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Enhancing Ontario's Forest Resources Inventory

A brief history

The Ontario Government has nearly a century of history developing inventory information for the province using aerial reconnaissance and interpretation. In 1946 the Forest Resources Inventory (FRI) undertook a major technological step with the integration of aerial photography technologies developed during the Second World War. Similarly, the current FRI has taken another major step with the development of digital, multispectral imagery, automated feature extraction, and softcopy interpretation. The primary objective of the FRI continues to be describing the current state of the forest. Information from the FRI is used to support a number of key business needs and applications, including forest management planning, wood supply and habitat analysis, and provincial reporting.

More information and increased demands

Today's users of the FRI require and demand more current, timely and effective inventory data. Reporting requirements have increased in complexity, the ability to model complex ecological processes has improved, and the ability for these models to process and store large FRI data sets has also increased. Additionally, as applications dependent on the FRI become more demanding and complex in relation to their data requirements, the scope and techniques to create the FRI continues to evolve.

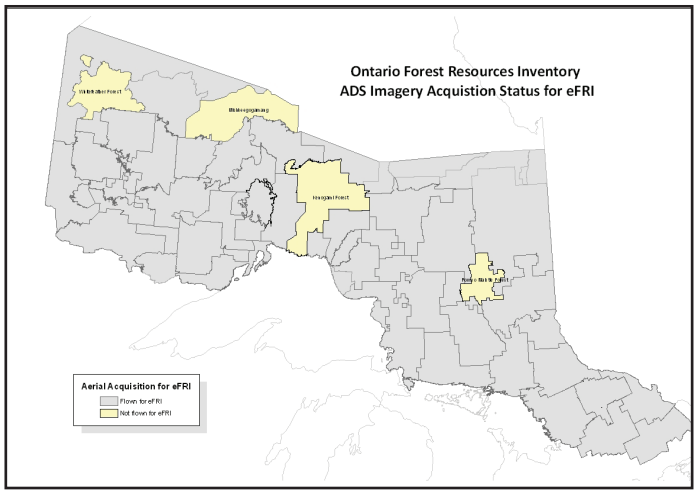
To meet these increasing demands, the FRI Program, announced in 2005, has integrated a number of enhancements. These include:

- Reducing the inventory cycle from 20 years to 10 years;
- Use of high resolution, digital airborne imagery and image products to produce the FRI;
- Use of technological advances in the geosciences, hardware, and software during inventory production processes;
- Introduction of new plot networks and an increased number of traditional calibration plots;
- Introduction of a new post production inventory assessment component; and,
- Expansion of traditional inventory lands to include the southern portion of the Far North Planning Area, and national and provincial parks.

Meeting future challenges

To meet some of the challenges associated with implementing the enhanced FRI program, the Forestry Futures Trust Committee (FFTC) and the FRI unit from the OMNR have undertaken a Knowledge Transfer and Tool Development program. The program has sought input from Sustainable Forest License (SFL) holders, inventory contractors, academia, and government to identify user needs and the ability of the inventory information to meet current and future business requirements. The FFTC (in partnership with OMNR) has undertaken the majority of these tasks; releasing a series of surveys, and holding workshops and a focus group in order to gather user needs and information requirements data. The initial summary of the results indicates the primary issues related to the FRI data are access to the data and training related to using the data. A number of possible forums have been brought forward as ways to impart this technical knowledge to those interested.

Status of 2011 FRI imagery acquisition.



So far, two workshops, tailored specifically for forest managers and the FRI data, have been held in Thunder Bay in partnership with the FFTC and Lakehead University. Efforts to offer these information forums will continue. If you are interested in attending a workshop please contact the General Manager, Forestry Futures Trust, 807-343- 8851.

