How to Not Ruin Your Vibe – Delineating Potential Risk Zones for Seismic Operations in Wetland-Dominated Regions Using Colour-Infrared and LiDAR

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Introduction

Alberta is comprised of wetlands which pose as adversative environment for seismic operations. Wetland conditions must be favorable in the load-bearing capacity aspect to accommodate heavy equipment passing on seismic pathways. In this paper, we generate an initial assessment on feasibility of seismic activities such as mulching low-impact seismic (LIS) lines and driving of vibroseis (“vibe”) trucks on wetlands by utilizing remote sensing technology, namely colour-infrared (CIR) and LiDAR. The application of geographic information system (GIS) acts as a decision support system in analyzing potential danger zones for seismic operations in wetland-dominated zones.

Study Area

The study area is located within the Lower Foothills natural subregion in Central Alberta. Evident productive timber operations and intensive oil and gas exploration development from past decades encompass the area. (Natural Regions Committee, 2006).

Wetlands

Wetlands are water-saturated lands that promote the formation of water-altered soils, growth of water tolerant vegetation and biological activity adapted to a wet environment (Government of Alberta, 2015). They are an abundant and complex landscape features across Canada that provide numerous benefits including water purification, flooding mitigation, wildlife habitat, and carbon storage (FP Innovations and Ducks Unlimited Canada, 2016). The hierarchical Canadian Wetland Classification System was adopted to differentiate various wetland characteristics.

Colour-Infrared Imagery

Colour-infrared (CIR) is a multispectral raster consisting of 3 bands: red and green as part of the visible spectrum, and near-infrared in the electromagnetic spectrum. Each wavelength reacts differently to various matters on earth. Different color in aerial CIR imagery represents different objects. For example, an intense bright red colour represents vigorous growing, dense vegetation with large amount of chlorophyll; and comparatively a lighter tone of red, magenta, and pinks could represent dying vegetation with reduced quantity of chlorophyll (Statewide Mapping Advisory Committee, 2011).

LiDAR

LiDAR (Light Detection and Ranging) is an optical remote sensing technology which measures properties of scattered light to find information of a distant target. The benefits come from its ability to provide information and calculation of statistics for object properties such as height. Using LiDAR data helps achieve the goal of producing high resolution elevation maps that detect details like holes, hills, streams and roads on the land's topography.

Methods

Image Classification – CIR Unsupervised and Supervised Classification

Identifying the type of wetland helps anticipate and predict the surface and subsurface water flow which aids in significant decisions on the timing of wetland crossings. Prior to determining the different types of wetlands, it was essential to first classify the whole CIR and subdivide it to the following land cover: cut blocks, developed areas, open water, wetlands, and forest. This resulting raster was then turned into a vector which allowed for the extraction of the wetland polygons. Subsequently, the CIR was then masked to the wetland polygons for further reclassification of different wetland types. Using ArcGIS Pro, unsupervised classification was performed on the CIR resulting to a segmentation of raster. The segmented portions were then clustered and relabeled to corresponding informational classes from the field samples through supervised classification. From this initial field collection, only five different types of wetlands were determined: graminoid fen, poor treed fen, rich treed fen, mixed wood swamp, and conifer wood swamp.

Out of 503 training samples (from the combination of 23 field samples and desktop observations), the assessment produced an accuracy value of 85.5% correct plots suggesting that the supervised classified wetland types are reliable. To correct for some overestimation and underestimation of wetland types, the result was cross-referenced to the field collection to validate the output values. Some areas being misclassified were then manually reclassified to the appropriate wetland type. Since the resolution of the wetland types inherited the original resolution of 1.5m from the CIR, the raster had to be resampled to a higher resolution of 1m to match the LiDAR data. The upsampling was done based on the nearest method used primarily for fast interpolation of discrete data.

Predictive Canopy Density

A LiDAR from June 2012 was acquired for this project to determine environmental factors such as the elevation, slope, canopy height and density. Canopy density plays a vital role in the stability of the soil and should therefore be assessed. The sparseness of the trees in a wetland zone may promote catchment erosion as presence of trees pull out water from the ground through their roots (Woodward, Shulmeister, Larsen, Jacobsen, & Zawadzki, 2014). The presence of the excess water compromises the stability of the soil which is critical for any loads that may pass through it. To calculate the density, LAS dataset was turned into raster for both above ground points and bare earth. The null values for each raster was converted to 0 values. The two raster datasets were then added together to find the total values per cell size. To obtain the overall canopy density, the above ground points were divided from the total values to reach a canopy density ranging from 0 to 1.

Elevation Model

Topography plays a significant part in water movements. Wetlands in areas of low relief may be more connected and share water flow. The location appears to have very little variance in relief. Because of the low relief presence, the drainage network may be more disorganized, with variable runoff and large groundwater recharge (FP Innovations and Ducks Unlimited Canada, 2016). Therefore, the DEM was reclassed to three different ranges of elevation to represent the slower water movement in higher elevation, and faster and more dynamic surface water movement in lower elevations. To accomplish this, the maximum wetland elevation from the suspected vulnerable wetlands based on the observations from the field collection was determined.

Suitability Analysis

From the integration of all 3 suitable factors, a travel suitability analysis was performed. The reclassification table below summarizes the ideal and non-ideal conditions for travel on wetland areas.

