REMOTE SENSING ASSESSMENT OF FIRE AND BURN SEVERITY IN THE ALASKA BOREAL FOREST REGION

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1. INTRODUCTION

Over the past 4 decades, there has been a doubling of the annual area burned across the North American boreal region [1], resulting in new challenges for fire management and intensified concerns about the effect that an increase in large wildfires may have on ecosystems and atmospheric carbon. The severity of a fire can be of great importance to the post fire environment, ecological recovery, and in quantifying carbon that is emitted to the atmosphere, in the form of carbon dioxide (CO_2) carbon monoxide (CO), and other greenhouse gasses [2, 3]. In this paper we review the utility and issues of using remote sensing to assess fire and burn severity in Alaskan boreal forests. Here, fire severity refers to the immediate impacts of fire on the environment, while burn severity references the degree of ecological change as a result of the fire [4].

2. BACKGROUND

The extensive impact of fire in boreal regions lends itself to study using satellite remote sensing. In boreal North America, however, issues related to sun elevation angle, plant phenology, and limited archived Landsat data – issues that are not factors in lower latitudes and more populated regions, such as the conterminous US – need to be considered when relying on remote sensing-derived information. In particular, methods that require anniversary images can be hampered by the limited data archives and large variability in inter-annual plant phenology [5]. Anniversary images can be very difficult to obtain for Alaska, due to data collection problems in much of the 1990's and in the year or two following the failure of Landsat 7 ETM+ scan line correction mechanism [known as SLC off condition; 6]. Approaches developed to use satellite remote sensing in boreal regions need to take into consideration these methodological issues as well as the ecological factors and management considerations related to site rehabilitation, site regeneration, wildlife habitat, and biodiversity.

3. METHODS: MAPPING SEVERITY WITH LANDSAT AND FIELD ASSESSMENT

This paper reviews several studies made to assess the utility of methods developed for the interagency Monitoring Trends in Burn Severity (MTBS) program (http://fsgeodata.fs.fed.us/mtbs/). The field data collection method and satellite remote sensing data process was first developed by Key and Benson [7] for use in all areas of the U.S. The field observation method used to assess damage from fire is the Composite Burn Index (CBI), and the satellite index used is the Normalized Burn Ratio (NBR) or the differenced NBR (dNBR) derived from Landsat TM/ETM+ data. The NBR is computed using two spectral bands of Landsat TM or ETM+ data from the Landsat 5 or 7 satellite sensors:

$$NBR = (NIR – SWIR) / (NIR + SWIR) \quad [1]$$

To account for pre-burn vegetation and topography, a differenced NBR (dNBR) is sometimes used as:

$$dNBR = NBR\ pre\text{-}fire – NBR\ postfire \quad [2]$$

The dNBR can theoretically range from -2.0 to +2.0; positive values are assumed to represent burned pixels, with fire severity increasing as dNBR values become more positive.

Three papers presented and discussed provide comparisons between the NBR and/or dNBR and the CBI [8-10]. Allen and Sorbel [8] found good correlations between field and remote sensing data while other studies produced poor correlations [9, 10]. To evaluate the ability of dNBR to map variations in CBI across Alaskan sites, we used the equation developed by Sorbel and Allen [11] to estimate CBI from Landsat dNBR data for the areas where Murphy *et al.* [10] and Hoy *et al.* [9] collected field data. The Sorbel and Allen [11] equation, used to predict CBI from dNBR in this analysis was derived by combining the data points from all of their sites into one analysis.

4. RESULTS

The relationship found by Sorbel and Allen [11] significantly underestimated CBI for the plots used in the Murphy *et al.* study that were established across all vegetation types in 7 separate fire events (Figure 1a). For data collected in black spruce stands in 2004 [9] the predicted CBI values followed the expected trend with the points being scattered around a line with a slope of 1 (Figure 1b). For the individual fire events, however, there were significant biases.

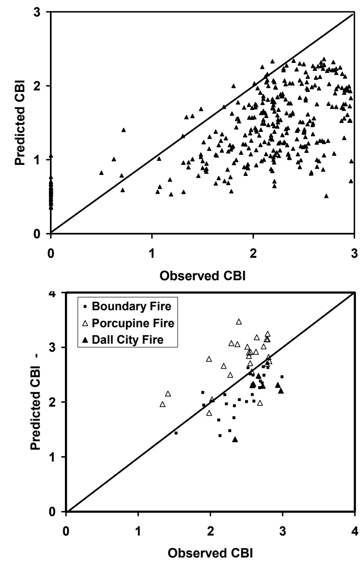

Figure 1. Comparison between CBI values predicted using dNBR with the equations of Sorbel and Allen [11]. a. CBI data for all vegetation types from Murphy *et al.* [10]. b. CBI data for black spruce data from Hoy *et al.* [9].

5. DISCUSSION & CONCLUSION

The data collected for three studies using the same methods in Alaska shows the dNBR/CBI approach has difficulties when applied to some situations. The predictor equation, developed by Sorbel and Allen [11] is not able to be used to predict severity from dNBR in most sites sampled. The reason for this is not fully understood. Murphy *et al.* [10] have considered some explanations, and collected additional information at sites to work through the disparity in the two outcomes. Their sites were more often found in lowlands, while the Sorbel and Allen [11] sites represent mostly upland types; the Hoy *et al.* [9] sites were also primarily upland sites. Both Murphy *et al.* [10] and Hoy *et al.* [9] collected data at sites that burned in the extreme fire year of 2004, while the Sorbel and Allen [11] sites are from more moderate fire seasons. The conclusion of Murphy *et al.* [10] is that the dNBR metric does not adequately differentiate severity levels in the moderate to high severity range, and suggest that dNBR can only be interpreted in conjunction with fire-specific field data. The results of Murphy *et al.* (this issue) and Hoy *et al.* (this issue) endorse a need for additional studies to assess the dNBR index under a variety of ecological and fire conditions.

11. REFERENCES

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