Following the implementation of the FRI calibration plot network in 2006, the FRI and Ecological Land Classification (ELC) program implemented a mandatory training program for both the field and image interpretation portions of the FRI. To date, 188 participants have attended the image interpretation training, with 71 participants becoming certified in the Boreal and 32 participants certified in the Great Lakes/St. Lawrence regions. Additionally, over 50 people enrolled for image interpretation training held in Sault Ste. Marie and Thunder Bay to support the contracted inventory projects for 2012. The field program has trained over 250 people to complete the FRI Field Calibration Plots and many of these people are trained in multiple forest areas within the province. These efforts have resulted in improved production capacity throughout Ontario's forest area.

Summer/Fall 2012 update

Imagery acquisition

Digital, airborne imagery has been acquired and is being used to generate the current cycle of inventories. The suite of imagery and image products includes the following:

- 20 cm resolution panchromatic stereo and orthoimagery
- 40 cm resolution multispectral stereo and orthoimagery
- Classified digital surface model
- Supervised water classification

Imagery acquisition began in 2007 and since that time imagery has been acquired for 508,000 sq. km. of the planned inventory lands. The planned inventory lands include the Area of the Undertaking as well as the southern portion of the Far North planning area. The imagery acquisition was completed in 2011. The imagery acquisition program was able to complete this area in half the time required for a traditional film program. With past inventory programs using traditional aerial photographs at 1:20,000 scale, roughly 25,000 photos would be required to capture the area in the Project Area. The storage of 25,000 aerial photos is relatively easy compared to the data storage capacity that the province has had to invest in for this round of inventory. Our current image acquisition program requires a data storage capacity of roughly 1.5 petabytes.

Despite the larger data storage capacity requirements, one advantage with the new inventory is the ability to have an image that can be displayed at all scales, effectively to 1:1,000 in multiple film types. To be able to do this with a traditional aerial analog camera, at 1:10,000 there would be 95,000 photos, 1:5,000, 391,000 photos, 1:2,000, 2.4 million photos and for 1:2,000 an additional 9.6 million photos. With digital imagery, FRI has all of these photos and in multiple band colour combinations without the requirement of manually handling all of these aerial photos.

Figures 1, 2, and 3 show the transition of the imagery technology, with Figure 1 being a 90 degree rotation of a panchromatic 1:20,000 analog photo. Figures 2 and 3 are the ADS digital imagery, showing the panchromatic in Figure 2, and Figure 3 shows true-colour and near infra-red data.

The Ministry of Natural Resources' Information Access Section is responsible for managing and distributing imagery and image products to all interested parties. Individuals and organizations interested in obtaining FRI imagery and image products are advised to contact the Information Access Section by telephone (705) 755-1878 or by e-mail lio@ontario.ca

There are many other benefits of digital airborne imagery that have been incorporated into the FRI production. One example of the benefits of digital imagery is the generation of a supervised water classification procedure to more accurately capture the boundaries of water features (excluding streams less than 10 metres continual width). The supervised water classification process uses the multispectral image data, as well as elevation data to delineate the boundaries of all water features. Multispectral image data allows the computer software to identify water from shadow and all other ground features, resulting in more accurate and consistent delineation of water resources. This process is referred to as "supervised", as a person must review the boundaries completed by the software; however the time and effort required to create the water information is significantly reduced. To date, supervised water classification has been delivered for Quetico and Wabakimi Provincial Parks, Big Pic, Pic River/Ojibway, Black River, Lakehead Forest, Gordon Cosens, Dog River-Matawin, Crossroute, Ogoki, White River, Red Lake, Wabigoon, Caribou, Abititbi Phase 2, Nipissing and the Cat Lake/ Slate Falls Management Units.

Digital airborne imagery also allows for the capture of digital surface models (DSM); a five metre resolution DSM was collected with the FRI program. It is important to note that the FRI program has not captured or created a new Digital Elevation Model (DEM) for the Program Area. A DEM product refers to a bare earth model and this cannot be derived from imagery that was captured in 'leaf-on' conditions. The FRI must capture imagery in 'leaf-on' conditions to identify required attributes of the FRI program, like tree species, crown closure, age, and ecosite.

