Spectral Characteristics and Landscape-Level Mapping of Selected Shrub Types in the Canadian Mixed Prairie

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Abstract

Background and Relevance

Remote sensing can capture large-scale ecosystem variabilities in vegetation distribution at multiple spatial and temporal scales. However, it is limited by its inability to capture sub-pixel variations while using sensors having moderate to coarse spatial resolution. This is critical especially in ecosystems such as mixed prairie which are characterized by variable vegetative type and cover and with high background noise.

Conservationists and ecologists now agree that mapping and management of shrubs are the best strategies for the population recovery of the many species-at-risk, conserving biodiversity, and maintaining ecological integrity of the Canadian mixed prairie (Connelly *et al.*, 2000; COSEWIC, 2004; Canadian Sage Grouse Recovery Team, 2001; Grasslands National Park of Canada Management Plan, 2001). Shrubs in the Canadian mixed prairie offers challenges to remote sensing due to their sparse distribution, dense cover, and high amount of non-photosynthetic vegetation. Spectral unmixing strategies such as through multiple endmember spectral mixture analysis (MESMA) of captured reflectance are required for retrieving sub-pixel information of the shrub endmembers on the landscape.

Methods and Data

Canopy spectral reflectance and biophysical data of commonly seen shrub types such as Silver sage (*Artemesia cana*), Snowberry (*Symphoricarpus occidentalis*), Pasture sage (*Artemesia frigida*), Rabbitbrush (*Chrysothamnus nauseosus*), Willow (*Salix* spp.), Thorny buffaloberry (*Sheperdia argentea*), Wood rose (*Rosa* spp.), Winterfat (*Eurotia lanata*), Creeping juniper (*Juniperus horizontalis*), Gooseberry (*Ribes* spp.), and Canada buffaloberry (*Sheperdia canadensis*) were collected. Intensive vegetation sampling was done in 41 randomly selected sites (minimum of 820 points) in the West block of Grasslands National Park (Parks Canada) during the summer of 2006 and 2007. Spectral reflectance of endmember shrub types were collected using a field spectroradiometer (FieldSpec®, ASD Inc.) under optimum sky and atmospheric conditions. The spectral reflectance measurements were taken at a spectral resolution of 3 nm in the 350-1000 nm and 10 nm in the 1000-2500 nm. Biophysical data such as Leaf Area Index (LAI-2000 Plant Canopy Analyzer®, LI-COR Inc.), Minimum Tilt Angle, foliar cover, plant height, vertical structure, and above-ground biomass were also collected. Collateral measurements included soil moisture, litter depth, elevation, and location information.

We studied the spectral reflectance properties of commonly occurring shrub types and created a spectral library of 11 pure shrub endmembers in a digital image processing software, ENVI (ITTVIS Inc.). Twenty two broadband and hyperspectral indices, first derivative spectra, and red-edge variables were computed to cull out the best predictor of an endmember fraction at the

landscape level. Continuum-removal (Kokaly & Clark, 1999); a normalization procedure, was performed on the shrub canopy reflectance values to remove background effects (Clark & Roush, 1984). A geometrically and atmospherically corrected ortho-rectified SPOT-4 image (acquired close to the field sampling time) was subjected to MESMA (Roberts et al., 1998). MESMA was performed using the eleven pure shrub endmembers to derive the fractions of various endmembers in each pixel. MESMA resulted in eleven shrub distribution maps, and these maps were validated with land cover classes identified through field observations, archived datasets, and that reported in the literature.

Results and Conclusions

We found that the spectral responses of shrub types in the Canadian mixed prairie are unique but are often contaminated by high levels of background noise. This warrants the essentiality of noise-removal procedures before subsequent analyses are performed with the spectral data. It was also found that hyperspectral and broadband vegetation indices computed were not significantly different among the various shrub types. Thus, the inherent noise in the canopy reflectance data makes it difficult to separate the shrub types at the landscape-level merely based on traditional methods of vegetative indices. Continuum-removal reduces albedo effects and emphasizes the location and depth of the absorption features, however, it did not significantly increase the spectral spectrability, especially in the near-infrared region, among different shrub types. This agrees with those reported in the literature (Schmidt & Skidmore, 2003). We recommend that a combination of spectral index, continuum-removal, and variabilities in biophysical parameters can be used to discriminate the shrub types. MESMA can be successfully employed to produce landscape-level shrub distribution maps if pure endmembers are available. We are confident that these shrub distribution maps can be used in ecosystem or habitat modeling exercises, or for studying vegetation dynamics and plant succession in relation to global climate change and natural- and anthropogenic-driven disturbances.

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