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Characteristics of nest mounds used by Snowy Owls in Barrow, Alaska, with conservation and management implications

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Snowy Owl *Bubo scandiacus* nest mounds from Barrow, Alaska, were characterized measuring several variables from 114 nests and 2280 random mounds. Mound height appeared to be the most important trait, as nest mounds averaged about 1 m tall, and were significantly different from random mounds in all years. Generally circular nest bowls (n = 91) were dug by females and averaged 47.5 x 44.0 x 9.6 cm (length x width x depth). Mound vegetation did not conceal incubating or brooding Snowy Owls. Tall nest mounds were advantageous in that they were drier (thinner snow cover which melted earlier allowing females to dig nest bowls), windier (relief from mosquitoes and cooler in summer) and allowed nesting owls greater vigilance against predators.

Key words: Snowy Owl, *Bubo scandiacus*, nest mounds, conservation, management

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INTRODUCTION

The Snowy Owl *Bubo scandiacus* is a large ground nesting species whose distribution is Holarctic (Holt *et al.* 1999, König *et al.* 1999). In North America this species breeds in Canada and United States (Godfrey 1979, Parmelee 1992). In the United States, Alaska is the only state where Snowy Owls breed (Gabrielson & Lincoln 1959, Parmelee 1992). The northern coastal tundra appears to be its main breeding range in Alaska (Gabrielson & Lincoln 1959). Currently in Alaska, the most consistent region for breeding encompasses the North Slope, primarily in the Barrow region (Petersen & Holt 1999).

The breeding biology of the Snowy Owl is well known (see reviews by Bent 1938, Mikkola 1983, Cramp 1985, Parmelee 1992, Holt *et al.* 1999). On the tundra where it nests, trees are absent or stunted in their growth. Snowy Owl nest sites have been described as being placed on promontories overlooking vast areas of land. For example, in Canada, nests have been recorded on rocks, tall mounds, hill-tops, ridges, and rocky outcrops (Sutton & Parmelee 1956, Watson 1957, Parmelee 1967, Taylor 1973). In southwestern Alaska, near Hooper Bay, nests were described as being on hummocks and gentle slopes (Murie 1929). In the northern most point of Alaska, at Barrow, Pitelka *et al.* (1955) described nests as being on high polygons, low ridges, or slopes.

The Arctic appears vast and empty; however, it has a long history of occupation, exploration, natural resource extraction, and scientific research (Vaughan 1992). Likewise, the village of Barrow, Alaska has been the focus of Inupiat natives' life for a millennium or more (Brower 1942, Brown *et al.* 1980). Here, subsistence hunting has been a driving force for survival. In particular, whale, seal, caribou, and duck hunting have been the main-stay for subsistence, supplemented by species such as Snowy Owls.

Figure 1. Snowy Owl feeding young at nest, showing use of polygon/mound landscape, Barrow, Alaska (photo Daniel J. Cox/NaturalExposures.com).

In the last 25 years or so, the Arctic has also become a recreation and tourist destination. As these endeavours grow, native villages have also grown. This growth has and will continue to expand onto Snowy Owl and other wildlife's habitat. Near Barrow, polygonal terrain is a major feature of the landscape and has been created through cryogenic processes over thousands of years (Brown *et al.* 1980). Thus, knowledge of Snowy Owl distribution, breeding biology, habitat associations, and nest sites, may be important for management and conservation of this species in Alaska. Herein we provide the first quantitative assessment of Snowy Owl nest site characteristics for North America.

METHODS

Study area

Our study area was located in the Arctic Coastal Plain near the village of Barrow (71°18'N, 156°40'W) and encompassed c. 200 km^2. The soil in this region is frozen during winter and underlain with permafrost at depths of 360 to 650 m below the active soil layer (Brown *et al.* 1980, Davies 2001). During summer, the thaw zone is approximately 30–40 cm and generally wet (Brown *et al.* 1980). The Barrow region is characterized by low relief, with elevations ranging from 5–10 m, and ice-wedge created polygonal terrain, and shallow lakes (Sellmann *et al.* 1972, Brown *et al.* 1980). Much of our study area is covered by polygonal terrain (Fig. 1), and approximately 65% of the landscape above 71°54'N is polygonal terrain (Brown *et al.* 1980).

