Moving Boreal Conservation Forward Through the Development of a New Remote Sensing-Based Approach to Earthcover Inventory

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Abstract

The Western Boreal Forest is a vast and largely unspoiled region that is home to some 13 million breeding ducks and a myriad of other wildlife. However, this region is also rich in natural resources and the increased development of oil and gas, mining, and forest industries has generated an urgent need for information that will help advance sustainable resource development and wise land-use decisions across the western boreal forest. Conservation planning and delivery throughout most boreal regions is often limited by a lack of high quality and current landscape-level datasets necessary to help advance sustainable development practices. To address this information gap, Ducks Unlimited Canada and Alberta-Pacific Forest Industries Inc. (Al-Pac) have established a multi-national partnership-based approach that combines industry, government, universities, and not-for-profit conservation agencies to produce landscape-level inventories including: satellite-based earth cover mapping; waterbird and riparian bird surveys; and water chemistry analyses. One such plan is being developed with (Al-Pac) on the 5.8 million-hectare (14.3 million acres) Forest Management Agreement (FMA) area in northeastern Alberta. This paper describes new technologies and methodologies that were developed to provide the baseline earth cover inventory for the FMA using newly developed, region-based eCognition software. Helicopter-based field surveys, Thematic Mapper (TM) and Radarsat SAR imagery, and Al-Pac AVI GIS layers were the input datasets for the classification. New technologies being developed as part of the Canadian Wetland Inventory (CWI) were also integrated to provide enhanced wetland maps for the Al-Pac FMA. The detailed datasets on earth cover and wetland types are the first of their type for the boreal region of Canada, and ultimately will be used in conjunction with the other inventories to assist watershed-based conservation planning, which benefits society, the environment, and the economy.

Keywords

Boreal wetlands, remote sensing, region-based classification, wetland mapping, conservation planning
Introduction

The Western Boreal Forest (WBF) of Canada, covering >3 million km², (300 million ha) comprises part of the largest forested region in the world. In addition to vast timber reserves, this region encompasses tens of thousands of km² of lakes, rivers, inland deltas and wetlands (i.e. marshes, bogs, fens and swamps), providing critical breeding, staging and molting habitat for North American waterfowl and other water birds. Little scientific information exists on waterfowl and water birds on many of these wetland systems, and less still is known about their values to the environment, the economy, and to society. Populations of certain waterfowl species have been declining over the past 20 years and reasons for these declines are unknown. Ducks Unlimited’s (DU) Western Boreal Program is working with partners in collecting much of the required scientific information on wetlands and water birds to advance sustainable development and protect key wetland systems.

The partnership of Ducks Unlimited, Inc. and Ducks Unlimited Canada has been mapping boreal habitats in Alaska since 1988 and more recently, in western Canada since 1998. To date, with the help of outside agencies and partners, DU has completed mapping on (or currently mapping) over 160 million acres (65 million ha) in Alaska and 126 million acres (51 million ha) in western Canada to help advance conservation in the boreal forest of North America (Figure 1).

DU’s approach is to map the boreal forest as an entire ecosystem using a standardized hierarchical classification scheme that is suited to analysis at multiple scales. This approach has proven to be more cost effective and ultimately more useful to resource managers for decision-making purposes. The data is openly shared with a wide variety of partners who have participated, through funding or data sharing, in our mapping and conservation planning efforts. DU’s mapping protocol consists of:

- Extensive helicopter-based ground-truthing.
- Experienced remote sensing specialists.
- An advanced suite of image analysis and GIS software.
- An applied methodology that generates high quality map products.
In northeastern Alberta, DU is working with Alberta Pacific Industries, Inc. (Al-Pac) and other partners to achieve and sustain the ecosystem health on the Al-Pac Forest Management Area through proactive watershed-based conservation. Identified as the “Boreal Conservation Project”, an important information need is to collect high quality and current landscape-level ecological datasets necessary to help advance sustainable development practices. New technologies and processes to provide such an earthcover and enhanced wetland inventory throughout the Al-Pac FMA will be used in conjunction with other inventories to assist in watershed-based conservation planning, which benefits society, the environment, and the economy. This information will also help implement an adaptive management approach, where we can assist in the development and testing of best management practices to help ensure that the boreal forest continues to produce economic and ecological returns.
Methodology

**Derivation of Earth Cover Inventory Database**

To address the information needs of the Boreal Conservation Project, a detailed earth cover mapping project was undertaken in 2002 for the Al-Pac FMA. The project was completed in early 2004. The goals of the earth cover mapping effort were to provide an accurate base map of earth cover types to be used in conjunction with other datasets to perform analyses that will provide information to assist conservation planning efforts.

