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| **Global estimations of forest biomass: a review study** |
| Accurate estimates of forest biomass (e.g., aboveground biomass - AGB) and carbon stocks are becoming more important due to the key role of forests in the global carbon cycle and climate change. Mostly, parties of the Climate Convention may be obliged to report annual estimates of carbon pool changes. Two main methods: design-based and model-based inference approaches are often used. However, these methods are characterised by several challenges such as lack of field data, coarse resolution or partial-coverage of remote sensing data, and incomplete comprehension of certain features of methods of inference. The resulting effects are large uncertainties in AGB estimates. Further, most studies tend to report conflicting findings, highlighting the various sources of uncertainty inherent in AGB surveys.  The purpose of this study was to assess methodologies used for AGB estimation and mapping from local to global scales. To this end, 80 studies conducted between 1992 and 2022 were systematically reviewed. As a basis for the review, we propose ideal methodological standards for different sections of a comprehensive AGB survey. It should be noted that fulfilling all parts of the standards is probably impossible in practice, and thus should mainly be seen as a tool for identifying which parts of AGB surveys tend to be more problematic than others. The selected standards are distinct between surveys adopting design-based inference (including model-assisted estimation) and those adopting modelbased inference. The standards comprise a set of criteria where a number of indicators describing quality and reliability were established. Examples of these criteria include properties of the remotely sensed data used, properties of the field data used, the statistical procedures applied, and the methods adopted for quality assurance and quality control. For each criterion, we grade the workflow from 1 to 5 ("poor", "fair", "good", "excellent", and "outstanding", respectively), and summarise the results across all studies.  Preliminary results show an increasing quality of forest biomass assessments during the last three decades. Many of these studies work on a small scale and obtain fair results and overall “good” to “excellent” quality in our review. The use of model-based inference approaches is increasing over time due to the recent advancements in remote sensing technologies. However, large-scale AGB assessments focused on model-based inference tend to be rated lower due to several issues, for instance, a lack of understanding of model prediction unbiasedness and statistical control of domain-specific model performance. Studies adopting model-assisted inference obtained better results compared to model-based due to the complete control of local errors in AGB maps using probability field samples.  We do not reveal our grading of individual studies but use the overall results for identifying what parts of surveys tend to be more problematic than others, and discussing what developments would be relevant from the point of view of enhancing the overall quality of large-area AGB surveys. |