

STATEMENT OF RESEARCH

for
Kevin McGarigal
September 2002

Goals and Philosophy

The goals of my research program are as follows:

- develop a diverse and productive research program in landscape ecology,
- provide a strong scientific basis for natural resource conservation decisions, and
- train graduate and undergraduate students in research and natural resource conservation.

The overall goal of my research program is to provide natural resource managers with information and tools that will enable them to become better stewards of healthy and sustainable ecosystems. Solutions to real-world natural resource problems typically require an understanding of basic ecological patterns and processes. Thus, my research strives to combine studies of basic ecological questions with applied research. Although my research program spans the continuum from basic to applied ecological questions, it focuses mostly on the conservation of biological diversity and providing a strong scientific basis for natural resource management decisions. Thus, my overall research program is very applied and is driven largely by the resource information needs of local, state and federal agencies, and nongovernmental conservation organizations.

Natural resource management issues are typically multidimensional and exist at multiple spatial and temporal scales. Dealing with such complex, multivariate and multi-scaled problems often invokes the use of quantitative and interdisciplinary approaches. Consequently, my research increasingly involves the development and use of computer models, geographic information systems (GIS), and multivariate statistical techniques, and working collaboratively in a multi-disciplinary environment.

Additionally, involvement of graduate students in research is a critical aspect of my research program. Through the research process I strive to train students in basic ecological concepts, research methodology, management strategies, and philosophies of science. I gain tremendous gratification from training and working with bright, energetic, young minds. I also take much enjoyment from expanding my research horizons in new areas of the world and with new research questions and technologies.

Research Focus

My research efforts focus on identifying and quantifying spatial patterns in the distribution of resources and the agents responsible for those patterns, how these patterns affect variation in the distribution and abundance of wildlife, how these patterns and processes change over time under

natural and anthropogenic influences, and how to apply this knowledge to manage natural resources. Because animals live in heterogeneous environments that are constantly changing in response to disturbance and successional processes, knowledge of how the spatial pattern of habitat influences animal movements and population dynamics is essential in order to predict and responsibly manage wildlife.

In order to understand how pattern affects animal populations, we must first be able to identify and quantify pattern. Thus, **a major focus of my research is on the development of methods to quantify spatial pattern.** For this purpose, I developed a computer software program called FRAGSTATS to quantify landscape patterns from spatial pattern data within a geographic information system (GIS). Basically, this program reads an input image representing a 2-dimensional mosaic of patches (e.g., habitat patches, land cover types) and computes several hundred metrics that characterize the composition (e.g., the amount of each patch type) and spatial configuration (e.g., size, shape, density, dispersion, interspersion, and diversity of patches) of the landscape mosaic. I completed development of the original program during my post-doctoral work at Oregon State University. I published the software and accompanying documentation as a U.S. Forest Service General Technical Report and made the software available to the public domain via a web-based distribution mechanism. Recently I completed a major revision of the software, including the development of a sophisticated graphical user interface and on-line help system, as well as the implementation of many new metrics and analytical capabilities. Currently, this program is used world-wide by hundreds of researchers and land management agencies, including federal agencies such as the U.S. Forest Service, Bureau of Land Management, and the Environmental Protection Agency, and is widely recognized as the leading program of this sort. The development and support of FRAGSTATS is the cornerstone of my service program (discussed below), but it has also provided me with a platform to investigate the theoretical and empirical behavior of landscape pattern metrics. Thus, a major focus of my current research program involves evaluating various methods and metrics for describing landscape patterns.

Another focus of my research is on developing an understanding of how landscape patterns influence the spatial structure and dynamics of animal populations. Although this research has many components and involves many studies, there are three primary thrusts. One thrust is on developing an understanding of the dynamics of spatial patterns in disturbance-dominated landscapes subject to both natural (e.g., fire) and anthropogenic (e.g., logging) disturbances and the implications for wildlife populations inhabiting these dynamic landscapes. To accomplish this, my students and I develop simulation models and habitat suitability models using spatially-explicit data within a GIS framework. The results of these studies are designed to help federal resource managers devise land management strategies that have a proper spatial-temporal reference to the natural range of variation in landscape patterns and wildlife populations. The second thrust involves field studies investigating the effects of habitat fragmentation on animal distribution and abundance. Here, we explicitly focus on empirical tests of theoretical predictions; specifically, whether threshold phenomena exist in the relationship between habitat loss and fragmentation and animal occurrence and abundance. Thus far, the emphasis has been on birds. The third thrust involves elucidating the factors controlling the spatial structure and dynamics of amphibian metapopulations inhabiting clusters of vernal pools. We employ a combination of computer modeling and field experimentation to address these

questions. This information is used in conservation planning and has played a vital role in informing land acquisition decisions.