Winters are long, dry, and cold. Temperatures remain below freezing for almost nine months per year, but can also fall below freezing at anytime during the three summer months (Brown *et al.* 1980). Snow melt begins in early June, and there is 24 h of light from 10 May to 2 August. Barrow's short summers (June to August) are cool (0.6–3.7°C), moist (8.9–26.4 mm precipitation) and windy (5.1–5.5 m/s) (Bunnell *et al.* 1975, Brown *et al.* 1980). However, Arctic temperatures have been increasing over the past 150 years, and are predicted to rise for the next 50 years (Mitchell *et al.* 1990, Overpeck *et al.* 1997).

DWH has been studying Snowy Owls in Barrow from 1992 to present. During this period Snowy Owls have nested only in 1993, 1995, 1996, 1999, 2000, 2002, 2003, 2005, 2006 and 2008. Although we did not monitor breeding activity in 1991, many nests were located by local researchers. We measured 114 nest mounds and 2280 random mounds for the years: 1991, 1993, 1995, 1996, and 2000. Our experience with definitions, recognition, and polygonal terrain ecology increased after the first two seasons. Thus, polygon recognition, and mound measuring precision improved with field experience.

Nest mounds

We used binoculars and spotting scopes to locate Snowy Owl nests. Owls observed in a horizontal (incubating/brooding) posture were investigated for nest sites. Nests were mapped and their GPS coordinates recorded. We measured the nest bowl length, width, and depth to the nearest cm. Nests enlarge and fill with debris during the nesting season therefore they were measured during incubation or early brooding. We visually estimated percent vegetation cover on top of each mound and recorded the four most abundant plant species. Vegetation was identified using Hulten (1974). We also recorded other cover types such as exposed soil (Brown *et al.* 1980), lichen and mosses (Thomson 1979, See 1981, Vitt *et al.* 1988).

Most Snowy Owl nests were on the tops of mounds within a polygon that appeared as a distinctive feature of the landscape. For these sites, measurements were taken in the following way. Length was measured as the furthest distances between two points defining the mound and dropping-off where the inflection of the mound changed from convex to concave. Width was measured perpendicular to length at the widest point of the mound and dropping-off at its inflection point. Height was measured at the highest point of the mound and the lowest level of its inflection point, although they tended to be uniformly level (Fig. 2). We did not include the man-made sites that the owls nested on such as dredge plies and gravel mounds, for this analysis.

Random points

We randomly selected 20 mounds within 100 m of each nest to make comparisons of used and unused mounds. To choose a random point we used a random number table to choose numbers between one and eight, to correspond to the cardinal compass directions; N, NE, E, SE, S, SW, W, NW. We then chose a random number between 1–100 m and proceeded along the compass line until a mound fell on the line or within 10 m of the line at the selected distance. That mound was then measured. If a mound was questionable in its definition, we replayed the random selections. We only did this one time, as not to bias our picking of one mound over another. Above all, a mound had to be a definable unit.

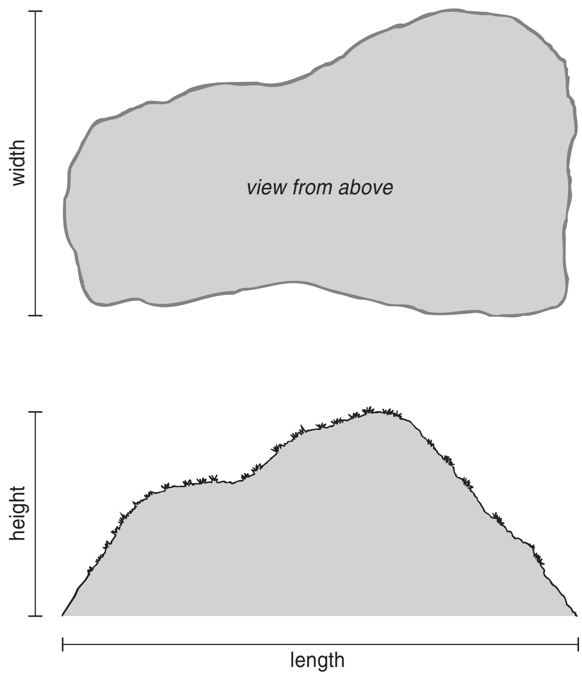

Figure 2. Variables measured at mounds within polygons at Barrow, Alaska (width, length, height). Both mounds with Snowy Owl nests and a random selection of non-used mounds were sampled.

