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Using satellite remote sensing to monitor and assess ecosystem integrity and climate change in Canada's national parks

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Canada's national parks system includes 42 parks that cover 3 percent (296 253 square kilometres [km^2]) of the country's land mass and represent the full diversity of its natural regions. Considering the vast and often remote areas under protection, Parks Canada Agency (PCA) envisions Earth observation (EO) technology to be an integral component of a national Ecological Integrity Monitoring and Reporting Program.

Natural Resources Canada (NRCan), PCA and the University of Ottawa are developing standardized EO-based methods for monitoring landscape and ecological change within and surrounding Canada's forested national parks. This work is supported by the Canadian Space Agency (CSA) under the Government Related Initiatives Program (GRIP).

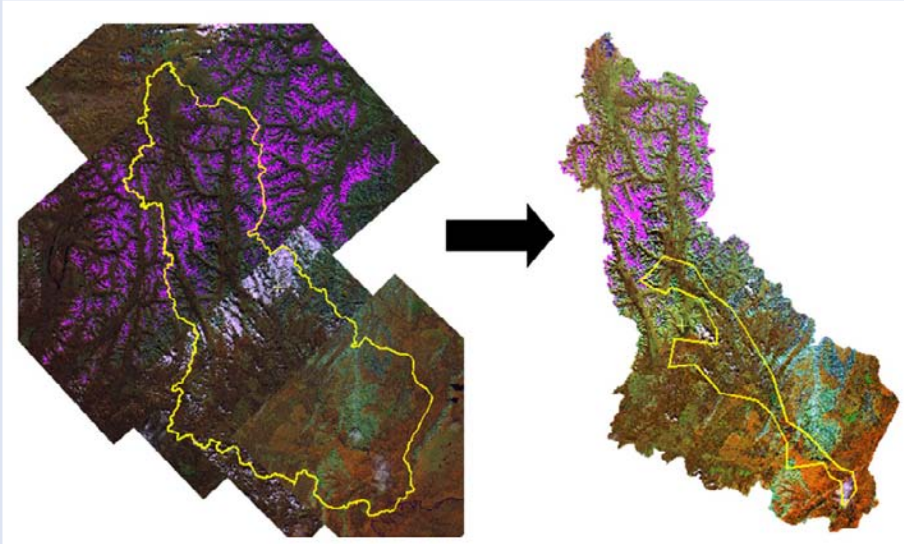

Figure 1. Satellite image processing for the Nahanni National Park Reserve

In Figure 1, six Landsat images covering the greater park ecosystem (GPE) of the Nahanni National Park Reserve of Canada (left) were radiometrically normalized to produce a seamless mosaic (right) for land cover classification. The yellow outline shows the GPE boundary (left) and park boundary (right).

Figure 2. Flat tower in Prince Albert National Park

Flat tower measurements of the inter-annual variations of annual net primary productivity (NPP) in Prince Albert National Park has shown ranges from 0.4 to 0.7 kg carbon/m^2.

Land cover and land use change

Land cover and land use change are often the major factors that impact the ecological integrity (EI) of terrestrial ecosystems. Although changes that occur within national parks are generally smaller than those in the greater park ecosystems, both have a strong effect on the species and processes that maintain EI. Land cover provides a key input to quantifying habitat fragmentation and its influence on an ecosystem and is an important variable for modelling plant productivity and biodiversity.

