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| **Improving neural network classification of indigenous forest in New Zealand with phenological features** |
| Accurate and up-to-date vegetation cover maps are essential for effective forest management and policy decisions. Phenological changes in spectral response captured by time-series data can potentially improve vegetation classification by distinguishing vegetation types more effectively. However, the specific phenological features that contribute most to classification of New Zealand’s native forests remain unknown. Feature selection has been proven as an effective solution to this problem. This study aimed to evaluate phenological feature importance and selection for classifying a 50 km² native podocarp forest in New Zealand using two-year Sentinel-2 (S-2) time-series data and single-date PlanetScope (PS) imagery.  The study area was classified into nine classes. Single-date PS and S-2 data were fused to create a base image with the same spatial resolution as PS and eight spectral bands from S-2. This fused image was used to derive 30 Vegetation Indices (VIs). Phenological features, including amplitude (AMP) and phase (PH), were extracted from the VIs using harmonic analysis in Google Earth Engine based on the S-2 time-series data. Three classification scenarios (fused bands & VIs, fused bands & phenological features, fused bands & VIs & phenological features) were developed using a Neural Network to accurately classify forests and identify the most important features. Variable Selection Using Random Forest (VSURF) was applied to these scenarios to evaluate the impact of feature selection on classification accuracy and efficiency.  Results indicate that VSURF reduced the time needed for classification while maintaining comparable accuracy. The incorporation of phenological features improved accuracy from 90% to 94%, primarily driven by Red-Edge Triangulated Vegetation Index-AMP&PH, Normalised Near-Infrared-PH, Greenness Index-PH. These features reflect changes in the canopy's structure, biochemical, and physiological characteristics.  In conclusion, this study demonstrates that specific phenological features can improve the classification of New Zealand's indigenous podocarp forests. The methodology presented in this study offers a potential approach to refine the classification of forests in New Zealand, which could lead to better-informed decision-making and more effective management of the country's indigenous forest resources in the future. |

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