# Mapping Banana Plants from Orthophotos to Facilitate Eradication of Banana Bunchy Top Virus in Queensland, Australia

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Abstract: The Banana Bunchy Top Virus results in reduced plant growth and prevents banana production. Because of the very large number of properties with banana plants in South East Queensland, Australia, a mapping approach was developed to delineate individual and clusters of banana plants. This will help finding banana plants and enable prioritisation of plant inspections. The developed mapping approach was based on very high spatial resolution airborne orthophotos. Object-based image analysis was used to: (1) detect banana plants using edge and line detection approaches; (2) produce neat outlines around classified banana plants; and (3) evaluate the mapping results. The mapping approach was developed based on 10 image tiles of 1 km x 1 km from September 2011. Based on field inspections of the classified maps, a user's mapping accuracy of 88% (n = 146) was achieved. The results will support the detection and eradiation of Banana Bunchy Top Virus.
Keywords: GEOBIA, orthophotos, banana plants, Queensland Australia, eCognition

## 1. Introduction

Banana Bunchy Top Virus (BBTV) was introduced into Australia in planting material from Fiji in 1913 . During the 1920s and 1930s BBTV devastated the banana industry in New South Wales (Dale, 1987). Banana plants can only be infected from (1) infected plant material and (2) the banana aphid when carrying the virus (Hook et al., 2008). The diagnosis of BBTV is generally performed by visual inspection. Symptom-bearing leaves develop dark green streaks of variable length in the leaf veins, midribs and petioles. As the disease develops, the leaves become more upright and bunched at the apex of the plant (Dale, 1987). Plant growth is stunted and the production of bananas stops when a banana plant becomes infected. Infected banana plants cannot recover from the disease (Hook et al., 2008). The only way to get rid of BBTV is by destroying the infected banana plant.

More than 90% of Australia's banana production takes place in North Queensland (ABGC, 2013). No outbreaks of BBTV have been identified in North Queensland since 1954. However, BBTV is currently present in New South Wales and in South East Queensland. It is essential to prevent the spread of BBTV to the major banana growing areas in Queensland, which would have significant economic consequences for the Australian banana industry. In South East Queensland there are many backyard growers, which make inspection of banana plants and identification of BBTV very time-consuming and labour-intensive. The Queensland Government regularly collects very high spatial resolution aerial orthophotos over urban and

peri-urban areas of South East Queensland. The development of a mapping approach for automatic detection and delineation of banana plants may facilitate the eradication of BBTV by targeting field based searches and inspections of banana plants. The objective of this research was to develop a transferable object-based approach to map banana plants for 10 selected 1 km x 1 km tiles using existing very high spatial resolution orthophotos.

## 2. Study area

The study area was located north of Brisbane on the Sunshine Coast, QLD, Australia. This area contains residential and semi-rural areas. Small tropical fruit farms, including banana farms, exist on the Sunshine Coast, but the majority of banana plants are found in backyards.

## 3. Methods

### 3.1. Image and field data

The 10 selected orthophotos captured between the 10$^{th}$ and 16$^{th}$ September 2011 represented a number of different environments from rural to high density urban areas. The orthophotos consisted of blue, green, red, and near infrared (NIR) bands with 0.10 m pixels. A field campaign was carried out on 25 and 26 March 2013, once the maps of delineated banana plants were completed, to collect independent validation data.

### 3.2. Banana plant detection and delineation

Very high spatial resolution image data are required to detect individual and small clusters of banana plants. Using orthophotos of 0.10 m pixels, GEOBIA was deemed to be the only suitable approach for mapping banana plants. Previously developed tree crown delineation approaches were not found suitable (Bunting and Lucas, 2006). The overall processing approach in the eCognition software included a number of main stages (Figure 1):

