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 are exploring the use of aerial and satellite remote sensing to assess stream stability to augment current ground-based monitoring efforts. To this end, we analyzed high spatial resolution 1:1250 (0.16m) digital orthophotography, QuickBird (0.6m and 2.4m) satellite imagery and LiDAR data to characterize the geomorphic condition and sensitivity of select river reaches in response to historic and current watershed and corridor stressors. For the Allen Brook and Indian Brook watersheds in Chittenden County, VT, stream centerlines were digitized from the QuickBird satellite and 1:1250 aerial imagery and sinuosity was calculated for each stream reach. Although significant shifts in the channel were documented between 1999 and 2004 and again between 2004 and 2005, sinuosity for stable reaches derived from the QuickBird imagery, VT ANR River Management Program (VT ANR/RMP) Phase I and II data, and 1:1250 imagery agreed well. Further, object oriented classification techniques incorporating imagery and LiDAR data were successfully employed to map indicators of stream stability.

Introduction:. Streams vary across temporal and spatial scales to maintain a dynamic equilibrium or stable state. Streams can become unstable due to anthropogenic disturbance in the watershed and, at times, result in fluvial hazards such as flooding which can threaten human life and property. With the advent of high resolution imagery and digital imaging technology, remote sensing provides new opportunities to study stream geomorphology and monitor stream stability. The ability to detect geomorphic features with advanced remote sensing technologies could provide oversight agencies such as VT ANR/RMP with cost effective tools to identify unstable stream reaches. The goal of this study is to assess the utility of high resolution remotely sensed data to map and monitor stream condition.

0.16m CIR Imagery

2.4m QuickBird satellite imagery

3.2m posting LiDAR

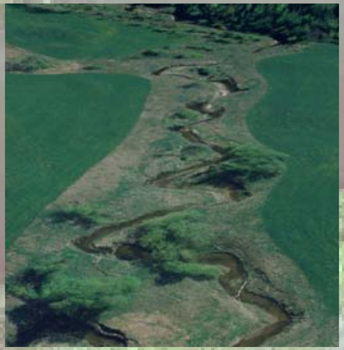

Figure 1. Very high resolution CCMPO, QuickBird satellite data, and LiDAR data (left) were utilized in the analyses. CIR imagery draped on LiDAR-derived digital elevation model near the mouth of Allen Brook (above).

Methods: A combination of high resolution satellite and aircraft imagery (Figure 1), object-oriented classification (Definiens Professional), and hydrologic modeling incorporating LiDAR-derived DEMs were used to carry out the analyses. High resolution satellite imagery (2.4m MSS and 0.6m panchromatic) captured by Digital Globe's QuickBird satellite on August 23, 2003 and April 16, 2005. Digital color-infrared (CIR) orthophotography (0.16m) and 3.2m posting LiDAR (EarthData, Inc.) data were acquired through the Chittenden County Metropolitan Planning Organization (CCMPO) on May 01, 2004 for Allen Brook and Indian Brook watersheds. Advanced object-oriented classification techniques (Figure 2) were utilized to map features indicative of stream stability/instability (steep banks, riparian vegetation, stream channel, stream and valley gradient, impervious surfaces, sinuosity, and channel migration over time) while hydrologic modeling was incorporated to differentiate total impervious areas from effective (hydrologically-linked to streams) impervious areas. Resultant output layers (Figure 3 and 4) were validated with survey data and by comparison with VT ANR/RMP Phase I and II stream geomorphic assessment data.

Figure 2. Object-oriented classification of impervious surfaces involves segmentation of pixel reflectance into homogeneous objects (i.e. polygons) followed by hierarchical decision rules for classification.

Results

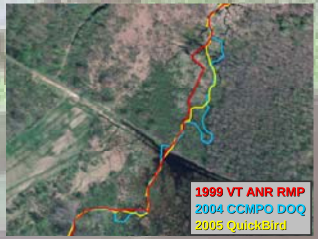

Figure 3. Stream centerlines derived from the QuickBird satellite data, Phase I geomorphic assessment (1:5000) data, and 1:1250 CCMPO imagery are shown for a section of reach M09 Allen Brook.

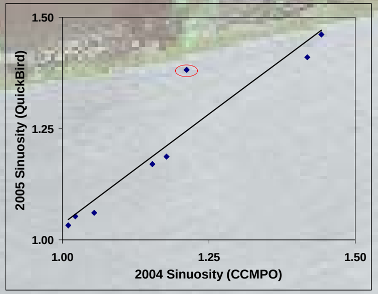

Figure 4. Channel sinuosity (n=8) derived from QuickBird satellite imagery (2005) compared to values calculated from photointerpretation of 1:1250 CCMPO imagery (2004) for Allen Brook watershed. The red circle indicates reach M09 which has undergone a significant change in sinuosity (see Figure 3 above).

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