A few nest mounds were not on polygonal terrain (e.g. on ridges or relatively flat tundra) and had zero or few adjacent mounds. In these cases we defined the nest mound as an independent unit defined by its inflection points from concave to convex. If possible, random sites were measured.

Analysis

We compared the height, length and width of nest mounds to those of random mounds within each year by calculating the percent of nest mounds that fell above a certain percentile of the distribution of random mounds. Additionally, we used a one-sample *t*-test to explore if the average difference between nest mounds and random mounds were significantly different from zero. Where large outliers in the distribution of differences occurred, a Wilcoxon sign rank test was performed. Alpha levels were set at <0.05.

RESULTS

Nest bowls

Female Snowy Owls dug a somewhat circular nest bowl at or near the top and centre of the mound (Fig. 1). In this depression the owls laid eggs on bare soil. No nest material was added. The length and width from 91 nests averaged 47.5 cm (SD 11.8, range 24–78) × 44.0 cm (SD 10.1, range 22.0–68) cm and the depth of 68 nests averaged 9.6 cm (SD 2.6, range 4.5–17.0).

Mound height

Mean nest height for 114 mounds was about 1 m (range 95–106 cm). In all years nest mounds were significantly higher than random mounds (Table 1). Sixty-three percent of nest site mounds were taller than all of the randomly selected mounds. In fact, almost all nest site mounds were >50th percentile of the distribution of random mounds (Table 2).

Mound length and width

While there were significant differences in mound length and width in 1991 and 1993, no significant differences occurred in 1995, 1996, and 2000 (Table 1). Only 67.8% (Table 2) of the 114 nest mounds were in the top 50 percentile of the distribution of random mound length at that site. About 80% of the nest mounds were in the top 50 percentile of the distribution of random mound width (Table 2). Defining mound length and width was sometimes problematic, especially in the early years of the study.

Nest mound vegetation

Vegetation from nest mounds was quantified in 1993 (n = 19) and 1995 (n = 19). All mounds had sparse vegetation <10 cm tall. Incubating Snowy Owls were not concealed by vegetation and were clearly visible from long distances. Higher and drier nest mounds had >50% *Poa* spp. grass cover, while lower and wetter

Table 1. Parameters of nest mounds used by Snowy Owls at Barrow, Alaska. n = number of nests measured; P = significance level (t-test).

		Mean height of mound ± SD (cm)		Difference between nests and random mounds	
Year	n	Nests	Random	Mean ± SE	P
1991	22	106.2 ± 35.2	49.4 ± 30.2	57.5 ± 28.9	<0.001
1993	19	104.9 ± 40.4	54.1 ± 25.9	50.8 ± 35.9	<0.001[a]
1995	39	94.9 ± 22.9	51.9 ± 21.4	43.4 ± 18.4	<0.001
1996	18	96.5 ± 14.5	57.0 ± 22.3	39.5 ± 9.5	<0.001
2000	16	102.0 ± 18.4	75.9 ± 17.8	26.0 ± 18.3	<0.001
		Mean lenght of mound ± SD (m)		Difference between nests and random mounds	
Year	n	Nests	Random	Mean ± SE	P
1991	22	9.8 ± 2.6	6.5 ± 3.5	3.2 ± 0.6	<0.001
1993	19	9.2 ± 2.8	6.7 ± 3.4	2.5 ± 0.6	0.002
1995	39	10.4 ± 3.0	11.1 ± 5.9	–0.6 ± 0.6	0.276
1996	18	12.0 ± 5.6	12.2 ± 6.1	–0.2 ± 1.3	0.861
2000	16	13.8 ± 5.7	14.0 ± 6.7	–0.2 ± 1.0	0.717[a]
		Mean width of mound ± SD (m)		Difference between nests and random mounds	
Year	n	Nests	Random	Mean ± SE	P
1991	22	7.0 ± 2.2	4.2 ± 2.6	2.8 ± 0.4	<0.001
1993	19	6.6 ± 2.0	4.6 ± 2.4	1.9 ± 0.4	<0.001[a]
1995	39	7.9 ± 2.4	7.2 ± 3.8	0.6 ± 0.4	0.166
1996	18	9.3 ± 3.1	7.9 ± 3.9	1.3 ± 0.6	0.058[a]
2000	16	10.9 ± 5.5	9.8 ± 5.1	1.1 ± 1.0	0.408[a]

