ESTIMATING WILDLIFE PRODUCTION WITH HABITAT MODELS

James M. Sweeney
North Central Forest Experiment Station
1-26 Agriculture Building
Columbia, MO 65211

ABSTRACT.

A variety of wildlife habitat capability models are available to assist resource managers in estimating wildlife production. The estimates provided range from simple habitat indexes reflecting population potential to actual population densities. PATREC is used as an example of individual, species-specific models that provide a static, one-point estimate of wildlife production. DYNAST is presented as an example of simulation systems that provide continuous estimate of timber and related benefits (including wildlife), and that account for the cummulative influences of a given silvicultural strategy. The advantages and disadvantages of these models are discussed. The resource manager can use both types of models in estimating wildlife production to facilitate land management decisions. Considerable time and effort must be placed into developing and testing the algorithms used in these habitat models if they are to be successfully used as estimators of wildlife production.

INTRODUCTION

Wildlife habitat models are as diverse as are wildlife modelers. The original objectives embodied in the designs of these models are probably equally diverse. The result is a plethora of habitat models, ranging from discrete to continuous, deterministic to stochastic, static to dynamic, and simple to complex. In this manuscript I will address two fundamentally different wildlife habitat capability models, PATREC and DYNAST, as examples of tools that can be employed by resource managers to estimate wildlife production.

OVERVIEW OF PATREC AND DYNAST

PATREC

PATREC models are species specific habitat evaluation models that incorporate the concepts of pattern recognition (Uhr 1964) and Bayesian statistical inference to generate a measure of habitat quality (Williams et al. 1977). That is, PATREC utilizes the habitat features associated with high population densities of wildlife species on a given area and the habitat features associated with low population densities within the same area as standards of habitat quality. Tied to these high and low habitat standards are the probabilities of a high or low density wildlife population being sustained on the area. These density probabilities are based on prior knowledge of the species and its frequency of occurrence in such habitats.

The basic structure of PATREC models is a series of multiple-choice questions concerning the status of key habitat features. Any characteristic of the habitat considered directly related to population density in the area can be incorporated into the model. This not only includes questions about vegetative parameters, but also such things as amount and kind of roads, distance to water, or level of grazing by domestic stock.

Each question provides 2 or more (usually 3 or 4) choices of answers that form a set of discrete classes for the habitat feature being measured. The probabilities of a high or low population present in the area are associated with each choice. Each question (habitat parameter) is evaluated and the resultant probability "scores" are combined with the prior probabilities to determine the probability of the area having the potential to support a high population density and conversely a low population density. These probabilities are applied to the highest known density and the lowest known density of the species in the area to calculate a density estimate for the study area.

PATREC models serve as an example of individual, species-specific models that provide a static, one-point estimate of wildlife production on an area. If current habitat characteristics are input, the density estimate is for the current habitat conditions. If future habitat characteristics (values obtained external to the model) are input, the density estimate is for that point in the future.

DYNAST

DYNAST is a multiple resource, systems dynamic model that simulates the biological processes of a forest to provide a continuous inventory of timber and related benefits (Boyce 1977, 1978, 1980). The model incorporates the theory of feedback systems to form a cybernetic structure that guides the simulated forest toward a steady state (constant annual output of all related forest products).

The main subprogram of DYNAST is an ecological model that carries each cover type within a forest from regeneration through old growth. The normal successional flow can be interrupted (managed) by specifying silvicultural controls of harvest rates, cutting unit sizes, and type and rate of conversions for each cover type. Output from the basic system is a simple simulation of the proportion of the forest in various age classes, stand areas, and types.

Associated with the basic subprogram are a series of modules each containing algorithms for a specific related benefit--wildlife, recreation, economics, and so on. Any forest related product that can be keyed to forest structure can be incorporated as a benefit module. In DYNAST, each species module is in essence an abbreviated pattern recognition model expressed in dynamic form and driven over time by changes of the forest structure from one successional state to the next.

DYNAST does not prefer one benefit over another nor will it treat one benefit as arbitrarily constraining another. Benefits are each directly related to forest structure, and results are output on a common scale of 0 (minimum) to 1 (maximum).

