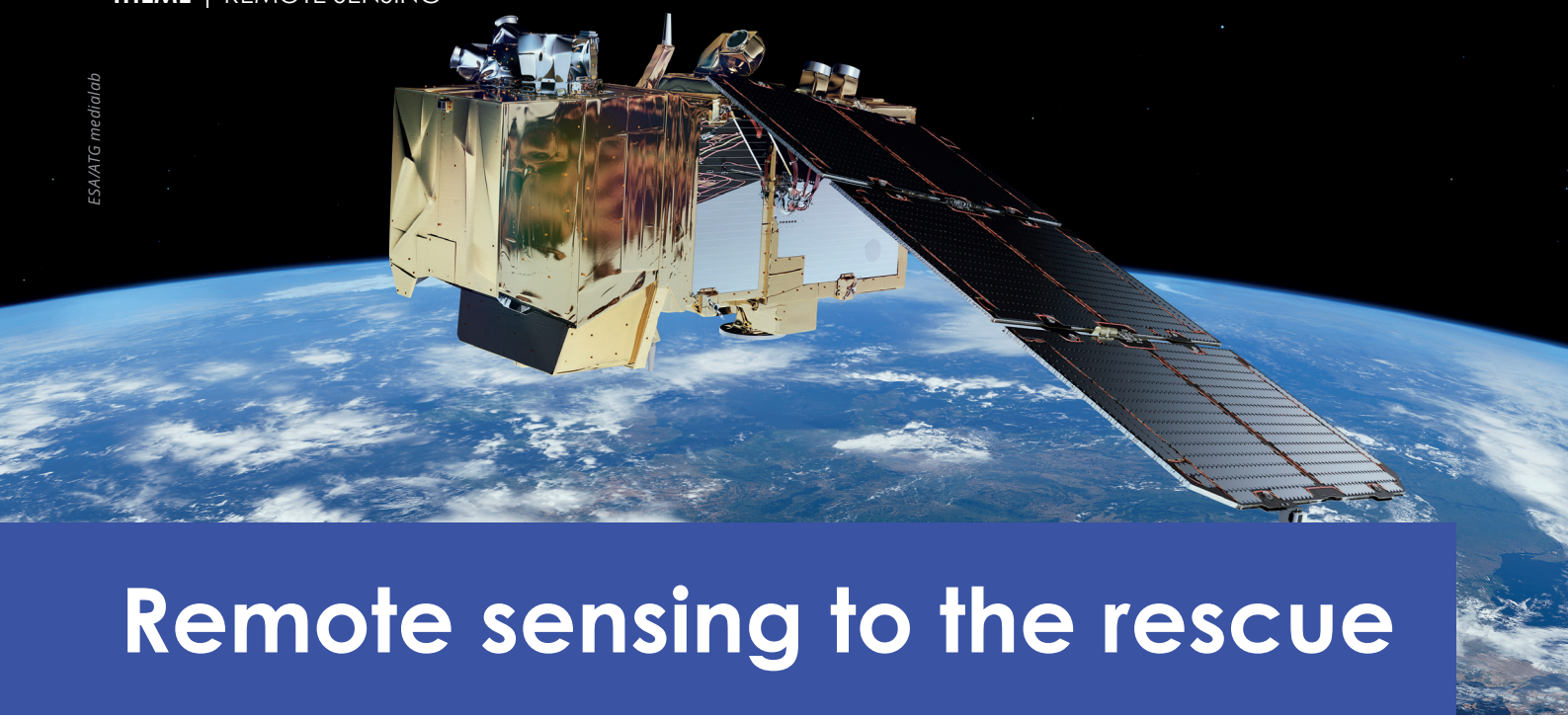


ESA/ATG medialab

Remote sensing to the rescue

Christine Cuénod explains how researchers used satellite imagery to develop a quick method of assessing pest infestations in forestry plantations

The province of Mpumalanga is home to 40% of South Africa's 1.3 million hectares of forested landscape, but an indigenous, wood-boring moth species is emerging as a significant threat to its eucalypt plantations.

The cossid moth, *Coryphodema tristis*, harms *Eucalyptus nitens* gum trees as its larvae – after hatching from eggs laid on the bark by adult female moths – feed on the bark, damaging the cambium and blocking the movement of water, which causes blackening of the trunk and branches. The larvae also bore into the tree, creating tunnels that reduce the value of the wood and weaken the tree, increasing the probability of early death or wind breakage. The tunnelling triggers the release of resin by the tree and this, together with sawdust around the base and pupal casings protruding from the bark, are typically the first signs of infestation.

Donald Owen, Bugwood.org, CC BY-NC 3.0

Feeding damage by the cossid moth larvae causes blackening and weakening of the tree trunk.

The cossid moth has a wide host range of both indigenous and exotic trees in South Africa, and was a well-known pest of fruit trees and grapevines in the south-western Cape before it was first detected in the exotic *E. nitens* plantations in Mpumalanga in 2004. The shift in distribution and target species is mainly attributed to the absence of natural predators, but has also prompted questioning of the role that climate change may be playing.

