A TECHNIQUE FOR DELINEATING OPTIMUM DEER MANAGEMENT REGIONS

by
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ABSTRACT

A technique is presented for delineating regions for improved deer management and planning. A G-value algorithm which maximizes the ratio between inter-county variability and statewide-variability among deer kill at each stage of grouping, was used to delineate most similar counties. The criterion used for preliminary regionalization in Virginia was deer kill per potential huntable land area per number of hunting days. Six regions resulted with an effectiveness rating of 0.9253. Comparisons made with present deer regions and state planning districts suggest a lower effectiveness in present regionalization. A concept of dynamic regionalization is proposed as an alternative to present methods.

INTRODUCTION

Wildlife management areas, regions, or management units (hereinafter called regions) determine spatial models for rational manipulation of man-population-habitat systems to achieve predetermined objectives. Regionalization provides an aid to look at aspects of such a system interactively, and to improve the amount and quality of inputs into resource-oriented decisions. It can assist in reaching reliable output-forecasting which is needed for planning and management (Graf 1973).

Morton and Cheatum (1946) recognized the regional variability in deer and related problems in New York. Gill (1956), Banasiak (1961) and McLaughlin et al. (1971) also found that knowledge of regional differences in deer would be helpful in deer management programs. Their deer management regions were based on physiological characteristics of deer. Management regions based solely on physiological characteristics do not reflect the temporal and spatial changes in the herd, habitat or land use patterns.

METHODS

Analytical techniques exist for regionalization (King 1969, Isard 1960, Lankford 1968, Ward 1963). Computing "distance statistics" is one technique for estimating similarity between points e.g. the centroids of counties or townships. As the distances increase between observation points in a scatter diagram of n dimensions, the dissimilarity of observations also increases. Distance may be measured by the formula:

$$d^2 1,2 = (x1,1-x1,2)^2 + (x2,1-x2,2)^2.$$

The concept is one of a geometric model of points lying in a multi-dimensional space, the axes corresponding to the characteristics on which the comparisons are to be made.

King (1969:212) stated that optimal regionalization is achieved where "...intraclass variability is minimized and interclass variability maximized." The algorithm employed in this paper is a binary hierarchical grouping formula which increases interclass variability and reduces intraclass variability and is based on Euclidean distance. It is an iterative process that avoids computing all possible combinations.

The algorithm groups most-similar observation points (e.g. counties) having single or multiple characteristics (e.g. deer kill figures, statistics, or other environmental information). An index of grouping, G, is calculated for each step in the grouping process. The highest G-value determines which observation points are grouped

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together. The grouping was similar to the methodology employed by Geissler and Hayne (1972); however, the G-value algorithm maximizes the ratio between interclass variability to total variability among observation points (e.g. counties) at each level of grouping.

Simplistically stated, if two counties were similar in characteristics, G would equal 1.000; and conversely, if two counties were dissimilar in relation to all other counties, G would equal 0.

This algorithm combines into one objective criterion, the G value, aspects of similarity between groups of counties and total variation of groups of counties. That is, it is a ratio of between-county variability to total variability. Simplified:

$$G = \frac{\text{interclass (between) variability}}{\text{total variability}}$$

Maximizing the G ratio assures that interclass (between) variability will be maximized in proportion to total variability.

The single variate case. For single variable situations, the algorithm used was:

$$G = \frac{\sum_{h=1}^{H} nh\,(xh-x)^2}{\sum_{h=1}^{H} \sum_{i=1}^{nh} (xih-x)^2} \qquad (1)$$

where:

H = number of classes
nh = number of cases in class h
xih = value of x for case i in class h
xh = mean of x for class h
x = "grand mean"

The numerator is the average distance from the group centroids to the overall center of gravity. The denominator gives the average distance from the observation points to the overall center of gravity. The denominator remains constant throughout the calculation of a matrix of G values. The index of G, a value between 0 and 1 (i.e. $0 < G < 1$), gives an indication of how well structured the classes are, that is, the variability and spread. Zero would represent the "worst" situation where there is little interclass variability and much within-class variability. A value of 1.0 would represent the "best" situation since there would be no variation within the classes and spread between the classes (each county in a state would be called a region).

