WORKSHOP

The Role and Management Implications of Modeling Owl Populations and the Habitats They Occupy

Amy E. Kearns[1]

Abstract.—Modeling ecosystems is an evolving science that is both practical and theoretical. The integration of modeling, landscape ecology, management, and rapidly changing technology offers an array of possible solutions to modern environmental quandaries. In order to address these concerns, a workshop was developed to discuss the role and management implications of modeling owl populations and their habitats. The purpose of the workshop was to reflect on the previous symposium's biological, environmental, and management research; as well as how modeling has affected our understanding of owl management. The workshop focused on the roles that Geographical Information Systems, Habitat Suitability Index models, Meta-population models and Population Matrix models have played in owl management. The group developed a set of strategies for using these modeling techniques to promote ecosystem management.

Modeling ecosystems is an evolving science that is both practical and theoretical. The integration of modeling, landscape ecology, management and rapidly changing technology offers an array of possible solutions to modern environmental quandaries. According to Naveh and Lieberman (1994), the quantitative analysis of landscape heterogeneity, recent advances in computer hardware, remote sensing, geographical system information theory, hierarchy theory, percolation theory, fractal geometry, and model development are borne from an iterative process of model and field experiments. From the simplest linear model to the most complex stage-structured population matrix model, scientists and managers use models to understand ecosystems at many levels. Modeling can be viewed as a holistic approach to scientific research and used to conceptualize complex phenomenon, make comparisons and predictions, assess environmental impacts and optimize environmental decision making (Hall and Day 1977).

Thus, ecosystems can be monitored to detect global change at varying scales. Models represent a set of choices among myriad techniques for understanding natural systems (Dunning et al. 1995, Turner et al. 1995).

Many owl biologists and managers believe the implementation of ecosystem management is at least a decade away. This workshop was designed to foster the development of a landscape and ecosystem approach to owl management by unifying prevalent ecological theories, applications and field research.

An earlier workshop (Haws 1987) focused on developing management plans for indicator species. The primary purpose of the present workshop was to reflect on the previous symposium's biological, environmental, and management research; as well as, how modeling has affected understanding of owl management. The specific objectives were:

1. to assess the role and management implications of modeling owl populations and their habitats ;

2. to investigate past, present, and future modeling techniques for managing owl populations;

[1] Natural Resources Institute, University of Manitoba, Winnipeg, MB R3T 2N2.

3. *to discuss the future of owl management and the importance modeling will have in owl management and;*

4. *to set goals that will foster the implementation of ecosystem management and landscape ecology principles into owl management.*

WORKSHOP DESIGN

The workshop consisted of opening remarks from the chair (Amy E. Kearns) followed by four presentations concerning the use of Geographical Information Systems (GIS) in conjunction with models, Habitat Suitability Index models (HSI), Meta-population models, and Population Matrix models by: William Trowell, Manitoba Department of Natural Resources; James Beck, University of Alberta; Richard Gerhardt, Oregon; and Gregory Hayward, USDA Forest Service, Laramie, Wyoming. Each panelist presented information about a prevalent modeling technique available to owl biologists and managers at this time. The 2-1/2-hour workshop integrated presentations and discussion.

RESULTS

GIS and Modeling

GIS technology is having a profound impact on the way landscapes are being viewed in relation to resource use, particularly with respect to endangered and threatened species. The integration of GIS technology and modeling has the potential to promote a more holistic view of ecosystems. GIS not only serves as a reservoir for information, it can be used as a simulation tool and as an adaptive management resource. Many scientists and land managers are beginning to integrate GIS into modeling exercises to develop management strategies (Akcakaya et al. 1995; Akcakaya 1996; Lahaye et al. 1994). Lahaye et al. (1994) developed a simulation model for the California Spotted Owl (Strix occidentalis occidentalis) using GIS. The model integrates meta-population theory, population matrix models, GIS and has had a profound effect on California Spotted Owl management.

