# Mapping Sugarcane Grub Damage from High Spatial Resolution Satellite Imagery

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Abstract: Canegrubs feed on the roots of sugarcane plants, reducing plant vigour and yield, and if left untreated they have the potential to rapidly increase the impacted area in the following year. For the targeted control of the canegrub, it is essential that the location of the affected areas is identified. However, identifying canegrub damage in the field is difficult due to the often impenetrable nature of sugarcane. The objective of this research was to use geographic object-based image analysis (GEOBIA) and high spatial resolution satellite imagery to map canegrub damage. The GEOBIA mapping approach used in this research was based on the following key steps for three selected study sites in Queensland, Australia: (1) initial segmentation of sugarcane block boundaries and further segmentation of each block into smaller homogenous objects; (2) classification and subsequent omission of fallow/harvested fields, tracks and other non-sugarcane features; (3) identification of 'potentially' grub-damaged areas within each block based on low NDVI and high image texture values; and (4) identification of 'likely' grub affected areas based on the absolute difference in NDVI and texture values between the 'potentially' grub damaged areas and the remaining parts of each block. Overall accuracies were between 53-79%. Further research will focus on improving these mapping accuracies. The results of this research will help cane growers to manage and reduce damage caused by canegrubs and increase future yields.
Keywords: GEOBIA, GeoEye-1, sugarcane grub damage, Queensland Australia, eCognition

## 1. Introduction

The greyback canegrub, *Dermolepida albohirtum*, is the principal pest of sugarcane crops in North Queensland, Australia. Previous estimates of annual loss of cane production caused as a result of grub damage are around $10 million (Allsopp *et al.*, 1993; Chandler, 2002). This pest exhibits a one-year lifecycle where adult beetles emerge following the onset of rainfall around October–December, and lay eggs in the soil in December–January. The larval stage has three instars feeding extensively on the root mass, causing reduced growth, stool tipping and ultimately plant death (Sallam, 2011). By the time damage symptoms are apparent in the field in May–June, it is too late and unfeasible to conduct chemical treatment because of the size of the sugarcane. Therefore, sugarcane growers need to apply chemical treatment well before the commencement of beetle flight (Sallam, 2011). Although it is difficult to predict where greyback cane beetles will lay their eggs, canegrub damage has been identified as a function of the extent of damage sustained in the same field or fields nearby in previous years (Sallam and Lowe, 2012). Hence, knowledge on the spatial location and extent of canegrub damage can facilitate the assessment of where damage is likely to occur the following year and hence where treatment should be applied to prevent the next crop/ratoon from becoming infested.

High spatial resolution satellite imagery collected in May-June when canegrub damage symptoms are most apparent may be used determine the location and extent and canegrub damage. The development of a mapping approach may reduce the time and costs of identifying areas with potential canegrub damage. High spatial resolution satellite imagery and geographic object-based image analysis (GEOBIA) were considered most appropriate for identifying canegrub damage because of the various spatial extents of damage. The aim of this research was to use GEOBIA and high spatial resolution satellite imagery to map canegrub damage in three selected areas in Queensland with known canegrub damage.

## 2. Study area

The three study areas were located around Mackay, Home Hill and Gordonvale in North Queensland, Australia. The selected location of each of the three study areas was based on records of canegrub damage in 2010 and a preliminary survey of farmers by Sugar Research Australia (SRA) during June-July 2011. The Gordonvale study area was located 10 km south of Cairns and covered 128 $km^2$. The Home Hill study area was located 7 km south of Ayr along the southern banks of the Burdekin River and covered 53 $km^2$. The Mackay study area was located approximately 15 km southwest of Mackay and covered an area of 66 $km^2$.

## 3. Methods

### 3.1. Field and image data

Field data identifying the location of canegrub damage were collected for all three study sites between March and June 2013 and included (1) damaged areas identified independently of the imagery; and (2) suspected canegrub damaged areas visually identified from the images prior to image processing and mapping.

High spatial resolution satellite imagery was collected by the GeoEye-1 sensor in 2013 for all three study sites. All the satellite images were radiometrically corrected to at-sensor reflectance values and orthorectified using the Shuttle Radar Topography Mission (SRTM) smoothed 30 m Digital Elevation Model (DEM). After the orthorectification, the panchromatic band (0.5 m pixels) was merged with the multi-spectral bands (2 m pixels) to pan-sharpen the images. Finally, the images were geometrically matched to the existing spatial GIS layers of sugarcane block boundaries.

### 3.2. GEOBIA method

The eCognition Developer 8.9 software was used to develop an approach for mapping of canegrub damage based on the pan-sharpened imagery. Initially, the existing GIS layer of block boundaries was used to segment the sugarcane block boundaries. Subsequently, all areas with sugarcane within the block boundaries were mapped to exclude fallow and already harvested areas from further analysis. Then, a fine scale segmentation at a new level was produced to divide each block into smaller homogenous objects.

As canegrub damage is often manifested by reduced growth, stool tipping and exposure of bare ground, the cane occurring within an object representing canegrub damage appeared less green than healthy undamaged cane. Hence, the NDVI was produced to automatically locate those parts of a block with the lowest 30 quantile of NDVI values. This threshold was empirically derived. As different blocks have different cane varieties and hence different reflectance properties, the analysis was done at the block level.