1. Vegetation mapping based on indices and multi-threshold segmentation.
2. Creation of base objects using the Multiresolution Segmentation algorithm followed by the customized Multi-Condition-Based Fusion algorithm to merge neighbouring objects with similar mean and standard deviation Blue, Green, Red, NIR values;
3. Production of edge detection bands using the Edge Extraction Lee Sigma algorithm for both dark and bright edges. The dark and bright edge extraction bands were added together and smoothed using the Pixel Filters Sliding Window algorithm and a Gaussian filters with a window size of 39 x 39 pixels, producing high pixel values, where many dark and bright edges appeared, such as areas with banana plants;
4. Detection of bright and dark lines with a length of 1-5 m using the bright and dark edge extraction bands, representing banana leaves or shadows of banana leaves;
5. Extraction of banana plant candidates based on bright areas within the smoothed edge detection band that were also classified as vegetation and occurred with sub-level bright and dark lines, 1-5 m long, within them;
6. Smoothed buffers were created around the banana plant candidates using Distance Maps and the Pixel-Based Object Resizing algorithm and the Growing mode.
7. Final visual classification of all banana plant candidate buffers using the eCognition Architect, an Action Library and an associated Architect Solution to manually accept or decline each of the banana plant candidate buffers.
8. In ArcMap, the delineated banana plant objects were assigned as “high confidence” or “low confidence” buffers, as some banana plants and clusters of banana plants were classified with various levels of confidence using the eCognition Architect.

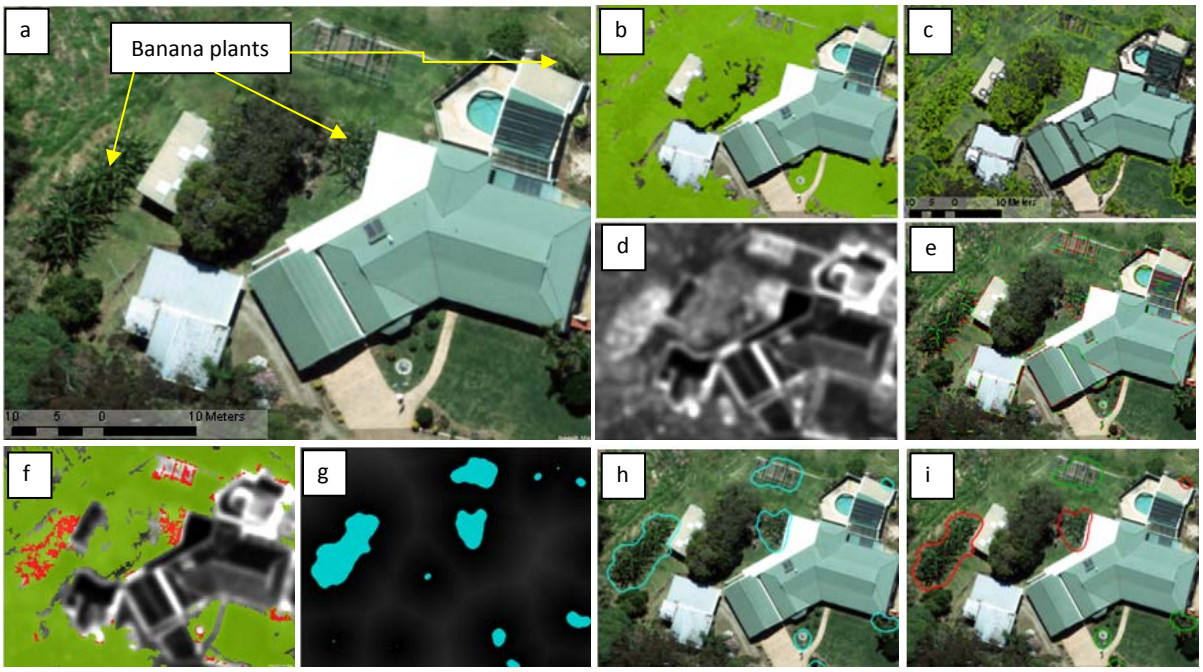

Figure 1. (a) Original true colour orthophoto; (b) vegetation classification (green); (c) base object segmentation; (d) smoothed edge detection band; (e) potential banana plant leaves (green lines) and shadows (red lines); (f) classification of banana plant candidates (red); (g) smoothed buffers around banana plant objects in distance map; (h) buffer outlines; and (i) final classification result after visual assessment (red outlines = banana plants).

