

## Mapping Forest Resources Using the k-Nearest Neighbor Method

*Forests play a major economic role in Minnesota, as the forest industry generates annual sales of \$8.5 billion. Minnesota forests also add significant environmental and recreational benefits.*

*For many years, natural resource professionals have used aerial photography to inventory and manage forests. Research demonstrates that remote sensing can provide quantitative information for forest resource inventory and management applications. The synoptic view of landscapes generated by satellite-borne multispectral sensors provides the opportunity for applications ranging from stand management to regional planning.*

*With representatives from government agencies and industry, we are using satellite remote sensing to map forest resources, improving forest inventory and management at local, state, and regional scales. Our goal is to develop remote sensing-based approaches to acquire up-to-date information on Minnesota forests, equipping forestry professionals with the tools to support management and policy decision making. This fact sheet is an overview of one such approach called the k-Nearest Neighbor method.*

The USDA Forest Service Forest Inventory and Analysis (FIA) program has been conducting state-by-state and ultimately nationwide forest inventories for decades. However, these field plot-based inventories have not been able to produce precise county and local estimates and useful operational maps.

Additionally, traditional satellite-based forest classifications have yet to match detailed forest type identification with ground-based survey definitions to produce for interpolation and extrapolation of FIA data. Precise classification has been limited to general or aggregate classes of little use to improving inventory precision and providing truly useful operational forest maps.

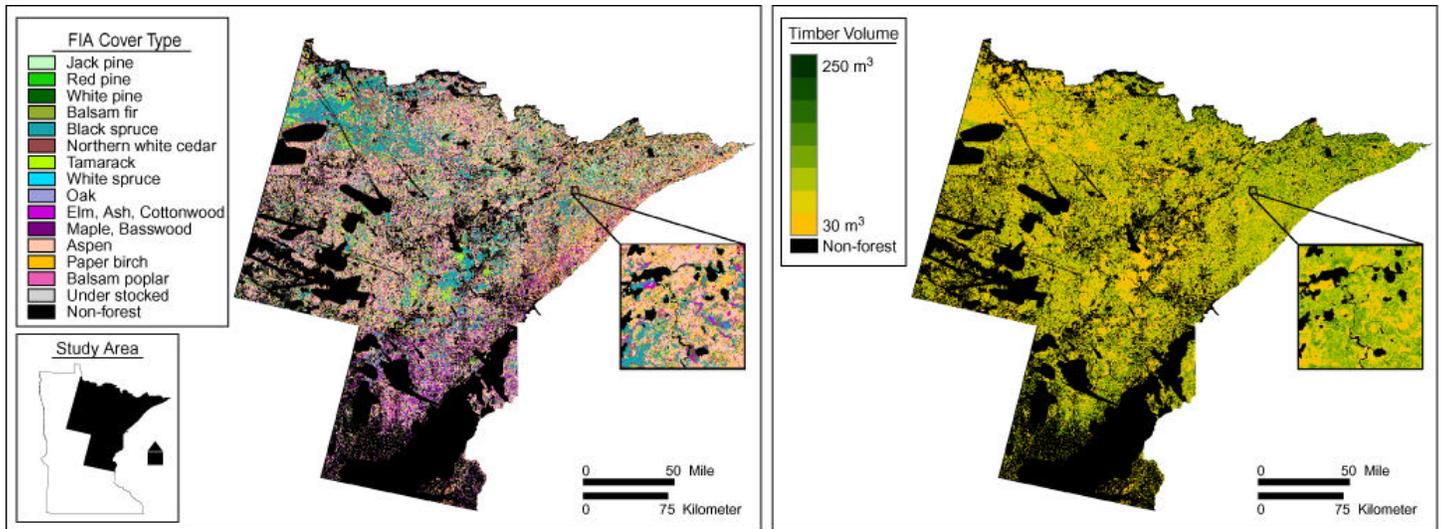
### MAPPING WITH K-NEAREST NEIGHBOR

Recognizing the great potential of satellite imagery to help meet the need for wall-to-wall digital mapping of attributes, the Finnish Forest Research Institute initiated the Finnish Multi-Source National Forest Inventory (FMS-NFI) in 1990. Since this time, FMS-NFI has made steady progress towards forest type and structure estimate mapping. First introduced to forest inventory practice by Tomppo (1991), the k-Nearest Neighbor



(kNN) algorithm is today the primary tool used by the national forest agencies of several Nordic countries to classify and map a host of forest attributes.

The kNN method assigns each unknown (target) pixel of a satellite image the field attributes of the most similar reference pixel(s) for which field data exists. The similarity is defined in terms of the feature space, typically measured as Euclidean or Mahalanobis distance between spectral bands. The non-parametric algorithm of this unique method overcomes low sampling restrictions to produce truly useful maps of forest attributes collected through field inventory (Franco-Lopez *et al.*, 2001).



**Figure 1. kNN estimate of forest cover type and timber volume in cubic meters with calculations based on 1,835 FIA subplots and 3 Landsat TM+ dates.**

The kNN multi-source inventory has proved timely, cost-efficient, and accurate in both the Nordic countries and initial trials in the U.S. (McRoberts *et al.*, 2002). This approach for extending field point inventories is ideally suited to the estimation and monitoring needs of federal agencies, such as the Forest Service, that conduct natural and agricultural resource inventories. It provides wall-to-wall maps of forest attributes, retains the natural data variation found in the field inventory (unlike many parametric algorithms), and provides precise and localized estimates in common metrics across large areas and ownerships (Figure 1).

#### References

- Tomppo, E. 1991. Satellite imagery-based national inventory of Finland. *International Archives of Photogrammetry and Remote Sensing*. 28: 7-1, 419-424.
- Franco-Lopez, H., Ek, A.R., and Bauer, M.E. 2001. Estimation and mapping of forest stand density, volume, and cover type using the k-nearest neighbors method. *Remote Sensing of Environment*. 77: 3, 251-274.
- McRoberts, R.E., Nelson, M.D., and Wendt, D.G. 2002. Stratified estimation of forest area using satellite imagery, inventory data, and the k-nearest neighbors technique. *Remote Sensing of Environment*. 82: 2-3, 457-468.

#### **For more information, contact:**

Alan Ek  
University of Minnesota  
Department of Forest Resources  
1530 Cleveland Ave. N.  
St. Paul, MN 55108

Phone: (612) 624-6400  
E-mail: aek@umn.edu

*Forest mapping research at the University of Minnesota is supported by:*

*NASA, the Minnesota DNR, and the USDA Forest Service*

*The University of Minnesota's Remote Sensing and Geospatial Analysis Laboratory (RSL), a unit of the Department of Forest Resources and College of Natural Resources, was established in 1972 and focuses on geospatial research and development for forestry and natural resources.*

*Current efforts emphasize quantitative approaches to natural resource assessment, carried out in cooperation with resource agencies. Core activities at the RSL include research, education and outreach, and the facilities feature an array of hardware and software for image processing, mapping, modeling, statistical analysis and visualization.*