DYNAST as a system, therefore, provides a continuous estimate of forest products from the present to some designated time in the future which may include 1 or more forest rotations. Estimated forest products may include age-class distributions, harvest acres and volume removals, regeneration and conversion acres, species-specific indices of wildlife production, recreational values, and economics. Output is specified by the user and is available as tables or graphs.

FUNCTIONAL DIFFERENCE BETWEEN DYNAST AND PATREC

There is a fundamental functional difference between PATREC and DYNAST models when used as tools to estimate wildlife production. PATREC models provide single time frame estimates of wildlife production for a specific area; DYNAST provides a continuous forest-wide estimate of wildlife production that includes the cumulative influences of a given silvicultural strategy. PATREC models are capable of including all key habitat features that influence population density; DYNAST relies on transformations in forest structure. As a result, PATREC models, because of their sensitivity to in-place variables, can best be utilized to evaluate differences in wildlife production potential between specific habitats for a given time (present or future). DYNAST, however, can best be employed to evaluate relative differences in wildlife production between management alternatives because of its continuous simulation of the entire forest ecosystem (an entire graph, not just a few points).

One model is not "better" than the other; nor is it "wrong" to use one or the other for estimating wildlife production. The key is to realize that these are fundamentally different models which provide complementary information. Therefore, the wildlife manager should use both types of models in land management decisions. For example, in evaluating alternative habitat management strategies, one could first use a continuous simulation system such as DYNAST to estimate the cumulative effects on habitat and wildlife. Examining the graphical output would reveal key points in time where sensitive density estimates could be calculated using a habitat evaluation model such as PATREC.

The following advantages and disadvantages of using PATREC instead of other similar habitat evaluation models, and of using DYNAST, instead of other similar simulation models, are not listed in any order of priority or perceived importance. But, as a package they represent the utility of PATREC and DYNAST as tools to support human decision making.

PATREC

Advantages---A distinct advantage of PATREC models, from the user's viewpoint, is they contain the necessary calculations for producing an actual estimate of animal density. Although this additional step from population index (probabilities) to animal number requires additional assumptions and is therefore a more tenuous (variable) result, it is a step often required of the land manager.

A second advantage of PATREC is the use of Bayesian statistics which permits the incorporation of prior knowledge of wildlife production into the habitat model. This allows the user to place realistic bounds on the model's probabilities and density estimates.

Another desired feature is that PATREC models are based on pattern recognition theory and therefore are designed to evaluate whole management areas, not single stands. This attribute reduces field time necessary in applying the technique.

Disadvantages---Perhaps the most significant disadvantage of PATREC models is the use of discrete variables. Values for the various habitat characteristics must be placed into one of several distinct classes. Population probabilites show no change to changing values of a habitat characteristic until that characteristic passes the artificial border between classes. Then, the associated population probability shows an immediate and significant change.

A second disadvantage of PATREC models is the use of probabilities. Unfortunately, the manipulation of probabilities is often difficult for users to comprehend. Although most habitat evaluation models at some point involve the use of complicated mathematical formula, the use of probabilities, and the resultant extremely low numbers obtained when multiplying percentages, is more difficult to understand than other algebraic manipulations. Thus, the mathematics tend to mask the ability of the user to track the contribution to population density of any one habitat feature.

DYNAST

Advantages---Because of its simplicity, DYNAST is easily and quickly adapted to local use. The resource manager must decide what major forest types he wishes to manage as distinct entities and define the age classes for each type. The only required input data are acreages in each age class and growth curves for each type. With specification of types, age classes, growth curves, and acreages, the basic core model is ready to run.

The fact that the related benefits models are set up as individual modular units also contributes to the simplicity of adapting DYNAST to local management needs. Benefit modules can be added or deleted based on their availability or needs to meet immediate management concerns. Model implementation need not be delayed while developing extraneous coefficients. Modular design also facilitates up-dating and improving relational algorithms for a given benefit.

