Spatio-temporal mapping of vegetative types in the Canadian Mixed Prairie

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Abstract

Remote sensing of vegetation in the mixed prairie offers challenges due to their variable vegetative type and cover and high amount of non-photosynthetic vegetation and background noise. Canopy spectral reflectance and biophysical data of commonly occurring vegetative types were collected by intensive vegetation sampling in 41 randomly selected sites (minimum of 820 points) in the West block of Grasslands National Park of Canada during the summer of 2006 and 2007. A 3-endmember model (green vegetation, soil, shadow) spectral library was created. Images were subjected to spectral unmixing. We found that the spectral responses of vegetative types in the Canadian mixed prairie are unique but are often contaminated by high levels of background noise and reflectance from dead materials. This warrants noise-removal procedures on the spectral data.

Background and Relevance

Remote sensing has been found effective to monitor vegetation dynamics in ecosystems at multiple- spatial and temporal scales. This monitoring is critical especially in Canadian mixed prairie ecosystems which are affected by various natural and human-induced disturbance regimes. However, remote sensing of vegetation in the mixed prairie offers challenges due to their variable vegetative type and cover and high amount of non-photosynthetic vegetation and background noise. Sensors having moderate to coarse spatial resolution are limited in their ability to capture sub-pixel variations. Spectral unmixing strategies such as multiple endmember spectral mixture analysis (MESMA) of captured reflectance are effective for retrieving sub-pixel information of vegetation endmembers on the landscape and detecting spatio-temporal changes.

Methods and Data

Canopy spectral reflectance and biophysical data of commonly occurring vegetative types were collected by intensive vegetation sampling in 41 randomly selected sites (minimum of 820 points) in the West block of Grasslands National Park of Canada during the summer of 2006 and 2007. Spectral reflectance of endmember types (field endmembers) 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.), foliar cover, plant height, vertical structure, and above-ground biomass were also collected.

Using the field and image endmembers, a 3-endmember model (green vegetation, soil, shadow) spectral library was created using software, ENVI (ITTVIS Inc.) and VIPER Tools (www.vipertools.org). The image endmembers were identified using the Pixel Purity Index (PPI;

Boardman et al., 1995) method from a SPOT-5 image after minimum noise fraction (MNF; Green et al., 1988) procedure. Orthorectified images, which were geometrically and atmospherically corrected, from Landsat-5 TM, SPOT-4, and SPOT-5 for 1998, 2006, and 2007 respectively. These images were subjected to spectral unmixing through multiple endmember spectral mixture analysis (MESMA; Roberts et al., 1998). MESMA was performed on the images using the model spectral library to derive fractions of various endmembers in each pixel. MESMA resulted in vegetation distribution maps for the different years, and these maps were used for change-detection analysis over the years. The vegetation maps were validated for accuracy of classification using landcover classes identified through field observations, archived field data, and other maps reported in the literature.

Results and Conclusions

We found that the spectral responses of vegetative types in the Canadian mixed prairie are unique but are often contaminated by high levels of background noise and reflectance from dead materials. Thus, the inherent noise in the canopy reflectance data makes it difficult to separate many vegetative types at the landscape-level merely based on vegetative indices. This warrants the essentiality of noise-removal procedures on the spectral data.

Mapping and management of vegetation are the best strategies for conserving biodiversity and maintaining ecological integrity of the Canadian mixed prairie (COSEWIC, 2004; Grasslands National Park of Canada Management Plan, 2001). Spectral unmixing through MESMA can be successfully employed for landscape-level mapping of vegetation types and for studying vegetation dynamics in the mixed prairie at various spatial and temporal scales. MESMA was found to perform better than simple SMA with an accuracy of over 60%, however, the accuracy of MESMA was highly dependent on the selection of best and optimum number of endmembers. Vegetation distribution maps produced by MESMA can be used for monitoring ecosystem or vegetation dynamics in the Canadian mixed prairie. We believe that our results can also aid in developing newer algorithms for spectral unmixing in semi-arid ecosystems, specifically such as the mixed prairie.

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