

SATELLITE IMAGERY IN FOREST MANAGEMENT IN SOUTH AFRICA

Separating the Weeds from the Trees

Weed infestation in young stands can severely affect tree growth, reducing volume production and decreasing seedling survival. In South African plantation conditions the first eighteen months are crucial. The authors developed a weed-control monitoring method based on combining textural analysis and spectral classification applied to high-resolution satellite imagery.

In monitoring forestry operations the assessment of conditions across whole stands from the ground is often difficult, assessments usually being based on sample observations. Airborne and satellite imagery have frequently been used to monitor various forest conditions, but it is also possible to monitor some key forestry operations, and high spatial-resolution satellites such as QuickBird and Ikonos are especially useful for this. One such operation is that of weed control in newly established plantation stands.

Textural and Spectral

Key to the use of satellite imagery for assessing weed volume is differentiation between weed and trees. Multispectral classification alone is insufficient for reliable results because tree crop and weed will have the same spectral characteristics. However, separation becomes possible based on the essential feature of plantation trees generally being planted in rows. Such linear features can be identified in satellite images using textural analysis in the panchromatic band. In contrast to the multi-spectral bands of QuickBird and Ikonos, rows are identifiable in the panchromatic band because the spatial resolution is four times higher than that of multi-spectral bands. The presence of vegetation, whether wood or weed, is identified by examining the multispectral bands using unsupervised classification, which ranks the degree of vegetation into four classes, from bare soil to very strong vegetation growth. Assuming that the vegetation present in the rows as identified by textural analysis represents tree crop and vegetation outside the rows, weed, it becomes possible to identify and quantify weed infestation.

Black Wattle

This method was tested on a site in the Midlands of KwaZulu-Natal Province, north of the provincial capital Pietermaritzburg. The area is covered with *Acacia mearnsii*, commonly known as Black Wattle and used for the production of wood chips for the pulp and paper industry. The study showed that it was possible to separate crop from weed but that stand age had an important effect. Four growth phases were noted which relate to degree of crop-row delineation:

1. One to three months after planting, when the crop is less than fifty centimetres high. Since the crop-row was not well defined, crop, soil and weed were insufficiently differentiated, creating a clumping effect. However, strong vegetation growth indicated a potential weed problem since the crop, being in the very early stages of development, could contribute only little to the vegetation signal.
2. Three to twelve months after planting, when the crop is characterised by much clearer crop-row delineation with improved separation between crop and weed. Cross-classification indicated heavy weed concentration and a potential weed problem. Light weed infestation was also separable from the crop-rows and could be identified as a potential problem area.
3. Twelve to sixteen months after planting showed best separation between crop and weed, crop-row delineation was very clear.
4. Older than sixteen months, when canopy closure has generally occurred and monitoring of weed status is no longer important.

Results

Areas of potential weed infestation could be identified and quantified (Figure 1), thus the method provides managers with useful information for focused management decisions. As with most remotely sensed information ground verification is still necessary, but accuracy assessments exceeded 80%. Age ranges given here are, however, not definitive, since there were slightly differing ages on different sites due to factors such as site quality and silvicultural treatments. In areas with very good crop growth and heavy weed growth crop-row delineation was poor, resulting in heavy vegetation growth being classified into clumps and leading to cross-classification of crop and weed. However, as this situation was indicative of heavy weed growth it still provided a useful indicator of the presence of weed problems. Areas of light to medium weed infestation were also clearly identified and distinguishable from crop-rows.

Other Applications

Using the crop-row as a means of separating crop from weed could have application for other row crops such as maize and in vineyards, provided that spatial resolution is sufficiently high to identify linear features. Although standard textural and spectral classification techniques have been used, more sophisticated techniques such as object-orientated segmentation techniques or neural network classifiers offer the possibility of improved results, particularly in crops without clear row delineation.

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