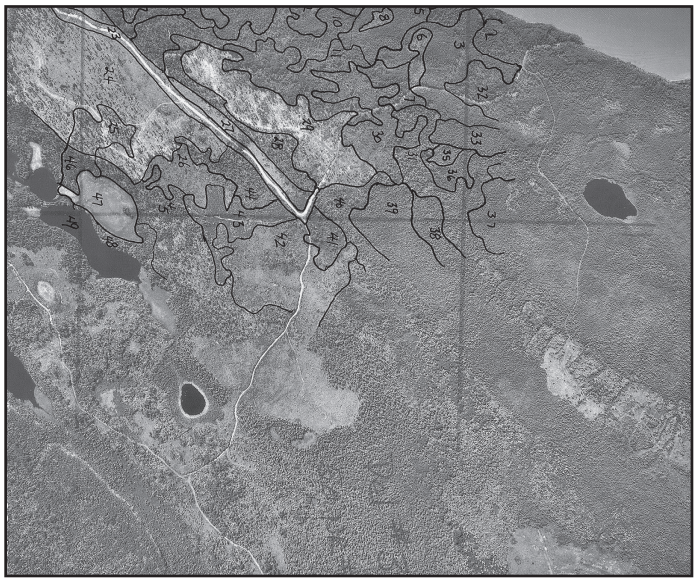


Figure 1. Panchromatic 1:20,000 analog photo.

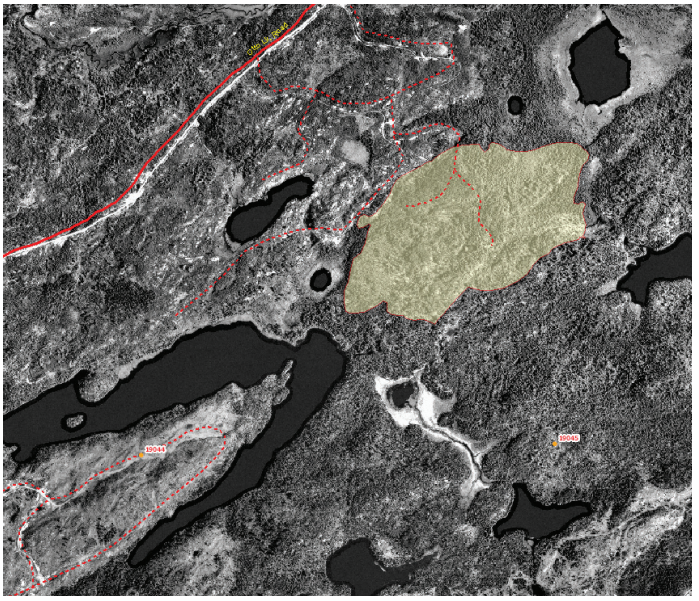


Figure 2. Panchromatic ADS imagery.

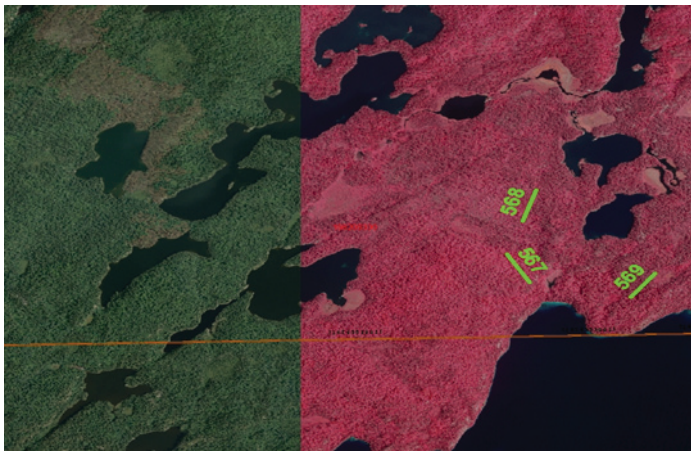


Figure 3. True colour and near infra-red ADS imagery.

