ANALYSIS OF MOOSE HOME RANGES

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Abstract: We analyze the late winter home ranges of 2 bull moose (Alces alces) in Denali National Park and Preserve, Alaska, with the program HOMERANGE. This program calculates minimum convex polygon, Jennrich-Turner bivariate normal, weighted bivariate normal and harmonic mean estimates of home range size, tests the assumptions of these methods, and tests for the presence of core areas within the harmonic home range. Outliers are readily identified and removed from the analysis if desired. The program plots home range boundaries, core areas and percent use contours within the home range.

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Moose home range sizes have been estimated by a variety of methods, including convex polygons (Van Ballenberghe and Peek 1971; Ritchie 1978; Pierce 1983), concave minimum polygons (Phillips et al 1973; Gasaway et al 1980; Hauge and Keith 1981), bivariate normal (Pierce 1983), weighted bivariate (Pierce 1983) and harmonic mean distance (Pierce 1983). Until recently there has been no firm basis for choosing the most appropriate technique from amongst those available. The development of tests of the assumptions of the various methods (Smith 1983; Samuel and Garton 1985) and their incorporation into a comprehensive computer program for home range analysis (Samuel et al 1983) provide a less subjective basis for evaluating home range data and estimating home range size. In this paper we utilize these techniques to estimate the sizes of late winter home ranges of two adult bull moose in Denali National Park and Preserve. The moose were radiocollared during summer, 1981. J.M. Peek made visual observations of them once or twice per day during the period from March 5 to April 14, 1982.

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The study area inside Denali Park and Preserve, Alaska, lies primarily in the shrubland zone (Viereck and Dyrness 1980). Most locations of moose were in tall shrub stands dominated by willows (Salix alaxensis, S. glauca, S. planifolia, or S. lanata). Scattered stands of spruce (Picea glauca) were used occasionally, as were the more well-drained sites dominated by shrub birch (Betula glandulosa). At the time of these observations in mid-winter, snow depths of about 120 cm did not appear to impede moose movement. Bull 2.8 was a large mature bull with antlers exceeding 30 cm in length, which traveled with one other bull of similar description. Bull 2.6, a smaller, younger individual, traveled with a greater variety of individuals and in groups of 3 to 13.

RESULTS

Bull 2.8 was located 69 times over a large area while 2.6 was located 67 times over a much smaller area (Fig. 1 and 2). The simplest approach available to estimate the size of home ranges of these two animals consists of connecting the outermost points to construct a convex polygon (Fig. 1 and 2). These convex polygons include 850

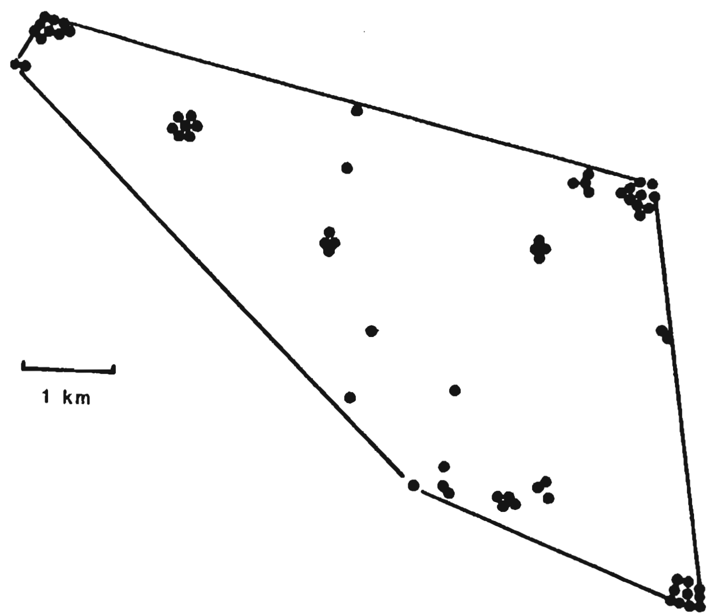

Fig. 1. Convex polygon home range inscribed on locations of bull 2.8 during late winter, 1982. Note that some locations were used repeatedly.

