Ungulate Habitat Selection Determined by Location Telemetry: An Approach

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INTRODUCTION

As our need to manage wild ungulates intensifies, the importance of developing quantitative measures of habitat preference also increases. Location telemetry is currently a very efficient and popular technique for acquiring movement data. However, the analysis of these data is often rudimentary. This paper outlines the approach taken in a recent investigation of wapiti habitat selection in a managed forest in western Washington (Schoen 1977). The major objectives of that study included testing the hypothesis that wapiti utilize their landscape selectively, and developing a model for seasonal habitat preference.

Radio-telemetry has been used as a technique for determining wildlife movements for about two decades. Aside from simply describing movements, however, it has become increasingly apparent that we must begin relating animal movements to the physical and biological features of the landscape, thus providing a clearer picture of the habitat requirements for individual species.

The behavior of the individual animal, moving about its home range in its constant efforts to obtain the necessities of life, can be thought of in terms of costs and benefits. It is thus presumably the result of selection for responses which contribute to individual fitness.

Since all animals are influenced by this pressure to optimize their use of the environment, we can hypothesize that an individual inhabiting a patchy environment (where food and cover are not distributed evenly) should utilize that environment, or home range, selectively. Further, we would expect that variations in habitat selectivity should occur where individuals inhabit areas which differ in their landscape composition.

Burt (1943) described home range as "that area traversed by the individual in its normal activities of food gathering, mating and caring for young." Although there are many minor deviations from this basic definition, we recognize that within most species individuals generally confine their activities to a small portion of their available range. This is an area with which we assume they become intimately familiar over time.

The relationship between the habitat attributes and the home range is of fundamental importance. Tester and Siniff (1973) emphasized this aspect and urged biologists to pursue a meaningful biological concept of home range which considered factors such as habitat, season and social interaction. As Sanderson (1966) concluded, it is of more value to determine how an animal uses its home range than to simply describe the pattern of animal movement.

Numerous habitat studies utilizing location telemetry have been conducted on a wide range of ungulate species including white-tailed deer (Rongstad and Tester 1969), moose (Berg and Phillips 1974), wapiti (Marcum 1975), and mountain goats (Rideout 1977). Many telemetry studies have described habitat use simply by determining the proportion of locations which occur within specific landscape variables (eg. 25 percent in open, 75 percent in forested habitat). Other studies (Nichols and Warner 1968, Marcum 1975,) have refined this approach by comparing the utilization of particular landscape variables to the availability of those variables within the study area. This approach offers the advantage of indicating preference or avoidance of particular variables. However, when data from individual animals are pooled the specifics of individual selection are lost.

To quote Moen (1973: 189): "The averaging of several individuals in a group, describing the group with a single number or by a mean with a standard deviation, masks the drama within the community as each organism meets the ecological forces in its day to day existence."

The approach we offer for consideration is one of first evaluating habitat selection by determining a seasonal home range area of use from the movements of each individual. Within each home range individuals' selectivity and levels of preference or avoidance are determined by comparing the utilization of particular attributes to their availability.

METHODOLOGY

For the purpose or organization we will first briefly describe data collection, then will develop the approach taken in data analysis.

Data collection

Much of the methodology of data collection will be only briefly described here. For a more detailed account refer to Schoen (1977). Wapiti were captured and instrumented with pulsing, two stage transmitters operating in the 150 MHz range. Average battery life was about one year. Receiving equipment consisted of an LA-12 AVM receiver and a telescoping eight element yagi antenna mounted on a van. The angular error of this system was calculated at $\pm$ five degrees. Because of the extensive road system within the study area, most locations, determined by one station triangulation, were taken at 90 degree intersections and within one half mile (0.8 km) of the transmitter resulting in an error polygon of ten acres (4.04 ha) or less. All locations utilized in the analysis of habitat use were of this level of accuracy.

Altogether, 36 wapiti were instrumented with transmitters. During the first year individual wapiti were located an average of three to four times per week. Through the second year, locations of individual wapiti were recorded from one to four times a day, five days a week. Individual locations were dispersed throughout the 24 hour day by six hour intervals. Since our particular objectives focussed on "seasonal" habitat selection our emphasis was more on daily than hourly locations.

