A preliminary conceptual model of remote sensing for detecting small outbreaks of *Mimosa pigra*

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Abstract

The ability to map small outbreaks of mimosa, *Mimosa pigra* L., is important for the success of management programs. Previous remote-sensing applications have not been successful in mapping small outbreaks due to the limitations of pixel-based classifiers and the reliance on a single data source. This paper offers a conceptual model that integrates multiple information sources to map areas that have a high probability of being satellite infestations. Our approach takes advantage of improvements in sensor technology and image-classification methods. Using radar imagery, we delineated vegetation community boundaries and woody vegetation before applying primitive spatial models to estimate the probability of woody outliers being mimosa. We present this conceptual model to stimulate discussion about whether the approach warrants further investigation.

Keywords: *Mimosa pigra*, remote sensing, mapping, spatial models.

Introduction

Satellite weed outbreaks have the potential to spread far more rapidly than single, large infestations (Moody and Mack 1988). Early detection of these satellite outbreaks is therefore vital for weed management success. This idea is strongly emphasised by the example of mimosa, *Mimosa pigra* L. This species has the ability to rapidly invade large areas of Northern Territory floodplains, making early detection a priority for controlling its spread. Existing mimosa management has focused on detecting satellite outbreaks in the field (e.g. from airboats, helicopters, four-wheel drive vehicles). This field approach is successful, but requires significant investments in time and money.

A potentially less-expensive approach to detecting mimosa has been remote sensing. Aerial photography has been used to detect small outbreaks of mimosa (Pitt and Miller 1988), but the cost of obtaining regular coverage of regions limits its use. Applications using satellite imagery from Landsat (Fitzpatrick *et al.* 1988, Fitzpatrick *et al.* 1990, Menges *et al.* 1996, Lyons 1999), and airborne radar (McIntyre 2001, McIntyre *et al.* 2001, Menges *et al.* 2001) have been unsuccessful in detecting small infestations. This lack of success was due to the limitations of pixel-based classification methods and the inability of the sensors to record small mimosa infestations. A small mimosa outbreak will not determine the reflectance value for a single pixel in an image because the mixture of cover types in a pixel containing the mimosa outbreak will cause the

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pixel to resemble the surrounding environment when classified.

Synthetic aperture radar (SAR) data are superior to optical remotely sensed data because woody vegetation on a SAR image is more distinct from the usual background, such as grassland and sedge-land. In the optical wavelengths, the near infrared only slightly enlarges the contrast humans can perceive i.e. different shades of 'greenness' of vegetation. At radar wavelengths, the foliage becomes increasingly 'invisible' with longer wavelengths. At longer radar wavelengths (P-band), all leaf matter becomes almost of no consequence. So, grass looks like bare soil, water looks like water, and trees look like stick figures. Even a single stick figure in grassland looks to the observer like a white area on a black background would for an optical sensor.

This paper presents a conceptual model for detecting possible satellite outbreaks of mimosa using remote sensing. In contrast with previous remote-sensing studies, our approach takes advantage of integrating SAR data with a land cover map, as well as new developments in image classification techniques. The rationale of the model is that mimosa is nearly ubiquitous in its potential distribution on the floodplain. However, the distribution of *Melaleuca* patches is assumed to be more dependent on distance from large mature stands of *Melaleuca*. The major assumption of the model is that woody vegetation not belonging to a *Melaleuca* class has a strong likelihood of being mimosa.

There are no field data available to test any results, and acquiring such data is an expensive exercise. We therefore present the conceptual model to ascertain whether the idea will be supported. A practical demonstration of the conceptual model using primitive spatial modelling was applied to a subset of the Mary River floodplain (MRF).

Study area

A 9.30 km × 11.79 km subset of the MRF was chosen as a test site for the model (Figure 1). The site includes a range of vegetation communities, including *Melaleuca* forest and woodland, mimosa shrub-land, and large areas of grass, sedge and herb communities.

