THE ROLE OF SAMPLING INTENSITY IN THE SELECTION
OF A HOME RANGE MODEL

by

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ABSTRACT

Numerous home range models have been proposed, ranging from polygons formed by the connection of outermost locations to probabilistic models based on the frequency distribution of locational data. Probabilistic models are gaining attention because intensity of use is considered in the perception of the home range; areas used infrequently are not regarded within the home range. One major assumption inherent in such models is that sampling effort is temporally and spatially unbiased. In my study of home range utilization of radio-transmittered sea otters (Enhydra lutris) in Alaska (1979-1982) I could not sample locations with the same intensity at night as during the day. Because sea otters frequently used different areas at night (feeding areas) than during the day (resting areas), the distribution of locational data differed from the true utilization distribution of the animals. This precluded the use of probabilistic models for examination of sea otter home ranges. Other researchers likely encounter difficulties trying to maintain a sampling intensity that is temporally and spatially homogeneous. Such difficulties may dictate the use of non-probabilistic home range models despite the advantages offered by more sophisticated models.

INTRODUCTION

Despite innumerable studies of animal movements and home ranges, the concept of a home range and the measurement of home range parameters such as size and shape remain elusive. Burt (1943) originally defined home range as the area traversed during normal activities of food gathering, mating, and caring for young. Commonly, the region enclosed by the connection of peripheral locations of an animal is used to represent this area (Mohr 1947). Employing the restriction that all outside angles of the home range boundary be convex yields a minimum-perimeter, maximum-area polygon generally referred to as a minimum convex polygon (Odum and Kuenzler 1955, Schoener 1981). This method alleviates subjectivity in the choice of peripheral points but does not necessarily produce the most realistic representation of home range boundaries, which may,

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in reality, have involutions.

Recently, several authors have criticized the use of the minimum convex polygon mainly because of its inherent constraint on shape and strong positive relationship between sample size and estimated home range size. Some have suggested methods to reduce the shape restrictions (Harvey and Barbour 1965) and minimize effects of sample size (Odum and Kuenzler 1955, Jennrich and Turner 1969, Schoener 1981) while retaining the basic concept of a polygonal area circumscribed by the connection of peripheral locations. Others have introduced probabilistic models to estimate home range size, and in so doing have reinterpreted the concept of home range as the area used by an animal during a certain percentage of its time, or the area in which an observer would have to search to locate an animal on a given percentage of occasions; Madden and Marcus (1978) discussed the distinction between these 2 rather similar probabilistic frameworks.

The probabilistic concept of home range seems to yield a more meaningful interpretation of home range size than the traditional (polygon) concept for animals that do not use all parts of their home range with equal intensity because regions used relatively infrequently are weighted less heavily in the calculation of utilized area. Also, as I have argued elsewhere (Garshelis and Pelton 1981), probabilistic models permit more justifiable comparisons of home range sizes within and among studies because results are at the same level of confidence. However, all probabilistic models currently advanced are based on assumptions, many of which may be difficult to meet (or even to test whether they have been met) in studies of animal movements. Assumptions dealing with home range shape and the distributional pattern of point locations within the ascribed home range (Calhoun and Casby 1958, Jennrich and Turner 1969, Koeppl et al. 1975) have been overcome in recent probabilistic models (Ford and Krumme 1979, Dixon and Chapman 1980, Anderson 1982), but even ·these models are plagued with assumptions concerning temporal and spatial homogeneity in sampling effort and independence of data points.

Dunn and Gipson (1977) proposed a model to deal with data that does not conform to the assumption of locational independence. In this paper I discuss difficulties in meeting the assumption related to sampling intensity, specifically in my attempts to analyze the movements and home ranges of sea otters (Enhydra lutris), and more generally in relation to the choice of home range models in other studies. Others have reviewed and evaluated most of the home range models currently advanced (Sanderson 1966, Van Winkle 1975, MacDonald et al. 1979), but I am unaware of material that addresses the issue of sampling intensity.

