

# REMOTE SENSING AND GEOSPATIAL ANALYSIS LABORATORY

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UNIVERSITY OF MINNESOTA  
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COLLEGE OF NATURAL RESOURCES  
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DEPARTMENT OF FOREST RESOURCES

## Managing Forests with GIS, GPS and Digital Imagery

*Jim Gabriel of UPM-Kymmene's Blandin Paper Mill in Grand Rapids, Minnesota is no stranger to forest management. He and several of his fellow foresters trek through the woods on a daily basis collecting the information that allows the company to manage forests for paper production in a sustainable and environmentally friendly manner.*

*For a long time, Gabriel's field crews used a combination of maps, aerial photographs and chain and compass to orient themselves and guide their activities. But as the realm of computer technology advances and the need for convenient, systematic forest data collection increases, new tools have emerged that are becoming more accessible to the forestry community. Recognizing these trends, Gabriel is in the process of outfitting his crews with state-of-the-art data collection and organization tools including GPS, GIS, handheld computers and compatible software. In combination with digital imagery, these tools have the potential to increase the pace and accuracy of forest management activities.*

*This fact sheet summarizes current field GIS solutions that have been evaluated as part of the University of Minnesota and NASA-funded eForest project.*

Forest management activities have an inherent and important locational component which requires spatial tools. Traditional tools, like a chain and compass, have been used for decades and will continue to be used in the future. But as the demand for wood products increases, forest managers will need to improve their ability to meet society's needs.

For this reason, forest management professionals are considering geospatial tools that computer technologies can offer. There are several good reasons. First, handheld pen-based computers, such as the Palm™, and compatible field-based GIS software can be easily customized for field forestry tasks. In conjunction with a GPS, such a system can bring greater locational accuracy and give crews the capability to edit polygons while in the field.

Second, instead of using imagery that is in hard-copy format, crews can

now use imagery that is in a digital format, such as a high-resolution satellite image or digital orthophoto (e.g., DOQ). The high-resolution satellite imagery can be particularly useful for identifying and mapping damage or areas under stress.

Third, enhanced GPS units with high locational accuracy allow crews to quickly determine their location in the field. Further, they work seamlessly with handheld pen-based computers, field GIS and satellite imagery.

Together, these new technologies can minimize three important limitations that forest resource managers face in their daily efforts - time, labor and error.

A field GIS computing system connected to a GPS unit can decrease time in the field by speeding travel to sample plots and more efficiently collecting data. It



can reduce the amount of labor needed by equipping fewer people with more user-friendly, capable tools for data collection, analysis and interpretation. Lastly, managers can reduce the likelihood of data collection error by creating customized data input tables that contain only correct entry options and by avoiding the task of manually transferring data from the field to the office.



**Figure 1. Compaq iPAQ handheld computer.**

While many forest resource managers will continue to use traditional forest management tools and techniques, others will choose to incorporate these new spatially advanced tools into their daily activities. This fact sheet serves to answer some of the basic questions that interested forestry professionals may have when considering a field-based GIS approach to forest management.

### 1. *What are current handheld computer options that support forest management activities and how do they compare?*

Several pen-based computers are currently on the market that are ideal for forest management tasks. To assist in a comparison of current handhelds, researchers at the University of Minnesota's Department of Forest Resources categorized them based on size - small, medium and large. Table 1 summarizes differences between these sizes.



**Figure 2. Fujitsu Stylistic 3500 pen-based computer.**

Small pen-based computers include products such as the Palm™ and Compaq iPAQ (Figure 1). These are commonly used as personal managers; however, their technological capability also allows users to display imagery and sketch, store, access and visibly interpret information which together matches the field-based information needs of forest crews. They are an ideal platform for collecting forest attribute data, such as species and timber volumes.

Medium pen-based computers include products like the Fujitsu Stylistic 3500 (Figure 2). As opposed to the small handhelds, medium pen-based computers are designed for more than personal management. They are essentially a small version of a laptop and can be used as both a field and desktop computer. They are ideal for field forestry tasks with a heavy emphasis on spatial data, such as delineating roads, stands and streams.

The midsize option has the advantage of being lightweight and portable like the small handheld computers; however, the larger screen dimensions and resolution better assist in spatial data collection and visualization. Aside from these advantages, other valuable aspects include more memory, faster processors and more resident data storage.

Large pen-based computers include products like the Fujitsu LifeBook® E2000 Notebook. These large handheld computers approach the power and flexibility of laptop computers and have the ability to run virtually any software that a desktop computer runs. This important aspect allows for seamless integration with desktop systems. The main disadvantage of large pen-computers is the combination of size and weight.

### 2. *What are current GIS software solutions that support field-based forest management activities?*

GIS software packages that support data collection and interpretation are continually being improved and upgraded. Key improvements include the ability to:

- Create user-friendly software interfaces such as customized data entry forms (Figure 3)
- Easily integrate GPS into software functions increasing the accuracy of polygon edits in the field (Figure 4)

**Table 1. Comparison of three handheld pen-based computer size categories.**

	Screen Size (diagonal)	Weight	Price Range
<b>Small</b>	3.7 – 6.5 in	10oz – 2lbs	\$500 – 1,000
<b>Medium</b>	7 – 8.5 in	2 – 4 lbs	\$1,000 – 3,000
<b>Large</b>	10 – 13 in	4 – 6 lbs	\$3,000 – 5,000

- Display raster and vector data
- Smoothly export data from field GIS systems to desktop GIS systems

Several GIS software options suitable for forest management tasks are compatible with the pen-based computers previously discussed. Options that researchers at the University of Minnesota’s Department of Forest Resources have evaluated include ESRI’s ArcPad, Condor Earth’s PenMap, PC GPS by Corvallis Microtechnologies, Sokkia’s iMap and SOLO CE from Tripod Data Systems. Table 2 compares these software packages. Primary differences between these options are the type of data that the software can support.

