Normalized difference moisture index (NDMI) approach for year of death determination in Mountain Pine Beetle forest stands

Background:

To track Mountain Pine Beetle (MPB) attack in forest stands across the province of British Columbia, we use Landsat satellite imagery to monitor moisture changes on a year-by-year basis. Landsat imagery records spectral information reflected from the Earth's surface at a 30m spatial resolution across six different spectral bands. In 2007, we used a Landsat time-series approach for identifying wetness changes from 1999-2006. In the 2007 analysis, the Enhanced Wetness Difference Image (EWDI) developed by Skakun et al, (2003) was used to determine when a forest stand was attacked by MPB. Since this method was originally designed to assess change over two-image dates (or over a two-year period) there were issues with this approach when it was applied to an entire image stack containing 8+ annual Landsat scenes. With this in mind, another approach was developed by Goodwin et al. (2008) and was shown to be quite accurate in identifying MPB attack in northern British Columbia using Landsat imagery acquired over a twenty-five year period. In this research, the authors use the Normalized Difference Moisture Index (NDMI) derived from Landsat spectral bands 4 and 5 and calculated using the following equation:

$$NDMI = [Band\ 4 - Band\ 5] / [Band4 + Band\ 5]$$

This index contrasts the near-infrared (NIR) band 4, which is sensitive to the reflectance of leaf chlorophyll content to the mid-infrared (MIR) band 5, which is sensitive to the absorbance of leaf moisture.

For 2008 MPB mapping in British Columbia, we have adopted the NDMI approach for assigning the year of death to a forest stand as it tends to be more consistent between years and produces more accurate results in comparison to the previous EWDI method. Because of this, it is inappropriate to compare the 2007 and 2008 MPB mapping products since they were generated using different methods and rule sets.

Methodology:

Under the new mapping methodology for 2008, the NDMI images were created for each year during 1999-2008. We calibrate changes in this index using a variety of forest stands that have been impacted by MPB and stands that have not. By analysing the yearly trajectories in NDMI we are able to develop threshold levels which highlight spectral changes in the imagery that can be associated with MPB attack in a certain year. Figure 1 shows an example graph illustrating the yearly NDMI trajectories in attack and non-attack forest stands.

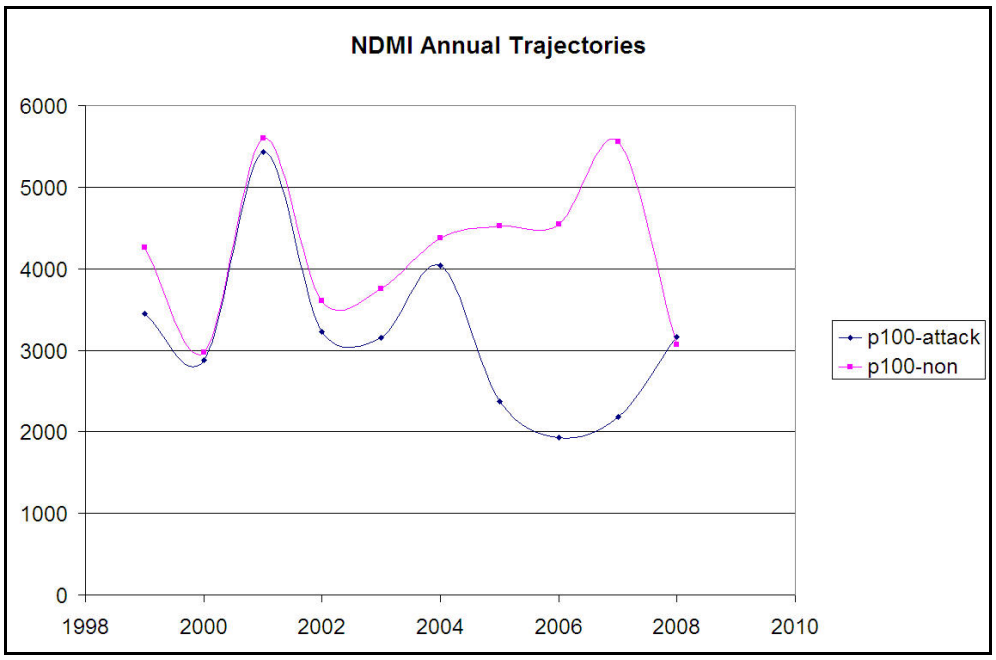
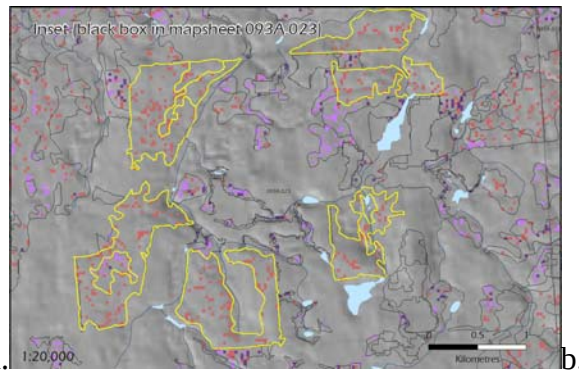


FIGURE 1 – Example NDMI trajectories in attack and non-attack pine stands.

In this case, the pine stand in blue started to show MPB attack in 2004 where the NDMI drops from 4000 in 2004 to 2300 in 2005. The stand illustrated in pink wasn't attacked until 2007 as illustrated by the sharp decline in NDMI during 2007-2008.

Once a significant amount of moisture is lost in the forest stand (as measured by change in NDMI) over a 30m area, a year of attack is assigned to that Landsat pixel. In the 2007 MPB analysis, these year-of-attack pixels were scaled up to the Vegetation Resource Inventory (VRI) polygon using a majority rule which states that the year of death that occurs most frequently in the VRI polygon will represent the year of death for that polygon. In the new 2008 MPB analysis, we are providing year-of-death information at both the; 1) raw Landsat pixel scale and, 2) VRI polygon scale (using the majority rule set). By providing both datasets, we hope to give the users of the data more flexibility for use in their needs. Figure 2 illustrates data at both the (a) raw Landsat pixel scale and (b) VRI polygon scale.

a. 

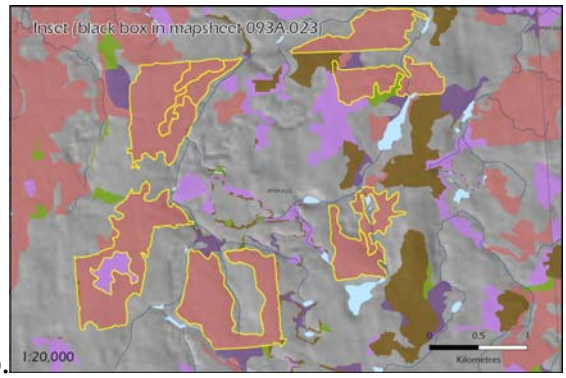
b. 

FIGURE 2 – Comparison of both mapping products. a) Raw Landsat scale, b) VRI polygon scale.

References:

Goodwin, N.R., Coops, N.C., Wulder, M.A., Gillanders, S., Schroeder, T.A. and Nelson, T. (2008). Estimation of insect dynamics using a temporal sequence of Landsat data. *Remote Sensing of Environment,* Vol. 112, Pp. 3680-3689.

Skakun, R.S., Wulder, M.A. and Franklin, .S.E. (2003). Sensitivity of the thematic mapper enhanced wetness difference index to detect mountain pine beetle red-attack damage. *Remote Sensing of Environment,* Vol. 86, Pp. 433-443.