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I studied movements of radio-transmittered sea otters in Prince William Sound, Alaska, from 1979-1982 (Garshelis 1983). Home ranges were characterized by heavily used areas within geographically distinct bays connected by less frequently used travel corridors between bays. This configuration seemed to lend itself most ·readily to analysis with probabilistic home range models that could delineate discrete areas of significant utilization (especially Ford and Krumme 1979, Dixon and Chapman 1980, Anderson 1982).

Despite the apparent advantages of probabilistic home range models, I considered such models inappropriate in this study because I was unable to achieve a homogeneous intensity of locational sampling. Some bays were monitored less frequently than others due· to their relative inaccessibility, thereby skewing the observed utilization distribution on which probabilistic models are based. Further biases in the observed utilization distribution resulted from temporal variability in sampling intensity due to transmitter expirations and seasonally poor weather. Also, fewer locations were obtained during darkness (19%) than during daylight due to constraints on the navigation of the small boat I used for radiotracking.

Locational sampling that varied with time of day biased the locational frequency distribution because activity of otters was highly related to time of day and spatial utilization was related to activity (some areas were used preferentially for resting and other areas for feeding). In 1 study area feeding constituted 37%·of the otters' daily time budget (estimated using automatic recording devices that produced an unbiased, continuous record of activity [Garshelis 1983]), but feeding locations comprised only 184 of 2017 total locations (9%) because otters in this area fed mainly at · night. Otters that routinely traveled· to particularly ·distant feeding areas at night rarely were located in such areas but were located readily when they returned to a resting area during the day.

An additional bias against feeding locations resulted from the use of flipper-attached radio-transmitters that were easily located when held above water in the otter's normal resting posture, but could not be received when submerged for long periods during feeding dives. Thus, although otters in a second study area spent ·59% of daylight hours feeding (based on ≥ 5000 otter-hours of automatic recordings [Garshelis 1983]), only 51% (745 of 1450) of the locations obtained during daylight hours in this area were of feeding otters ($\chi^2 = 39$, $P < 0.001$). Otters swimming between feeding and resting areas were similarly difficult to locate due to intermittent submergence of transmitters and their high rate of travel (> 5 km/h [Garshelis 1983]).

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These biases resulted in an underrepresentation of areas used for feeding in the perceived utilization distribution. Probabilistic models thus would underestimate actual home range sizes by excluding feeding areas where few locations were obtained. In recognition of this difficulty, I decided against the use of a probabilistic model.

The minimum convex polygon method of area estimation is less affected by biases in sampling intensity, such as the bias generated by sampling locations of primarily resting otters, so it was the technique of choice in my study. Locations within feeding areas, despite small sample sizes, were always included within the polygons, often being peripheral points. I minimized biases related to sample size by restricting the analysis to data sets of a minimal size (40 locations), above which increased sampling did not appreciably increase the area of the polygon (Garshelis 1983). Constraints on shape were reduced by eliminating land areas falling within the ascribed home range, and by limiting the investigation of home range area to heavily used regions within geographically distinct bays where travel corridors were of minimal importance. Travel routes would have been disregarded by probabilistic models as well because few locations were obtained there. I considered travel corridors in a separate, equally important analysis of home range length (distance between extreme locations).

GENERALIZATIONS

Difficulties in obtaining spatially and temporally homogeneous sampling intensities likely are encountered by many researchers investigating animal movements. Many species are more readily located at nest sites, den sites or other frequently used resting areas than when searching for food over large areas, where the search pattern fluctuates in reponse to resource distribution. Conspicuous examples include many nocturnal predators, roosting birds, and marine mammals that haul-out to rest. Additionally, mountainous terrain or dense vegetation may restrict access by the observer, precluding a random sample of locational information.

Although the probabilistic concept of home range may be appealing in many respects, researchers should be aware of the many inherent assumptions of this approach and possible misleading results obtained when these assumptions are violated. Areas remote from the center of activity may be of extreme importance to an animal but may be excluded by probabilistic home range representations if locations in remote areas are not adequately sampled.

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