The multi-variate case. In a multivariate situation the G algorithm used was:

$$G = \frac{\sum_{h=1}^{H} \sum_{j=1}^{J} nh(xhj-xj)^2}{\sum_{j=1}^{J} \sum_{h=1}^{H} \sum_{i=1}^{nh} (xjki-xj)^2} \qquad (2)$$

where:

nh = number of items in group h
xjki = value of item i on variable j in group h
xj = mean value of variable j
xhj = mean value of variable j in group h

Data in multivariate cases were transformed to standardized scores or values. When using distances as a measure of similarity, the axes must be measured on the same scale. Transforming the variates into standardized scales satisfies this requirement (King 1969:195). Every variable was expressed in a standardized form with zero mean and unit variance. The form was obtained by dividing the difference between the measurement and the mean by the standard deviation. This adjusts the data for variability, i.e., it assigns higher weight to data of lower variability. The formula, is standard score = (raw x-mean)/standard deviation.

The Computer Program

A computer program was written to calculate G-values in single and multiple variable situations employing formulas (1) and (2). A program listing is available from either author.

G-Value Plots

The G-value expresses how well groupings take into account the variables studied; it helps discriminate between land units that otherwise seem similar and may suggest reasons for dissimilarity. Multiple regressions may be interpreted as explanatory. The G-value may be considered in the same way. The computer program causes a graph to be drawn (Fig. 1) of changing G-values at each stage of grouping. A subjective judgment is made about the tradeoff between simplicity (fewer groups) and explanatory ability (higher G-values). The best estimate of this point is the asymptote of the curve (Fig. 1) and it was used (Kruskal 1964) as an aid to determine the optimum number of groups of counties. Other methods exist.

Below the asymptote, added regions result in diminishing G-values or returns, i.e., very little information is gained by subsequent partitioning of the area.

Various methods exist for determining the asymptote. A line 45 degrees to the G-value axis graphically represents equal importance assigned to simplicity and explanatory ability. The stage number closest to this line indicates the starting point for the regionalization.

County Unit Data

The county is often a desirable land unit for grouping and forming regions. In Virginia (99 counties), the county is the smallest political unit for which deer kill data are regularly published. Counties were numerically coded.

Grouping Criteria

A requirement for contiguity of counties was imposed on the grouping algorithm and incorporated into the computer program. The selection of criteria for the delineation of a region depends on the purpose for that region.

Deer seasons vary spatially, temporally and legally. This makes undesirable the use of deer kill data as the single determinant for grouping. The hunting laws regulate the location, time and amount of allowable kill for a state. Other variables associated with deer kill also merely reflect the law. The regionalization could then be based on herd and environmental characteristics. Various environmental or biophysical factors could be used as determinants for grouping.

Integrators of Environmental Information

Organisms that occupy an area can be considered integrators of their environment. The concept of integration can be used in studying the white-tailed deer, *Odocoileus virginianus*. Deer integrate environmental information directly and indirectly from their environment. Natality, deer kill, and deer weight are useful quantitative measures of the integration of information. Quantitative measurement of the deer herd is a better index to the quality of the herd's environment than any set of environmental factors man can select. The concept of integrating environmental information has merits for defining management regions.

Grouping Criterion

Total deer kill is a function of deer population and deer population is a function of habitat. Buck kill and total deer kill are fairly constant and predictable. The environment for deer is fairly constant. Since the population is a function of the habitat, counties may be grouped on the basis of buck kill or total kill. However, buck kill and total kill must be adjusted to the hunting season. Kill figures were adjusted to the seasons by dividing deer kill by the number of hunting days. This adjusted deer kill was put on a crude energy base by dividing the adjusted deer kill by the potential huntable land area in each county.

The huntable land area in each county was approximated as the number of acres of forest and open land that could potentially be hunted by someone. The data were obtained from the Virginia Conservation Needs Inventory Committee (1970). Potential huntable land area in each county was calculated by subtracting from the total land acreage of the county the urban and built-up acreage and the small water acreage in the county.

The following county index (CI) was developed for each of the 99 county units and used as the criterion for grouping counties in Virginia.

$$CI = \text{Deer kill} \;/\; \begin{matrix}\text{Number of}\\ \text{hunting}\\ \text{days}\end{matrix} \;/\; \begin{matrix}\text{Potential}\\ \text{huntable}\\ \text{land area}\end{matrix}$$

To incorporate time as a variable and the influence of annual change upon regional boundaries, a concept of average region over time was developed. This was accomplished by using data for several years. For example, CI was calculated for each county unit for 5 years (1965-1970) and grouped as a multivariate problem. By considering the time element, time-average regions were developed.

