No 1 NEWSLETTER December 2003

About ForestSAFE

ForestSAFE is an international project funded by the **EU LIFE –Environment programme** which is set up to demonstrate new ideas, methods or technologies for environmental protection and management.

An International Partnership

The ForestSAFE project is an international partnership among nine institutions involving researchers and foresters from both Sweden and the UK.

	Sweden	UK
National Forestry	National Board of Forestry	Forestry Commission
		Forest Research
Regional Forestry	Regional Forestry Board of Vaesterbotten	Forest Enterprise, Kielder
	Regional Forestry Board of Vaestra Goetaland	Forest Enterprise, Galloway
Research Institutions	Swedish University of Agricultural Science	Durham University

Figure 1. ForestSAFE partners

Project Aims

The project aims to develop innovative scientific methods that combine satellite imagery and ground survey data with planning and monitoring tools to demonstrate how public authorities, forest companies and private forest owners can access up-to-date forestry and landscape information.

Project Objectives

Monitor changes in the forest due to planting, harvesting, silvicultural operations and areas of damage from wind, snow or fire.

Identify areas of high environmental value e.g. riparian zones with a large proportion of deciduous tree species, very old forests, and wetland forests.

Estimate growing stock, age and tree species composition at stand, local and landscape level.

Demonstrate methods to track stands with poor or good growth potential over time.

Demonstrate how up-to-date information can be provided to users through the internet.

Project Website

For further information, visit our website at www.svo.se/forestsafe or e-mail Lars Björk (project leader) at lars.bjork@svsac.svo.se

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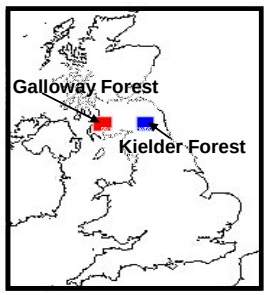
Study Areas



In the UK, two areas have been selected for detailed study. They are Kielder Forest (Northumberland, England) and Galloway Forest District (SW Scotland).

A range of forest conditions are represented within these sites.

In Sweden there are two main study areas: one in Vaestra Goetaland and one in Vaesterbotten. Each study area includes a small test site that will be used to assess the accuracy of the estimates such as growing stock, age and tree species composition derived within the project.

Figure 2. Test areas

Satellite Imagery

Remotely Sensed Imagery is just one new technology that can assist with the management of forests. The tables below illustrate some of the different sensors along with their applications for forestry.

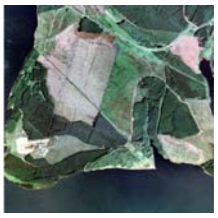
Passive Sensors	Landsat	SPOT	Aerial Photography	Airborne LiDAR
Example Image (Kielder Forest)				
Advantages	✓ Relatively cheap ✓ Covers a broad range of the electromagnetic spectrum	✓ Finer ground resolution	✓ Far more detailed impression of ground conditions with less than 1 m resolution.	✓ Works at night ✓ Produces accurate surface height map.
Disadvantages	× Relatively coarse ground resolution	× Relatively small scenes	× Limited to visible spectrum	× New Technology. Relatively expensive.
Applications	⇨ Prediction of Young Stand Forest Variables ⇨ Forest Change Detection ⇨ Private Forest Monitoring		⇨ Tree Counting ⇨ Manual Stand Delineation ⇨ Detailed Monitoring	⇨ Creation of Digital Elevation Models ⇨Tree Counting ⇨Tree Height Mapping

Figure 3. Remote sensing data

Equipment

Satellite remote sensing produces quick overviews of large areas of land. Information can be extracted by integrating satellite images with field survey data. The addition of field data makes it possible to build statistical relationships between remotely sensed data and important forest parameters.

The process of field data collection takes advantage of a variety of newly available hardware devices and software packages. Tree parameter data are measured using traditional field equipment and ultrasound vertexes for accurate height measurements. GPS units are used to measure accurate locations with up to +/- 10 cm accuracy in open areas.

All data is recorded directly to a database in a handheld computer in the field and downloaded to a specially designed relational database in Microsoft Access for analysis.

The advantage of this system is that it is paperless, enabling rapid and accurate data collection and analysis.

Young Stand Height Prediction

As trees grow, the ground vegetation whether it is grass, heather, moss or brash, is obscured by the tree canopy. As a result the spectral properties and amount of light reflected from the surface changes with forest development. This relationship between reflectance and growth allows tree parameters such as height and diameter to be predicted and mapped automatically from satellite images.

Example height prediction map

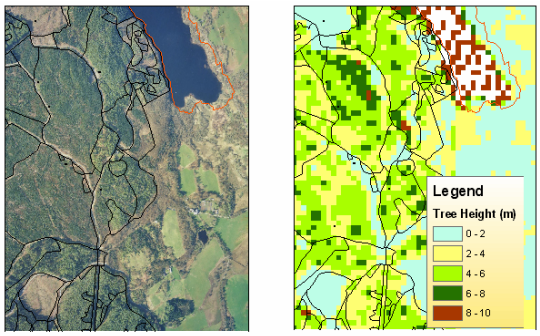


Figure 4. Height prediction map

Forest Change Detection

Changes in the forest can be seen and mapped by comparing images of different dates.

For example, to the right is a map of an area of Galloway Forest produced by overlaying the height prediction layers for 1989 (Red), 1995 (Green) and 2001 (Blue). The resultant map highlights felling, growth and canopy closure providing a simple monitoring tool.

