# Tracking vegetation change in a manipulated tundra lake basin using sub-meter resolution imagery.

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## Introduction

Developing accurate, low-cost, and time-efficient methods for arctic tundra monitoring is essential for spatial and temporal assessments, as well as quantification of biogeochemical processes such as greenhouse gas emissions.

The primary factors limiting analyses of land cover changes in arctic regions are the expensive and time consuming nature of aerial photographic approaches when spanning large areas, and the relatively coarse spatial resolution of most satellite sensors (Noyle, 1999; figure 1).

Commercial high-spatial resolution imaging systems such as Quickbird provide a new tool for mapping arctic vegetation at a finer scale. **This study aims to characterize the highly heterogeneous vegetation communities in coastal arctic tundra using Quickbird imagery, and assess land cover change in the Biocomplexity experimental area.**

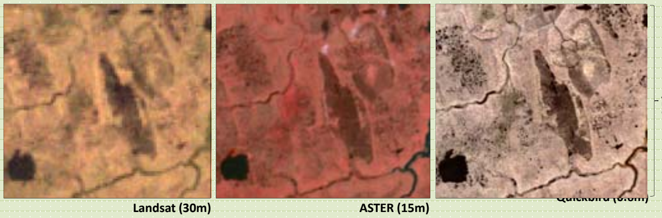


**Figure 1. Resolution comparison between different satellite sensors used in tundra mapping.**

## Data and Methods


This study focuses on the Biocomplexity experiment site (590 ha) near Barrow, Alaska. Barrow is situated approximately 320 miles North of the Arctic Circle. Much of the tundra at Barrow is characterized by ponds, meadows, high-center polygon tops, polygonal rims and troughs.

The Biocomplexity experiment (2005-2009) manipulated water table levels in an existing and naturally occurring drained lake basin. The three water table treatments included a treatment enhanced soil moisture (target water table of +10cm compared to 'natural conditions'), with a treatment with reduced water tables (-10cm below 'natural') and a control treatment. These soil moisture conditions were created by placing three dikes across the vegetated drained lake basin.

Quickbird cloud-free data acquired on August 1, 2002 and July 30, 2008 from the Barrow, AK area was used to develop the land-cover maps. The datasets, composed of four multispectral (2.4m) and one panchromatic (0.6m) bands, were orthorectified and corrected for radiometric, sensor, and geometric distortion by the provider (DigitalGlobe). The multispectral bands were fused with the panchromatic scene using a Principal Components sharpening method, which is characterized by the maintenance of spatial and spectral quality (Vijayaraj et al., 2006).

Land cover types were divided into nine classes containing seven plant communities described by Webber (1978) using Hierarchical Clustering Analysis. A supervised classification using a minimum distance algorithm was performed to construct the land-cover map based on training classes from plot data, ground and aerial photos.

After completing the classification, a majority filter with a kernel size of 3x3 was applied to the map to obtain spatial coherency among classes. We built an error matrix to estimate the accuracy of the resulting map by comparing the output map and the ground truth data, acquired from plot and tramline data from the Barrow-Arctic Information Database (BAID). We estimated overall accuracy, Kappa coefficient, errors of commission and omission as described in Kohavi & Provost (1998).