Data recorded at the time of location included animal number, date, time, location, and weather and snow conditions. When individuals were visually observed additional information including behavior, group composition and habitat characteristics were recorded. USGS seven and one-half minute quadrangle maps (scale 1:24,000) were used as base maps. An x,y grid coordinate system was superimposed on this base map with a grid size of ten acres (4.04 ha). All wapiti locations were recorded relative to this coordinate system.

In order to relate wapiti locations to habitat parameters, each 10 acre (4.04 ha) cell of the Cedar River Watershed, our 90,000 acre (36,450 ha) study area southeast of Seattle, Washington, was described from topographic and cover maps with respect to the following landscape attributes: elevation, slope, aspect, distance to water and roads, cover type, canopy closure, and date of timber harvest.

Both wapiti location data and landscape attribute data as well as a program for integrating the two were handled as major computer systems: ELKFILE, CELLFILE and PROCESSOR respectively (Thornburgh 1975). These programs, were processed on the University of Washington CDC 6400 computer and CalComp plotter.

Data Analysis

In comparing the proportion of use of various landscape attributes to the availability of those attributes, we assume that each portion of the individual home range is equally available to the individual wapiti, so that our selection and rejection of landscape attributes are due to choices by that individual.

The computer ELKFILE stored, retrieved, updated and manipulated wapiti telemetry and visual locations. The Statistical Package for the Social Sciences, SPSS, (Nie et al. 1975) provided data retrieval and manipulative functions, and performed many parametric and non-parametric statistical tests. SPSS also produced stored data for use in other programs.

A permanent SPSS file was created for two years of wapiti data. This file handled each marked wapiti as an individual subfile and each attribute as a variable.

Each individual wapiti's location data were analyzed separately with respect to a particular portion of the landscape (its home range), and by discrete time intervals corresponding to biologically meaningful periods or seasons.

The CELLFILE program performed similar retrieval and manipulation tasks on the landscape data. The system utilized here was a version of the Snohomish Valley Environmental Network, SVEN, information system (Bare and Cook 1974).

Basically CELLFILE was capable of retrieving data on a cell-by-cell basis either randomly or sequentially. Any or all of the attributes describing a cell could be retrieved, constrained (i.e. assigned specific values), or updated. This system printed stored data in the form of maps, summaries and listings. These data could also be input into other programs for processing.

As opposed to our cell system, the polygon system was another method for handling landscape data. Although a polygon system would have worked nicely in exactly defining the total area of different attribute types it was not as readily available and was thus uneconomical for our purposes.

Since natural vegetative cover does not occur in discrete geometric patterns it would be impossible using a cell system to accurately describe each cell in terms of one cover type unless a cell were significantly smaller in scale than the cover types represented. In our case cells could only be as small as the accuracy of our telemetry system. With the system we used, then, each cover type present in each cell was recorded. Among other things, this permitted an estimate of the cover heterogeneity of each cell. However, in our initial habitat use analysis we selected the dominant cover type to represent cover types for that cell.

The PROCESSOR program used data generated from the previous two programs and performed various analyses. One capacity of PROCESSER was to plot two and three dimensional movement and distribution plots of wapiti. The most important function of PROCESSER, however, was to generate the habitat preference program which analyzed landscape utilization for any individual or combination of wapiti during any time interval for each landscape attribute.

Using an x,y coordinate system, an activity center (Hayne 1949), which is the geometric center of activity ($X = x/n$, $Y = y/n$), was calculated for each seasonal home range. We could then use one of several mathematical models to describe each seasonal home range area. On the basis of an analysis of wapiti locations processed by the "standard diameter" home range model (Harrison 1958), it was determined qualitatively that a circular model was not the most accurate approximation of home range for Cedar River wapiti. Mohr and Stumph (1966) and Van Winkle at al. (1973) demonstrated that the location data of many species are in fact non-circular. A more realistic model of wapiti home range proved to be an elipse based on a bivariate normal distribution (Jennrich and Turner 1969; Mazurkiewicz 1969, 1971; and Koepple et al. 1975).

We followed Koepple et al. (1975) and used a 95 percent confidence ellipse, corrected for orientation on a two dimensional grid, to define each individual seasonal home range, for use both in graphical plots (see example in Fig. 1) and as a basis for determining habitat preferences. According to Koepple et al. (1975) a reliable estimate of actual home range requires the number of locations used in mathematically calculating the elliptical model to be greater than 20, and to be well distributed throughout the sample period, in order to realistically approximate the actual home range area.

