Type: Birds of a Feather – Biodiversity and Ecosystem Informatics

Radar Remote Sensing of Habitat Structure for Biodiversity Informatics

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Introduction

A core need of biodiversity informatics is the capability to provide maps not only of locations of known species occurrences, but also potential locations of the same species based on similar habitat properties (Pennisi 2000). In the context of landscape ecology, landscape structure is increasingly studied as a primary basis for biodiversity and habitat preferences of bird species. Patch composition, density, size, and edge, are among the more common variables contributing to a quantitative definition of landscape structure (McGarigal and Marks 1995) but spatially continuous geostatistical methods and neighborhood-based descriptions for categorical or continuous data may also be employed (Gustafson 1998). In both cases, this concept of landscape structure has a largely horizontal definition, whereas real landscape structure is multi-dimensional. Landscape ecology biodiversity analyses rely increasingly on remotely sensed datasets. However, the capabilities of optical sensors such as Landsat or AVHRR are largely restricted to the horizontal mapping of structure Only radar and lidar have the capability to directly quantify multi-dimensional structure of vegetation(M. Craig Dobson 1992; Bergen and Dobson 1999). We are developing a demonstration study and evaluation of the contribution of new radar remote sensing instruments to mapping habitat for biodiversity informatics.

Scientific Background: Radar, Habitat, and Remote Sensing of Habitat

Imaging radars are active sensors that propagate their own energy, receive all or part of it back, and form an image. Radar backscatter is dependent on the larger structural properties of vegetation, and the capability of much longer off-nadir wavelengths to penetrate through the vegetation canopy is the basis for radar's ability to directly estimate multi-dimensional vegetation structural parameters (Dobson, Ulaby et al. 1995; Bergen 1997). Our work on a NASA test site for the SIR-C/X-SAR radar flown on the Space Shuttle in 1994 confirmed the ability of radar to directly estimate biophysical variables: height, density, basal area, and trunk, crown, and total biomass, and to map these as continuous fields.

Much has been researched and written on the importance of two-dimensional landscape structure in habitat preference of birds. Other studies have concentrated on particular bird species and their relationship with multi-dimensional vegetation structure. Theoretical models based on field data and habitat suitability databases specify vegetation composition, height (or height/age relationships) and density requirements. The NORTHWOODS database, developed at the USDA Forest Service North Central Research Station (NCRS) and derived from field data, is one example.

Use of remote sensing for acquiring horizontal or multi-dimensional structure has received less attention than field investigations. One study has focused on radar mapping of vegetation structure and bird habitat. Airborne multi-frequency polarimetric radar showed that 1) radar was successful in discerning structural differences relevant to bird habitat within otherwise similar community composition, and 2) the abundance of individual bird species were observed to change significantly across both floristic and structural gradients (Imhoff, Sisk et al. 1997).

Research Approach

Our approach involves the implementation and evaluation of two modeling methodologies. We will: 1) integrate radar-derived variables of multi-dimensional vegetation structure with a priori rule-based habitat models and produce maps of potential habitat, 2) use the same radar data with a sample of known species locations and genetic algorithm software (GARP) to predict potential habitat, 3) evaluate the results from the two methods compared with use of multi-spectral (e.g., Landsat) imagery alone and in synergy, and 4) produce educational materials and communicate results.

NASA established the Michigan Forests Test Site (MFTS) in the eastern Upper Peninsula of Michigan for radar ecology in 1990. Spatial biophysical datasets (for forests composition, height, basal area, trunk, crown, and total biomass) have been derived from radar sensors. The NCRS supports the NORTHWOODS database of species habitat preferences. The Hiawatha St. Ignace District Office has research reports and observation datasets for bird species that they study or monitor.

First, we are applying a deductive approach using previously derived data for both habitat structure description and bird species habitat requirements. The remote sensing datasets include mapped vegetation composition, height, basal area, and trunk, crown and total biomass derived from SIR-C radar imagery of an approximately 20 by 50 km area in the MFTS. The bird habitat dataset is the NORTHWOODS database that contains summary habitat requirements for 389 species of birds and other animals derived from original field sighting data. The models will use standard Boolean procedures, and may be simple or more complex. We are implementing these in the Modeler module in ERDAS Imagine. This software is designed for interactive model development on multi-layer thematic or continuous datasets.

Second, we will also implement a complementary (i.e., inductive) modeling method for mapping predicted species habitat. We will be using the GARP genetic algorithm software, associated with the Biodiversity Workshop: http://biodi.sdsc.edu/Doc/GARP/ (Payne and Stockwell). Our overall approach is to run the program for the selected species of interest using observation data from the Hiawatha, the radar-derived data, and any ancillary data employed in the first method as the environmental input datasets. The output datasets will be maps of potential suitable habitat. Our rationale for using the derived radar datasets is 1) this will allow us to compare the two modeling methods, and 2) radar-derived datasets of e.g. vegetation height and biomass are likely to be increasingly available.

To do an evaluation, first we will use Landsat-derived data and compare model results based on two-dimensional structure information only (i.e., the current state-of-the-art) with results from model runs that also include multi-dimensional structural information derived from radar images. Second, by comparing the rule-based deductive model of species presence and preference with the genetic algorithm-based inductive approach, holding input data constant, we will develop an understanding of the degree of variability in model results that is attributable to modeling method.

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