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| **UAV-LiDAR as a scaling tool for quantifying vegetation biomass and structural diversity in heterogeneous landscapes** |
| Quantifying the spatial diversity of above ground biomass across landscapes is essential for carbon accounting and habitat structural diversity assessment. As the need for natural ecosystem accounting increases globally, accurate maps of above-ground biomass are essential for fostering trust and transparency in natural capital markets. However, in the heterogeneous landscapes of Australia's rangelands—marked by low, variable rainfall and disturbances such as fires and droughts—this task poses significant challenges. High-resolution 3-D structural data collected by survey grade UAV-LiDAR offers a potential pathway for quantifying landscape heterogeneity and incorporating it when upscaling to larger area satellite-based observations.  We used field-based estimates of above ground biomass in conjunction with a high-quality UAV-LiDAR data (Riegl VUX-120 payload on Acecore NOA airframe), to capture spatial variability across diverse Australian rangeland landscapes and explored the potential for scaling biomass from plot (1 ha) to landscape scales (100-1000 ha). The field data was used to train and test Random Forest models based on structural metrics derived from the UAV-LiDAR surveys. Our analysis showed that UAV-LiDAR structural attributes were able to account for 75 % of the variability in above ground biomass, with an RMSE of 8.49 Mg ha −1 across diverse landscapes.  Our findings show the potential for UAV-LiDAR to be used as an intermediate scaling tool to derive biomass estimations at landscape scales (100-1000 ha) from plot level (1ha) estimates, which are required for land managers and natural accounting programs. Furthermore, we illustrate how UAV-LiDAR can complement satellite-based models, and can be used to to establish scaling pathways, enhancing the spatial and temporal coverage of observations from landscapes to regional scales. Such large-scale monitoring tools will become increasingly important in addressing global challenges of natural resource accounting and habitat conservation. |