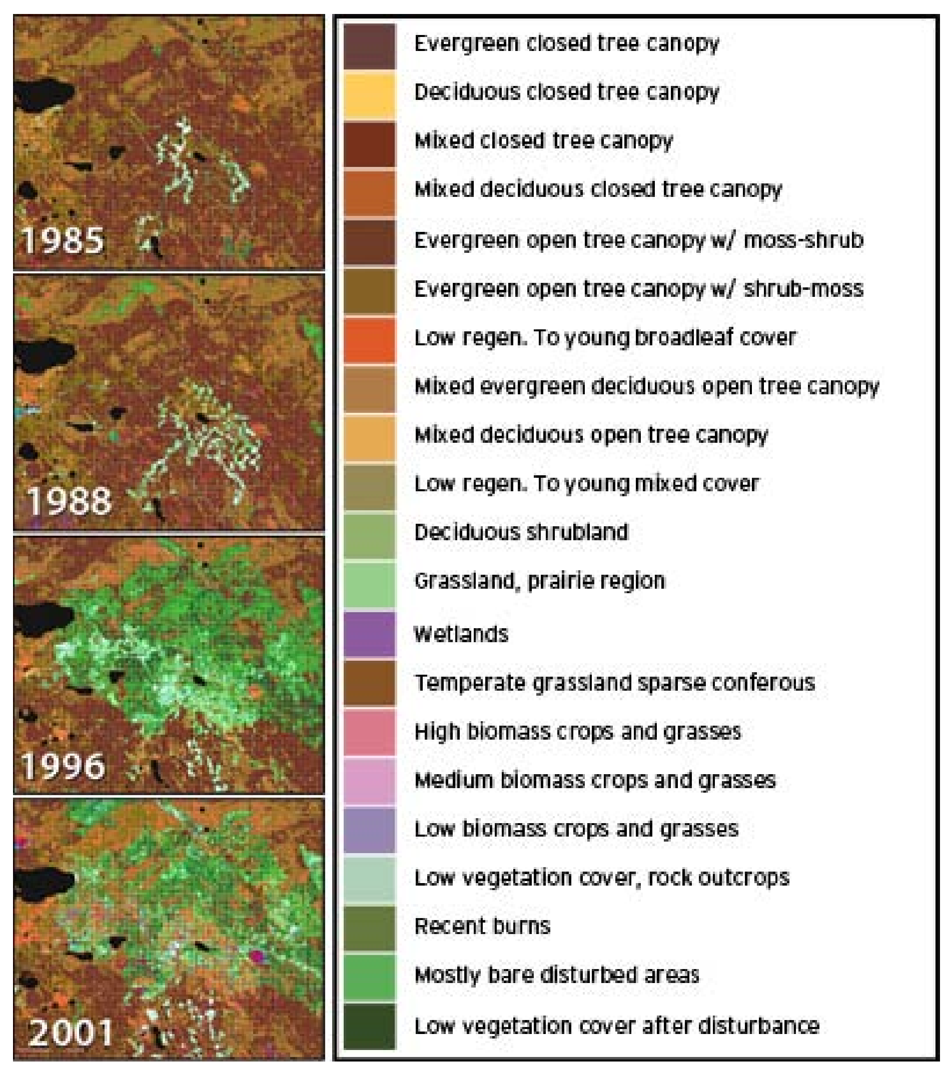

Figure 3. Changes in Prince Albert National Park, 1985 to 2001

Figure 3 shows that significant vegetation disturbance has occurred in the Prince Albert National Park Greater Park Ecosystem, resulting in local losses of closed canopy ecosystems and an increase in open canopy and grasslands.

Detecting change

NRCan scientists have developed a protocol called Automated Multi-temporal Updating by Signature Extension (AMUSE) that automates detecting change in land cover as much as possible while still employing expert analyst guidance and quality control. The procedure was developed by using Landsat TM and ETM+ data and consists of seven major steps:

1. Radiometrically normalize baseline (master) imagery to 1-km imagery.
2. Produce a master baseline land cover classification.
3. Remove haze and topographic effects.
4. Radiometrically normalize imagery from other dates to the master classification.
5. Identify changed pixels by using change vector analysis.
6. Update land cover by using constrained signature extension.
7. Validate the baseline land cover and changes.

