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| **GEDI and Sentinel Integration for Quantification of Poplar Plantation Stocks** |
| **Introduction** Agroforestry represents a strategic asset to contrast climate changes and environmental impacts of agriculture intensifications and a natural-based solution for landscape resilience. Particularly, poplar plantations, thanks to their fast growth rate, conserve and create ecological networks in homogeneous agricultural land, together with the production of plywood, high demanded by several industries, ensuring the storage of a large amount of CO2 in durable manufactured products. Owing to rapid growth, short rotation features, and the dependency on the timber price market, poplar plantations are characterized by large inter-annual fluctuations in their extent and distribution. Therefore, monitoring poplar plantations requires a frequent update of information that is not feasible for conventional National Forest Inventories due to their periodicity. Remote sensing emerges as the most suitable tool for monitoring, both for mapping poplar plantation locations and for more in-depth estimation of structural plantation variables. Accordingly, our goal was to estimate the amount of aboveground biomass and carbon stocks in a large flat study area (more than 46 000 km2) in Po Valley (Northern Italy). **Methods**To do so, we developed a deep learning model based on multi-stream remote sensing measurements to create a high-resolution canopy height map. Our deep learning U-Net model uses multi-band images from Sentinel-1 and Sentinel-2 with composite time averages as input to predict tree height derived from GEDI waveforms. The model outputs allow us to generate a 10 m resolution canopy height map (CHM) of the whole Po Valley for 2021, with a mean absolute error of 2.6 m on external validation data from forest inventory plots. Moreover, based on previous studies, yearly poplar plantations maps in the study area were available. Therefore, based on the poplar-specific yield table carried out through terrestrial laser scanner data in plantations included in our study area and the modelled CHM, we estimated the growing stock volume (GSV), aboveground biomass (AGB), and carbon stock (CS) in all poplar plantation stands. **Results**The results were compared with available data from field surveys. The RMSE was 19%, 30%, and 37% for DBH, H and GSV, respectively. The estimated average GSV was 70 m3 ha-1, while the AGB and total CS were 23 Mg d.m. ha-1 and 12 MgC ha-1, respectively. The poplar plantation map update for 2022 allowed us to estimate the total harvested GSV of poplar trees cut and destined for industrial purposes to be 370 000 m3, corresponding to66 000 MgC ha-1. The average harvested area was 1.5 ha from which an average of 130 m3 was obtained.**Conclusion**The integration of multiple remotely sensed data and new machine learning approaches enables the monitoring of dynamic forests such as poplar plantations, not only spatially but also in quantifying variables critical to climate change mitigation, such as carbon stock estimation for durable goods. |