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The role of predictive model data in designing mangrove forest carbon programs

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Abstract

Estimating baseline carbon stocks is a key step in designing forest carbon programs. While field inventories are resource-demanding, advances in predictive modeling are now providing globally coterminous datasets of carbon stocks at high spatial resolutions that may meet this data need. However, it remains unknown how well baseline carbon stock estimates derived from model data compare against conventional estimation approaches such as field inventories. Furthermore, it is unclear whether site-level management actions can be designed using predictive model data in place of field measurements. We examined these issues for the case of mangroves, which are among the most carbon dense ecosystems globally and are popular candidates for forest carbon programs. We compared baseline carbon stock estimates derived from predictive model outputs against estimates produced using the Intergovernmental Panel on Climate Change's (IPCC) three-tier methodological guidelines. We found that the predictive model estimates out-performed the IPCC's Tier 1 estimation approaches but were significantly different from estimates based on field inventories. Our findings help inform the use of predictive model data for designing mangrove forest policy and management actions.

1. Introduction

Forest carbon offset programs are controversial, partly due to the high levels of uncertainty associated with estimating carbon fluxes from land use change (Grassi *et al* 2008, Griscom *et al* 2009, Vanderklift *et al* 2019). The validity of these programs for mitigating climate change depends in part upon these estimates and it is therefore important for them to be accurate (Grassi *et al* 2017). One key step in accurately estimating the climate benefits from these programs is the estimation of baseline carbon stocks, or the reference levels upon which potential project interventions are evaluated (Bento *et al* 2016, Gren and Zeleke 2016). Despite their importance, obtaining accurate estimates of baseline carbon stocks can be a barrier for program design due to the costs of implementing statistically valid field inventories. There has consequently been longstanding interest in improving both the accuracy and precision of baseline carbon stock estimates at lower costs (Willcock *et al* 2012, Langner *et al* 2014).

The Intergovernmental Panel on Climate Change (IPCC) is the foremost authority on inventorying ecosystem carbon stocks. The IPCC provides a three-tier system for categorizing the accuracy and uncertainty of baseline carbon stock estimates (IPCC 2003). Under the IPCC's guidelines, the Tier 1 and Tier 2 approaches use global and regional default parameters, respectively. The Tier 3 approach uses 'higher-order methods,' which may include models or field data from national forest inventories to meet country-specific conditions. Inventorying baseline carbon stocks under the Tier 3 approach provides