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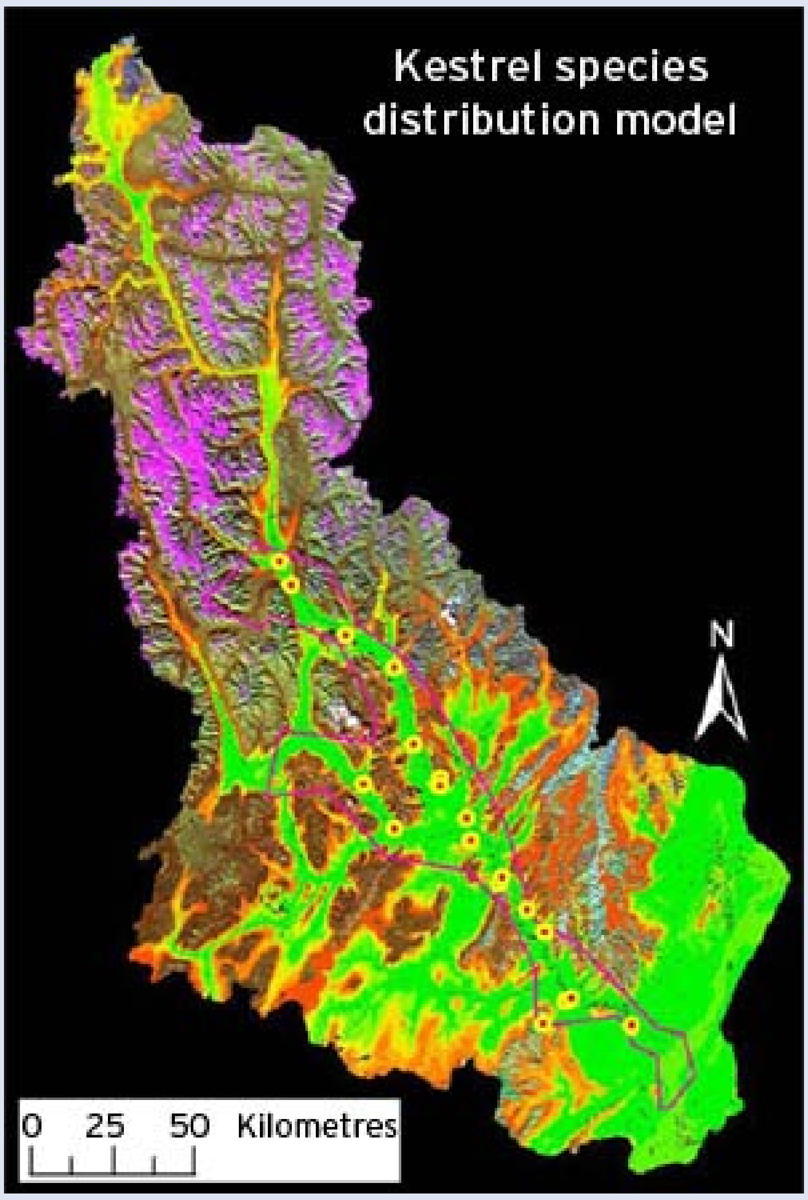

Figure 4. Kestrel niche model

Species distribution modelling is performed with DesktopGarp (Genetic Algorithm for Rule-set Production) and maximum entropy techniques based on species observations, land cover and elevation. Figure 4 shows the American Kestrel (Falco sparverius) in the Nahanni National Park Reserve. Green areas indicate the likely distribution of the Kestrel.

Six national parks served as pilot sites to develop, test and demonstrate the methods for change mapping. The Kejimkujik, La Mauricie, St. Lawrence Islands, Prince Albert, Nahanni and Pacific Rim national parks represent a range of forested bioregions across the Parks Canada system.

Results

The resulting time series of land cover data can serve as a primary input for deriving various landscape-level EI indicators related to habitat fragmentation, succession and retrogression, net primary productivity (NPP), and focal species distributions. The methods developed in this collaborative project will be applied by PCA to provide information for future *State of the Parks Reports*, beginning with Pacific Rim National Park in 2008.

A joint follow-on project by Parks Canada Agency and the Canada Centre for Remote Sensing is now underway, with funding from the CSA, to develop satellite-based EI monitoring methods for Arctic and sub-Arctic parks. This ParkSPACE initiative will focus on detecting and quantifying the impacts of climate change on vegetation, permafrost and wetlands.

References

R.H. Fraser, I. Olthof, and D. Pouliot, 2009. "Monitoring land cover change and ecological integrity in Canada's national parks." *Remote Sensing of Environment* 113:1397-1409.

Acknowledgement

This work was generously supported by the Canadian Space Agency's Government Related Initiatives Program (GRIP).

Cat. No. M114-23/2011E-PDF (On-line)
ISBN 978-1-100-19036-5