### 3.3. Validation

Upon completion of the maps of banana plants, nine out of the 10 image tiles were visited in the field to assess errors of commission and omission. Areas that appeared to have changed, e.g. if banana plants were present at the time of the field trip, but did not appear in the orthophotos, were excluded from the accuracy assessment.

## 4. Results and discussion

The identification and delineation of clusters of banana plants worked very well using the developed rule set (Figures 9 and 10), whereas individual banana plants were in some cases omitted. Those that were omitted generally had limited contrast against the ground (Figure 11), whereas those showing more contrast or creating distinct leaf shaped shadows on the ground were automatically identified (Figure 12).

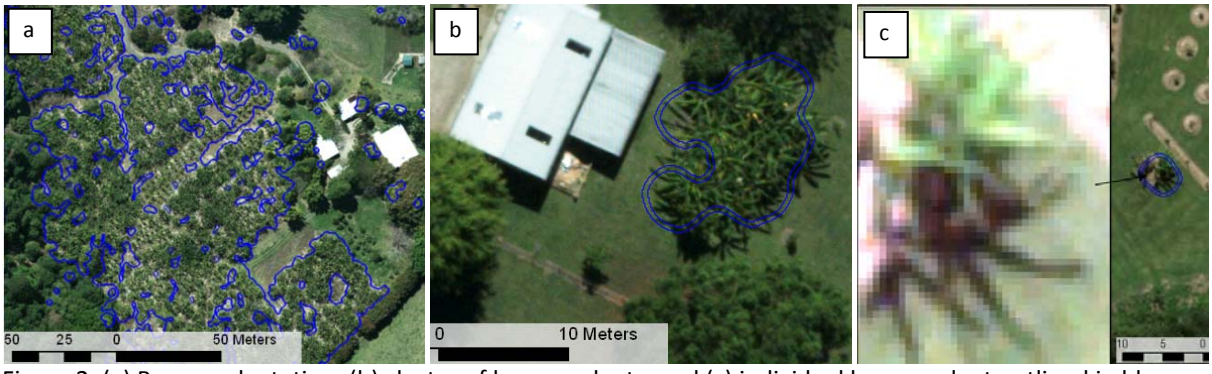

Figure 2. (a) Banana plantation; (b) cluster of banana plants; and (c) individual banana plant outlined in blue.

Based on the field validation data, 94 of the 96 banana plant objects classified with high confidence were in fact banana plants. This yielded a user's accuracy of 98%. Of the 50

mapped low confidence objects inspected in the field, 35 of them were in fact banana plants. This yields a user's accuracy of 70%. Features being incorrectly outlined as banana plants were a combination of palms, *Heliconia* sp. and *Strelitzia* sp. That means if all mapped objects (146 in total) were inspected in the field, there is over 88% probability that the object will in fact represent banana plants. A total of 35 banana plants / clusters of banana plants were not identified by the mapping approach. A total of 19 objects of banana plants were found underneath trees and could not be identified in the orthophotos. Some of the other unidentified banana plants were either too small to identify in the images or lacked contrast against the ground, which resulted in the lack of edge and line detection in the rule set. The dwarf banana plants varieties were in general more difficult to identify. The denser populated areas, e.g. Buderim, had many single banana plants or small clusters of banana plants, which made these areas the most challenging to map, especially when combined with the heterogeneous urban landscape with many other distinct edge and line features. The automatic processing method produced a large number of false positives, which emphasize the need for the final step using the eCognition Architect solution to visually accept or decline banana plant objects. On average 13 minutes were spent for one image tile on the visual assessment in the eCognition Architect. This is significantly faster than visually assessing an image tile without the use of the object-based classification approach.

## 5. Conclusions

This research focussed on delineating banana plants to facilitate the eradication of Banana Bunchy Top Virus in South East Queensland, Australia. Object-based image analysis was used to identify and delineate potential banana plants followed by a final visual step to accept or decline the outlined banana plant candidates. This approach is significantly faster than solely using manual image interpretation and at the same time achieved high mapping accuracies. The mapping approach has the potential to assist identifying banana plants to target field inspections to facilitate the eradication of Banana Bunchy Top Virus in the future.

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