In Virginia, the deer hunting season is manipulated to regulate the deer herd. The presence and duration of a doe season is a crucial factor in this regulatory mechanism. Typically, by allowing a county doe season and increasing the number of days of the doe season the total deer harvest is increased. Since the buck kill for a particular year would be less variable than the total deer kill for that same year, it would seem that buck kill would be a preferable variable for use in the grouping criterion. This is not the case.

By grouping counties using natural log of the buck kill, natural log of the total kill, buck kill and total kill in a single variable situation and comparing the plotted G-values, the area under the total kill curve was greatest. There is more explanatory ability at a given level of groups by using total kill.

There were a few counties that had a "bucks only" season in 1970, and most counties had an "either sex" season. This resulted in the state being more uniform with respect to total harvest and resulted in a G-value plot of greater area for total kill. The greater the area under the G-value curve, the more similar are the characteristics among counties. Total kill was selected as the variable to use in the final grouping criterion.

Existing deer management regions appear to be based on physiographic boundaries, and designed to aid in providing "...*optimum* and *sustained* numbers of deer for maximum public enjoyment" (Guynn 1965:4). Guynn (1965:6) reported deer management regions were developed so that separate regulations could be established in each region. He said, "This would permit uniform hunting regulations within three to six large regions and take into consideration the variabilities in hunting pressures, hunting conditions and deer populations." A G-value was calculated for the existing regions.

Similarly, comparisons were made with the 22 uniform regional planning districts operative in all state agencies.

RESULTS

The asymptote of the plotted G-value was determined and a stage number of 88 and a G-value of 0.92 was obtained (see Fig. 1). A work map was developed showing the regions (Fig. 2). The asymptote gives the investigator the "optimal" regionalization scheme. The computer program can be modified to reflect constraints on region size or the number of regions in a state.

A G-value of 0.38 was obtained for the existing deer management regions of Virginia. This value indicates low effectiveness in the present regionalization and little correlation between stated management objectives and present regions.

The G-value for planning districts was 0.64. This value was higher than the above value for existing deer regions because it was obtained for 22 rather than 6 regions.

DISCUSSION

An unstated goal of all managers and administrators is to resist suboptimization. Suboptimization in resource management may occur when resources traverse human-imposed boundaries. Describing regions that are "optimum", or homogeneously responsive to decisions made to achieve specific human objectives, can produce the base criteria for later comparisons. These regions may not be suitable due to certain political, administrative or personnel considerations. Adjustments in regions can then be made, but the comparison to the base provides a measure of suboptimization. Of course, other suboptimization may occur when poor criteria are selected, when results are read erroneously, or when there is a limited, biased, or erroneaous data base. Gould (1962:48) implied that data or certain environmental factors can create conditions of real uncertainty. When regions are based on such criteria, they have only limited value as a framework for rationalizing management. None of these latter causes of the inadequacies and ineffectiveness of regionalization seem serious if operative within the context of a policy of advancing from the present, using the best information available, and employing feedback and feedforward at all levels of administration and planning.

There seems to be a major, viable *dynamic appraoch* to regionalization for deer management. Dynamic regions present a major alternative to regionalization. Natural resources - both their supply and public demands for them - are dynamic. Changing agricultural practices influence wildlife populations. Static regions, those right for the data-of-the-day, are no longer right. Suboptimization of regions is likely to occur at an increasing rate (Toffler 1970). The structure of regions must be checked periodically and regions changed (e.g., every few years) when information shows significant change has occurred in the criteria defining the regions (McDonald 1966). This is especially true with the dynamic characteristics that identify deer populations and their habitat.

With the computer technology displayed herein, it is now possible to form regions based on annual, biennial, or even 5-year sliding mean data. Again, although less simple, the method is sure to produce more optimum allocation of limited public resources and achieve great cost effectiveness in securing natural resource and other benefits.

