

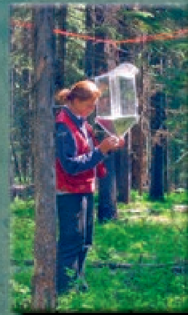

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A technique for mapping the impact of mountain pine beetle

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Strategic Importance

Infestations of mountain pine beetle, *Dendroctonus ponderosae,* are a major forest disturbance affecting mature lodgepole pine stands in western North America. In the central interior region of British Columbia populations of mountain pine beetles have reached epidemic proportions. Therefore, detection and mapping of trees killed by beetles is critical information for effective and efficient forest management.

Currently, killed trees are detected by aerial surveyors noting their locations (Figure 1). Satellite imagery offers advantages over aerial surveys because the data is continuous, processing is unbiased and the locations are geometrically accurate. This note presents a technique, called the Enhanced Wetness Difference Index, for mapping red-attack trees (trees with red needles following severe mountain pine beetle attack) using satellite imagery.

Figure 1. Mixture of healthy and attacked trees. The red trees are those where the needles have dried up and turned red (red-attack). After some time the needles will drop off as in the grey trees (top-center of photo).

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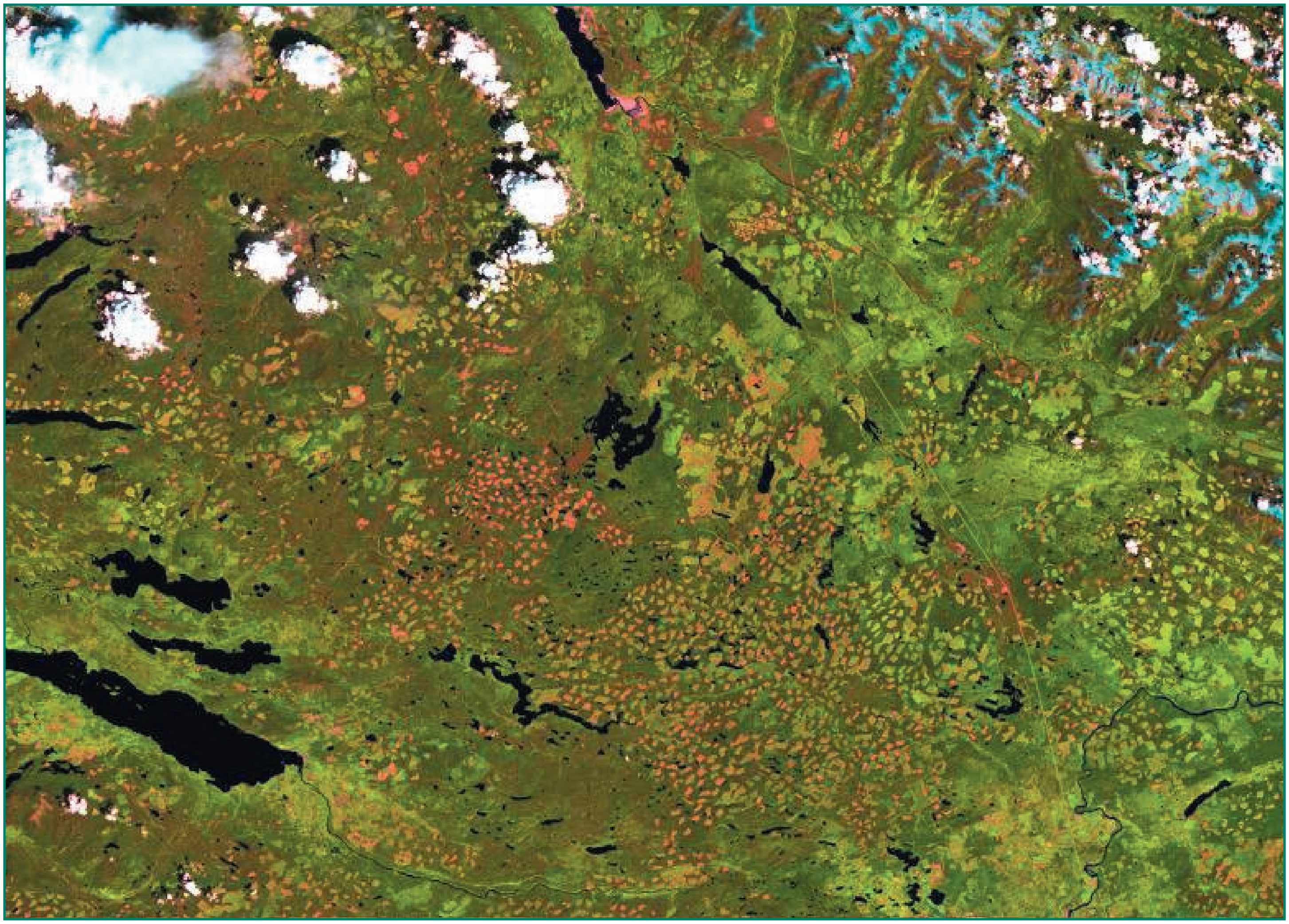

Figure 2. Example Thematic Mapper scene from the Prince George area acquired on June 26, 2000.