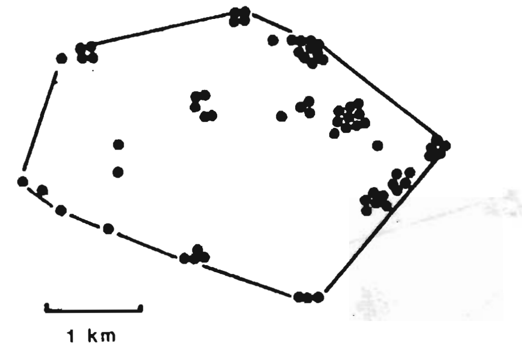

Fig. 2. Convex polygon home range inscribed on locations of bull 2.6 during late winter, 1982. Note that some locations were used repeatedly.

hectares for bull 2.6 and 2020 hectares for bull 2.8 (Table 1). These areas and all other estimates mentioned hereafter are easily calculated with the computer program HOMERANGE (Samuel, et al 1983). The convex polygon is only appropriate if the animals' use follows a uniform distribution. Using a Cramer-von Mises statistic to test the goodness-of-fit of a uniform distribution to the locations of the animals (Samuel and Garton 1985) revealed that use by bull 2.8 was not uniformly distributed (Table 1). Use by bull 2.6 was fairly non-uniform, but not significantly so ($0.10<P<0.15$).

Jennrich and Turner (1969) suggested treating home range locations as a sample from a bivariate normal distribution and

Table 1. Homerange estimates and tests of assumptions for two bull moose observed daily during late winter, 1983 in Denali National Park, Alaska. All estimates were obtained with the program HOMERANGE (Samuel et al 1983).

Method	Statistic	Bull 2.6	Bull 2.8
Convex Polygon	Homerange Area	847h	2018h
	Goodness-of-Fit Test(W2)	0.166	0.805
	Significance	0.1<P<0.15	P<0.01
Bivariate Normal	75% Homerange Area	784h	3284h
	95% Homerange Area	1696h	7102h
	SE of 95% Area	207h	881h
	Goodness-of-Fit Test(W2)	0.388	1.292
	Significance	P<0.01	P<<0.01
Weighted Bivariate	75% Homerange Area	694h	3129h
	95% Homerange Area	1508h	6798h
	SE of 95% Area	186h	852h
	Goodness-of-Fit Test (W2)	0.526	1.412
	Significance	P<0.01	P<<0.01
Harmonic Mean Distance	75% Homerange Area	676h	1391h
	95% Homerange Area	1287h	2194h
	Core Areas: Area	435h	562h
	% of Use	54%	47%
	% of Area	30%	29%

estimating the area which includes 95% of the locations. This area included 1700 (±400) hectares for bull 2.6 and 7100 (±880) hectares for bull 2.8 (Table 1). However, goodness-of-fit tests revealed that this model is even less appropriate than the convex polygon for these two animals (Table 1).

The weighted bivariate estimate is similar to the bivariate normal except that it is less sensitive to outliers or extreme values due to occasional travels out of the home range (Samuel and Garton 1985). The program HOMERANGE identified three locations for bull 2.8 as outliers. No locations for bull 2.6 were outliers. For these two animals the

weighted bivariate estimates are similar to the bivariate normal estimates (Table 1). This model does not provide a good fit to the distribution of locations for these two animals (Table 1), though it does closely describe the extent of locations for bull 2.6 (Fig. 3 and 4).

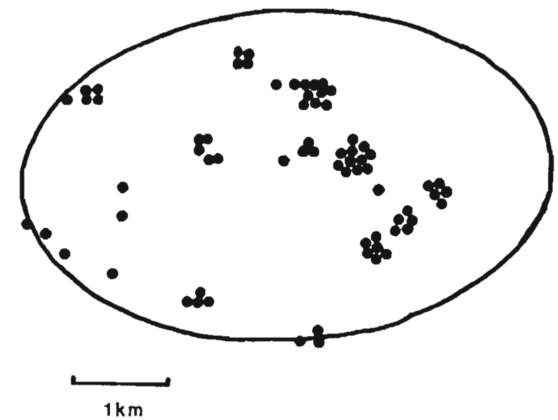

Fig. 3. Weighted bivariate normal home range (95% area) for bull 2.6.