The damaged areas often displayed a 'rougher' texture than healthy cane. Hence, an edge detection filter was used to identify distinct brightness edges. To reduce noise, a Gaussian smoothing filter was used to highlight areas with rough texture. Subsequently, the 70 quantile (30% of highest values) of the smoothed edge layer was used to identify the 30% brightest objects, indicating areas with lots of edges, i.e. rough texture, which can be expected in areas with damaged sugarcane. This calculation was also done for each individual block to avoid confusion caused by different cane varieties. If these conditions were fulfilled, the objects were considered to be potential grub damage.

As tracks between individual blocks were often incorrectly classified as grub damage, these were subsequently excluded, if the objects were elongated, narrow, had smooth edges and had a direction of +/- 5 degrees of the main block direction. As the potential 'grub damaged' objects only represented those areas with the lowest NDVI values and roughest texture within each block at this stage in the mapping approach, it was considered important to assess the absolute NDVI and texture difference between the potential grub damage objects and the remaining parts of each individual block. Hence, a number of conditions were specified in the rule set to classify the likelihood of an object representing grub damage based on how different the NDVI and texture values were in relation to the remaining parts of the block. For an object to be classified as 'likely' grub damage, absolute differences above a set threshold in both NDVI and texture values were required. Further refinements to the classification was also performed, e.g. by excluding very small objects (< 50 pixels) and, if an object classified as low likelihood grub damage was completely enclosed by likely grub damage objects, the 'low likelihood' objects were reclassified 'likely'.

## 3.3. Validation

The classified maps were imported into ArcGIS for interpretation and validation purposes. These field based observations were compared to the mapping results and used to calculate the mapping accuracy.

## 4. Results and discussion

The developed rule set was found to be transferable between the three study sites, as it was developed based on statistics related to each individual image scene and individual sugarcane blocks within each image scene. An example of the canegrub damage mapping results is provided in Figure 1. The field based observations of the Gordonvale area were categorised into light, moderate and heavy grub damage, whereas grub damage was noted as present or absent at the Home Hill and Mackay sites.

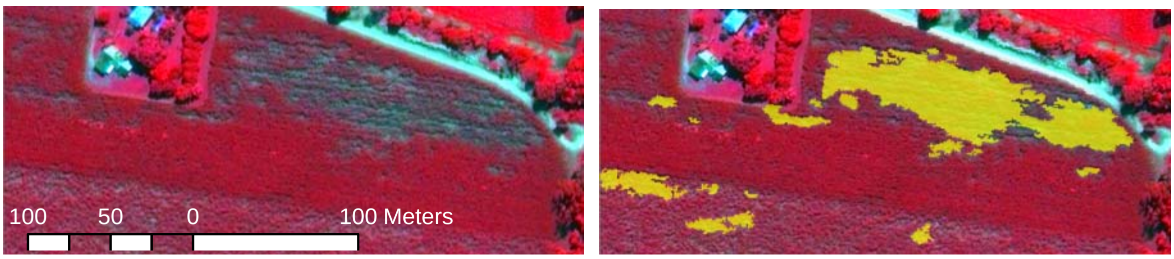


Figure 1. (a) The original image and (b) the mapped canegrub damage (yellow) for an area around Gordonvale.

Between 70% and 80% of the grub damage was correctly mapped for the Gordonvale site using the rule set developed in the eCognition software, relative to field-based validation (Table 1). The locations with heavy grub damage had the highest mapping accuracy, which is not surprising as these areas appeared visually more distinct in the satellite imagery. The mapping accuracies for the Home Hill and Mackay sites were 52.9% and 67.3% respectively. Several locations without grub damage, but classified with grub damage, occurred. The locations incorrectly classified with grub damage did, in most cases, appear with some level of disturbance caused by the presence of weeds, rat and pig damage, sprawling or water inundation. Therefore, the mapping results may be used to alert growers to where damage of various kinds is present. As damage cause a reduction in yield, it can be assumed that growers would be interested in inspecting any kind of damage occurring on their property before a subsequent treatment strategy is decided upon and applied.

Table 1. Accuracy assessment of mapped grub damage based on field data.

| | Light grub damage | Moderate grub damage | Heavy grub damage |
|---|---|---|---|
| Classified correctly | 68 | 36 | 11 |
| Not classified | 36 | 21 | 3 |
| % correctly classified | 65.4% | 63.2% | 78.6% |

## 5. Conclusions and future work

This research provides an automated canegrub damage mapping approach using high spatial resolution satellite imagery and the eCognition software. The initial mapping results appeared with mapping accuracies between 53-79%. It is expected that a refined mapping approach will produce higher mapping accuracies based on additional information to be included in the mapping approach: (1) soil type; (2) distance to neighbouring mapped grub damage; (3) grub damage history based on mapped time-series (currently including 3 years of imagery); and (4) years since last soil treatment. The research results will help cane growers to manage and reduce damage caused by canegrubs and increase future yields.

## Acknowledgements

Sugar Research Australia provided funding for this research. Respective Mills, and Productivity Services provided different types of GIS data layers and direct help with this research. Thanks to all the local cane growers involved for contributing to this work and to Dr Francois-Regis Goebel (CIRAD, Montpellier, France) and his research team for help.

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