appeared to be similar to other populations of western Canada geese (Krohn and Bizeau 1980). During this study an accurate production estimate was established by conducting intensive nest census that required two visits to each nest. Subsequent brood counts showed an average count between 48-60% of the goslings estimated to be present from the nest census. Water and vegetation conditions appeared to affect brood visibility the most for both aerial and ground censuses. Probably the most accurate count was during the banding effort during 1984, which accounted for 80% of the goslings hatched on the reservoir.

Formation of Gang Broods and Creches

Gang brood behavior appeared to be a common family arrangement that incorporated about half the goslings on the reservoir. Little is known about gang brood behavior in wild populations. Factors that influence gang brood formations may include crowded nesting conditions and close association of family groups (Warhurst et al. 1983). Hanson and Eberhardt (1971), Sherwood (1967), and Collias and Jahn (1959) all observed goslings absorbed into broods of adults that were not their parents. Warhurst et al. (1983) noted that some goslings were members of as many as three broods during the season and found that gang broods generally consisted of 15-30 goslings, which approximates gang brood sizes on Ninepipe.

Creche formation presumably reduces vulnerability to predation by increasing the number of vigilant adults and may also transfer brood-rearing skills from experienced pairs to younger pairs. Sherwood (1967) observed that a two-year-old goose with her first brood formed a creche with her parents and their brood. Brakhage (1965) felt that creche formation was likely due to crowded conditions on brood-rearing areas. On Ninepipe broods were often in contact with other broods, particularly when fleeing from a perceived danger on shore. These associations may have encouraged creche formation. However, MacInnes and Lieff (1979) found that Canada geese formed creches even on the open McConnell River delta system in the Northwest Territories.

Brood Size

In addition to creche formation, relatively low predator populations on the refuge could have contributed to gosling survival. Krohn and Bizeau (1980) reported a mortality rate of 5-8% for the Rocky Mountain populations around the Northwest. The Ninepipe population probably has a similar mortality rate based on the stable gosling and brood counts during each season. In addition, gosling counts during the banding operation of 1984 showed that at least 80% of the goslings survived to near fledging. During 1985 the highest count made on the ground accounted for 85% of the goslings, and the aerial survey counted 96% of the goslings estimated to be present. Hanson and Eberhardt

(1971) reported higher mortality rates primarily because of coyote predation. The broods vulnerability to predators may have increased when they were forced to cross large expanses of mud or sandbars to their grazing areas (Ball et al. 1981).

Gang broods also showed stable gosling numbers throughout the brood-rearing period. Therefore, I do not suspect that gosling mortality was influenced by gang brooding behavior on Ninepipe. In areas of higher predator densities gang brooding behavior may influence gosling survival. Creche formation probably masked effects of gang brood formation since both single broods and gang broods were involved in creches. Brood mixing was often apparent in creches and therefore whether a gosling was a member of a single brood or gang brood was immaterial in terms of benefitting from additional adults.

Brood Locations, Activity Centers, and Habitat Use

Shifts in brood activity centers around the reservoir between years appeared to be caused by lower water levels during 1985. The retaining dike provided a good view of the surrounding area and was adjacent to grazing habitat. The grasslands provided grazing areas and adjoined the security of the water. Exposure of vegetated mudflats attracted broods away from the retaining dike and grasslands surrounding the reservoir. When water levels dropped, the mudflats afforded good forage, excellent visibility of surroundings, and essentially zero distance to water. Broods preferred vegetated mudflats when they were available over all other habitat types. Proximity to water proved to be an important factor for brood use and was reflected in the steady decrease of pellets as distance from water increased. The lower use around the first 6 m of shore line reflected the low use of reed canarygrass that tended to grow at the waters edge and the greater difficulty of detecting goose pellets in rank canarygrass. Higher brood observations in canarygrass than measured by pellet counts, reflected the brood sightings in canarygrass that was partially submerged and hence not included in the upland analysis.

During 1985, pellet transects correctly estimated the relative use of uplands surrounding the reservoir but could not appropriately reflect the use of exposed mudflats. However, upland habitat use in relation to availability remained remarkably similar between years. Most habitat types were used in much the same proportion but not the same intensity during 1985 as during 1984, an indication that upland habitat preference did not shift with decreased use.

Habitat Manipulations

The effects of burning and grazing on habitat use were masked somewhat by the exposure and heavy use of vegetated mudflats; however, some changes were apparent. The burned area showed an increase in proportional use even with the decrease in overall use of upland. When mudflats were not available, the center of brood activity was located just offshore of the burned area. This also suggests that the area was preferred by broods. Nonbreeding geese were observed on the area during the incubation period also and may have influenced pellet counts.

Grazing may improve goose brood-rearing habitat the season following the livestock use. But even while cattle were using the area, sightings and pellet densities indicated that geese often ignored them and used the area during the grazing year.

Management Recommendations

1) Burning to reduce rank growth and rejuvenate grasses appears to increase use by broods. I recommend that the practice be continued but limited, as much as is practical, to the narrow (30-40 m) strip along shore that broods prefer. Scattered small (<1 ha) strips may provide adequate brood habitat while preserving upland nesting habitat for ducks.

2) Drawdowns of the proper magnitude and timing may be useful in providing preferred habitat for goose broods.

3) Mowing the grasses in strips along the shoreline during late spring and early summer would provide succulent new growth for broods to browse. A mowed swath about 6 m wide along areas of the south and north shoreline would provide excellent brood habitat. Strips could be of equal size of those that were burned (<1 ha) thus minimizing any impact on upland nesting habitat.

SUMMARY

Canada goose broods were monitored from hatching to fledging. Gosling survival, the impact of gang brood and creche formation on survival, and habitat use were examined. Gosling survival was measured by relative

brood size throughout the brood-rearing period. Brood size remained stable for single broods at around 4.2 goslings/brood in 1984 and 4.1 goslings/brood in 1985. Gang brood size stayed stable at 17.4 goslings/brood in 1984 and 20.2 goslings/brood in 1985. Regular counts of goslings during the period comprised an average of 55% of the gosling estimated to have hatched. The best census indicated that at least 80% of the estimated number of goslings hatched survived to fledging in 1984 and 96% in 1985. Sightings of broods were recorded daily and analyzed with a Harmonic Home Range Program. Brood locations corresponded with areas of mudflat exposure during low water periods but shifted to other areas during periods of high water. Brood use of grasslands was determined by establishing goose "pellet" transects. Relative pellet densities showed an inverse relationship between distance from the reservoir edge and use.

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