**3. What are digital imagery options that foresters can use with field GIS systems?**

Aerial photographs, either color infrared or black and white, that have been digitized and rectified are one option. While they offer high resolution and may be quite recent, the cost of rectification can be significant. A more affordable option is a digital orthophoto (DOQ) which has already been rectified. Although DOQs are usually only available in black and white, they are widely available and GIS-ready. However, in Minnesota, most DOQs date back to the early 1990s.

Aerial images acquired by digital cameras or other multispectral electronic sensors are a third option. They are already in digital format (although they may or may not be rectified), and the better systems include several spectral bands in the visible and the near infrared. At this time, the cost of this option may be beyond what can be justified for many forestry applications.

A fourth option is digital, high-resolution satellite imagery which is now approaching the spatial resolution of digital photographs. It provides four bands of multispectral imagery in a GIS-compatible format. Generally, it can be acquired within a short time, making it a good option when up-to-date information is needed. However, current costs of about \$3,000 for a township size area may preclude its use. For more information on high-resolution satellite imagery, see Fact Sheet 3: Using High-Resolution Satellite Imagery to Monitor Natural Resources.

When multispectral imagery (with red and near infrared spectral bands) from digital cameras or satellite sensing systems is available, the normalized difference vegetation index can be a useful image transformation. NDVI is sensitive to the amount of green vegetation and enhances differences between vegetation and other cover types.



Figure 3. Customized data entry form for a regeneration survey.

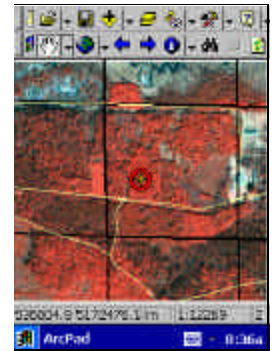


Figure 4. GPS digitizing in ArcPad with satellite imagery as backdrop.

Table 2. Comparison of some GIS mapping software packages.

Features/Product	GPS Capability	Pen Digitizing Capability	Raster Data Compatibility	Vector Data Compatibility	Vertex Editing Capability	Data Entry Form Customization	Cost (Approx.)
ArcPad 6.0	Yes	Yes	CADRG, BMP, JPG, MrSid (8-bit only)	Shapefiles	Yes	Yes	\$500
PenMap	Yes	Yes	BMP, JPG, ESRI TIFF, World Files, import of GeoTiff	Shapefiles and DXF files	Yes	Yes	\$2,400
PC GPS 3.7	Yes	Yes	BMP, JPG, GeoTIFF, DOQ, DRG, TFW	Shapefiles, AutoCAD DXF files, ASCII	Yes	Yes	\$1,300
iMap	Yes	Yes	BMP, JPG, GeoTIFF, TIFF	Shapefiles, AutoCAD DXF files, ASCII, MIF	No	No	\$1,000
SOLO CE	Yes	Yes – but one point at a time	JPG, GeoTIFF, TIFF	Shapefiles, AutoCAD DXF files, ASCII, MIF	Yes	Yes	\$1,000

# CASE STUDY: FOREST REGENERATION SURVEY

Recognizing the field utility and geospatial capability of current field GIS packages, researchers at the University of Minnesota’s Department of Forest Resources have evaluated a combination of the Compaq iPAQ handheld computer with a Magellan GPS15 unit, Arcpad 6 software and high-resolution IKONOS imagery to conduct a forest regeneration survey.

This particular GIS package equipped crews with the ability to: (1) layout and traverse sample plot centers before going in the field (Figure 5), (2) easily navigate with GPS capability, (3) delineate polygons in the field with a satellite imagery backdrop, (4) collect and enter data, such as species, size and stocking information, at each sample plot into customized data entry forms, and (5) open the plot for updating any particular feature of the plot by tapping on the plot center with the stylus.

The high-resolution satellite imagery also gave crews the opportunity to identify and locate potential problem areas before going to the field. By transforming the multispectral data of the satellite imagery using NDVI and image processing software such as ERDAS Imagine, differences between healthy and non-healthy forest regeneration were accentuated. Once delineated, these problems were verified in the

field and their identification allowed users to better focus their management efforts (Figure 6).

Jim Gabriel, UPM-Kymmene, says their crews are just beginning to take GIS and digital imagery into the field, and they have yet to use high-resolution satellite imagery. While field-based GIS systems are relatively new to the crews, they have realized their potential compared to traditional forest management tools.

“It has made us better foresters,” says Gabriel. “These are tools that are changing the way we approach field forestry. We make decisions based on better data, in a more timely manner, with increased accuracy, resulting in improved outcomes.”

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*This fact sheet was compiled by Sarah R. Finley, Editor, Department of Forest Resources, University of Minnesota*



**Figure 5. Stand boundary with traverse and sample plot centers.**



**Figure 6. NDVI-derived map of healthy and non-healthy vegetation. Delineated “holes” are unhealthy (or absent) vegetation.**



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*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.*

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