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| **Automatic Detection of Red Needle Cast Outbreaks in Radiata Pine Plantations in New Zealand using Multi-scene, Multi-temporal Satellite Imagery** |
| Red needle cast (RNC), caused primarily by the oomycete pathogen, *Phytophthora pluvialis*, has quickly emerged as a significant foliar disease affecting radiata pine (*Pinus radiata* D. Don) in Aotearoa New Zealand. Symptoms of the disease typically appear on the lower branches of infected individuals, rapidly spreading upwards through the canopy turning the needles red which are eventually shed from the tree. Research by Scion at heavily infected sites has shown RNC to reduce stem basal area growth by approximately 35% in the year following disease. Radiata pine comprises approximately 90% of the plantation forest estate throughout the country, hence the disease poses a considerable biological and financial threat to the resource. Therefore, the development of a method to accurately detect and monitor the spread of this disease over large areas has become increasingly important.  This study presents a framework for using very high resolution (VHR) satellite imagery to automatically map and monitor outbreaks of RNC in planted radiata pine forests. This methodology was tested on five WorldView satellite scenes collected over two study sites within the Gisborne Region of New Zealand’s North Island. Each scene was acquired in September across a timespan of five years. Four scenes were acquired yearly (2018 - 2020 and 2022) for Wharerata, while one additional scene was obtained in 2019 for Tauwhareparae. Training areas selected for each scene were manually delineated, combined with pixel-thresholding rules inferred by normalised difference vegetation index values (selected empirically) to produce ‘pure’ training pixels for each class. A leave-one-scene-out, pixel-based, random forest classification approach (RF-LOSO) was developed and used to classify all images into three distinct classes: healthy pine forest, unhealthy pine forest, and background.  The overall accuracy of the models on the internal validation dataset ranged from 92.1% to 93.6%, while overall accuracies calculated for the left-out scenes ranged from 76.3% to 91.1% (mean overall accuracy of 83.8%). The user’s and producer’s accuracies across the three classes were 60.2 – 99.0%, and 54.4 – 100%, respectively. The results from this study demonstrate the potential of using a random forest classifier trained on a set of satellite scenes for the classification of healthy and unhealthy pine forest in new and independent scenes. The framework developed here paves the way for a scalable and largely autonomous forest health monitoring system based on the annual acquisition of VHR satellite imagery at the time of peak disease expression. This approach will reduce the need for manual interpretation and delineation. |