Remote Sensing-based Landcover Classification to Support Northern Woodland Caribou Conservation

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Abstract

In order to establish associations with vital landcover and plan conservation efforts, caribou recovery plans require standardized information on forest inventory and landcover classification over their entire range. Medium-spatial resolution satellite sensors provide an important supply of vegetation and landcover information over large areas, for a minimal cost. A nine-class landcover classification was produced using variables derived from Landsat TM data and DEM data. A classification tree approach using data mining software produce a map product with an overall classification accuracy of 83% and a KHAT statistic of 0.83, compared to an historical forest inventory product that has an accuracy of 33% and a KHAT statistic of 0.25. This new lancover classification containing vital caribou classes can now be used to derive landcover associations that will feed into wildlife recovery plans and conservation efforts.

Background and Relevance

Woodland caribou (*Rangifer tarandus caribou*) occupy a diverse range of ecological conditions and human disturbance levels in Canada. Recent extinctions of several mountain caribou herds (eg. Wittmer et al., 2005a, Hebblewhite et al., 2010) have sparked concern for proactive habitat-conservation measures, and have prompted federal managers to list the northern mountain caribou as a species of special concern under the Species at Risk Act (SARA) (Kinley and Apps, 2001; Thomas and Gray, 2002; Seip et al., 2007). Because of the remote nature of much of the range of northern mountain caribou, combined with complex jurisdictional and political issues, few efforts to standardize information on forest inventory over large areas have been initiated. The development of these inventories and classifications are an important step in developing wildlife recovery plans (Johnson et al., 2003; McDermid et al., 2009), which will be needed in order to establish well executed conservation efforts.

Medium-resolution satellite sensors such as those on board the Landsat, SPOT, and IRS platforms provide an important supply of vegetation and landcover information with several key advantages over traditional sources (e.g. aerial photography, that is often focused over only commercially viable areas) (McDermid et al. 2009). A mounting number of researchers have reported on the use of satellite-derived landcover maps to document important caribou-habitat relationships (e.g. Poole et al. 2000, Johnson et al. 2003, Bechtel et al. 2004). However, detailed descriptions of the *methods* required to process satellite data reliably over large, diverse study areas are largely absent from the wildlife literature. As a result, the goal of our research was to develop a strategy for performing remote sensing-based landcover classification in a manner capable of supporting detailed caribou habitat conservation planning.

Methods and Data

This study occurred within the 48,000 km² traditional territory of the TRTFN in the Skeena region of northwest BC near the town of Atlin (59° 35' N, 133° 40' W). Following a stratified random sampling design, we visited 617 sites between 2003 and 2008 and recorded spatial location using handheld GPS, landcover type and detailed species composition in each layer of the vegetation structure. In addition, we supplemented this data with 356 locations from a similar inventory of alpine environments and 151 additional locations collected from Landsat TM imagery for broad, non-vegetated classes, which were cumulatively used to define landcover information classes that are important for caribou.

A study area-wide set of geospatial predictor variables was assembled to generate the final classification product, derived from two Landsat TM images, (path/row) 57/18 and 57/19, acquired on July 26, 2006 and September 15, 2006, respectively, as well as a digital elevation model (DEM). Orthorectification was performed using ground control points from existing geographic information system (GIS) layers. Brightness, Greeness, and Wetness variables from tasseled cap transformation (Crist and Cicone, 1984) were derived, following a conversion to top-of-atmosphere reflectance. Wetness difference was calculated from wetness information for each acquisition date. Slope and aspect were both calculated using the Spatial Analyst extension in ArcGIS (Redlands, California). Compound topographic index (CTI), which is well known for its surrogate ability for soil attributes, was also derived.

A classification-tree approach for determining landcover was performed using See5 datas mining software (Rulequest Research, St. Ives Australia). A training dataset, consisting of 1124 locations with one of 9 landcover classes and values from each geospatial predictor variable, was processed to create a set of decision rules defining the occurrence of each class on the landscape. Validation of the final landcover model was performed using a k-fold cross validation, with a k-value of 10 (eg. Friedl et al., 2000) to produce confusion matrices. User's, producer's, and overall accuracies were calculated, along with a KHAT statistic as a measure of agreement between the observed and predicted classes. In addition, validation of a pre-existing forest inventory from the same area using historical methods was performed and the results were compared.

Results

The overall accuracy of the land cover classification model is 83%, with producer's accuracies ranging from a low of 36% for the mixed tree class to a high of 100% for the water class. User's accuracies range from a low of 48% for the mixed tree class to a high of 100% for the snow and ice class. The KHAT statistic is 0.80, indicating that the classification is 80% better than one resulting from chance. Conversely, the historic forest inventory has an overall accuracy of just 33%, with producer's accuracies ranging from a low of 0% for the tall shrub and low shrub classes, to 100% for the snow and ice, rock/rubble/bare soil, and water classes. User's accuracies range from 0% for the tall shrub and low shrub classes to 95% fpr the rock/rubble/bare soil classes. The KHAT statistic for the historic classification is 0.33, indicating that the classification is 33% better than one resulting from chance.

Conclusions

Using medium-spatial resolution satellite imagery and a classification tree approach, we successfully performed a remote sensing-based landcover classification in a manner capable of supporting detailed caribou habitat conservation planning. With accuracies far exceeding that of a pre-existing historical forest and landcover inventory, the classification we produced now provides an accurate and reliable inventory that includes classes that are relevant to caribou habitat use. This inventory will be used in future investigations to assess caribou landcover associations, which will feed into wildlife recovery plans and conservation efforts.

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