William Trowell demonstrated a GIS ArcInfo based program developed by Linnett Geomatics for the Manitoba Department of Natural Resources. The program is entitled Wildlife Habitat Assessment Modeling (WHAM) and is designed to integrate habitat suitability index models (HSI) and forest resource inventory data bases. Trowell used a Barred Owl (Strix varia) model to demonstrate the modeling program's capabilities. He began the demonstration by showing the participants a blank map of a township. Afterwards, he began to add thematic map layers and intersected these map layers with the HSI model. The resulting map and associated table conveyed the suitable habitat available to the Barred Owl within the township.

During Trowell's presentation, many people asked questions about the program's ability to incorporate spatio-temporal parameters into the model. In particular, the participants were interested in the program's ability to recognize the interaction between different habitat types. Currently, WHAM is unable to perform these sorts of analyses; however, these capabilities can be built into the GIS ArcInfo program.

Habitat Models

Dr. James Beck presented information about habitat modeling, in particular HSI models. He conveyed the importance of validating models and presented some information about field testing models. HSI models have evolved from the Habitat Evaluation Program which was designed to address the need for modeling the interaction between animals and the habitats they occupy. In the past, these models were developed by consulting literature and by using baseline field data. Many of these HSI models have received limited validation resulting in the model's limited applicability. The main purpose of these models has been to set interim forest management recommendations. Beck emphasized the need to develop models using information collected in the field.

The most critical decision that must be made when developing HSI models is deciding which variables to include and exclude from the model. The discussion group agreed that more emphasis should be placed on incorporating less resource-based variables and more universal habitat component variables. These models attempt to retain the essential elements of quality wildlife habitat for a particular animal; however, they can be oversimplified and coarse grain. Beck emphasized this point by showing an image of an owl fashioned from letters, dashes and numbers commonly found on a keyboard. This image was used as an analogy between HSI models and reality. Even though

the image retained all of the essential elements of an owl, the finer details of the owl were not included.

Many suggestions were made for improving habitat suitability models, e.g., incorporation of spatial and temporal dynamics into the models. Turner et al. (1995) stated that habitat suitability models have attempted to prescribe the range of habitat conditions that will provide the requirements for a particular species; however, these models do not incorporate spatial dynamics. The group also suggested including more detailed information about the interaction between populations and measurements of reproductive fitness.

Meta-population Models

Dr. Richard Gerhardt presented information about the progress that has occurred over the last 10 years with respect to meta-population research and theory. An enormous amount of interest in the dynamics of meta-populations has emerged over this time period (Mangel and Tier 1993). He began the presentation by defining the terminology associated with meta-population analysis and demonstrated the need to integrate the theories associated with meta-population analysis into field research. Gerhardt emphasized the connection between meta-populations and habitat. One of the central factors influencing movement between populations is the surrounding habitat. The amount of suitable habitat present within a given area greatly influences the cycle between local population extinctions and colonizations and persistence of a species over a broad landscape. Dytham (1995) described one model that incorporated a two-way interspecific competition between two organisms and their presence in the landscape.

Genetics is an important tool for monitoring movement of individuals among populations. By investigating the meta-population concepts in the field, information concerning the movement of individuals between populations and how habitat characteristics influence these movements can be examined.

Modeling these interactions can improve understanding of the ecosystems occupied by owls.

Population Matrix Models

Dr. Gregory Hayward introduced the topic of population matrix models. The Leslie matrix and some measure of fitness (λ) form the basis of these models. Once demographic data have been collected, they are organized into a population matrix. These matrices can be organized into an age-structured model or a stage-structured model. Accurate information about the age structure of a given population is necessary for developing an age-structured model; whereas, stage-structured models are more flexible and can utilize a wider variety of information. Stage-structured models are concerned with such parameters as density dependence, senescence and reproductive change over time. A more in-depth discussion can be found in Hayward and McDonald (1997) in this proceedings.

Dr. Hayward described how these models could be used to design efficient field protocols. Dunning et al. (1995) suggested using population simulation models to study population dynamics in heterogeneous landscapes. For a more in-depth discussion of Hayward's presentation see Hayward and McDonald (1997) in this proceedings.