The DSM refers to measured elevations of each pixel of the multispectral data (60 to 80 cm). This provides an elevation for bare earth, roads, lakes, trees, urban and residential areas. This data is collected in stereo and provides the ability to measure heights in the softcopy interpretation environment. The quality of the DSM is dependent on the quality of the ground control used in the imagery collection and is dependent on the complexity of the ground terrain and the size of the pixels. In the FRI program, DSM technology has changed significantly in the last five years. The initial five meter resolution has changed to the delivery of a new process, and derivative data set to generate the DSM, called Semi Global Matching (SGM).

The products being derived from the DSM are as follows:

- Raw 5 metre strips DSM for facilitating digital 3-dimensional viewing (crown surface level);
- Classified DSM using a supervised classification (using the 40 cm multispectral data 1, 2, 3 bands) to stratify water, ground, and forest areas;
- Semi Global Matching (SGM) is new technology that creates a very detailed elevation dataset that is referenced exactly to the imagery (an 80cm resolution); and,
- National Forest Inventory and Permanent Forest Inventory Photo Plots that have been flown to date have SGM capability.

The 2010 and newer FRI scheduled inventories have available SGM data. This data is similar to LiDAR in that it has a very accurate x, y, and z coordinate but is unlike LiDAR in that the collected data is 'passive' and not an 'active' measurement. SGM is derived using an algorithm to determine a parallax measurement of two identical geographic points, (e.g. a tree crown of white pine). When creating stereo data, the overlap of the photos creates two perspectives of the same tree crown and this is the basis of the SGM. The algorithm, in combination with imagery data that is very spatially accurate, creates a very accurate elevation point for the same geographic location.

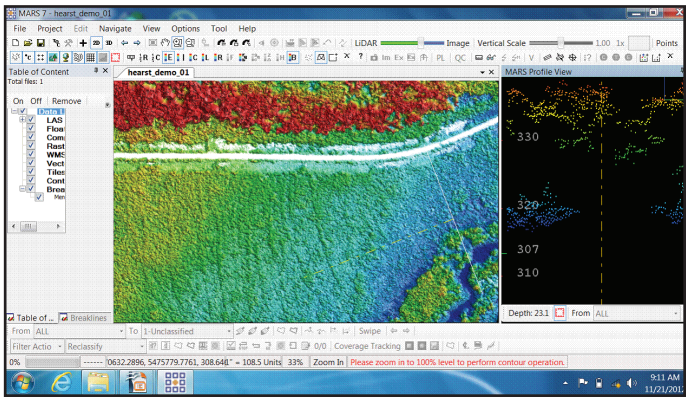


Figure 4: Sample SGM data in MARS7 software package displaying NADIR view and 3D profile.

Note: the blue colour represents the lowest elevation points, red represents the highest, and the white represents a feature with a high reflectance value (road and woody slash piles). In the bottom right corner of Figure 4, the stream channel (linear blue feature) is easily discernible as is the road (linear white feature), this elevation information in combination with the imagery should provide for more accurate representation of the landbase for land use planning.

The provincial Digital Terrain Model can be assessed for accuracy and precision and can be augmented with SGM data to add resolution to the DTM. This can result in better height measurements within the FRI. Figure 4 provides an indication of the potential of the SGM data.

Inventory production projects

The FRI production process for individual forest inventories typically spans two years after imagery acquisition: The first year includes field work, water classification and interpretation begins. The second year involves the remaining field sampling, water classification, and the majority of the soft copy imagery interpretation.

Seven new inventory production projects (the Abitibi River Forest Phase Two, Wabakimi Provincial Park, Gordon Cosens, Dog River/Matawin, Cat Lake/Slate Falls, Caribou, and Nipissing Forests) were tendered and awarded in the late summer of 2012. The 2012 FRI production year is an ambitious year as these seven inventory projects represent over 89,000 square kilometres of inventory lands and will include establishment and measurement of more than 12,000

calibration plots under the contract area. As these new inventory projects begin, completion of existing inventory projects continue. Figure 5 details the status of the existing FRI contract areas.