The habitat preference program received location data from ELKFILE for specific wapiti during defined time intervals (our six seasons). A

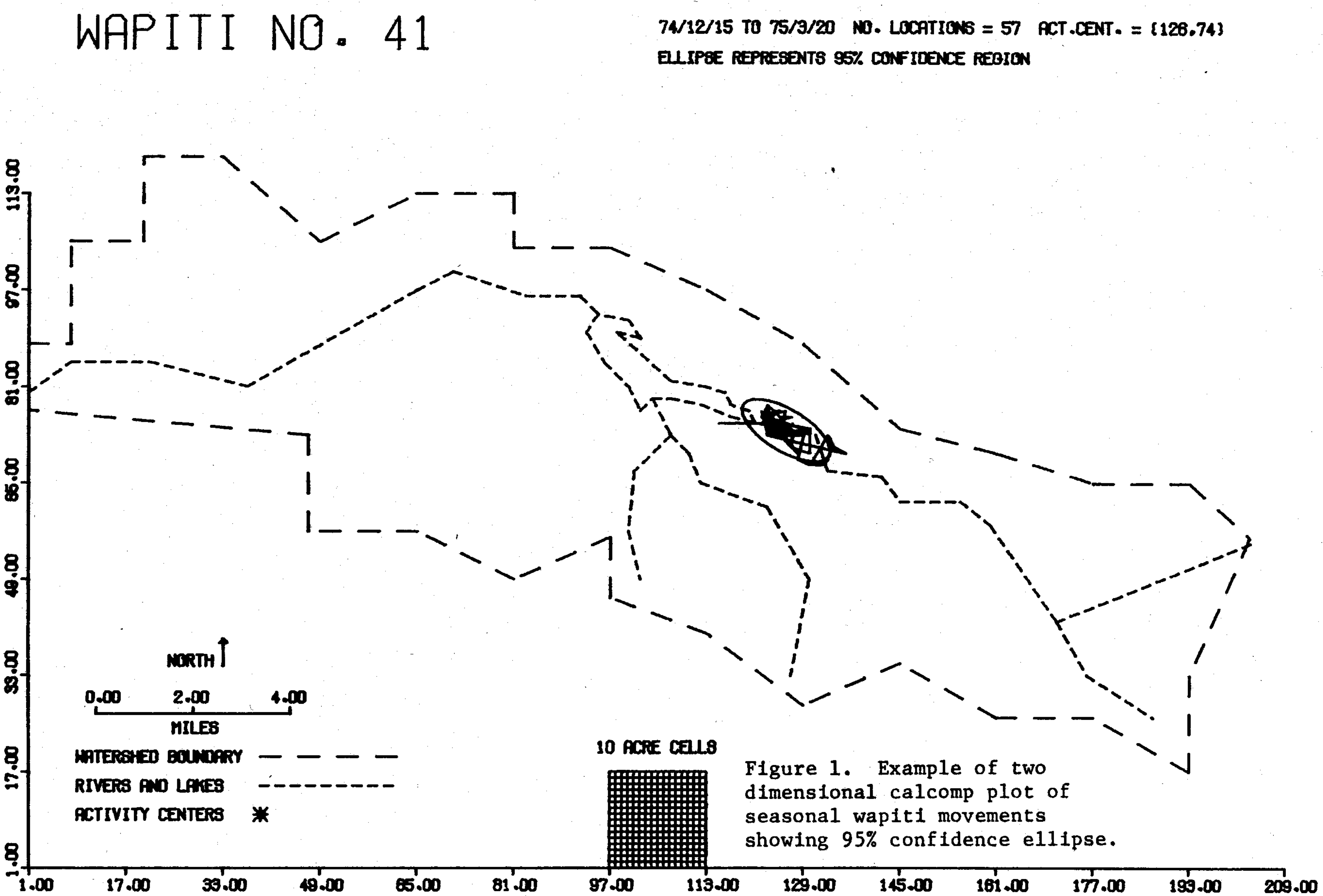

Figure 1. Example of two dimensional calcomp plot of seasonal wapiti movements showing 95% confidence ellipse.

