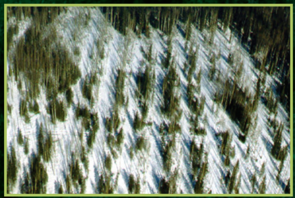
EMEND




ECOSYSTEM-BASED MANAGEMENT EMULATING NATURAL DISTURBANCE

EMEND Insights #14

Seeing the forest through new eyes: using remote sensing data to understand forest responses to variable retention harvesting

Research led by Wiebe Nijland, Nicholas Coops, Ellen Macdonald, Scott Nielsen, Christopher Bater, Barry White, Jae Ogilvie, and John Stadt

Ecological Messages:

- Pre-harvest forest productivity was a strong indicator of post-harvest productivity and regrowth.
- Wetter sites had lower productivity than drier sites for all four forest cover types.

Management Implications:

- LiDAR and Landsat imagery are both able to efficiently capture fine-resolution information on forest structure and productivity across large, complex landscapes.
- Landsat imagery can be used to predict forest productivity, while LiDAR can be used to monitor stands for re-growth and structural retention targets.

Recent advances in remote sensing technology have made information on forest structure and composition available over large areas at an unprecedented resolution. Light Detection and Ranging (LiDAR) and publicly available Landsat images now have the potential to inform estimates of stand-level structure, site productivity, and stand regrowth. These advancements could improve the efficiency and reliability of large-scale forest inventories.

However, it was previously unclear whether these remote sensing tools can be used effectively in forests with large variation in canopy tree species or where retention harvesting has been employed.

The potential applications of LiDAR and Landsat in forest management planning were explored in a study on the EMEND landscape. EMEND contains sites representing a range of forest cover-types, partial retention harvest treatments, and stand productivity levels, providing an ideal opportunity to test these remote sensing tools.

We found that LiDAR and Landsat were effective for characterizing the varying stand types at EMEND. These tools were useful for assessing pre-harvest site productivity, predicting vegetation re-growth, and characterising forest residual structure following partial harvesting.

Clearly, LiDAR and Landsat provide exciting opportunities for forest managers to complete forest inventories and monitoring in a more efficient, accurate way than traditional techniques like ground surveys and interpretation of aerial photographs.

Remote sensing tools will help characterize forest structure and productivity in complex landscapes. Photo by J. Witiw (DMI).

Modern tools for modern challenges

Aerial photo interpretation and ground surveys have long been staples in forest management inventories and planning. However, they can be time consuming, expensive, and prone to errors. For example, manual interpretation of aerial photographs can be very time consuming and is limited by the resolution of the images and what is visible in them. Field surveys, in contrast, make it possible to capture information at a finer scale and below the canopy, but it is difficult to sample enough plots to fully represent a large area, much less a landscape.

Remote sensing technologies are advancing to fill the need for accurate, high-resolution, landscape-scale information. Light Detection and Ranging (LiDAR) and long-term Landsat imagery can now be used to obtain large amounts of information comparatively quickly, and at a very fine scale (less than one meter for LiDAR). They present an exciting opportunity to expand and improve the information available for forest management.

Like any new tool, there is a need to test these technologies before adopting them: how well do they perform, and are they appropriate for the job at hand? The landscape at EMEND provides the perfect testing ground. The patchwork of forest types, harvest treatments, and site conditions represents a wide range of stand- and landscape-level complexity for testing these tools.

About EMEND:

The Ecosystem-based Management Emulating Natural Disturbance (EMEND) Project is a multi-partner, collaborative forest research program. The EMEND project documents the response of ecological processes to experimentally-delivered variable retention and fire treatments. The research site is located in the western boreal forest near Peace River, Alberta, Canada, with monitoring and research scheduled for an entire forest rotation (i.e. 80 years).

Can we use remote sensing to derive site productivity across a landscape?

Site productivity is an important metric in forest management, providing forest managers with key knowledge about forest growth rates and regeneration potential following harvesting. Traditionally, edatopic grids have been used to assess site productivity by pairing a site's nutrient regime with its moisture regime. However, a core limitation is the requirement for detailed site information. This information is often collected by field crews, which can be costly, and limits the spatial area that can be covered by sampling.

We tested whether Landsat imagery could be used to estimate the pre-harvest productivity of stands on a landscape, and whether topographic information and moisture regimes derived from LiDAR data and the Wet Areas Mapping tool could be used to predict vegetation regrowth following variable retention harvesting.