CONCLUSIONS AND RECOMMENDATIONS

The primary recommendation developed from the workshop was support for the integration of population models and habitat suitability models. Participants suggested HSI models should incorporate some measure of fitness. By incorporating reproductive fitness into the equation, a more realistic depiction of the relationship is possible. Another suggestion made was to incorporate spatial and temporal variation and interactions into habitat models. These models should be designed to answer questions about how different habitat attributes interact and work synergistically to affect animal populations. According to Holt et al. (1995) this will involve the judicious meshing of different spatial and temporal scales. Kareiva and Wennergren (1995) agree that one of the critical tests of ecological sciences will be to see if scientists can profitably use insights from these spatially explicit models to solve practical problems facing biologists today. Future discussion should emphasize investigating the possibility of using fractals to remedy problems associated with scaling problems.

The discussion group recognized the need to communicate the results of modeling to the public. The group recommended that model developers should work on making their models understandable and useful to mathematicians, theoretical ecologist, wildlife managers, biologists, and the general public alike.

LITERATURE CITED

Akcakaya, H.R. 1996. Linking metapopula-tion models with GIS for population viability analysis: conserving species dependent on older forests: a population viability assessment workshop. In: Flemming, S., ed. Ecosystem Science Review Reports. Parks Canada: 1-12.

Akcakaya, H.R.; McCarthy, M.A.; Pearce, J.L. 1995. Linking landscape data with population viability analysis: management options for the Helmeted Honeyeater Lichenostomus melanops cassidix. Biological Conservation. 73: 169-176.

Dunning, J.B.; Stewart, D.J.; Danielson, B.J.; Noon, B.R.; Root, T.L.; Lamberson, R.H.; Stevens, E.E. 1995. Spatially explicit population models: current forms and future uses. Ecological Applications. 5(1): 3-11.

Dytham, C. 1995. The effect of habitat destruction pattern on species persistence: a cellular model. Oikos. 74: 340-344.

Hall, C.A.; Day, J.W., Jr. 1977. Ecosystem modeling in theory and practice: an introduction with case histories. New York, NY: Wiley-Interscience Publications.

Haws, K. 1987. Owl management techniques. In: Nero, R.W.; Clark, R.J.; Knapton, R.J.; Hamre, R.H., eds. Biology and conservation of northern forest owls: symposium proceedings; 1987 February 3-7; Winnipeg, MB. Gen. Tech. Rep. RM-142. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station: 302-304.

Hayward, G.D.; McDonald, D. 1997. Matrix population models as a tool in development of habitat models. In: Duncan, J.R.; Johnson, D.H.; Nicholls, T.H., eds. Biology and conservation of owls of the northern hemisphere: 2d international symposium; 1997 February 5-9; Winnipeg, MB. Gen. Tech. Rep. NC-190. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station: 205-212.

Holt, R.D.; Pacala, S.W.; Smith, T.W.; Liu, J. 1995. Linking contemporary vegetation models with spatially explicit animal population models. Ecological Applications. 5(1): 20-27.

Kareiva, P.; Wennergren, U. 1995. Connecting landscape pattern to ecosystem and population processes. Nature. 373(26): 299-302.

Lahaye, W.; Gutierrez, R.J.; Akcakaya, H.R. 1994. Spotted Owl metapopulation dynamics in Southern California. Journal of Animal Ecology. 63: 775-785.

Mangel, M.; Tier, C. 1993. Dynamics of metapopulations with demographic stochasticity and environmental catastrophe. Theoretical Population Biology. 44: 1-31.

Naveh, Z.; Lieberman, A.S. 1994. Landscape ecology: theory and application. 2d ed. New York, NY: Springer-Verlag. 360 p.

Turner, M.G.; Arthaud, G.J.; Engstrom, R.T.; Heil, S.J.; Liu, J.; Loeb, S.; McKelvey, K. 1995. Usefulness of spatial explicit population models in land management. Ecological Applications. 5(1): 12-16.