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Development of Remote Sensing Techniques for Regional Reclamation Monitoring of Peatlands in Alberta – Phase 2

Report

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1. Introduction

The scope of this report is to document the assessment of airborne hyperspectral data for mapping vegetation recovery in reclaimed wellsites. A brief description of airborne data acquisition, atmospheric correction, feature extraction and data classification in the Matrix study area is provided.

2. Airborne Data Acquisition

ITRES Research Limited (*ITRES*) was contracted by C-CORE to acquire and process airborne hyperspectral imagery of five test sites located in the Beaverhills area East of Edmonton and in a second area South of Fort McMurray, Alberta, Canada. Hyperspectral data were collected from Sunday, August 20th, to Tuesday 22nd August, 2017, using the CASI-1500h and SASI-Hi/Lo instrument suite. A detailed description of the airborne campaign and data pre-processing carried out by ITRES can be found in the ITRES 2018 report. For the MATRIX site (Figure 1), five flight lines were acquired on August 21st around 16:00 GMT from an altitude of 2440 meters. Airborne data were calibrated, geometrically corrected, mosaicked and resampled to a 2-meter pixel size.

Figure 1: *The Matrix study area*

3. Atmospheric and Geometric Correction

Atmospheric correction was performed to retrieve surface reflectance using the FLAASH package embedded in the ENVI image processing software. The center latitude and longitude of the image data were automatically collected. The sensor altitude, flight date and flight time were collected from the flight logs. A Sub-Arctic Summer atmospheric model and a rural aerosol model were applied to all images. The 1135 nm water absorption feature was used to conduct water retrieval estimates and the 2-Band (K-T) was applied for aerosol retrieval. The image acquisition angle was set to nadir since multiple angles for the same image couldn't be applied. Assessment of geometric accuracy using the national road network identified some areas where geometric errors were present. A set of ground control points were collected and geometric correction was applied using a nearest neighbor resampling and a first degree polynomial interpolation. A root mean square error of 1.84 pixel was achieved. Inspection of the spectral signatures for a selection of pixels, in the image data and for various targets, highlighted a random displacement in the surface reflectance magnitude around 1001 nm and 1547 nm that was corrected for.

4. Features Extraction and Thematic Classification

The surface reflectance data were first subset to extract flight-line pixels that were acquired with a zenith view angle equal or smaller than 10 degrees. The Minimum Noise Fraction (MNF) bands were calculated for each of the five flight lines and visually inspected to select only MNF's that carried mainly information and a minimum noise. Between seven and ten bands located within the first ten MNF's were extracted depending on the flight line. An unsupervised classification was applied to the selected MNF bands for each flight line separately using a k-means classifier, 100 clusters and 50 iterations. The 100 clusters were labeled based on a visual inspection of the hyperspectral data and using the Alberta Vegetation Inventory. The clusters were merged and a set of 11 landcover classes were identified including: water/shadow, Bareground/built-up, shrubs, grass/herbaceous, regeneration, Trembling Aspen, White Birch, Jack Pine, White Spruce, Black Spruce, and Tamarack.

5. Accuracy Assessment

Accuracy assessment of the Matrix landcover map was conducted using the ground data acquired in July 2016 by Matrix Solutiosn (Rochdi et al., 2017). Two modes of accuracy assessment were adopted. Mode-1 (Table-1) uses the dominant vegetation type in the Matrix ground data as a reference in the accuracy assessment. Mode-2 (Table-2) address the difference in the mapping-unit size between ground data (10x10 meter test plot) and the landcover classification (2-meter pixel) as well as the presence of geometric errors. The second mode assumes that, if the type of landcover mapped with hyperspectral data is identified within the 10x10 test plots, there is an agreement between the landcover classification and the ground data. Overall accuracy and Kappa coefficient for Mode-1 were 57 % and 0.46 while they were higher for Mode-2 and equaled 79 % and 0.73 respectively. For Mode-1 user's and producer's accuracies were low to moderate not exceeding 72 %. Conversely, higher user's and producer's accuracies were observed for Mode-2 with values higher ranging from 72 % to 93 %, for the shrubs, jack pine, regeneration and Trembling Aspen (Table-2).

6. Vegetation Recovery in Reclaimed Wellsites

One hundred reclaimed wellsites were identified in the matrix study area. Based on the landcover classification, vegetation percent cover per landcover type was calculated for each of these wellsites. Average and standard deviation values of the percent fractional cover per landcover type were derived (Figure 2). Shrubs and regeneration landcover types were the most dominant with average percent fractional cover values exceeding 30 %. Average percent fractional cover for grass/herbaceous was close to 20 % while for bareground/built-up it did not exceed 7 %. For tree species, average percent fractional cover did not exceed 5 %

