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| **Forest age estimation in New Zealand's small-scale plantation forests: Integrating LiDAR-derived height metrics, site productivity with automated harvest detection** |
| The National Exotic Forest Description (NEFD) is a database that describes New Zealand's exotic planted production forests. Among the 1.76 million hectares of planted forests, approximately 30% are categorised as small-scale (<1000 hectares). However, NEFD has been noted to be inaccurate in the estimates of small-scale forests, particularly for those under 100 hectares. This has led to an insufficient understanding of the wood supply from these forests, posing challenges as the majority of them are approaching maturity and are anticipated to contribute more than 40% of the wood supply in the next decade. Accurate assessing forest age is crucial for understanding regional wood availability and facilitating effective planning in marketing, harvesting, logistics, and transport capacity. However, due to the impracticality of collecting information from individual forest owners, the age of small-scale forests remains unexplored.    The availability of remote sensing data, such as publicly accessible LiDAR and Sentinel imagery, presents an opportunity to estimate the age of these small and fragmented forests. This research aims to develop a method for estimating forest stand age in the East Coast wood supply region of New Zealand. Initially, annual forest harvesting was identified using a random forest classifier with annual Sentinel-2 mosaics collected from 2016 to 2022. For harvested forest stands, age was estimated as the year of harvesting plus one, assuming trees are planted one year after harvesting. For unharvested stands, as forest age and height are closely related, age was calculated inversely from a national height-age model, incorporating LiDAR-derived H99 as a proxy for Mean Top Height (MTH), site index, latitude, and elevation of each forest stand.    The harvest detection approach using random forest effectively identified harvested areas, achieving overall accuracies above 0.98. Forest age was estimated for all small-scale forests in the East Coast, ranging from 1 to 56 years. Preliminary assessment compared the estimated stand age with actual stand age information collected from forest growers, resulting in an R2 of 0.93, with a Mean Absolute Error (MAE) of 1.86 years and a Root Mean Square Error (RMSE) of 3.26 years. The age-class distribution of small-scale forests in the region differed significantly from the NEFD. Our estimates showed considerably less area for older stands and more area for young stands, indicating that NEFD does not account for the harvesting and replanting of these resources. This study demonstrates that using remote sensing data can accurately estimate age for small and fragmented small-scale plantation forests, which is crucial for regional planning and management of these resources. |