The procedure used to generate the base layer earth cover maps is shown in Figure 2. The main benefits of this procedure are:

- Used to map over 286 million acres in a fifteen year period
- Extensive field sampling – helicopter based for orthogonal viewpoint
- Standardized earth cover class hierarchy
- Classification is mutually exclusive and totally exhaustive
- Complimentary to Canadian Wetland Inventory (CWI) classification
- Detailed Accuracy Assessment

![Figure 2. Earth cover mapping processing methodology.](image-url)
The classification procedure is region-based and uses segmentation techniques to cluster groups of similar pixels. While pixel based classifications typically only utilize spectral features, these region-based segments can be classified using spectral, spatial, and relational features that allows for more detailed classification of earth cover types. Helicopter based field sample sites are divided into two groups: two-thirds to train the classification, and one-third to provide a detailed accuracy assessment. A detailed report outlining the Al-Pac classification (Ducks Unlimited, 2004) can be obtained by contacting the corresponding author.

The final earth cover classification for the 8.3 million acre Al-Pac study area is shown in Figure 3. The 40 earth cover classes mapped included the major forested and non-forested vegetation types, as well as land use classes such as agriculture and urban, and recent fire areas. The overall accuracy at the +/- 5% level of variation was 77%. This base-layer dataset provides resource managers, researchers, industry, and other institutions with a detailed earth cover inventory dataset.
Figure 3. Earth cover map of the Al-Pac project area.

**Post Classification Products**

Many forest inventories are geared primarily as a timber inventory (as opposed to an ecosystem-based inventory) with an emphasis on the productive land base (productive in the sense of managing merchantable timber). As such the non-merchantable areas of the traditional forest inventory (e.g. Alberta Vegetation Inventory or AVI) may not be completed or detailed enough for large areas of many forest management areas. This presents limitations when developing forest management plans and subsequent operations.
that are sensitive to various wetland conservation strategies. The earth cover inventory, which is satellite based and at a coarser resolution than the aerial photo-based timber inventories, is intended to be complimentary to, and not a replacement for the existing inventories.

One of the post classification products of the earth cover inventory is a wetland classification layer, which provides detailed information about wetland types in the non-merchantable wetland areas (Figure 4). One of the advantages of this dataset is that because of the larger spatial coverage of classified areas (not just stand-specific areas within an FMA boundary), this allows for resource managers to look at watershed-based analyses and management plans.

![Wetland Classification](image)

**Figure 4.** Example of the wetland classification for non-merchantable timber areas.

Many other post-classification products to aid conservation planning are possible with the base datasets of earth cover and wetland classifications. As more of the data-gathering inventories such as water chemistry analysis, waterbird surveys, and research such as hydrologic flow regimes, nutrient transfer in different wetland systems, and other information is gathered, these datasets will be incorporated with the existing earth cover and wetland inventories to provide more detailed and more robust conservation planning tools.

**Discussion - Benefits to forest industry**

The uses and benefits of the earth cover and wetland inventory datasets described in this paper are as follows:

- Forest management planning – e.g. assist with road placement and zoning of the landscape for hydrologic risk and eventual linkage to Best Management Practices as they relate to water/wetland conservation.
- Potential for a cost saving if an inventory (and updates) of the lowlands can be completed via satellites (wetland classification) vs. a photo-based inventory.
• Provides for a more complete inventory suitable for ecosystem-based forest management.
• Can assist in biodiversity conservation strategies for wetland-oriented species (e.g. woodland caribou) by providing additional inventory information.

These inventory datasets, used in conjunction with other boreal inventory products, can provide information that may be used by the forest industry for:
• Development of forest management plans – helps fill in the gaps on wetland communities and associated values
• Forest certification schemes (e.g. CSA, FSC). Can be used as a baseline that can be monitored over time with periodic updates.
• Water chemistry and waterbird survey data can be used as a baseline indicator for long term monitoring of the influence of forest management on water quality.
• Use of all inventory datasets for modeling applications to provide critical information for conservation plans.

Summary

This paper presents a broad overview of the earth cover and wetland inventories being processed for large portions of the boreal forest of Canada, and their uses to promote conservation planning efforts. An example of how these datasets can be applied to a forest management area is shown for the Al-Pac FMA in Alberta. Ongoing research, inventory data collection, and classification of additional areas in the boreal forest will continue to close the information gap, and provide resource managers, researchers, industry, government agencies, and other organizations with critical information to promote conservation planning throughout the boreal forest. These efforts are part of the Western Boreal Program of Ducks Unlimited Canada’s Boreal Vision:

An ecosystem of forest, rivers, wetlands, and lakes that will continue to sustain the historical diversity and abundance of wetlands, waterfowl and associated water birds.
References