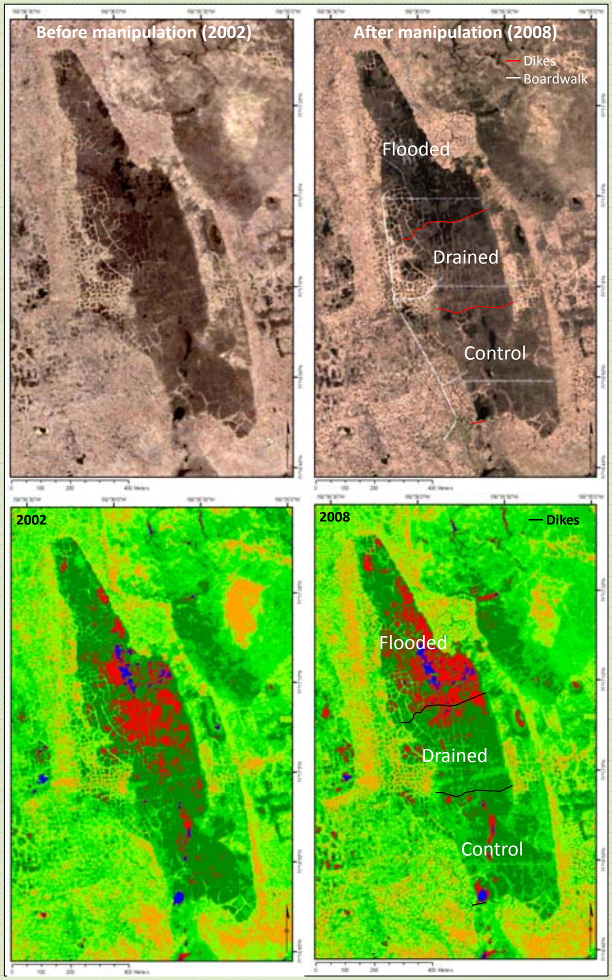


Figure 2. Satellite images of the Biocomplexity experiment site from 2002 (top left) and 2008 (top right) and Land-cover maps for 2002 (bottom left) and 2008(bottom right).

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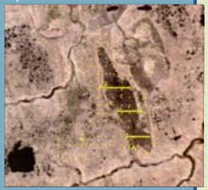
## Results

Six vegetation communities were successfully characterized using a minimum distance classification algorithm with good overall accuracy (Table 1). A total of 1016 ground truth points were used to assess the map accuracy (Table 1).

**Table 1**. Error matrix of the classification maps. (Right) Distribution of field validation points (yellow) across the study site.

| Land Cover Class | 2002 Vegetation map | | 2008 Vegetation map | |
|---|---|---|---|---|
| | User | Map | User | Map |
| **1** | 100 | 100 | 85 | 96 |
| **2** | 84 | 91 | 89 | 75 |
| **3** | 92 | 92 | 88 | 71 |
| **4** | 89 | 73 | 51 | 90 |
| **5** | 70 | 83 | 67 | 71 |
| **6** | 85 | 82 | 78 | 63 |
| **7** | 50 | 47 | 31 | 67 |
| **Overall Accuracy** | 87.5 | | 74.4 | |
| **Kappa Coefficient** | **0.82** | | **0.64** | |



Between 2002 and 2008, little land cover change occurred throughout the study area (Figure 2). The most marked land cover change recorded between 2002 and 2008 was associated with the experimental manipulation. The greatest change was noted in aquatic, seasonally flooded and wet land cover types. In the flooded treatment area, there was a marked reduction in seasonally flooded land cover class 3 and an increase in aquatic land cover class 2. Figure 3 displays the cumulative total percent change from the wettest to the driest land cover types, and highlights the above inter-annual trends with 2008 appearing slightly wetter than 2002, which is consistent with annual rainfall records. The control treatment responded in a similar fashion to the overall Biocomplexity experimental area, whereas the flooded and drained treatment areas displayed noticeable flooding and draining respectively.

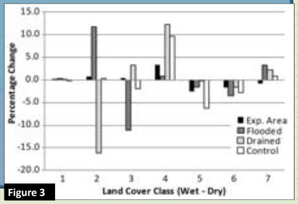



**Figure 3**

## Discussion

The high spatial resolution of Quickbird (0.6m) was successful in characterizing the high heterogeneity of tundra vegetation communities. This analysis demonstrates the potential utility of space-borne systems for generating high spatial resolution data on Arctic tundra mapping and its importance for assessing land-cover changes. This method may improve the quantification and extrapolation of plot level measurements to the landscape scale.

With the absence of extensive field monitoring, the combination of GIS, remote sensing, and field observations proved to be a powerful tool for large scale spatial assessment of tundra vegetation.

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