The Emerging Role of UAVs in Restoration of Seismic Lines

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### Common Remote Sensing Instruments

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#### Processing Workflows: Spectral Analysis
Processing Workflows: Digital Aerial Photogrammetry

Processing Workflows: Softcopy Interpretation
**Provincial Restoration Framework**

- Designed to assist woodland caribou population recovery
  - Encourage return to forest cover
  - Limit human and predator movement on the landscape

**Targets for an Emerging Remote-Sensing Toolkit for Assisting Restoration Efforts on Seismic Lines**

- Seedling detection and stocking
- Vegetation height
- Coarse woody debris
- Microtopography
- Groundwater
- Canopy structure and openings
Targets for an Emerging Remote-Sensing Toolkit for Assisting Restoration Efforts on Seismic Lines

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Target 1: Seedling Detection

- Can UAVs be used to rapidly identify regenerating coniferous seedlings using consumer-grade cameras and straightforward image handling?
A Sampling-based Approach

Results

• 75.8% overall accuracy based on independent test data (n = 149)

• Slight tendency to underestimate the seedling density when large numbers of seedlings are present, but plot-level associations with ground surveys were very high (Pearson's r = 0.98; n = 14)

• Relies on narrow phenological window
Target 1: Seedling Detection - Summary

- Can UAVs be used to rapidly identify regenerating coniferous seedlings using consumer-grade cameras and straightforward image handling?  
  - Yes  
  - Our workflow relies on seasonal leaf-off windows where seedlings are visible and spectrally distinct from their surroundings  
  - Differential errors between the pine seedlings and spruce seedlings suggest that operational workflows could benefit from multiple decision rules

Target 2: Vegetation Height

- Can UAV photogrammetry be used to measure vegetation height on seismic lines?
- Do you need supplemental terrain information from LiDAR?
- How much does it cost?

Methods

- We used a point-intercept sampling strategy to measure vegetation heights along long and cross transects spanning 150m lengths of 30 seismic lines distributed across the Lower Athabasca
- Sample locations were determined with survey-grade GPS
Methods

Results: Sample Cross Transects
Results: Statistical Analysis

• Overall RMSE (n=30)
  – UAV_LiDAR: 15cm
  – UAV_UAV: 8cm

• Paired-sample z tests showed that there was no significant difference between field-measured and UAV-estimated heights

• Supplementary terrain data from LiDAR does not significantly improve results

Target 2: Vegetation Height

• Can UAV photogrammetry be used to measure vegetation height on seismic lines?
  – Yes, particularly at the line level where our estimates are statistically identical to field measurements.

• Do you need supplemental terrain information from LiDAR?
  – No.

• How much does it cost?
  – We estimate $350 per site for a 30-site survey, a cost savings of 38% over traditional veg surveys.
Processing Tech: SfM Photogrammetry

- 35 mm pixels
  - 38,000 pts/m²

- 75 mm pixels
  - 6,500 pts/m²

- 2.5 cm pixels
  - 700 pts/m²

Results: Height Assessment

- Field height vs. UAV height
- Adjusted $R^2 = 0.74$
- RMSE = 0.14 m
- Bias = -0.1 m
Target 3: Microtopography

• Can photogrammetry capture terrain elevation under a variety of vegetation/surface-complexity conditions?

• Can this terrain elevation be used to classify peatland microtopographic features (hummocks and hollows)?

• Do you need supplemental terrain information from LiDAR?

Methods

• We used cluster-sampling and transects to measure terrain elevation at 678 locations in a treed bog near Peace River

• Sample elevations were determined with survey-grade GPS
Results: Statistical Analysis

- RMSE ranged from 14–42 cm, depending on the state of vegetation/surface complexity. In classes 0, 1, and 2, RMSE was in the ~15-20 cm range.

- Supplementary LiDAR data did not improve results significantly, nor did it perform well as a stand-alone technology at the low densities typically available to researchers.

Microform Classification

Class Rules:
- Hummock > 0
- Hollow < 0
- Tree = 0

Reference Surface (2m mean filter) = Microtopography

DTM

Boreal Ecosystem Recovery & Assessment
Results: Microform Classification

• Overall accuracy = 84%
  (kappa: 0.7579)

• Most of the errors were in the “transitional zone” within 5cm of the reference surface. Distinct microforms were very well-classified

Target 3: Microtopography

• Can photogrammetry capture terrain elevation under a variety of vegetation/surface-complexity conditions?
  – Yes. *We judge the technology to perform well under all but the most-complex conditions, where ground visibility is hindered by thick vegetation.*

• Can this terrain elevation be used to classify peatland microtopographic features (hummocks and hollows)?
  – Yes.

• Do you need supplemental terrain information from LiDAR?
  – No.

Target 4: Groundwater

- Can photogrammetry be used to measure groundwater levels in peatlands?

Mapping Ground Water with Drones

Assumptions:
1. Peatlands are internally porous with flat or gently sloping water tables
2. There is an abundance of surface-water features that are tightly linked to ground water
3. These surface-water features can be mapped accurately in three dimensions
Mapping Groundwater with Drones

- RMSE in the 20-cm range based on 31 temporally coincident water well measurements
- Errors concentrated in upland portions

Groundwater Level (meter)

623.45
620.63
Target 4: Groundwater

- Can photogrammetry be used to measure groundwater levels in peatlands?
  - Surprisingly, yes – under the assumption that peatlands are internally porous with flat or gently sloping water tables.

Summary

- UAVs fill a critical gap in near-surface remote sensing, with the capacity to complement and in some cases supplement boots-on-the-ground field measurements
  - Seedling detection and stocking
  - Vegetation height
  - Coarse woody debris
  - Microtopography
  - Groundwater
  - Canopy structure and openings

- This is an emerging platform, and practitioners should be wary of developing or under-developed sensor technologies

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