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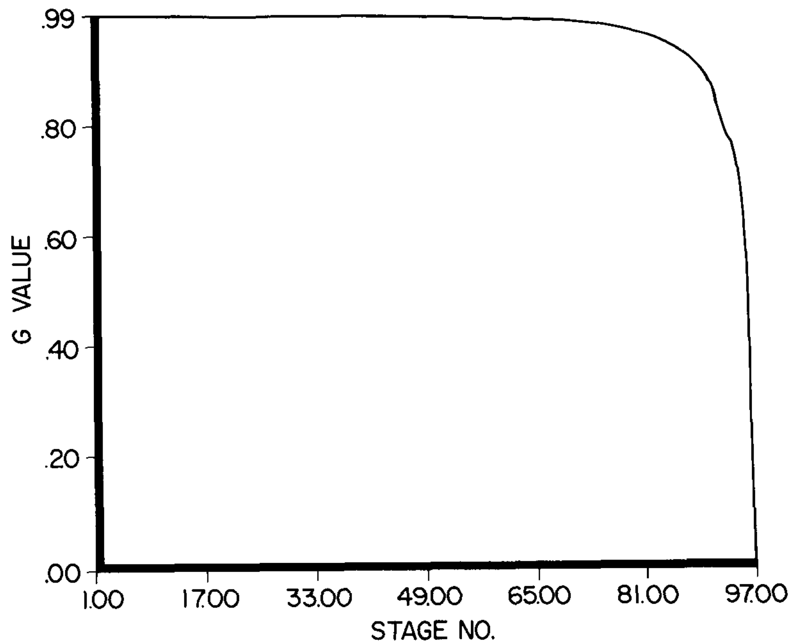

Figure 1. G-value plot of county index (CI).

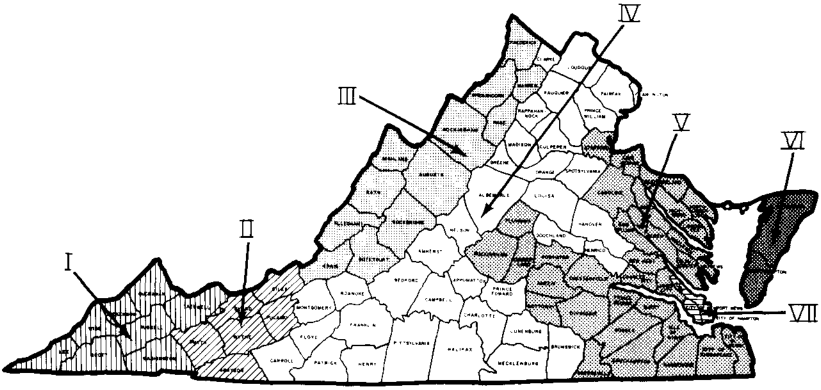

Figure 2. Preliminary deer management regions of Virginia based on calculated G-value.

OVARIAN FOLLICULAR AND RELATED CHARACTERISTICS OF WHITE-TAILED DEER AS INFLUENCED BY SEASON AND AGE IN THE SOUTHEAST[1]

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ABSTRACT

Ovaries, anterior pituitary glands and pineal glands of 206 white-tailed deer collected from 6 areas of the Southeast over a 3 year period during the four seasons of the year were examined. Ovaries were sliced and all follicular and luteal structures $\geq$ 1 mm were measured and counted. Significant seasonal effects were found on ovarian weight, average diameter of the 2 largest follicles, and anterior pituitary weights. Follicular development was greatest in the summer and fall seasons although large follicles were present on ovaries during all seasons. Ovarian weights were greatest during the winter and anterior pituitary weights were greatest in summer. Ovarian and anterior pituitary weights increased significantly with age but the size and number of follicles did not. Little relationship was found between follicular measurements and ovulation or fetal rates when data were examined for each of the areas.

Several workers have reported on the use of ovarian luteal structures (corpora lutea, corpora albicantia, corpora rubra) to evaluate reproductive performance of female deer. Among these are Cheatum (1949), Golley (1957), Trauger and Haugen (1965) and Mansell (1971). Mansell (1971), citing work by Gibson (1957), discussed the validity of and the sources of error in the use of luteal structures in assessing reproductive performance. While undoubtedly one of the best methods currently available for determining past and potential productivity of deer herds, the use of luteal structures has several shortcomings and is not always feasible or desirable. Many states have doe seasons which coincide with or precede the period of breeding and ovulation. In does killed prior to ovulation, data can be obtained only on the prior reproductive

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