Abstract

The presence and spread of the invasive *Acacia longifolia* in Portuguese dune ecosystems results in a negative impact on native and endemic species and biodiversity, but most of the studies are limited to plot or stand level. It is a very promising approach to apply hyperspectral remote sensing to analyse the impact and to upscale the results from leaf to ecosystem scale. In order to distinguish *Acacia longifolia* from other invasive and native species, leaf reflectance spectra (350-2500 nm) and tannin concentration were used to develop a robust classification model. In field, an ASD FieldSpec FR Spectroradiometer attached to an ASD single leaf clip assembly allowed to collect 750 in-situ leaf reflectance spectra of seven different plant species in three sub-plots. Additionally, leaves of the spectrally measured species were sampled for chemical analysis. The so called hide powder method serves as a reference measuring the tannin concentration of the collected leaves samples. Firstly, partial least square regression was used to link the obtained leaf reflectance spectra of *Acacia longifolia* individuals to their corresponding tannin concentration. Five wavelength regions (675-710 nm, 1060-1170 nm, 1360-1450 nm, 1630-1740 nm and 1840-1920 nm) being highly correlated with tannins, were identified. In a second step, a spectral-based classification model of the different plant species was calculated using linear discriminant analysis combined with principal component analysis. For the prediction 35 bands in the ultra violet / visible range (675-710nm) are sufficient to achieve a prediction accuracy of 92.9% for *Acacia longifolia* and 89.7% for non *Acacia longifolia*. In comparison, selecting the entire wavelength range, only 85.7% of *Acacia longifolia* individuals were correctly predicted. The classification model is intended for future application on canopy and ecosystem scale.

Keywords: *Acacia longifolia*, classification, invasive species, leaf optical properties, Mediterranean dune ecosystems, multivariate data analysis, tannin

1. Introduction

Leaf chemical properties are distinctive indicators for plant physiology and reflect functional and biological diversity in terrestrial ecosystems (Asner et al. 2009). They are not only playing a leading role in ecosystem nutrient dynamics (Hooper & Vitousek 1998), but they also control and influence important vital functions of plants like growth, respiration, light usage, protection and stability (Lambers et al. 2008). Several studies indicate that biochemical and structural features enable characterisation and improve identification of plant functional types and species within and across ecosystems by remote sensing applications (reviewed by Kokaly et al. 2009, Ustin et al. 2009, He et al. 2011). Based on spectral data obtained on leaf and canopy scale, it is possible to classify species as Clark et al. (2005) have successfully shown. The authors have used a laboratory spectrometer and airborne hyperspectral sensors (HYDICE, 400-2500 nm) to gather spectral data of seven emergent trees with which they developed a robust classification model in order to discriminate various tropical rain forest tree species. On leaf scale, a classification accuracy of 100% was achieved.

On canopy and landscape scale, however, the accuracy of classification models decreases, as demonstrated by Clark et. al (2005). Problems, that one encounters using airborne measurements, are the spectral and structural homogeneity of vegetation and the high intra-species variability that may deteriorate the accuracy (Clark et al. 2005, Andrew & Ustin 2008, Hestir et al. 2008, Youngentob et al. 2011). Moreover, variation in landscape topography, canopy structure and viewing geometry may minimize the performance of classification and mapping methods due their dependence on albedo (Asner et al. 2000, Andrew & Ustin 2008, Féret & Asner 2011, Youngentob et al. 2011). In summary, the success of classification and mapping methods decrease from leaf to landscape scale measurements using airborne sensors (Clark et. al 2005, Asner & Martin 2008) due to an increase in complexity of the “sample”.

Nevertheless, the current trend is to map species and their spread on a landscape scale in order to quantify the effects of human interference on the different ecosystems and the spread of invasive species as well as their influence on biodiversity. Recent technical development of hyperspectral sensors (reviewed by Ustin & Gamon 2010) led to new prospects for detailed measurements of functionally important biochemical contents such as leaf nutrients, water content and