Table 1: Confusion matrix for Mode-1 accuracy assessment

		Ground Data								
		Shrubs	Grass/Herbaceous	Jack Pine	Regeneration	Black Spruce	White Birch	Trembling Aspen	Tamarack	Total
Classification	Shrubs	23	3	1	1	1	2	1	0	32
	Grass/Herbaceous	3	3	0	0	0	0	0	0	6
	Jack Pine	2	1	20	6	2	0	2	0	33
	Regeneration	10	4	3	23	0	2	1	3	46
	Black Spruce	0	1	0	2	1	0	0	0	4
	White Birch	1	1	2	1	0	4	2	0	11
	Trembling Aspen	1	1	1	0	0	1	8	0	12
	Tamarack	0	1	0	0	0	0	0	0	1
	Total	40	15	27	33	4	9	14	3	145
	User's Accuracy (%)	72	50	61	50	25	36	67	0	
	Producer's Accuracy (%)	58	20	74	70	25	44	57	0	
	Overall Accuracy (%)	57								
	Kappa	0.46								

Table2: Confusion Matrix for Mode-2 Accuracy Assessment

		Ground Data								
		Shrubs	Grass/Herbaceous	Jack Pine	Regeneration	Black Spruce	White Birch	Trembling Aspen	Tamarack	Total
Classification	Shrubs	23	3	1	1	1	2	1	0	32
	Grass/Herbaceous	0	4	0	1	0	1	0	0	6
	Jack Pine	1	2	27	1	2	0	0	0	33
	Regeneration	1	2	0	41	0	1	1	0	46
	Black Spruce	0	1	0	0	3	0	0	0	4
	White Birch	0	2	1	0	0	7	1	0	11
	Trembling Aspen	1	1	0	0	0	1	9	0	12
	Tamarack	0	1	0	0	0	0	0	0	1
	Total	26	16	29	44	6	12	12	0	145
	User's Accuracy (%)	72	67	82	89	75	63	75	0	
	Producer's Accuracy (%)	88	25	93	93	50	58	75	0	
	Overall Accuracy (%)	79								
	Kappa	0.73								

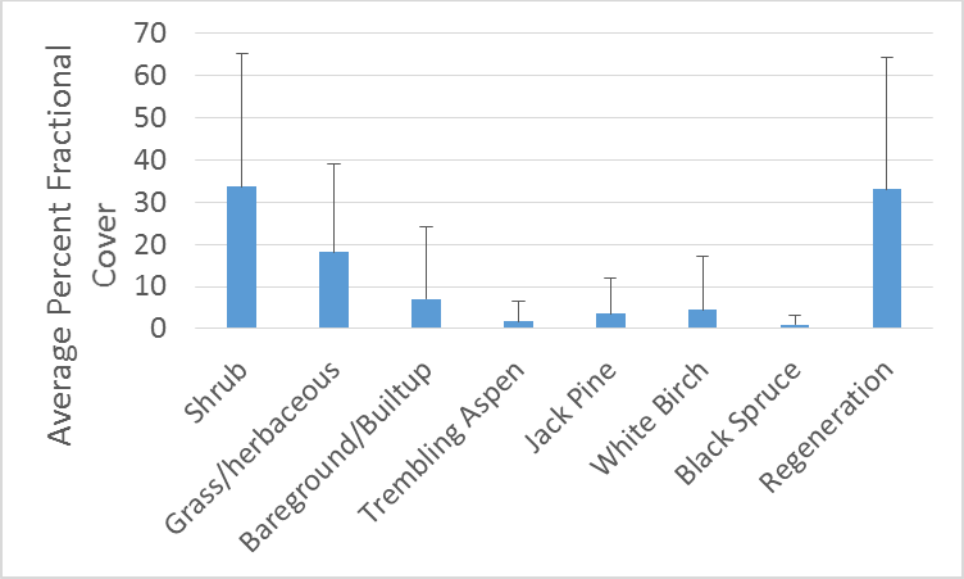

Figure 2: average percent fractional cover per landcover type calculated based on the hyperspectral landcover classification for 100 reclaimed wellsites. Error bars indicate one standard deviation

7. Conclusions

The present report summarizes the methodology used to assess airborne hyperspectral data for mapping vegetation type in reclaimed wellsites. Taking into account the footprint difference between the 10-meter test plot and the 2-meter pixel size, and geometric errors in the accuracy assessment, a close to 80 % overall accuracy was achieved. Moderate to high user's and producer's accuracies were obtained for shrubs, regeneration, Jack pine and Trembling Aspen classes. The sample size used in the accuracy assessment for landcover types such as grass/herbaceous, black spruce and tamarack was limited not exceeding 16 pixels, and might explain the low accuracies obtained for these classes.

8. References

Rochdi, N. and Bracken, A., 2016. Development of Remote Sensing Techniques for Regional Reclamation Monitoring of Peatlands in Alberta – Phase1. Technical Report, 49 pages.

ITRES, 2018. Northern Alberta Acquisition, 2017 - Hyperspectral Data Collection. Technical Report, 29 pages

9. Contacts

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