Earth Observation for Sustainable Development of Forests (EOSD): Project Overview

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Abstract- **Canada requires a next generation forest measuring and monitoring system that responds to key policy drivers related to climate change and to report upon sustainable forest development of Canada's forest both nationally and internationally. The Canadian Forest Service, in partnership with the Canadian Space Agency, is using space-based earth observation (EO) technologies to create products for forest inventory, forest carbon accounting, monitoring sustainable development, and landscape management. The Earth Observation for Sustainable Development of Forests (EOSD) initiative will work in partnership with the Provinces and Territories and develop a land cover map of the forested area of Canada.**

Research programs are also a component of EOSD to develop techniques for change monitoring, biomass estimates and automated processing to aid in production. Inputs from EOSD will be an important data source in the National Forest Carbon Accounting Framework and will also be used to enhance Canada's new plot-based National Forest Inventory. Initially EOSD, working with the provinces, territories, universities and industry, will work to develop a national map of the forested land cover of Canada with the long term goal of producing not only land cover maps, but maps of forest change over time, and biomass. The National Forest Information System will be used to integrate and synthesize applicable data and products and make them accessible to a wide range of users through the web.

Introduction

Canada s forests are vast−nearly 50% of the total landmass of the country is covered by forests[1]. Canadian forests make a significant contribution to global cycles by filtering air and water and regenerating soils and preventing erosion. Forestry is the largest industry in Canada, supporting 373,000 direct jobs and contributing over $37 billion to our balance of trade [1]. Our forests support a multibillion-dollar recreation and tourism industry. Sustainable management of forests continues to be one of the key environmental issues in Canada in the early 21st century. Environmental issues such as climate change and biodiversity are the focus for much attention in the national and international arenas.

Canada s ability to manage its forest resources in a sustainable manner is being challenged, not only in international market places, but at home as well. Our ability to respond to this criticism and deliver on our national and international commitments on sustainable forest management is currently beyond the combined capacity of federal, provincial, territorial and industrial inventory and information systems. Failure to provide these data quickly conveys a strong message to the world that Canada is a poor steward of its forest resources.

Consequently, Canada requires a forest measurement and monitoring system that can provide timely forestry information to respond, at both the national and international levels, to policy issues related to the sustainable development of Canada s forests. A next-generation measurement and monitoring system, illustrated in Fig. 1, is being developed to address key policy issues by identifying and bringing together the best available geographic information and tabular data to address these questions.

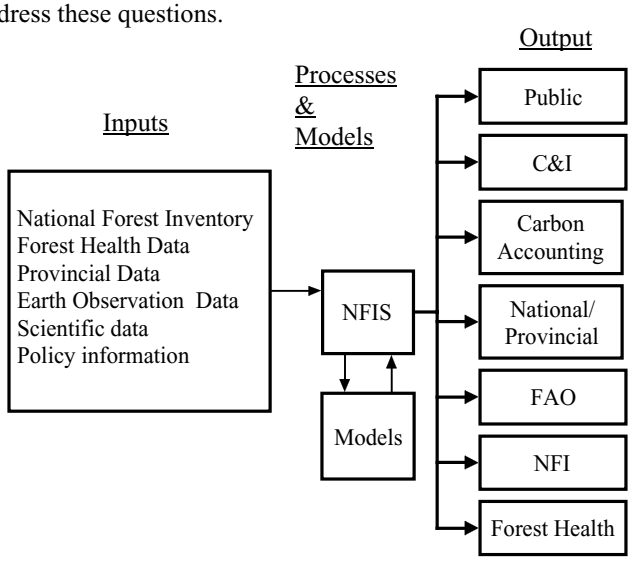

Fig. 1. An illustration of Canada s next measurement and monitoring system.

Recognizing that many complex policy questions can be neither answered by individual scientific studies nor single disciplines, many core data sets, such as inventory, earth observation products derived from satellite imagery, and other federal and provincial geographic information will be integrated using the latest data handling technologies in a nationally distributed system (National Forest Information System [NFIS]). The data within NFIS will be available to modellers to conduct analysis and generate reports.