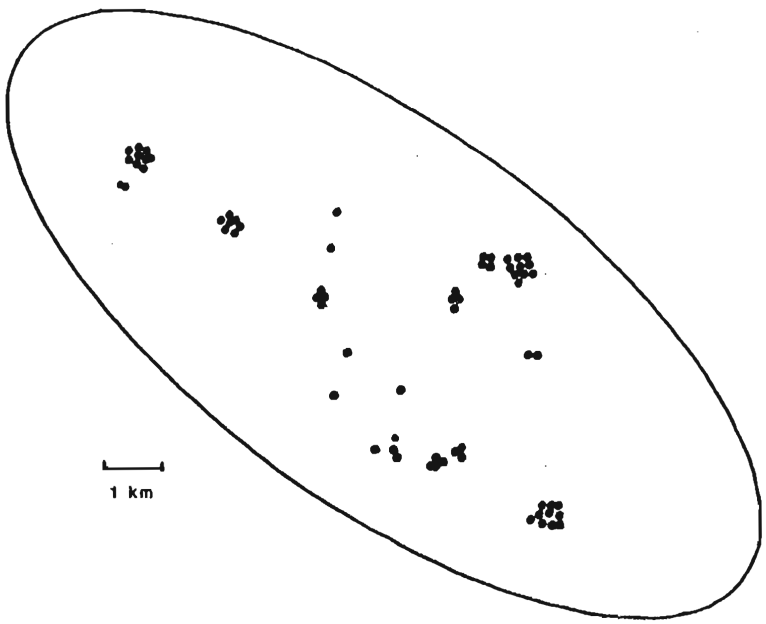

Figure 4. Weighted bivariate normal home range (95% area) for bull 2.8.

The homerange model based on harmonic mean distances (Dixon and Chapman 1980) is the most flexible of the models considered here. It only assumes that the distribution of use is smooth and continuous. This model produces estimates of 95% home range size for bulls 2.6 and 2.8 of 1290 hectares and 2200 hectares, respectively. The program also identified statistically significant ($P<0.05$) core areas (Samuel et al 1984) for each animal. Bull 2.6 had a core area 430 hectares in size

which included 54% of its use (Fig. 5). Bull 2.8 had a 560 hectare core area which included 47% of its use (Fig. 6).

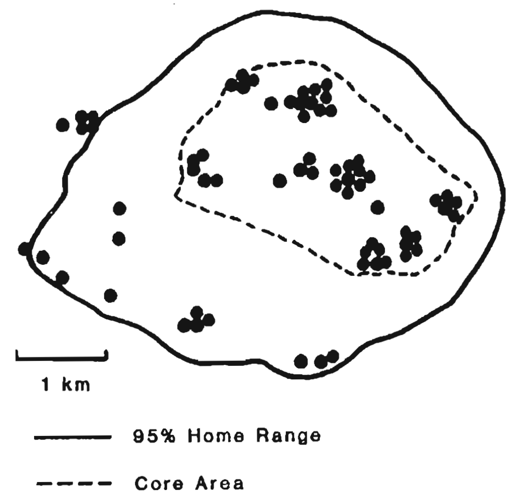

Fig. 5. Harmonic mean distance home range (95% area) and core areas for bull 2.6.

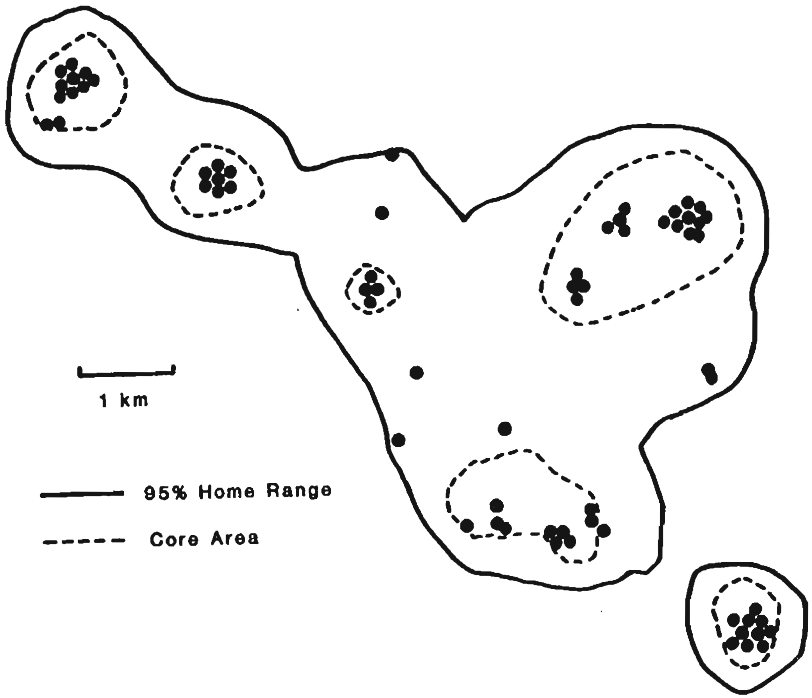

Figure 6. Harmonic mean distance home range (95% area) and core areas for bull 2.8.