95 percent confidence ellipse was then calculated which defined the region of home range use for that wapiti. The grid coordinates of the landscape cells and wapiti locations within this region were determined and the landscape attributes for both the total home range area and the cells where wapiti had been located were retrieved from CELLFILE. The first hypothesis, that wapiti use the landscape selectively with respect to each landscape attribute (e.g. elevation, slope, aspect and so on) was tested by a chi-square test of the null hypothesis (the frequency of use of each attribute variable is proportional to the frequency of occurrence of that variable within the home range). In generating this hypothesis, it will be recalled, we made the assumption that each wapiti knows every cell within its own home range ellipse. In contrast, to assume that a given wapiti would know all the cells within the total study area would probably be incorrect. Our approach was to look first at the individual and define from that individual's observed movements a home range area of use and assumed knowledge from which to base our habitat preference analysis.

The next step was to determine the type and degree of selectivity for the variables of each attribute. Neu et al. (1974) presented a method of evaluating selectivity based on the Bonferoni Z statistic. This technique, however, was considered reliable only when a small number of variables (less than 5) was considered. We had up to 20 variables. Therefore, we utilized Ivlev's (1961) Electivity Coefficient, $E = (r_i - p_i)/(r_i + pi)$ where E = the coefficient of electivity or index of selection, r_i = the proportion of the variable which was utilized and pi = the proportion of that variable occurring within the environment or home range. The value E ranges from -1, negative selection, through 0, no selection, to +1, positive selection. Finally, confidence intervals of 90, 95 and 99 percent were computed for the Electivity Coefficient. This confidence interval, based on a bivariate probability distribution, was calculated as follows: $r_i \pm (\sqrt{r_i(1 - r_i)/n})\, t$, where r_i = the proportion of the variable utilized, n=the number of locations, and t = a factor, determined from a normal distribution table, representative of the level of confidence (Chapman, pers. comm.). Two new Ivlev values were then calculated based on the two new r_i values. If the confidence interval was on one side or the other of zero then we had that level of confidence such that there was signigicant selectivity for or against the variable measured.

The habitat preference analysis was performed both on single wapiti and selected groups of wapiti lumped together. The analysis compared individual wapiti locations to home range ellipse and the watershed as a whole as well as the home range area to the watershed.

After the landscape utilization of individual wapiti was analyzed the landscape utilization of individuals was compared (by chi-square) within each season, to determine individual differences. Comparisons (also by chi-square) of landscape utilization were also made between different daily periods, seasons and years.

The next step in our analysis was to determine what general pattern of seasonal habitat preference could be developed from our data. Location data from instrumented wapiti were pooled by season and analyzed by the habitat preference program with respect to the available area of the watershed which changed seasonally because of snow conditions. From this analysis a preliminary descriptive model of seasonal landscape utilization was developed from our sample of instrumented wapiti.

DISCUSSION

The results of the investigation described here supported the hypothesis that wapiti utilize their landscape selectively and that seasonal patterns of habitat preference can provide the basis for predicting seasonal distribution. Although numerous generalizations were made in the final synthesis, it was also emphasized that wapiti were observed to be highly individualistic in their home range use. In addition, we found varying levels of selectivity during different seasons.

Although we feel the basic methodology utilized here is a reasonable approach to evaluating habitat preference, there remain many areas where refinement is necessary. For example, sample size and sampling interval might well be increased and adjusted to more accurately determine area of use and levels of preference. Also, the use of a confidence ellipse to determine home range, while perhaps applicable to a species such as wapiti, might not be as appropriate for a species like mountain goat for example which inhabits an extreme three dimensional environment. We believe, however, that the importance is not in the particular model chosen to define home range but in defining a realistic area of use with which to evaluate individual selection. Again we emphasize the value of recognizing the degree to which individual variability exists within a given population.

The approach presented here also employs very simple and basic statistical analysis. The advantage of this is that it is easily understood by a wide audience and simple to apply. We recognize that we have evaluated habitat preference in terms of single and arbitrarily chosen attributes. The individual animal, however, relates to its habitat as a total system, responding to the interacting combinations of these and other attributes. Some of these relationships perhaps can be assessed by more advanced analyses. For example Radler (1978) recently analyzed the same data employing discriminant analysis.

Hett et al. (1978), utilizing the original data for wapiti selectivity combined with data on forest succession, have developed a model simulating the effects of various timber management plans on the carrying capacity of wapiti summer range within the same watershed.

Certainly we have arrived at the point where it is now logistically feasible to collect a large volume of movement data for a wide range of wildlife species by utilizing radio telemetry. Such data, gathered and treated as set forth in this report, can add appreciably to our knowledge of the selection and avoidance of specific habitat parameters, and thus provide a more precise understanding of the ecology of the individual and the species.

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PROCEEDINGS

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