The Canadian Forest Service (CFS), in partnership with the Canadian Space Agency has developed a new initiative using space-based earth observation technologies to create products and develop methods for the forest measurement and monitoring system. The Earth Observation for Sustainable Development of Forests (EOSD) project will produce land cover map products to support Canada s national and international reporting requirements. Research programs are also a component of EOSD to develop techniques for change monitoring, biomass estimates and automated processing to aid in production. Existing partners include the CFS, the Canadian Space Agency, Canada Centre for Remote Sensing, Environment Canada, Universities (Sherbrooke, Victoria, Calgary, Alberta, UQAT, and Maryland). Ongoing discussions are taking place with the provinces and territories on the completion of a national land cover map of forested areas. The provinces and territories are vital to the implementation process.

This paper describes the EOSD project, discusses several planned applications and concludes with a status report outlining what has been accomplished, as well as the present and future directions and priorities.

OBJECTIVES FOR EOSD

The long term goals of the EOSD Project for all of Canada s forest lands are:

- To support with space-based technology the Government of Canada s priorities and international commitments for monitoring sustainable development of its forests (Criteria and Indicators), contributing to core forest information needs of the Kyoto Protocol and the United Nations Framework Convention on Climate Change (UNFCCC), and quantifying major changes in the composition, distribution, structure and function of forests over time;
- To produce earth observation data sets and derived products which can be used as input to national and global forest inventories and as geospatial information on forest cover change, forest productivity, forest carbon stocks, and carbon and water exchange;
- To provide government, industry, academia and public access to accurate and timely spatial information of Canada s forests;
- To enhance the use in education and by academia of remote sensing as one primary information tool for monitoring the sustainable development of forests and changes in forest carbon stocks;
- To develop and apply operational information systems for providing government, industry, academic and public access to accurate and timely spatial knowledge of Canada's sustainable use of forests;
- To provide international leadership and opportunities for Canadian value-added exports of remote sensing information systems and services for monitoring sustainable development of forests.

The EOSD project has five theme areas: forest cover [2], forest cover change [3], biomass [4], automated processing research and development [5], and application of new technologies. Using satellite data as the primary data source, methodologies are being developed to map forest cover, forest change and biomass.

EOSD was initiated in the fall of 2000 with funding from the Canadian Space Agency and Canadian Forest Service. Techniques have been developed to map land cover in Canada using a classification legend that is based upon the NFI land cover classification scheme. Methods are also under development to map biomass using remote sensing, inventory, and GIS data sets. Research is also being conducted on forest cover change and natural disturbance monitoring techniques.

EOSD products include a land-cover map of forested areas of Canada that will be produced using Landsat TM data. The land-cover map will provide some NFI attributes, particularly in the north, and inputs for the National Forest Carbon Accounting Framework. Change monitoring methodologies and systems will be developed that will provide spatially explicit maps of major forest changes on a 5 to 10 year basis and more subtle changes on a sample basis with annual imagery. Maps of forest change are required to help monitor Canada s forests nationally and for the National Forest Carbon Accounting Framework. It will also assist in determining the need to revisit NFI plots. With a combination of remotely sensed data and forest inventories techniques, procedures are being developed to map the forest biomass of Canada from EOSD and using these maps to fill gaps in the national biomass inventory. Through EOSD, methods and systems will be developed and made available to the Geomatics industry for the development of value-added products.

APPLICATION OF EOSD

The EOSD project will use space-based earth observation technologies to create products to support the measurement and monitoring of the sustainable development of Canada s

forest as well as to support reporting requirements related to climate change (Kyoto Protocol) and landscape management. Monitoring of disturbance and change, reforestation, afforestation, and deforestation are essential elements. Spatial information will be produced with the aid of automation that can be used for analysis, visualization, and integration with other national spatial data sets. The analysis methodologies, visualization tools, and automated procedures are products that will benefit the value-added industry. These space-based techniques and tools will be made available to the broader forestry and remote sensing community for use at the local, regional and national levels. These products can be used on their own or in combination with Canada s National Forest Inventory via the National Forest Information System (NFIS).