[a]Wilcoxon sign rank test.

Table 2. Percent of nest mounds (n = 114) that fell above and between the 50th and 100th percentile of the distribution of randomly selected mounds. For example, for the height variable, 99% of the nest mounds fell above the 50th percentile of the random mounds.

Percent	50	75	90	95	97.5	100
Height	99.0	95.0	87.0	80.0	72.0	63.0
Length	67.8	35.6	10.4	10.4	8.7	5.2
Width	80.0	46.1	20.9	13.0	7.0	5.2

random mounds had <20% *Poa* spp. cover. Differences in vegetation at nest and random mounds were associated with mound age, height and moisture levels.

DISCUSSION

The Barrow region is presently the primary breeding area for Snowy Owls in Alaska, an area with the highest densities of Brown Lemmings *Lemmus timurcronatus* on Alaska's North Slope (Pitelka & Blatzi 1993). Collared Lemmings *Dicrostonyx rubricatus* also occur, but are much less common. Indeed, diet of Snowy Owls in Barrow is >90% lemmings (n > 33 400 identified prey remains; D. Holt, unpubl. data).

In general, Snowy Owls in North America are said to nest on high points such as mounds, hummocks, ridges, hills, and even rocks (Bent 1938, Parmelee 1992, Holt *et al.* 1999). Our results were similar to what Pitelka *et al.* (1955) qualitatively reported from the Barrow region. Similarly, these types of nest sites have also been reported from Norway (Hagen 1960), British Isles (Tulloch 1968), Russia (Portenko 1972, Menyushina 1994), and Sweden (Wiklund & Stigh 1986). We could find no comparative data quantitatively describing the nest mounds/sites of Snowy Owls to make further comparisons. Importantly, these sites provide a panoramic view of the surrounding tundra. Given that Snowy Owls are ground nesters, they must be vigilant to a diverse suite of mammalian predators, including humans that coexist on the Arctic tundra. Secondary benefits of selecting high mounds may include: less snow cover and early spring snow melt during nest-site selection, early thawing of the active soil layer allowing females to dig their nest bowls, a relatively dry site, a breezy environment that may aid in thermo-regulation such as cooling the female and older nestlings during warm days, relief from mosquitoes and flies, and a vantage point for hunting.

Our nest bowl dimensions were similar to the 50 cm wide and 10–15 cm deep dimensions previously described from Norway (Hagen 1960, Portenko 1972 in Mikkola 1983). Murie's (1929) observation that only females dig nest bowls is consistent with what we observed, however, Mikkola (1983) stated that males and females dug out the nest bowls.

Nest mounds

The polygonal mounds used by nesting Snowy Owls in Barrow are important to the management and conservation of this species. The formation of high-centred polygonal mounds by the freezing and thawing of the ground has been underway for c. 14 000 years in the Barrow region (Brown *et al.* 1980, Davies 2001). The process starts when the ground rapidly cools and begins a contraction and cracking process at about –15°C (Davies 2001). Snow, ice, and water are then able to penetrate the space during the freeze-thaw period. Ice wedges form in the cracks and over centuries of repeated thawing, freezing, and cracking, the wedge grows in depth and width (Davies 2001). As the volume of ice increases, land above it is heaved upwards on both sides of the wedge. Coupled with melting of the top of the wedge, parallel rims and a lower trough are formed (Fig. 3). Troughs are interconnected and further define the polygonal appearance. Over time, the upheaved terrain goes through many landform stages of