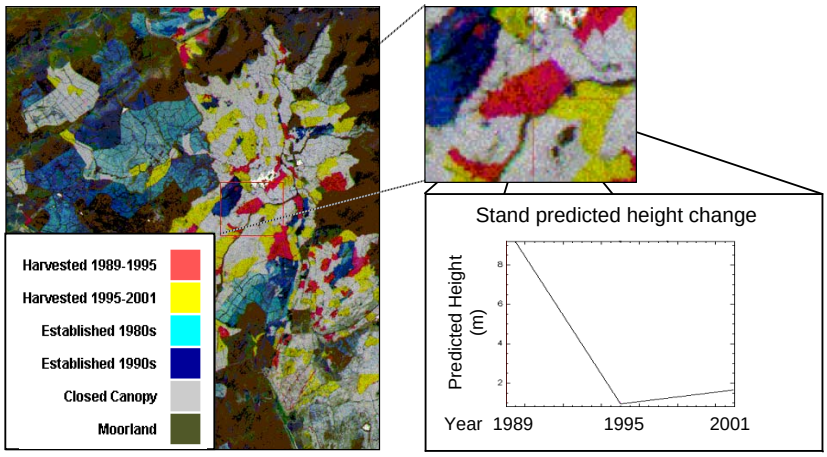


Figure 5. Change detection

Estimation methods

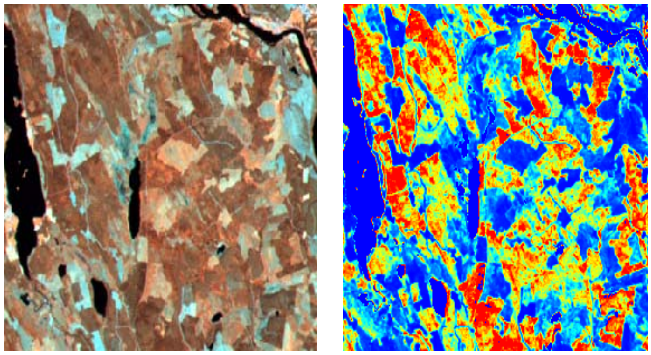
There is a need for forest companies, private forest owners and other organisations to have up-to-date and reliable data describing the forest landscape. Traditionally, this has been collected using ground-based surveys and aerial photography. Today, remote sensing provides unique possibilities to derive estimates of important forest variables at stand, local and landscape level in a cost-efficient way. There are several estimation methods that will be tested and demonstrated in ForestSAFE, for example the kNN method.

Mapping of forest parameters

Estimates of total volume, volume per tree species, stand age and tree height have been derived by combining single date satellite images and field data using both the k Nearest Neighbor (kNN) method and regression techniques. Both Landsat TM and SPOT data were used for the estimation of forest parameters.

Since satellite images cover relatively large areas, the estimates provide an excellent tool for describing the forest on both local and landscape level. The accuracy on a stand level is however slightly lower for satellite based estimates than for estimates based on traditional field surveys. This is partly explained by the fact that the information content in a satellite image is limited in older forest.

To improve the quality of estimated parameters, new methods are being developed which use a combination of satellite data with different resolutions and data from old forest maps, lidar, radar and aerial photographs. Artificial neural networks and regression has been used to integrate different combinations of these data types with data from field surveys. The results show that variables such as stand volume can be estimated with similar or higher accuracy than usually obtained using traditional field surveys.



Example showing a Landsat TM image (left) stand volume estimates (right).

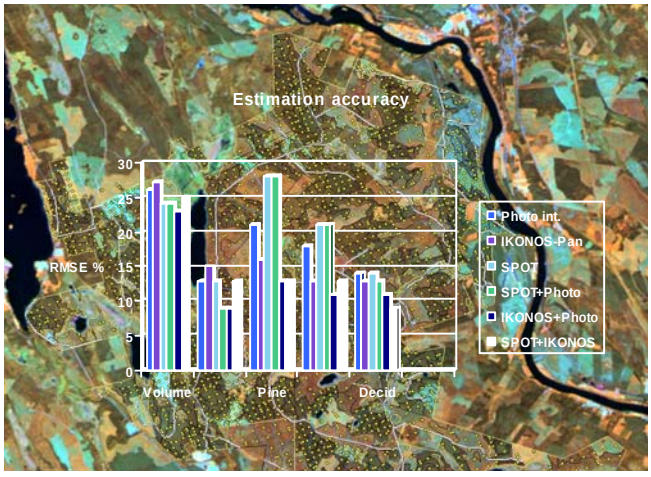


Figure 6. kNN estimates

Segmentation

A segmentation method developed at the Swedish University of Agricultural Sciences has been implemented and demonstrated for automatic delineation of homogeneous forest patches or forest stands. These patches have been assigned mean values of estimated forest variables from, for example, the kNN dataset. The segmentation has also been used for stratification prior to field surveys, which has reduced inventory costs.

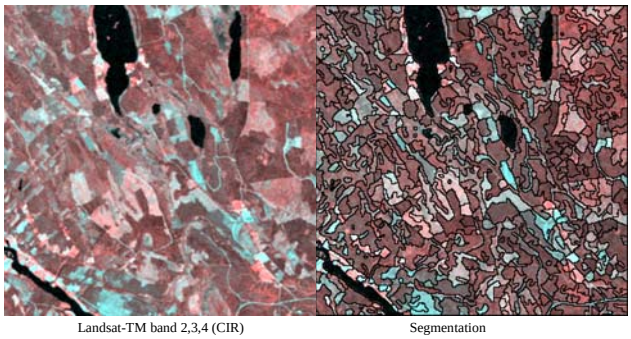


Figure 7. Segmentation