A focus of EOSD will be the integration of methods and products to provide enhanced information, and to make the products available to the public and interested parties. The linkage of plot-based and earth observation data will facilitate the use of space technologies for forest management. A challenge for the project is to evolve the methods and analytical systems even as the remote sensing sources change and evolve over the course of the project.

In the fall of 1997 the Canadian Forest Inventory Committee (CFIC) and representatives from the CFS agreed on a new format for the NFI. Instead of a periodic compilation of existing inventory information from across the country, a plot-based system of permanent observational units located on a national grid was adopted. The basic design of the new NFI includes the establishment of photo and ground plots. From these photo plots calibrated with the ground plots a 1% survey of Canada s land mass will be used to generate reliable statistics. The EOSD project provides satellite data and analysis to enhance the basic NFI design through the use of a land cover mapping legend that is fully compatible with NFI and the CFIC recommendations. In addition, satellite remote sensing will provide data to the NFI by providing the attribute information for remote northern areas not covered by photo or ground plots, extending the inventory beyond the photo plots to provide information on the entire land base. In addition, EOSD data will be used to assess the extent of change and to define the need to revisit NFI plots, and to provide other area-based parameters.

Under the UNFCC, Canada is required to report the annual anthropogenic greenhouse gas emissions by source and removals by sinks from land use change and forestry in the managed forest. Once the Kyoto Protocol is ratified, Canada must ensure that it can meet the reporting provisions of the Protocol related to forest sinks to be in compliance and to obtain any potential credits for carbon sinks. Countries are required to show demonstrable progress towards the implementation of capabilities to monitor and report carbon stock changes by 2005. The EOSD project is making a significant contribution to the National Forest Carbon Accounting Framework. For example, the EOSD project will provide forest cover maps, methods for estimating biomass using satellite and inventory data, and techniques to identify areas affected by land-use change and natural disturbance events (e.g. fire, insect, harvesting etc.). The EOSD project is collecting data on intervals corresponding to national reporting commitments beginning with data representing 1990, the base year for the Kyoto Protocol. Forest carbon stocks will be generated through the integration of forest cover, inventory polygons, change detection and productivity indices.

EOSD PROGRESS

Although the EOSD project was conceived of four years ago [5], we are now a year and a half into executing the EOSD plan. To date, work has focused on planning, methodology reviews, methods development for land-cover, change and biomass mapping, data acquisition, and the development of pilot projects and plans. Workshops have been held to determine EOSD requirements and future plans. In addition, an international workshop has been held on radiometric correction and methods have been developed. A study has also been carried out to translate several provincial and international land-cover classification systems into the EOSD land-cover system Pilot regions have been established to test land-cover, change and biomass methodologies that have been developed to date. EOSD production centres will be distributed across Canada. Products created through the EOSD system will be distributed to the public via the NFIS.

The top priority for the EOSD project is the mapping of land-cover of the forested areas of Canada. It is anticipated that this will take four years to complete and will be accomplished in partnership with provinces and territories. Other EOSD priorities include biomass mapping on the non-inventoried forested areas in the north and the development of methods and systems to monitor disturbance and change events.

SUMMARY

EOSD was developed by the CFS in partnership with the Canadian Space Agency and other organizations to use space-based earth observation technologies to create products to support forest measurement and monitoring.

EOSD products include:

1. Land-cover map of forested areas for 2000 and eventually for 1990 (base year for Kyoto reporting), 2007 and 2012.
2. Methods and systems to spatially map natural disturbances and change events such as reforestation, afforestation, and deforestation and eventually map these for the above dates.

3. Inventory and remote sensing techniques to map forest biomass plus biomass maps integrated with products from the land cover and change themes.
4. Automation methods and systems to achieve economies of scale and achieve quality control standards at widely dispersed production centres.

These EOSD products are important for the National Forest Inventory and the National Forest Carbon Accounting Framework. EOSD products will also be made freely available over the web to the public and other interested parties. The linking of ground and space-based data will facilitate the use of space technologies in forest management systems. The methods and automated procedures developed under EOSD themselves are products that will be available to others. It is anticipated that after the successful completion of the EOSD project, satellite imagery and analysis methods will be a major component of an operational system to monitor and report on Canada s forests.

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