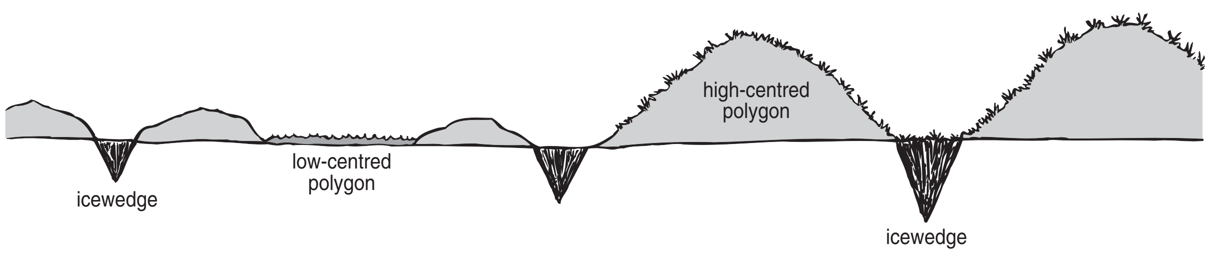

Figure 3. Progression of polygon/mound evolution and the formation of high-centred polygons used as Snowy Owl nest mounds.

growth and deformation from low-centred to high-centred polygons, to decay. It is the older high-centred polygon mounds where most Snowy Owl nests are located in the Barrow region. The high-centred mounds used by Snowy Owl can be 10 000 or more years old (Brown *et al.* 1980, Pielou 1994, Davies 2001).

Snowy Owl habitat conservation

Barrow was once called Ukpiagvik, meaning a place where owls are hunted, met or found. Native peoples throughout the Arctic and the Snowy Owl have had a long history. Snowy Owls have been a food source, kept as pets, honoured in artwork, and its body parts used for various cultural functions (Brower 1942, Bailey 1948, Vaughan 1992). Currently the logo of the Alaska United Eskimo Corporation is the Snowy Owl.

During this study, we recorded the loss of Snowy Owl nesting areas to development of the growing Barrow community. The drier upland sites where Snowy Owls prefer to nest are also the sites most appealing to housing development. On the other hand land has been set aside (Barrow Environmental Observatory Research Area) by the native people of Barrow as a conservation and research area benefiting all plants and animals. Development however, does increase access to Snowy Owl nest sites to residents, their pets, tourists, and researchers. This will push Snowy Owls to other areas for nesting. Snowy Owls are a forgiving species, and with management guidelines, both community development and Snowy Owl breeding can co-exist in Barrow. As Barrow grows and the surrounding land is used for expansion, city planners and mangers will need to conserve Snowy Owl habitat and nest sites. How human population growth will effect local lemming populations is unknown.

It is also unknown how climate change might affect the cryogenic process that creates the polygonal terrain surrounding the Barrow region. However, there is ample evidence of changes in Arctic climate (Mitchell *et al.* 1990, Chapin *et al.* 1992, Overpeck *et al.* 1997, Divoky 1998).

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SAMENVATTING

In 1993–2008 zijn in Barrow, Alaska, 114 nestheuvels van Sneeuwuilen *Bubo scandiacus* en 2280 willekeurig gekozen verhogingen in het veld met elkaar vergeleken. De hoogte van de heuvels was het belangrijkste onderscheidende kenmerk tussen de twee groepen. Nestheuvels waren gemiddeld 1 m hoog en in alle jaren significant hoger dan willekeurig gekozen verhogingen. In het algemeen werden de nestkuilen door de vrouwtjes geschraapt. De vrijwel ronde kuilen waren gemiddeld 47,5 cm lang, 44,0 cm breed en 9,6 cm diep. De uilen werden door de vegetatie op de nestheuvels niet aan het gezicht onttrokken. Hoge nestheuvels hadden het voordeel dat ze droger waren (minder sneeuw die bovendien vroeg wegsmelt, waardoor de uilen vroeger een nestkuil konden schrapen), meer wind vingen (minder last van muggen en 's zomers koeler) en de uilen een beter uitzicht boden om eventuele predatoren te ontdekken.

ARDEA

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