The Advantages of Satellite Imagery

One advantage to using satellite images in mapping red-attack trees is that they contain continuous data across the landscape (Figure 2). In this way, all trees are examined for possible red-attack, independent of accessibility or position in a watershed.

Another advantage is that satellite imagery mapping is unbiased. The application of documented techniques reduces the influence of the person doing the work. By not using visual interpretation, the products have greater consistency and reliability between different areas or dates.

Greater reliability also results from the high locational accuracy of imagery data. The standard pre-processing of satellite images results in data that can be confidently integrated with forest inventory polygons and other spatial data sets (e.g., habitat maps).

Using Satellite Imagery

Satellite imagery can be used with a technique called the Enhanced Wetness Difference Index (EWDI) which was developed specifically for mapping trees killed by mountain pine beetles (Skakun et al. 2003). This technique uses the low moisture content of dead tree crowns to distinguish them from healthy trees. The system is calibrated with ground plots so the results can be reliably tied to ground-based activities. The resulting map is tested with similar plots so that the accuracy and reliability are known.

The EWDI can, for example, be used to update forest inventory databases. This was done for a 500,000 ha landscape near Prince George, B.C. to account for the impact of mountain pine beetle.

The first step was to acquire satellite imagery from 2000 and from 2001. Because of the size of the area, costs were kept minimal by using 30 m resolution imagery from the Landsat Thematic Mapper (TM) sensor (Figure 2). Changes in the forest cover were somewhat visible when comparing the raw imagery from year to year.

The second step was to enhance that change by calculating the EWDI (Figure 3).

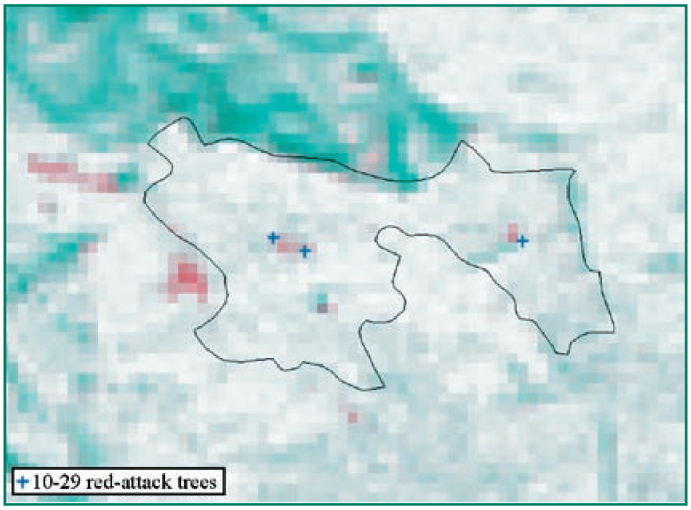

Figure 3. Example of EWDI depicting forest change (outlined area) on a forest stand. Red areas have become drier. White and blue areas have no change or have become wetter. Crosses are aerial survey points of small red-attack clusters.

The third step was to use ground observations to classify red-attack areas (Figure 4).

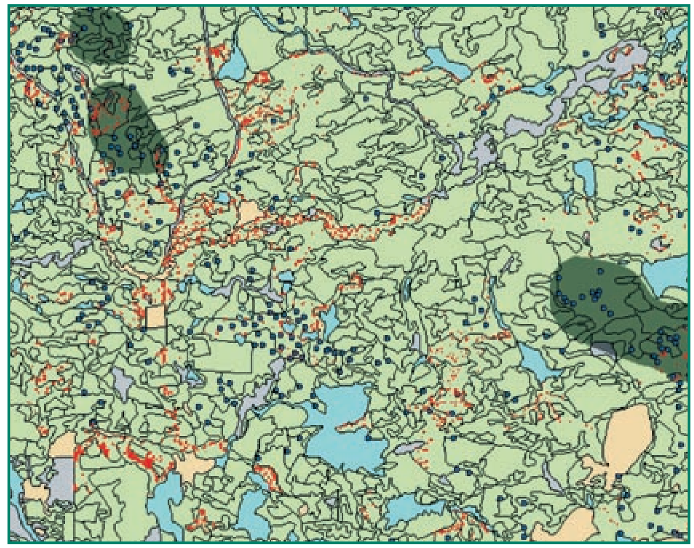

Figure 4. The red dots are 30 x 30 m cells containing red-attack trees detected using EWDI. The underlying data shows the forest inventory polygons: green = working forest, blue = water, yellow = cutblocks, grey = unproductive forest.