Box 1. The Remote Sensing Toolbox:

Vegetation structure (LiDAR): High-resolution measures of forest vegetation (including vegetation under the canopy) can be used to evaluate effects of variable retention harvesting, including monitoring regeneration and comparing stand structure among disturbance types.

Wet Areas Mapping (LiDAR): Soil moisture estimates based on fine-scale differences in topography can be used to predict site productivity and identify operationally sensitive areas.

Long-term Landsat imagery: Landsat images can be used to derive an indicator of productivity known as NDVI (Normalized Difference Vegetation Index). By measuring variations in this indicator, pre-harvest time series can be used to evaluate site productivity and predict site-level regeneration potential.

Example WAM output of the south end of the EMEND project area. Dark grey represents areas predicted to have relatively high moisture (from Nijland et al. 2015a).

Stand composition was found to vary along a moisture gradient. Photo by J. Witiw (DMI).

We measured variations in pre-harvest productivity using a series of Landsat images collected from 1990–1998 (see Box 1), which allowed us to accurately predict site productivity and vegetation regrowth. Unsurprisingly, sites we identified as highly productive also had rapid regrowth following harvesting. This finding reinforces the importance of a forest's history in predicting its future trajectory, and may allow forest managers to predict how well a forest stand will recover following harvesting.

Furthermore, combining Landsat and LiDAR data allowed us to accurately differentiate forest cover types across the landscape. They generally followed a gradient of increasing moisture across the landscape, with aspen-dominated stands on drier sites and an increasing coniferous (spruce) component as sites became wetter. These results suggest that stand composition in mixedwood boreal landscapes may not only be influenced by time since disturbance. Mixedwood stand composition has long been thought to be linked to stand succession, with aspen typically dominating shortly after disturbance and stands transitioning to conifer-dominated forests over time. However, this study and other work at EMEND suggest that the relationship may be more complex, with moisture regimes playing an important role.

Our results demonstrate that both Landsat imagery and LiDAR data paired with the Wet Areas Mapping tool could effectively distinguish among sites varying in productivity on a landscape. This information helps explain the landscape-scale distribution of forest types as well as patterns and rates of vegetation regrowth after disturbance. ***These methods could prove helpful in conducting efficient, landscape-level predictions of forest growth following disturbances.***

Can we use remote sensing to monitor changes in forest structure following harvesting?

We found that LiDAR data could be used to reliably detect subtle differences in forest structure arising from variation in retention levels and cover-types across the EMEND landscape. Data collected using LiDAR revealed information about stand characteristics that cannot be captured by conventional ground-based measurements, such as canopy closure or basal area. These nuances in stand characteristics detected by LiDAR have important implications for stand productivity, understory diversity and productivity, and wildlife habitat values.

From our work, it is clear that LiDAR presents an efficient way of assessing stand structure after harvesting, and could prove useful in monitoring structural retention targets or changes in structural attributes over time. Further, it could be used to compare the structure of stands subjected to innovative harvesting approaches with those resulting from natural disturbances, such as wildfire.

Remote sensing tools are sensitive to differences in stand structure after retention harvesting. Photo by J. Witiw (DMI).

Management Implications

Forest management is occurring on a large scale across complex mixedwood landscapes, and the forest industry in Alberta is held to a high environmental standard. As a result, forest managers need the best possible information to produce long-term plans for harvesting, operations, monitoring, and adaptive management.

Our studies have shown that remotely-sensed data derived from LiDAR and long-term Landsat imagery can be used to predict site-level productivity and capacity for post-harvest regrowth across landscapes.

Further, LiDAR data can be used to characterize subtle differences in vegetation structure that are indicators of forest productivity, vegetation regrowth, and habitat value. This information could be used to determine whether a harvest treatment is achieving structural retention targets, compare the structure of partial retention stands to that of burned stands, and monitor changes to structure over time.

Whether planning harvesting, assessing performance against objectives or regulations, or monitoring stands for adaptive management, these new and improved remote sensing tools be extremely valuable for characterizing and understanding our forests.

Further reading

Nijland, W., N. C. Coops, S. E. Macdonald, S. E. Nielsen, C. W. Bater, B. White, J. Ogilvie, and J. Stadt. 2015a. Remote sensing proxies of productivity and moisture predict forest stand type and recovery rate following experimental harvest. Forest Ecology and Management 357:239–247.

Nijland, W., N. C. Coops, S. Ellen Macdonald, S. E. Nielsen, C. W. Bater, and J. Stadt. 2015b. Comparing patterns in forest stand structure following variable harvests using airborne laser scanning data. Forest Ecology and Management 354:272–280.

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