Calibration plots

FRI calibration plots are generally established at a frequency of one plot for every 5 to 8 square kilometres of area within a given inventory project area. Data collected from the measurement of FRI calibration plots provide photo interpreters with valuable information concerning forest conditions associated with their respective inventory projects. Photo interpreters use this knowledge of local forest conditions as an aid in the interpretation of adjacent and surrounding lands which lack ancillary data. Over 28,000 calibration plots have been established and measured since beginning the new inventory cycle in 2007.

An additional 12,150 calibration plots will be established and measured during the 2012-2013 production year.

Post inventory assessment

Traditional Forest Resources Inventories in Ontario lacked information describing the overall quality of the inventory product, however, the enhanced FRI Program addressed this and now includes post inventory assessment activities as an integral part of the inventory process. This new enhancement is intended to provide FRI end-users with a statistical evaluation of key forest inventory metrics, and promote continuous improvement in the FRI information product.

In February, 2010, a four step process was used to develop the sampling protocol, specifically:

1. User needs analysis and assessment;
2. Development and discussion of sampling protocol options;
3. Development and review of draft sampling protocol;
4. Final review and approval of sampling protocol.

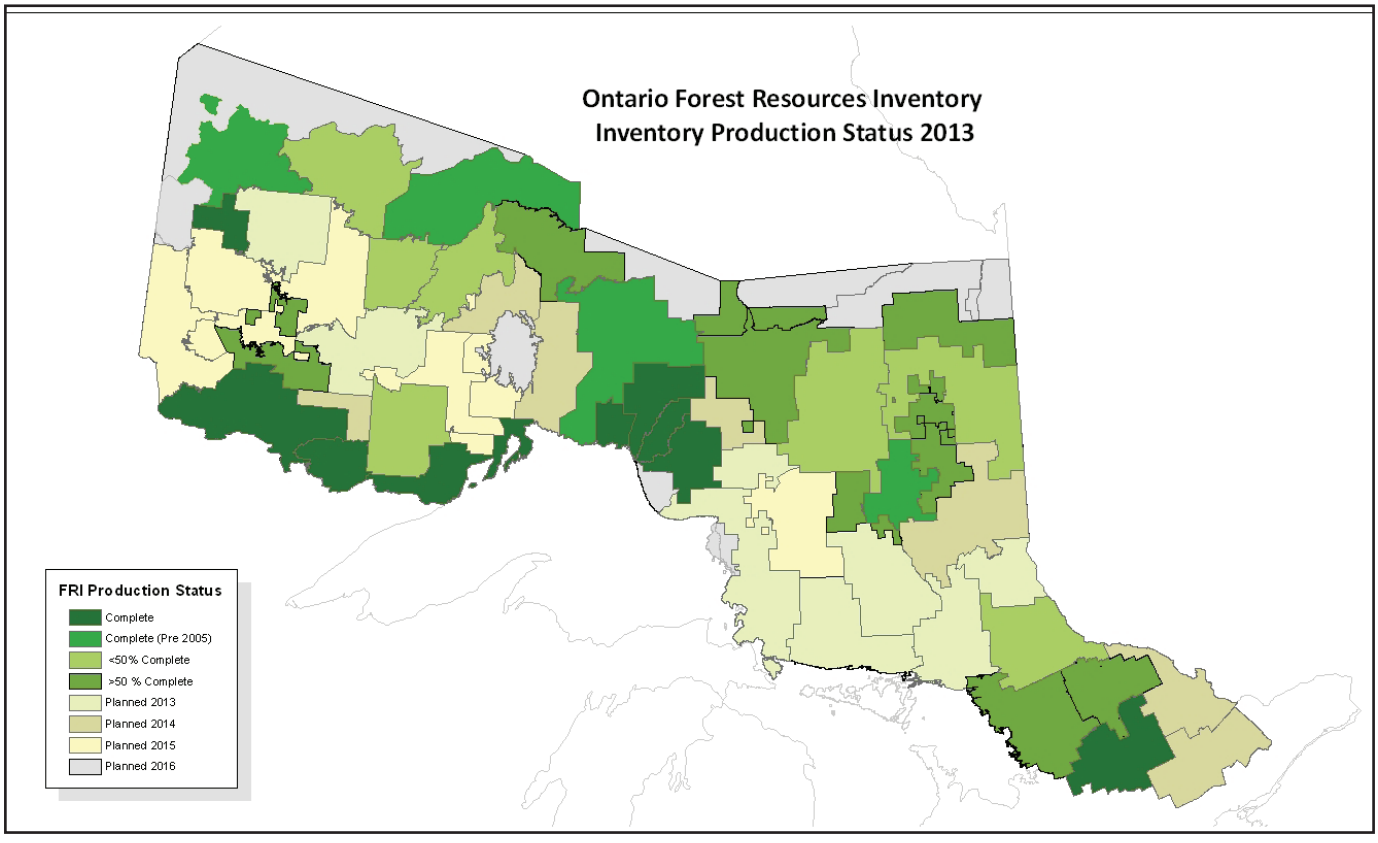


Figure 5: Status of FRI interpretation.

Personal interviews and surveys with both internal and external client groups were conducted in Timmins, North Bay, Thunder Bay, and Sault Ste. Marie. The inventory assessment procedure will report on the accuracy of the volumes generated with the new eFRI procedures aggregated to the Provincial Forest Unit.

An Inventory Assessment Plot Specifications Manual has been developed; the sampling protocols have been implemented with OMNR FRI staff and they have begun testing the procedures during the fall of 2012 on the Marathon Block. From the pilot program any procedural modifications required with the field procedures or from the analysis perspectives will be reviewed and altered where necessary before external contracting begins.

