DEVELOPMENT AND USE OF FOREST INVENTORY AND ANALYSIS (FIA) MAP PRODUCTS

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ABSTRACT

Users of forest inventory data are requesting map products that show distributions of forest resources in addition to the traditional population estimates. Here we describe methods for generating spatially explicit maps of forest inventory variables and demonstrate some interactive tools for summarizing and querying these maps. Statistical models and geographical information system (GIS) tools are used for integrating forest inventory data with satellite data and environmental data such as elevation, aspect, slope, and geology, resulting in predictive map products. The maps are packaged within ArcView GIS where users can display and analyze forest resource diversity and distribution across the landscape.

INTRODUCTION

The Forest Inventory and Analysis (FIA) program of the USDA Forest Service conducts comprehensive inventories of forest resources across the United States. FIA inventory is designed to determine the status and trends of the nation’s forested communities by estimating population totals of variables such as area, volume, growth, and mortality. The Interior West Resource, Monitoring, and Evaluation (IWRIME) FIA unit, Rocky Mountain Research Station, as part of its national FIA duties, collects data in over eight interior west states and generates summary tables and reports by forest, state, and ecoregion. Current requests from users of IWRIME’s data, however, involve more than the traditional population estimates and summary statistics. IWRIME’s users want to know not only how much of various forest resources there are, but also how these resources are distributed spatially across the landscape. The addition of spatial map products of forest resource data to IWRIME reporting will satisfy these requests, providing information on where to focus management and research actions.
Working in cooperation with the USGS Biological Resource Division, Utah State University, the Remote Sensing Applications Center, and Fishlake National Forest, we are developing methods for generating spatially explicit map products integrating forest inventory data with remotely-sensed data and available digital environmental data. We are also investigating ways to package these maps in a user-friendly environment, providing interactive tools for visualizing and analyzing the diversity and distribution of forest resources across the landscape. Here we describe the general techniques we are using to generate IWRIME map products and our on-going research for improving model efficiency and map accuracy. We then present the use of ArcView GIS for displaying and querying spatial data, using an example of map products generated for the Uinta Mountain Range in northern Utah.

MAP PRODUCTS

Our methods for generating map products involve extensive use of statistical models and geographic information system (GIS) tools. Forest inventory variables are modeled as nonparametric functions of satellite-based predictor variables including Landsat Thematic Mapper (TM) and advanced high resolution radiometer (AVHRR); topographic predictor variables including elevation, aspect, slope, and geology; and geographical predictor variables including spatial coordinates. Within a GIS environment, model predictions are made at grid cell intervals based on continuous coverages of the predictor variables. The predictions are divided into class intervals and mapped for each forest variable.

In past research, we applied and tested these methods using IWRIME data collected in northern Utah. Spatially explicit maps of forest attributes were generated within the Uinta Mountain Range in northern Utah (Fig. 1a) and validated with an independent set of data collected in the Evanston Ranger District (Fig. 1b). A class of statistical models called generalized additive models (GAMs) was used to model two discrete forest variables (forest cover and lodgepole forest type) and three continuous variables (basal area per acre, number of snags per acre, and percent shrub cover per acre). All five forest variables were modeled as functions of satellite-based predictor variables including TM, AVHRR, and classified TM; climate and topographic predictor variables including temperature, precipitation, elevation, aspect, slope, and geology; and geographic predictor variables including spatial coordinates and district boundaries. One-hectare resolution maps were generated for each forest variable based on the model predictions.

We compared the predicted data to the field validation data to determine map accuracy. The models predicting forest cover and lodgepole forest type were 88% and 80% accurate, respectively, within the Evanston Ranger District, and an average 62% of the predictions of basal area, shrub cover, and snag density fell within 15% deviation from the field validation values. The addition of TM spectral data and the GAP Analysis TM-classified data were found to contribute significantly to the models’ predictions, with some contribution from AVHRR data (Frescino et al. In Press).
Research is currently underway to improve model efficiency and map accuracy by comparing a set of nonlinear and nonparametric models for predicting forest resources in six western ecoregions (Fig. 2). The comparison involves six statistical modeling techniques for predicting forest type, tree basal area per acre, average tree age, average tree size, and percent tree crown cover. The six modeling techniques include: linear models (LM), linear discriminant functions (LDF), generalized additive models (GAM), classification and regression trees (CART), multivariate adaptive regression splines (MARS), and artificial neural networks (ANN). The analyses are being conducted within six ecologically unique regions using topography, spatial position, and unclassified spectral data from AVHRR and Sea-viewing Wide Field-of-view Sensor (SeaWIFS) as predictor variables. The models will be evaluated for performance in the six ecoregions and for their suitability in a production environment.
IWRIME’s final map products are currently packaged within ArcView. ArcView is a powerful GIS tool for displaying, summarizing, and querying digital map data. Here we demonstrate ArcView features using examples of IWRIME map products generated for the Uinta Mountain Range in northern Utah, described previously. Spatially explicit map products were generated for variables of forest cover, lodgepole forest type, basal area per acre, percent shrub cover, and number of snags per acre. These maps were assembled within ArcView along with digital overlays of political and ecological boundaries and hydrologic and road features.

With ArcView’s display features, spatial distributions of forest resources can be viewed using IWRIME plot-level data (Fig. 3a) as well as the spatially explicit predictive maps (Fig. 3b) modeled from IWRIME field data, satellite data, and digital environmental data. Geographical features can be overlayed and labeled as desired.
Additional tools, including summary and query tools, are being developed within ArcView to provide interactive ways to analyze the map products. The summary tool generates charts of selected summary statistics by user-defined groupings based on the predicted values of the map (Fig. 4). The query tool displays maps of areas within a selected region meeting specific criteria defined by a user (Fig. 5). For example, a user interested in locating areas unique to a certain species of wildlife can use the query tool to select forest habitat features associated with the species, resulting in a map of areas meeting the habitat’s criteria. The query tool can also be useful to determine possible harvest areas or to discover areas that are potentially in risk of fire or insect infestation. ArcView’s user-friendly environment and powerful interactive tools provide a valuable interface for analyzing FIA data in many ways.

Fig. 4. An example of output from the ArcView summary tool. A map and chart of mean snag density per acre by forest district within the Uinta Mountains, Utah.
Fig. 5. An example of output from the ArcView query tool. A map of areas within the Uinta Mountain range, Utah having tree basal area greater than 110 square feet per acre, elevation greater than 9500 feet, and shrub cover greater than 20 percent.

CONCLUSION

FIA’s population estimates have provided valuable data for resource managers and analysts since the 1920’s. With modern technology such as GIS and predictive models we can enhance FIA data products by generating maps of forest resources as well as reporting the traditional statistical summaries. Although map accuracy is limited by many factors such as resolution and georectification of digital data, model variance, and human error, predictive maps can provide more information of the spatial distribution of forest resources in areas that are not sampled on the ground. The methods described demonstrate a systematic approach for modelling forest attributes using forest inventory data, satellite imagery, and environmental variables. These methods may be applied to various ecological parameters measured in the field and interpolated within a specified range.

ArcView’s display features and programmed analysis tools allow users to assess FIA data based on individual needs, thereby providing valuable information for research and management applications, such as estimating forest attributes at regional, ecosystem, and global scales; detecting forest change; and delineating forest patches, corridors, and fragmented areas. Also, resource and habitat loss can be quantified and tracked from human and natural disturbances, such as logging, fire or insect and disease damage.

REFERENCE