DISCUSSION

Home range estimates based upon convex polygons are simple to obtain, yet this desirable characteristic must be weighed against their undesirable sampling characteristics. Convex polygons are very under-

biased at small sample sizes (Anderson 1982) and over-biased by extreme values (Samuel and Garton 1985). Bivariate normal estimates remove the small sample bias and weighted bivariate normal estimates remove both of these problems (Saumel and Garton 1985). However, all three of these simple estimators assume very specific and unlikely distributions of use. It is essential to verify the appropriateness of these underlying distributions if the estimators are to be used. They will be inappropriate for most home ranges as they were for these two moose. The more complex estimators based on harmonic mean distances (Dixon and Chapman 1980) and Fourier series (Anderson 1982) should be used where none of the simpler methods are valid. These estimators are not perfect, however, as they require large sample sizes to accurately depict complex distribution and they do not handle sharp boundaries or discontinuities well. Testing the assumptions of home range models, choosing the most appropriate methods and obtaining the estimates are greatly facilitated by the computer package HOMERANGE (Samuel et al 1983). This program is available from the senior author.

Perhaps the most important assumption required to estimate home range size is the assumption that the animal does have a home range. Many animals make long distance dispersal movements or long wandering travels at certain times in their life history. These are most pronounced for juvenile males in the mammals. At such times, the animals do not confine their movements to a circumscribed area or home range that they know from intimate experience. It is not reasonable to speak of a home range for such situations or to attempt to measure its size. The movements of bull 2.8 during this 50 day period almost appear to be random wanderings (Fig. 7). It is possible that this bull has used this area repeatedly in other seasons or winters and does know it intimately, but this is not obvious from these data. In contrast, bull 2.6 moved about a circumscribed area during this same period (Fig. 8). There is a real need for a statistical test of this most basic assumption of home range estimation methods.

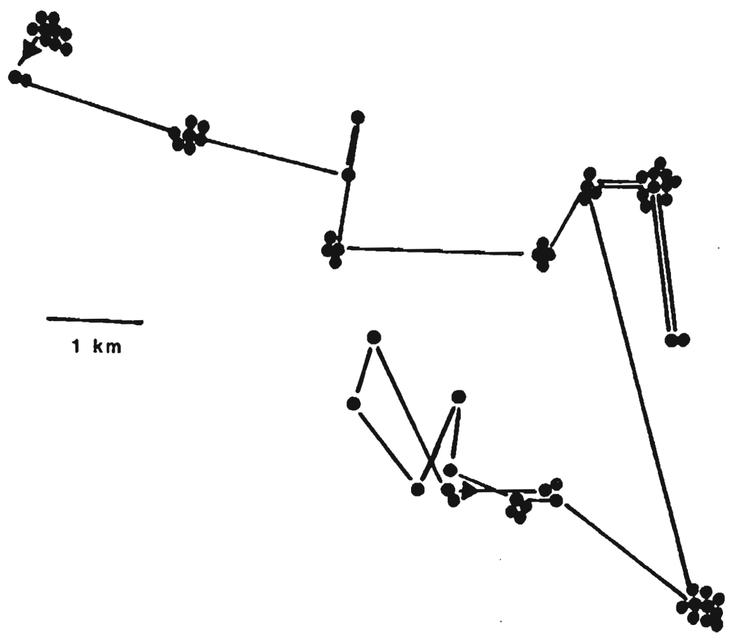

Fig. 7. Pattern of movement of bull 2.8 during the 50 day period in late winter from March 5 to April 24, 1982.

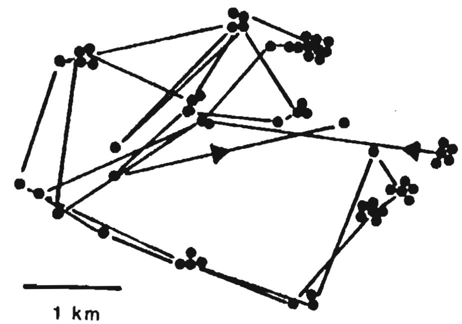

Fig. 8. Pattern of movement of bull 2.6 during the 50 day period in late winter from March 5 to April 24, 1982.

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