The classification product was then compared with helicopter survey points locating stands with red trees. The map had an overall accuracy of 74% (Table 1.)

Table 1. Accuracy assessment for EWDI classification based on 180 aerial survey points.

	User's accuracy[1]	Commission error[1]	Producer's accuracy[2]	Omission error[2]
Unattacked forest	72%	28%	80%	20%
10-29 red- attack trees	73%	27%	67%	33%
30-50 red- attack trees	78%	22%	75%	25%

1. User's accuracy indicates how reliable the red-attack would be if you were to take it out in the field. For example, seventy-three times out of a hundred, the mapped small clusters of red-attack would be small clusters of red-attack when you visited them. The flip side of this is the Commission error. Twenty-seven times out of a hundred, those mapped small clusters would not be red-attack trees.

2. Producer's accuracy indicates how much confidence there is in the map produced. For example, out of a hundred helicopter survey points locating small clusters of red-attack trees, sixty-seven of them were accurately mapped. The remaining thirty-three were missed or omitted. This is referred to as the Omission error.

Once the red-attack was mapped, the last step was to integrate the information into the forest inventory database. Polygon decomposition was used in this step. The pixels classified as red-attack were located within each polygon and tabulated to indicate the area and proportion affected (Figure 5). The result is additional information in a GIS format that forest managers currently use in making decisions.

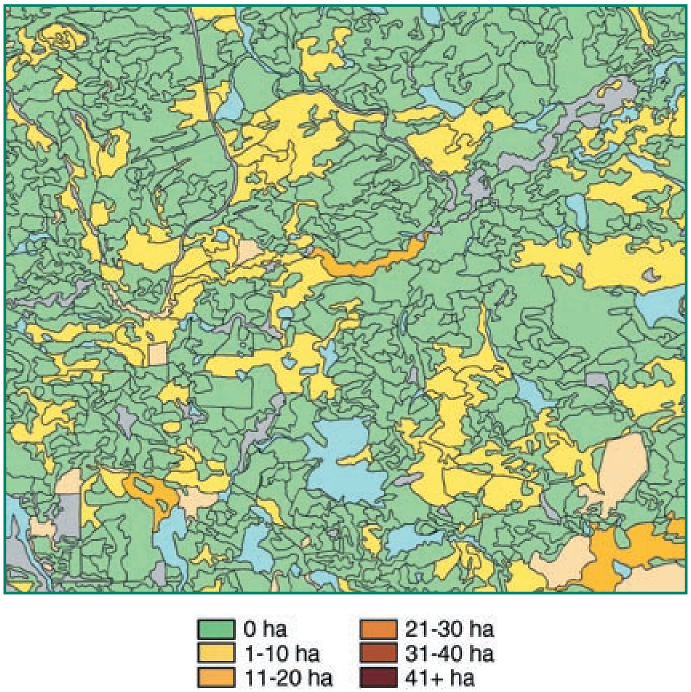

Figure 5. Result of polygon decomposition procedure showing integration of detected red-attack and forest inventory. Colours denote area (ha) of red-attack within a forest polygon.

Conclusions

The Enhanced Wetness Difference Index and satellite imagery can be used to map changes in a forest. Forest inventories can be updated to reflect those changes, including volume losses caused by mountain pine beetle.

With this up-to-date information, managers can make cost-effective management decisions such as harvesting and planting plans. Furthermore, a manager can determine the impact of mountain pine beetle on timber volume. This information can also be used as input for growth and yield models, timber supply reviews and land-use planning.

For further information on implementing this technique, see the following documents:

Franklin, S.E.; Wulder, M.A.; Skakun, R.; and Carroll, A. 2003. Mountain pine beetle red-attack damage classification using stratified Landsat TM data in British Columbia, Canada. Photogrammetric Engineering and Remote Sensing, 69(3):283-288.

Skakun, R.S.; Wulder, M.A.; Franklin, S.E. 2003. Sensitivity of the Thematic Mapper Enhanced Wetness Difference Index (EWDI) to detect mountain pine needle red-attack damage. Remote Sensing of Environment, 86(4): 433-443.

Wulder, M.A.; Franklin, S.E. 2001. Polygon decomposition with remotely sensed data: Rationale, methods, and applications. Geomatica, 55(1): 11-21.

Wulder, M.A.; Skakun, R.S.; Franklin, S.E. 2003. Mountain pine beetle red-attack polygon decomposition. Forestry Chronicle, in press.

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(web site: mpb.cfs.nrcan.gc.ca)

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