A final focus of my research is on developing new tools (e.g., decision-support systems) for resource managers to identify conservation priorities and to develop landscape-level, biodiversity conservation strategies. This research aims to make the best scientific information on biodiversity available to the managers responsible for making decisions regarding biodiversity conservation. This research involves synthesizing vast amounts of complex scientific data, developing computer models for the analysis of complex spatial data, and working with experts and various stakeholder groups to develop conservation strategies.

Major Accomplishments

Since beginning my current appointment at the University, I have obtained \$1,453,100 in support from state and federal agencies and NGOs for research. My research efforts to date (including graduate and post-graduate work) have led to publication of 23 refereed papers (15 submitted since 1997), 9 technical papers (3 since 1997), 4 book chapters (2 since 1997), 1 book (since 1997), 5 major reports or published abstracts (2 since 1997) and 22 presentations of my research at professional meetings at the regional, national and international levels (9 since 1997). Copies of the refereed papers, book (title and table of contents pages only), book chapter, and technical papers are included in the Research Appendix. My major research accomplishments can be summarized as follows:

First, I authored a textbook, published in 2000 by Springer-Verlag, New York, on the use and application of multivariate statistics in wildlife and ecology research. This textbook represents a major accomplishment and has been a significant focus of my efforts over the first few years of my appointment at UMass. It represents the first multivariate textbook written from a conceptual and practical perspective designed for nonstatisticians in the fields of wildlife and ecology and serves as the primary text for a graduate-level course on the subject that I teach in the Department of Natural Resources Conservation.

Second, because this faculty position represents my first appointment after completing my post-doc position at Oregon State University, I came to this institution without external grant support. Therefore, the majority of my research effort has been devoted to obtaining external funding to establish a new research program. To this end, I successfully led efforts to obtain external funding to begin several new research initiatives, which now form the major foci of my research program, as described above. In addition to several small research projects, I obtained \$193,000 from the USDA Forest Service to investigate landscape dynamics on the San Juan National Forest in southwest Colorado. Based on preliminary accomplishments, I was successful in obtaining an additional \$354,000, bringing the total to \$547,000. Similarly, I obtained \$160,000 from the Massachusetts Natural Heritage and Endangered Species Program and The Nature Conservancy to investigate marbled salamander ecology and conservation. Finally, I obtained \$200,000 from the Massachusetts Executive Office of Environmental Affairs to develop a decision-support system for identifying priorities for conservation action based on a biodiversity assessment, and recently obtained an additional \$100,000 to extend this work. These

research grants have allowed me to take on 9 graduate students (6 MS, 3 PhD), 1 post-doctoral associate, 4 full-time equivalent professional staff research assistants, and several part-time field research assistants. This represents my major research achievement thus far and promises to pay great dividends over the next few years in terms of publications and grants (see below).

Future Plans

My plans for the future involve building strength in each of the focal areas of my research program, as outlined above. Specifically, I plan to build on the initial capital investments made in each of these research areas by using the investments as leverage to attract additional external support. In addition, as these initial projects mature over the next few years I plan to focus on publishing results. My specific publication plans, including probable authors, title, and possible publication outlet, for the next three years are as follows:

Year 2002-2003

- McGarigal, K., S. A. Cushman, and C. Regan. A protocol for assessing habitat fragmentation. USDA Forest Service General Technical Report. [*will be ready to submit Fall 2002*].
- Garrett, J. and K. McGarigal. The importance of eastern hemlock to avian communities in western Massachusetts. Conservation Biology. [*will be ready to submit Fall 2002*].
- Jenkins, C., K. McGarigal, and L. Gamble. Timing, orientation, and habitat use of marbled salamander breeding migrations in western Massachusetts. Journal of Herpetology or Conservation Biology. [*will be ready to submit Fall 2002*].
- McGarigal, K. Use of stone wall corridors by forest floor vertebrates in western Massachusetts. Landscape Ecology or Conservation Biology.
- McGarigal, K., C. Griffin, S. Jackson, and others. Strategic biodiversity conservation planning: a landscape ecological approach. Conservation Biology.
- McGarigal, K., C. Griffin, S. Jackson, and others. Comparing the use of coarse- and fine-filter strategies for evaluating biodiversity potential at the watershed scale. Conservation Biology.
- Gamble, L., K. McGarigal, and C. Jenkins. Metapopulation structure of marbled salamanders in western Massachusetts. Conservation Biology or Ecology.

Year 2003-2005

- McGarigal, K., S. A. Cushman, M. C. Neel, and E. Ene. Landscape Structure Analysis: Theory and Applications using FRAGSTATS. [potential publishers include Kluwer, Springer-Verlag, and Island Press].

- McGarigal, K., S. Cushman, and S. G. Stafford. Multivariate Statistics for Wildlife and Ecology Research, Second Edition. Springer-Verlag, New York. [*substantial revision, including several additional chapters on newer statistical techniques and additional empirical examples; publisher has already strongly endorsed the project*].

In addition to my plans for continued investment in these current research efforts and corresponding publication plans, I plan to seek new opportunities for collaborative, multi-disciplinary research projects. In particular, I hope to expand my involvement in international research programs.