Reclassification Table				
Suitability for Travel on Wetland Zone	**Cautionary Levels**	**Wetland Class**	**Canopy Density (%)**	**Elevation (m)**
Least Suitable	High	Graminoid Fen	0 to 19	925 to < 935m
	Moderately High	Poor Treed Fen	20 to 39	935 to < 945m
	Moderate	Rich Treed Fen	40 to 59	945 to < 955m
	Moderately Low	Mixed Wood Swamp	60 to 79	955 to < 965m
Most Suitable	Low	Conifer Wood Swamp	80 to 100	≥ 965m

Table 1. Classification parameters for suitability travel on wetland areas.

Next Steps and Conclusion

Further work must be implemented on this initial assessment for the data to reflect reality. Additional delineation of other wetland types within the sampled area must be deployed through supplementary field observations to enhance the wetlands as classified by the CIR. Further reclassification will lead to a better explanation of wetland phenomena. To augment the delineation, deliberation of other hydrological factors such as conducting measurements of the depth-to-water ratio can help. Moreover, vintages of the LiDAR and the CIR must be taken into consideration when providing a more detailed and up-to-date prediction on wetland analysis. Finally, to confirm the vulnerability of the wetland condition, ground truthing of the predictive danger zones must be accomplished.

By defining the vulnerable areas of low soil-bearing capacity, equipment can avoid exerting ground pressure in these areas that may promote impairment to wetland waterflow by rutting and compaction (FP Innovations and Ducks Unlimited Canada, 2016). This analysis aids in lowering the chances of equipment sinkage which in turn increases equipment productivity and efficiency by lowering such risks.

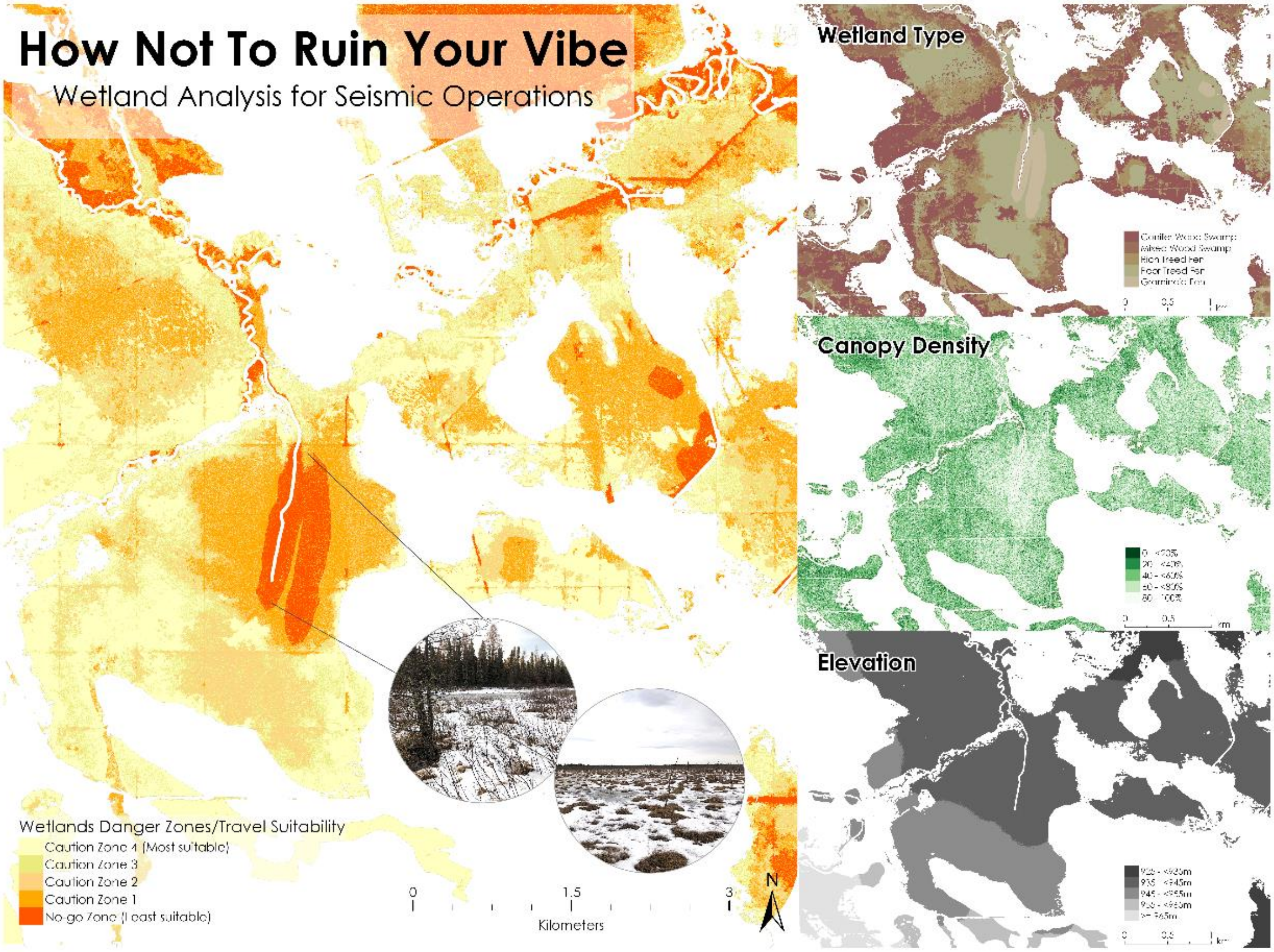

Figure 1. Danger zones on wetland area.

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