Data and methods

For this study, one remotely sensed and one ancillary data set were used. The ancillary data set consisted of a 1:50,000 vegetation map of the MRF (Lynch 1996), and the remote-sensing data set was a combined TopSAR and Landsat ETM+ image.

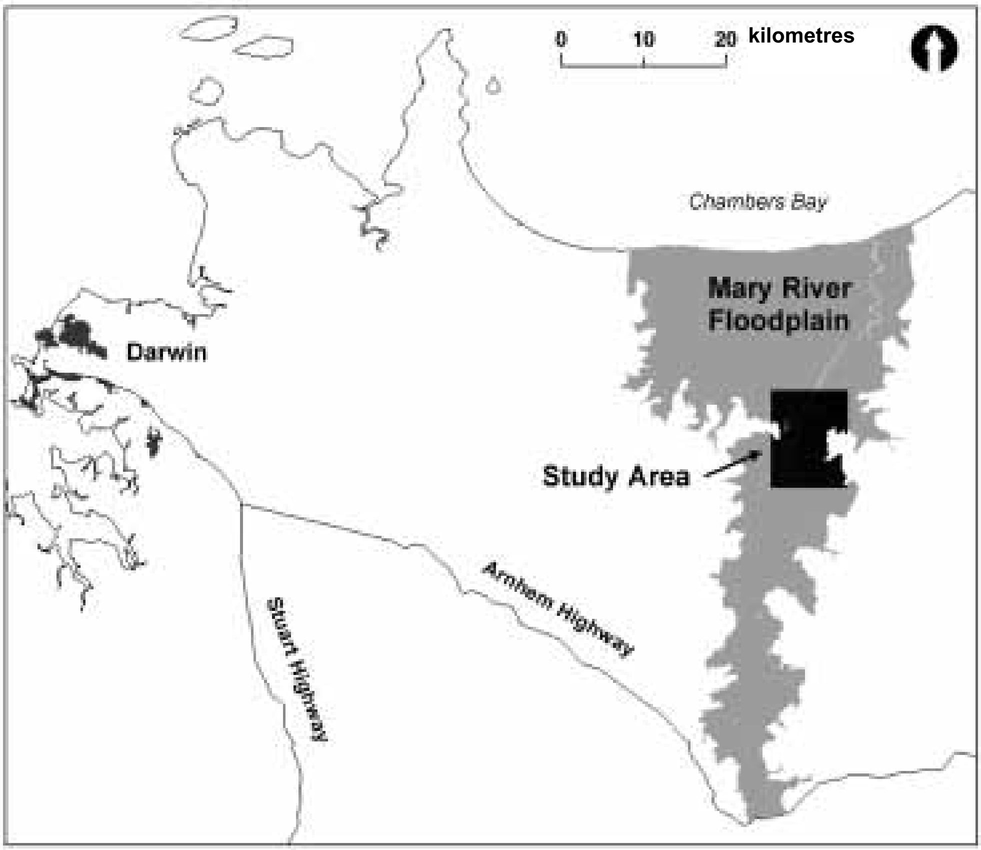

Figure 1. Location of study area.

Details of the TopSAR and Landsat ETM+ data are provided in McIntyre *et al.* (2001) and McIntyre (2001).

The conceptual model methodology is summarised as a flow chart (Figure 2).

The Lynch (1996) vegetation map is accurate for representing ground-cover details, but not for vegetation boundaries. Therefore, a vegetation/land cover map for the study area was required that accurately represented the boundaries of vegetation communities. A segmentation function (e-Cognition) was applied to the bands of the TopSAR/Landsat ETM+ image. Segmentation is a process of dividing an image into separate regions or objects. These objects are comprised of groups of adjoining pixels that have similar spectral properties. The Lynch (1996) vegetation map was integrated into the segmentation process to provide general information on the distribution of major vegetation community types. A standard classification approach was then used to produce the land cover map from the land cover objects (Figure 3).

A finer scale segmentation process was applied to the TopSAR bands, producing image objects as small as individual pixels. Image objects that had high levels of P-band interactions were classified as being 'woody'. Using the vegetation/land cover map, all objects in the woody class were classified as having a likelihood of being mimosa or *Melaleuca,* based on their distance from the boundary of the *Melaleuca* classes.

