High Resolution Remote Sensing to Characterize Geomorphic Stability of Stream Reaches

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As part of a larger study addressing stream geomorphology, we evaluated the use of aerial and satellite remote sensing to assess stream stability in Allen Brook and Indian Brook watersheds in Chittenden County, VT to augment current ground-based monitoring efforts. To this end, we analyzed high spatial resolution digital orthophotography, QuickBird satellite imagery and LIDAR elevation data to characterize the geomorphic condition and sensitivity of stream reaches in response to historic and current watershed and corridor stressors. Over the 6-year period of study we observed extensive channel migration in both watersheds. Quantifying these changes over time also provided an efficient means to estimate streambank erosion. Our results demonstrate the value of remote sensing to quantify the spatial and temporal variability of fluvial geomorphic change at watershed scales.

Introduction: Streambank erosion is one of the most important but least understood nonpoint sources of sediment and phosphorus threatening the impairment of surface waters within the Lake Champlain Basin. In particular, the high spatial and temporal variability and the difficulties of quantifying erosion rates at watershed scales have severely limited understanding the role and relative contribution of streambank erosion to water quality degradation. The goal of this study was to evaluate the utility of high spatial resolution remotely sensed data to derive improved geomorphic variables for input into ANNs to assess the geomorphic condition and inherent vulnerability of stream reaches.

0.16m CCMPO orthophotography

2.4m QuickBird satellite imagery

3.2m posting LIDAR

Figure 1. Very high spatial resolution orthophotography (CCMPO), QuickBird satellite data, and LiDAR data (left) were utilized in the analyses. The image above was created by draping natural color orthophotography over a LiDAR-derived digital elevation model. The area shown is located near the mouth of Allen Brook.

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Methods: Stream centerlines were digitized from the 2005 (2.4m MSS and 0.6m panchromatic) QuickBird satellite and 2004 1:1250 (0.16m) CCMPO digital orthophotography and compared with stream channel data (VT Hydrography data) derived from 1:5,000 panchromatic digital orthophotos acquired in 1999 (Figure 1). Streambank heights were calculated based on (3.2m posting) LIDAR-derived digital surface models (DSM). Channel migration was mapped as the lateral and vertical shift in stream centerlines between any two dates of observation (Figure 2) and summarized by reach and watershed.

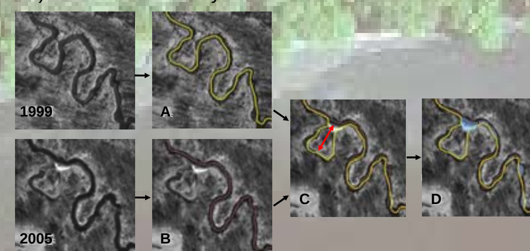

Figure 2. Key steps in measuring channel migration. Data for 1999 (A) and 2005 (B) imagery for reach M02 of Indian Brook are shown. Stream centerlines were digitized for each image date and then overlain in ArcGIS to derive measures of channel lateral migration (C; red arrow) and soil loss due to streambank erosion (D; shown in light blue).

Results: Substantial channel migration was observed over the 1999-2005 study period within both the Allen and Indian Brook watersheds (Figures 3 and 4) despite little change in sinuosity. For example, within Indian Brook 111 migrations ranging in size from 2.3 - 59m, and representing a net total migration of 917m were observed although sinuosity varied little (1.1 to 1.9). The total number of migrations and cumulative sum of migration distances for Allen Brook were consistently less than that for Indian Brook, but nonetheless were substantial (n = 71, range = 2.5-49m, sum = 608m).

Figure 3. Stream centerlines are shown for a portion of reach M04, Indian Brook.

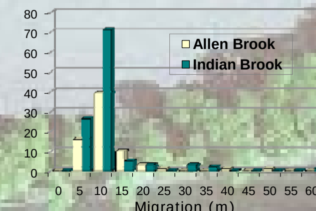

Figure 4. Histogram of lateral channel migration for Allen Brook and Indian Brook watersheds.

We observed large spatial and temporal variability in channel migration for reaches within each watershed, highlighting the value of watershed-scale synoptic observations offered by remote sensing (Figure 5).

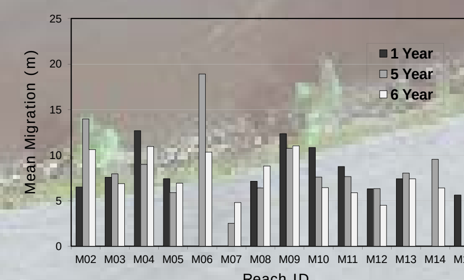

Figure 5. Total lateral channel migration summarized by reach for Indian Brook.

LIDAR-derived bank heights and channel migration data were then combined to estimate streambank erosion. Preliminary estimates of soil loss from Allen and Indian Brook watersheds, respectively, ranged from 22,000-42,000m^3.

Conclusions: These results demonstrate that remote sensing offers the potential to map and monitor stream channel changes throughout the watershed consistently, accurately, and at relatively low cost. The ability to augment geomorphic studies using advanced remote sensing technologies could greatly aid oversight agencies in corridor planning and management.