Estimating Aboveground Biomass in Interior Alaska with Landsat Data and Field Measurements

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1. Introduction

Alaska’s ecosystems play important roles in the investigation of global climatic change because of the area’s extreme environments (e.g., limited sunlight, low temperature, and short growing season), its strong response to global warming (e.g., thawing of permafrost and melting of ice masses), and its representative role in the global system. Terrestrial biomass is a key biophysical parameter in the studies of Alaska’s ecosystems and their response to global warming. However, there is a lack of detailed biomass estimates for this vast and remote region. Our research objective is to produce a 30-m resolution aboveground biomass (AGB) dataset for the Yukon River Basin of Alaska and Canada using Landsat data and field observations acquired in recent years. The AGB estimates for the Yukon-Flats Ecoregion in this study is a prototype of regional AGB mapping for the entire basin.

2. Study Area

The Yukon Flats Ecoregion is a relatively flat, marshy basin. The Yukon River and several smaller rivers running through the area, and numerous river tributaries, lakes, and ponds are distributed throughout (Figure 1). According to 2011 the National Land Cover Database (NLCD 2001), the major land cover types are deciduous forest (20.5%), evergreen forest (36.2%), mixed forest (9.1%), shrubs, and grasslands (10.8%), woody and emergent herbaceous wetlands (15.0%), and open water (6.4%). Wildfires are very common in the ecoregion. Figure 2 shows the typical vegetation communities in the ecoregion.

3. Data

1. Landsat TM data

We selected six cloud-free Landsat 5 Thematic Mapper (TM) scenes acquired from 21 August to 1 September 2008 covering the entire Yukon Flats Ecoregion (Figure 1). We converted the original digital number data to at-sensor reflectance and land surface temperature (LST). A linear regression technique was used to match adjacent scenes, resulting in normalized at-sensor reflectance images.

2. Airborne lidar data

A lidar dataset was collected for an area in the southern-central part of the ecoregion in mid-July and early September 2009 (Figure 1). The data products were acquired with an aircraft-carried Optech ALTM Gemini system operated by Aeron-Metric, Inc. The company processed the raw data and delivered the 2.5-m raster dataset of bare-earth digital surface model (DSM) and first-return DSM.

3. Field measurements

We preselected 22 sampling sites based on land surface characteristics observed from satellite images and other geospatial data. These were the factors we considered in the site selection: (1) land cover type, (2) vegetation density, (3) walking distance from the base camp to the sites, and (4) public domain. A field campaign was carried out in the areas near Boot Lake and Canusavuck Lake from late August to early September 2009. The AGB measured in the field consisted of tree and shrub biomass, coarse woody debris (CWD) biomass, and understory biomass.

4. Results and Discussion

2.1. Estimation of AGB using field data

2.2. Comparison of estimated AGB and lidar vegetation data

3. Regional AGB pattern

5. Conclusions

Acknowledgements

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Table 1. Summary of field plots and the sampling sites

<table>
<thead>
<tr>
<th>Plot Number</th>
<th>Site Name</th>
<th>Land Cover Type</th>
<th>AGB Estimate (t/ha)</th>
<th>Lidar Vegetation Height (m)</th>
<th>Lidar Vegetation Cover (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Boot Lake</td>
<td>Deciduous forest</td>
<td>25.2</td>
<td>1.5</td>
<td>23.4</td>
</tr>
<tr>
<td>2</td>
<td>Canusavuck Lake</td>
<td>Mixed forest</td>
<td>30.8</td>
<td>2.0</td>
<td>34.6</td>
</tr>
</tbody>
</table>

Figure 1. Map of the Yukon Flats Ecoregion showing the Landsat TM images mosaicked from six scenes. The red polygon outlines the area where Landsat TM data and lidar data were acquired.

Figure 2. Photographs showing the typical vegetation communities in the Yukon Flats Ecoregion. (a) Open water. (b) Water sedge (Carex aquatilis). (c) Mixed deciduous and coniferous forest. (d) Water sedge (Carex aquatilis). (e) Mixed deciduous and coniferous forest. (f) Water sedge (Carex aquatilis). (g) Mixed deciduous forest.

Figure 3. The map of total AGB estimation for the Yukon Flats Ecoregion.

Figure 4. The map of total AGB estimation for the Yukon Flats Ecoregion.

Figure 5. Density scatterplots of AGB estimates vs. lidar-derived vegetation height (a) and cover (b). Red curves indicate exponential regression lines.

Figure 6. Frequency chart of AGB frequency distribution for the Yukon Flats Ecoregion.

Figure 7. Total AGB estimates overlaid with historical fire perimeters (U.S. Forest Service, 2009). The inset is the histogram chart of the AGB estimates by land cover type and historical burn.

Figure 8. Frequency distribution of AGB estimates for the Yukon Flats Ecoregion.

Figure 9. Frequency distribution of AGB estimates for the Yukon Flats Ecoregion.