Results and discussion

Figure 4 shows the classified image objects according to their likelihood of being mimosa. The statistics for the three classes are shown in Table 1.

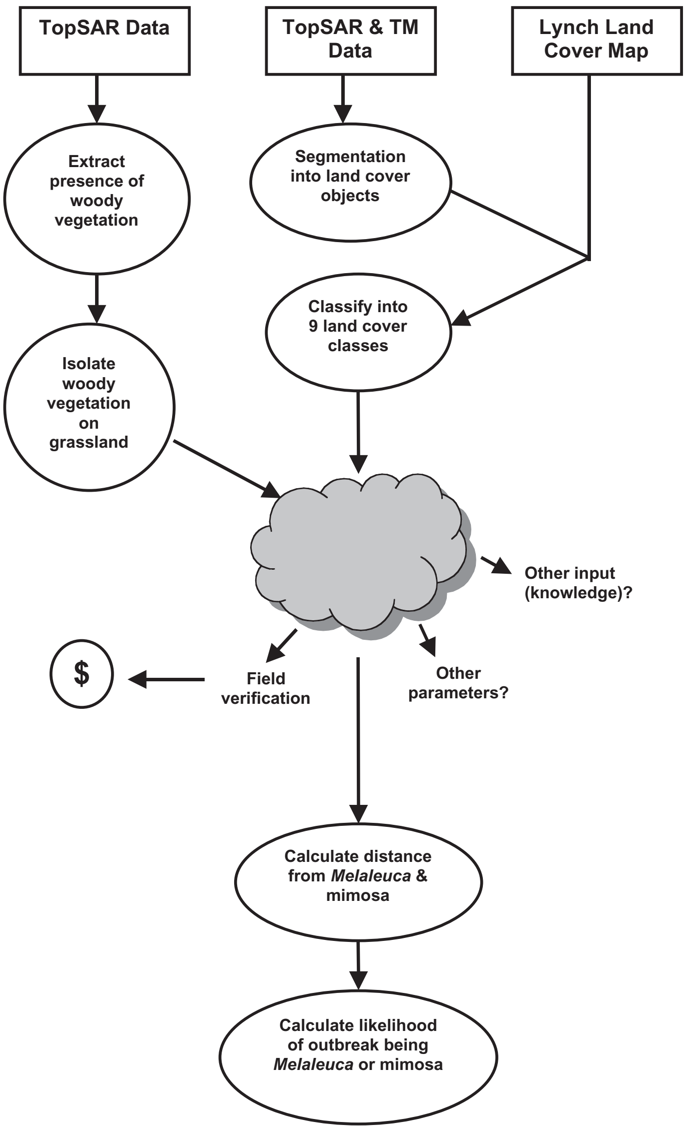

Figure 2. Flowchart of methodology.