Although operating cost may not be as important as biological or statistical considerations when developing a model, it is a primary concern influencing day-to-day utility. Compared to other simulation systems, DYNAST is a small, simple model requiring limited computer resources (usually less than 500 K and 0.5 minutes CPU time) and ordinarily costing less than $5.00 per run depending on local charges.

DYNAST output is user-friendly. The user specifies what data or results are to be recovered from DYNAST simulations and whether they are to be presented in clearly labeled graphs or tables. Timber production and benefits values can be displayed in any combination needed to answer the question of decision makers. All of the above advantages combine to make an easily accessed model in which silvicultural controls can quickly be modified and results clearly displayed.

Disadvantates---DYNAST is not an optimizing simulation model. It does not automatically examine all possible combinations and permutations of silvicultural strategies to search out an optimum plan to meet some specified goal. However, a resource manager can approach that optimum goal through a series of trial runs while exploring realistic options. Optimizing models do not always stay within the realm of reality.

DYNAST does not maintain specific stand records, nor does it provide specific stand manage-prescriptions. In some cases this level of accuracy may be necessary; but many times the increased complexity in use and interpretation and the increased cost are not justified in day-to-day decision making.

Inherent to this simplicity, DYNAST uses average site conditions. For example, one average growth is assigned for all stands within a specified forest type. As a result, simulated outputs are averages and do not reflect site specific extremes. This must be noted and kept in mind when interpreting results. However, this is not a debilitating problem when using DYNAST as a tool in evaluating alternative silvicultural strategies. All results are based on the same set of averages, are therefore relative, and thus assist decision making. Simulated outputs are not intended as predictions of absolute values.

An additional disadvantage of DYNAST is that it is written in the DYNAMO language. The DYNAMO compiler (Pugh 1976) is not commonly available at computer installations, particularly within the natural resources field. Therefore, adapting DYNAST as a tool may necessitate the purchase of additional computer software. Also, syntax for the DYNAMO compiler is distinctly different from many more commonly used computer languages. Although it is designed to provide greater flexibility in statement formulation and arrangement, most resource users already familiar with other computer languages will have no ready frame of reference.

A NOTE OF CAUTION

In the foregoing discussion I assumed that the habitat models used to estimate wildlife production are biologically sound. However, important questions recently have been posed about the basic underlying assumptions that allow us to use habitat models as tools to estimate wildlife production. For example, ecological theory indicates that communities exist as continua and not as discrete entities. Therefore, is a "habitat" an entity that can be consistently represented by a set of quantitative characteristics? Also, Van Horne (1983) provides evidence that density can be a misleading indicator of habitat quality. Therefore, can we always assume a positive correlation between density and habitat quality?

Such concerns do not represent insurmountable problems. However, as these questions are explored, it is becoming increasingly evident that the critical selection of key habitat variables and the subsequent development of biologically sound quantitative relationships that relate these habitat characteristics to the population demography of a species are extremely important. Considerable time and effort must be placed into developing and testing algorithms used in habitat models if they are to be used successfully as estimators of wildlife production.

LITERATURE CITED

Boyce, S. G. 1977. Management of eastern hardwood forests for multiple benefits (DYNAST-MB). USDA For. Serv. Res. Paper SE-168. 116 pp.

Boyce, S. G. 1978. Management of forests for timber and related benefits (DYNAST-TM). USDA For. Serv. Res. Paper SE-184. 140 pp.

Boyce, S. G. 1980. Management of forests for optimal benefits (DYNAST-OB). USDA For. Serv. Res. Paper SE-204. 92 pp.

Pugh, A. L. 1976. DYNAMO user's manual. 5th ed. The MIT Press, Cambridge, Mass. 131 pp.

Uhr, L. 1964. Pattern recognition. IBM Medical Symp. 6: 305-323.

Van Horne, B. 1983. Density as a misleading indicator of habitat quality. J. Wildl. Manage. 47: 893-901

Williams, G. L., K. R. Russell, and W. K. Seitz. 1977. Pattern recognition as a tool in the ecological analysis of habitat. pp. 521-531, in Classification, inventory, and analysis of fish and wildlife habitat--the preceedings of a national symposium. FWS/OBS-78/76, 604 pp.