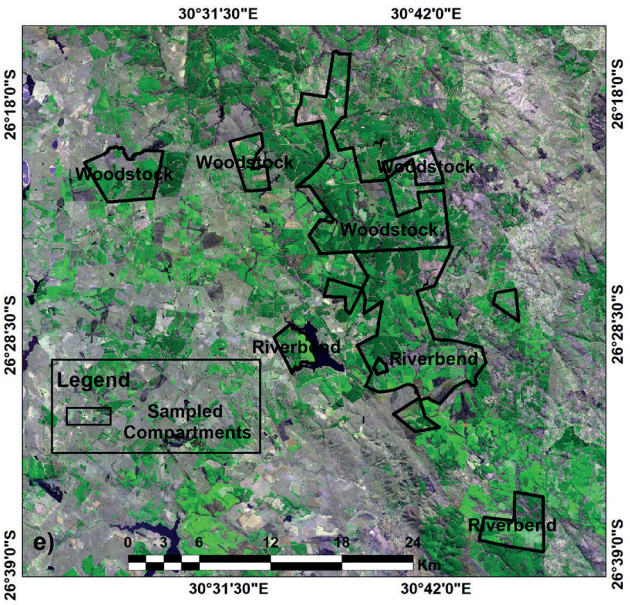
It is estimated that the moth affects up to 80% of some *E. nitens* compartments, raising concerns about the consequences on yield quality and quantity, and the resulting economic impact. Researchers from the University of KwaZulu-Natal and Sappi identified the need for methods allowing swifter detection of cossid moth infestations, given that by the time sawdust, resin and pupal casings on and around the trees are discovered in more traditional field surveys, which are both time-consuming and labour-intensive, most trees are beyond salvageable. They set out to fill a gap in research on monitoring and mapping the occurrence of this insect pest, building on previous work that identified the environmental variables predicting its spatial distribution, including the age of trees affected, elevation, rainfall and temperature conditions of infestation sites.

Their investigation used a multispectral image from the European Space Agency's Sentinel-2 satellite, which measures the solar radiation reflected from the Earth's surface in 13 spectral bands ranging from visible to shortwave infrared regions of the electromagnetic spectrum. Reflectance from vegetation is known to change with plant type, leaf pigments, water content and other factors, so by measuring variations in reflectance from the plantations, the researchers hoped to be able to detect trees that were unhealthy or stressed

Cossid moth larvae tunnel through the wood as they feed, reducing its value.

because of attack by the pest. For example, the Sentinel-2 multispectral instrument's red-edge bands are known to be useful for assessing canopy chlorophyll content, which can be used as an indicator of forest defoliation.

The multispectral image selected for the study was acquired by the satellite in the same week that the researchers visited two plantations in the target area to conduct traditional field surveys. Working with Sappi plantation management teams, they set up pheromone traps in 878 *E. nitens* compartments and inspected trees for resin and sawdust indicating the pest's presence. In this way, 371 compartments were positively identified as infested, and their locations used to generate cossid moth presence data. This, together with spectral bands and vegetation indices derived from the multispectral data, was fed into the Maxent algorithm for analysis. Maxent is freely available, open-source software that uses a machine-learning technique for modelling species distribution. The algorithm was 'trained' using 70% of the presence data, with the remaining 30% used to test the model's performance.



The compartments sampled during the field survey are shown on a false-colour composite of the Sentinel-2 multispectral image, using bands 4 (red), 8 (near-infrared) and 2 (blue).

The results allowed the researchers to ascertain which variables performed best in matching the pest's presence as recorded in the field survey, and hence would have the best potential to predict moth infestations elsewhere. Of the spectral bands, the red-edge band 5 was the most influential in the modelling process, while Photosynthetic Vigour Ratio (PVR) was most important amongst the vegetation indices. The researchers found, however, that spectral bands and vegetation indices combined together in the model provided more accurate predictions of cossid moth occurrence than using them on their own.

The model output revealed some areas with a high probability of the pest's occurrence where it had not been detected during the field survey, confirming that the method presents a quicker and more accurate way of improving pest monitoring in plantations, and can play an important role in supporting forestry management strategies. There are currently no effective biological or chemical control solutions for cossid moth infestations, so plantation managers' present approach to mitigating losses is to harvest trees earlier to minimise the extent of the damage, which they can do more easily if infestations are detected early.

This method of identifying infestations to support forest protection interventions has applicability beyond just *E. nitens*, with researchers saying that the method would be effective for any eucalypt species, with the appropriate amendment of vegetation indices.

"The application of remote sensing and GIS technology is important for the protection of plant health," said Mr Samuel Kumbula, who wrote up the research as part of his master's thesis. "The use of reflectance to indicate plant health and identify any changes improves decision-making capabilities, and can be used for crop monitoring where biological and chemical agents are available to remediate the problem."

Kumbula remarked that while GIS and remote-sensing divisions for monitoring and evaluation are being established in government departments, the private sector has adopted this technology much more quickly.

In the context of a changing climate, with pests and diseases likely to undergo shifts in target and distribution, crop management is in need of detection methods with quick results. This research highlights a tool that could support much of Africa in the monitoring of pest infestations, with the aim of ensuring better crop protection.

- Kumbula ST, Mafongoya P, Peerbhay KY, Lottering RT and Ismail R, 2019. Using Sentinel-2 multispectral images to map the occurrence of the cossid moth (*Coryphodema tristis*) in *Eucalyptus nitens* plantations of Mpumalanga, South Africa. *Remote Sens*. 11(3): 278. https://doi.org/10.3390/rs11030278

Christine Cuénod is the primary journalist for the College of Agriculture, Engineering and Science at the University of KwaZulu-Natal, and also acts as the networking facilitator for the College's agricultural alumni association, Friends of UKZN Agriculture.

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