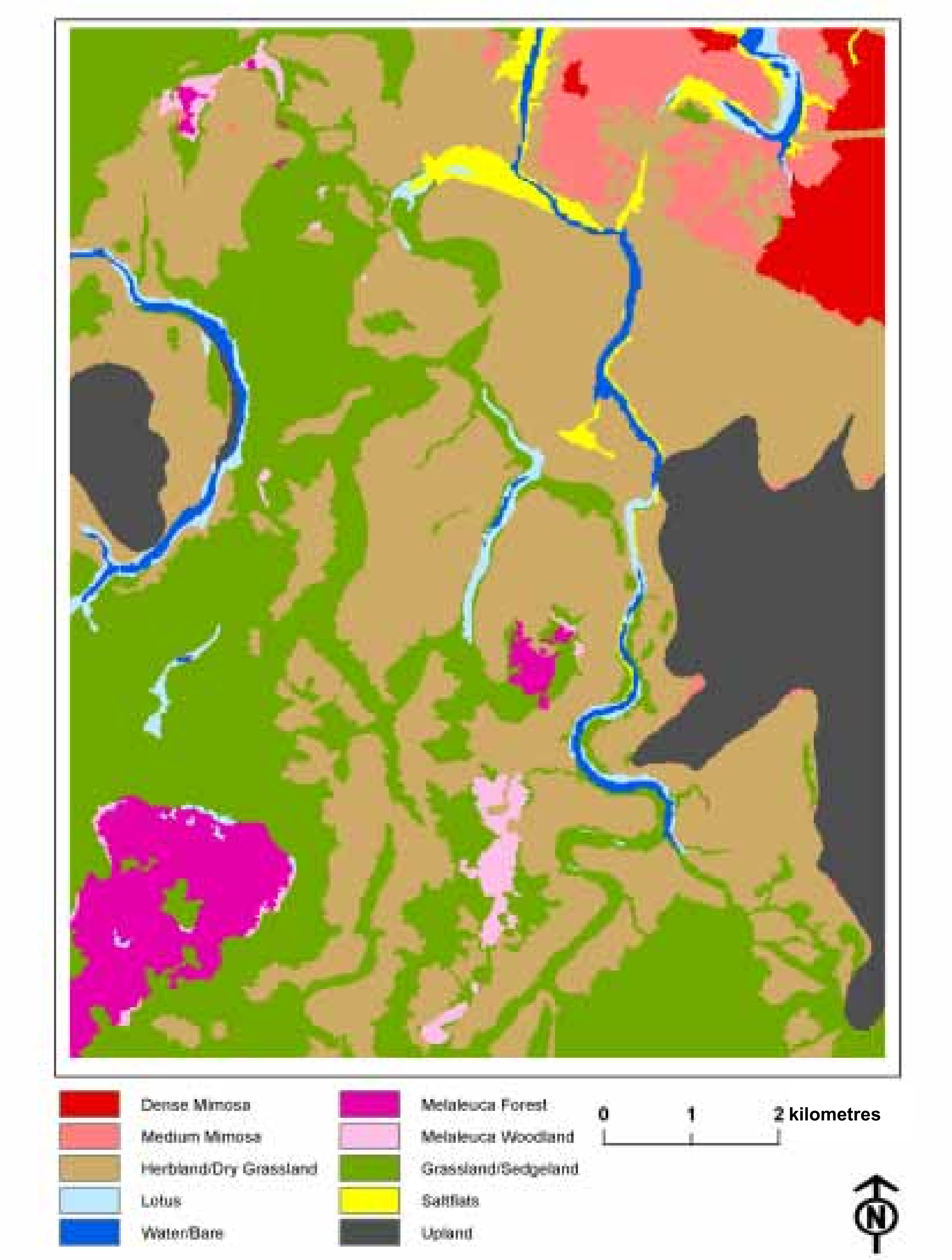

Figure 3. Major land-cover types in the study area.

There were over 1,000 image objects predicted by the model as having a high likelihood of being mimosa. The classified objects ranged in size from 1 pixel (100 m^2) to 28 pixels (2,800 m^2).

The strength of the outlined model will depend on how successfully TopSAR can detect small woody patches on the floodplain. Field validation will be essential for checking suspected infestations, especially the 'high mimosa' outbreaks. Field validation will need to be done regularly to steadily eliminate 'false alarms', resulting in an improvement in the reliability of the model over successive years. Field validation will also determine the smallest area of woody vegetation that can be reliably detected on the radar imagery. The high cost of field work may require the use of field data from existing programs, e.g. from the mimosa control program.

