Abstract

Increasing and maintaining structural diversity in forest stands has become an important forest management strategy for adapting climate change. Furthermore, structural diversity is a straightforward indicator of potential biodiversity in forest landscapes because a diverse stand structure provides better habitat for forest-dwelling organisms. Therefore, a stand structural diversity map is needed for a wide variety of purposes related to biodiversity conservation, climate change adaptation and sustainable use of forest resources. At the same time, the high requirement and expense for time-consuming and mapping stand diversity in particular large forest areas. Also, aerial photography is a slow and time consuming process and often inconvenient to integrate into the new way widely used automated data capture and GIS technologies. Therefore, reliable remote sensing methods offer a cost-effective alternative to aerial photography. The first-order texture and second-order texture features of forest stands were investigated using RapidEye satellite data. The correlation analysis was applied to predict the DBH diversity. As a result, our best model explained the variation of 66% in the DBH diversity (p<0.01). A cross-validation approach with leave 25% out sampling objects was performed in a plantation forest (brutian pine - Pinus brutia Ten.) stands. Specific objectives are:

- To determine the criteria for optimal image segmentation to generate the most appropriate image objects.
- To determine the relationships between field-based structural diversity and the spectral and textural information of the image objects.
- To estimate and map stand structural diversity using an object-based image analysis (OBIA) and stepwise regression.

Material and Methods

Introduction

Forest managers have been seeking a feasible way to integrate biodiversity issues into management planning. It may be the next practical way to study the biodiversity in forest ecosystems. Broadly accepted, a structurally diverse stand (e.g. old-growth forest) is a better predictor of biodiversity than a pure commercial species. Forest diversity is correlated to the diversity of their habitats. The structural diversity can be characterized by diameter distribution of trees, density of trees, and the average height of the forest. Therefore, forest managers can decide the forest management regimes and practices based upon these maps in order to maintain biodiversity.

Object-based image analysis is an effective way when working with very high resolution satellite images (Blaschke, 2010). Meaningful image objects such as forest stands can be automatically segmented to extract structural characteristics using spectral and textural information of image objects. Therefore, continuous diversity maps can be obtained using appropriate modeling techniques.

Objectives

The aim of this study is to assess stand structural diversity using RapidEye satellite image in a forest composed dominantly of brutian pine (Pinus brutia Ten.) stands. Specific objectives are:

1) To determine the criteria for optimal image segmentation to generate the most appropriate image objects.
2) To determine the relationships between field-based structural diversity and the spectral and textural information of the image objects.
3) To estimate and map stand structural diversity using an object-based image analysis (OBIA) and stepwise regression.

Methods

Remote sensing data: The RapidEye satellite image, acquired on June 30, 2010, with 5 m spatial resolution and 5 spectral bands (blue, green, red, near infrared and shortwave infrared) was used in this study. The additional red-edge band does not provide any contribution to estimate stand structural diversity (Blaschke, 2010). The study area of about 1200 ha is a managed forest located in southwestern Turkey in the municipality of Antalya (Figure 1). The dominant tree species is brutian pine (Pinus brutia Ten.). In this study, three different age classes of brutian pine stands were investigated, i.e., riparian woodlands and cultivated fields are the other land cover types.

Results

The correlation analysis showed that there were statistically significant (p<0.01) correlations between Gini coefficient and the first- and second-order texture features derived from mean-centered band (R=0.79 for the Standard Deviation of Grey Levels, 0.55 for the Contrast, 0.51 for the Energy of the GLCM). Moreover, a statistically significant but weak correlation was observed between the texture features derived from the bands including the blue, green, and red bands and the Gini coefficient. The texture measures derived from the bands including the blue, green, and red bands were not correlated with the Gini coefficient. The cross validation test confirmed that the predictive ability of this regression model was statistically (R²=0.50 and p<0.01). The texture measures derived from the bands including the blue, green, and red bands were not correlated with the Gini coefficient. The cross validation test confirmed that the predictive ability of this regression model was statistically (R²=0.50 and p<0.01).

Discussion and Conclusions

The results is promising for predicting and mapping the stand structural diversity based on Gini coefficient and texture measures. The two approaches were not directly compared with relevant researches using texture measures because published results were not in literature used satellite imagery derived from different high spatial resolution multispectral airborne and Redundancy Analysis. The additional red-edge band does not provide any contribution to estimate stand structural diversity based on Gini coefficient. Therefore, a reliable comparison.

For pure brutian pine forests, following conclusions can be drawn from this work;

1) The first order texture (Standard Deviation of Grey Levels) performs obviously better than the second-order texture measures calculated based on GLCM for mapping stand diameter diversity.
2) The texture features calculated from NIR band of RapidEye image are more strongly correlated with the diameter diversity.
3) The multiregion segmentation image analysis algorithm is a effective tool for generating meaningful image objects for retrieving stand structural diversity.
4) The additional red-edge band does not provide any contribution to estimate stand structural diversity.

References

Pasher, J., King, D., J., 2010. Multivariate forest structure modeling and mapping using high resolution airborne imagery and Redundancy Analysis. The additional red-edge band does not provide any contribution to estimate stand structural diversity.