Permanent Forest Inventory Ground Plots (PFIGP)

Permanent Forest Inventory Ground Plots (PFIGP) represent another component of the FRI field program. These plots consist of a network of 0.04 hectare ground plots systematically positioned on a provincial 20 kilometre by 20 kilometre grid, which corresponds with the grid used by the National Forest Inventory program. The current objective of the PFIGP program is to capture baseline land cover and ecological data for Ontario's AOU forest, Far North and southern regions of the province. The FRI program now gathers a larger variety of information, and this data is being collected across the entire province. This will permit the direct evaluation of both traditional (forest growth and condition) and non-traditional (biodiversity, biomass, carbon, and climate change) trends in Ontario's forests. As the plots are permanent and measurements repeatable, this provides statistical rigour for the current inventory process; key to effective monitoring and reporting, and a means of validating the overall accuracy of the current inventory model. To date, over 431 PFIGPs have been successfully established, leaving 76 plots to be completed during the next year.

Permanent Forest Inventory Photo Plots (PFIPP)

Permanent Forest Inventory Photo Plots (PFIPP) are also a required component of the FRI Program and consist of two kilometre by two kilometre plots systematically positioned on the same 20 kilometre by 20 kilometre provincial grid as the PFIGPs. Similar to the PFIGPs, data collected from repeated measurements will provide statistically defendable, high value information suitable for monitoring, reporting, and modelling purposes.

The province has a total of 2524 plots that are on a ten year remeasurement cycle. To date, over 500 PFIPPs have been interpreted and automated. Up to an additional 710 PFIPPs were tendered for interpretation in the 2012-2013 fiscal year.

Please watch for future FRI updates concerning image acquisition and inventory production status.

More information:

For more information on the Forest Resources Inventory, please contact the Forest Resources Inventory Coordinator, (705) 946-7450

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