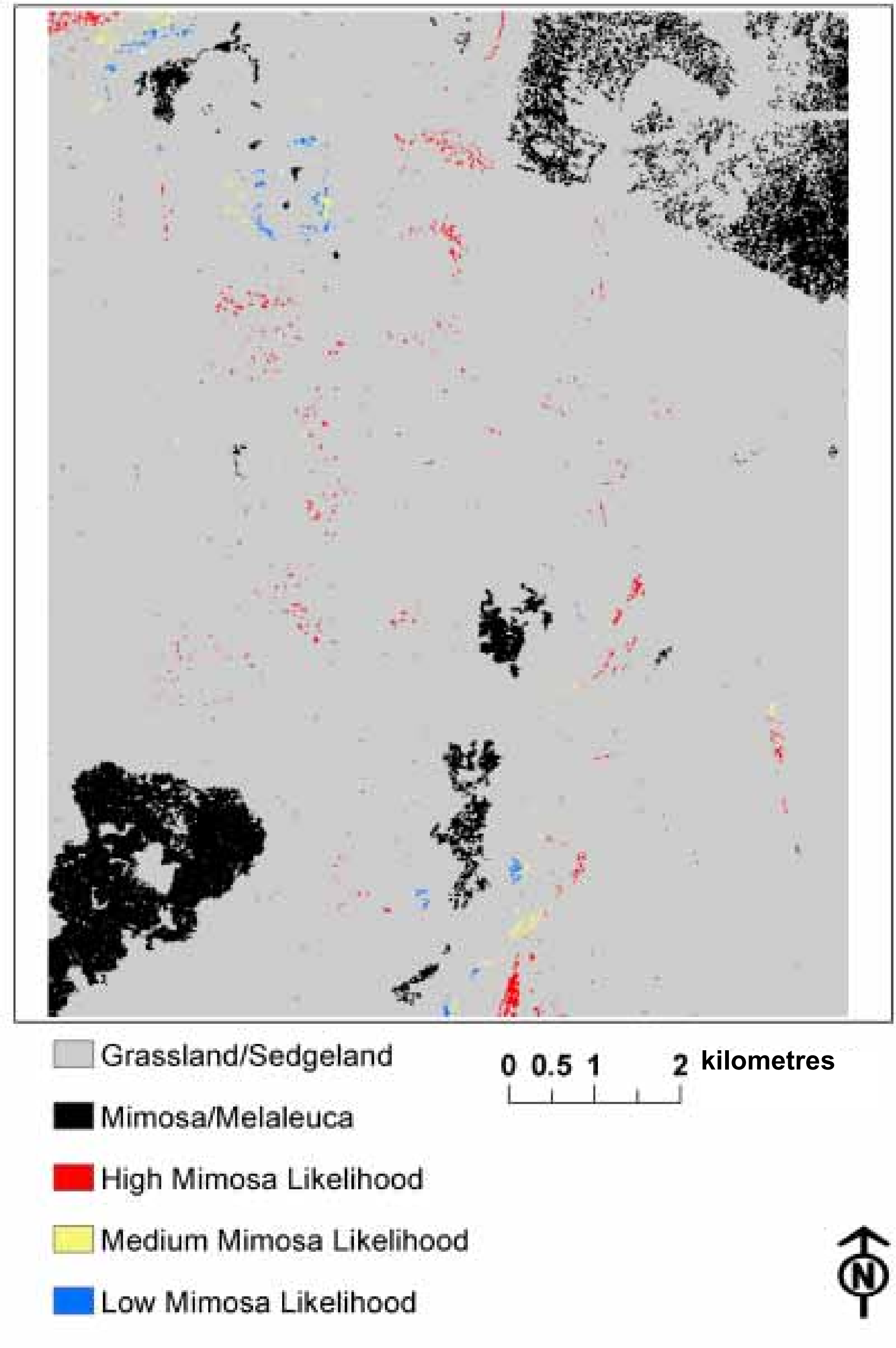

Figure 4. Likelihood of occurrence of mimosa outbreaks in the study area.

The model has the potential for further improvement by the addition of new knowledge (input). An important input to the model will be a current vegetation map that is accurate in describing the various land-cover classes, and for delineating the boundaries of those classes. Other knowledge sources to the model could include models on how mimosa seeds are distributed across a floodplain, and where seedling success is greatest.

Table 1. The results of the woody vegetation classification.

Class	Number of woody outbreaks	Total area (km^2)
High mimosa/low melaleuca likelihood	1,190	0.497
Medium mimosa/medium melaleuca likelihood	428	0.179
Low mimosa/high melaleuca likelihood	248	0.129

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