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# Comparison of different methods of image analysis for quantifying bare soil in rangelands

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Many authors emphasize the importance of vegetation in maintaining low levels of soil loss by means of its positive influence in reducing erosion. In some low-vegetated Mediterranean rangelands, especially those with high livestock densities, water erosion can ultimately lead to a partial or total loss of soils, particularly at the beginning of the rainy season, when the surface cover is reduced after the dry summer period. In relation with this, it is essential to develop accurate methods allowing the quantification of bare soil which, in turn, can inform about the influence of different livestock management alternatives over the land system.
The main goal of this work is the comparison of the ability of various pixel-based as well as object-oriented methods of image classification for the quantification of bare soil at a fine spatial resolution. The study area is a farm located in a woody rangeland (dehesa) in SW Spain covering a surface area of 1,024 hectare. A three bands (RGB) orthophoto image with a pixel size of 0,4 metres was used, together with its brightness component, to compare the classification of bare soil vs covered soil by means of the following methods: unsupervised classification (k-means algorithm), supervised classification (maximum likelihood classification, minimum distance or nearest neighbour and Mahalanobis distance) and object oriented classification through a multiresolution segmentation. The results of classification were tested using 700 to 1000 points of field validation. Different combinations of image layers as well as validation algorithms were applied to assess for the better classification results.
The best unsupervised classification was obtained from a combination of the RGB layers with the brightness component of the image. A total of 93.1 % of the field data were correctly classified and the Area Under the Curve (AUC) obtained with the ROC (Receiving Operating Characteristic) validation technique amounted to 0.91. With this classification 14.6 % of the study area was estimated as bare soil surface.
For the supervised classification, three different parametric algorithms were used to classify the image pixels: maximum likelihood, minimum and Mahalanobis distances. The more accurate algorithm was the Mahalanobis distance which showed poorer results than those of the unsupervised classification: 91.7 % of the field data was correctly classified and with an AUC of 0.87. The bare soil surface area estimated by this method was 13.4 % of the total study area.
An object-based classification was also performed using a multi-resolution segmentation algorithm for the delimitation of the image objects. Definiens Professional 5.0® software was used to classify a combination of the image RGB and brightness image layers. The results obtained were similar to those of the unsupervised classification: 90.9 % of correctly classified field data points and an AUC of 0.90. The bare soil surface area estimated was 13.8 %. Although the results were comparable in terms of percentage accuracy, the final classified image obtained by the object-based method differs strongly as compared to those resulting from the pixel-based methods by removing the “salt and pepper” effect.