Assessing the forest carbon budget for the state of Maine, USA: the importance of including lateral fluxes

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Abstract

Lateral carbon fluxes, including timber harvesting and terrestrial-aquatic dissolved organic carbon (DOC) loading, facilitate carbon relocation from forest ecosystems where it is sequestered from the atmosphere. Timber harvesting redistributes carbon stored in forest sectors to wood products pools of varying life cycles. Concurrently, a substantial volume of DOC is transported from forest soils to coastal oceans via inland water systems, thereby connecting terrestrial and marine carbon reservoirs. Consequently, incorporating lateral carbon fluxes into forest carbon budget assessments is crucial, as they have been identified as major contributors to discrepancies between top-down (atmospheric inversion models) and bottom-up (inventories and biosphere models) assessments at regional to global scales.

Project overview

In this study, we employed multiple estimators and models (i.e., Wood Products Carbon Storage Estimator, Terrestrial-aquatic DOC Fluxes model, and Coastal Particle Tracking model) to quantify the impact of timber harvesting and terrestrial-aquatic DOC flux on assessing forest carbon sequestration in Maine, USA, during 1990-2019.

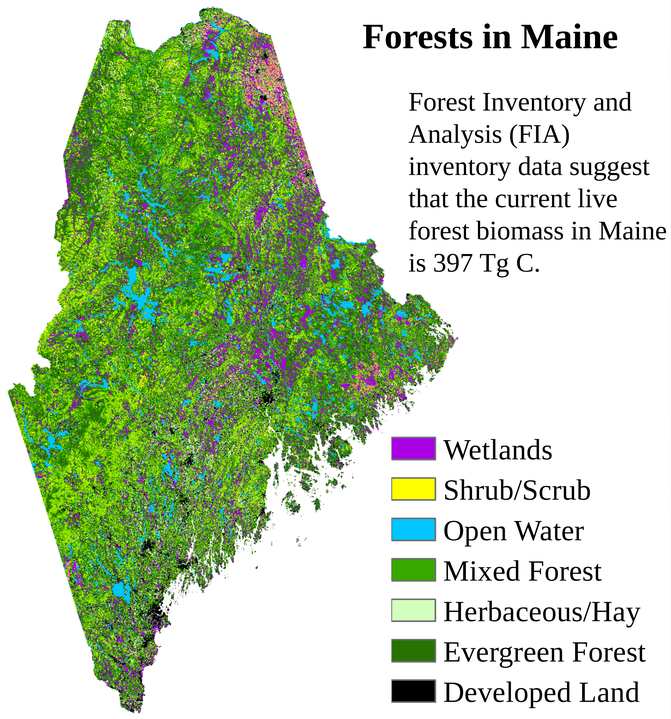

Figure 1. The land cover of Maine. (NLCD 2019)

Methods

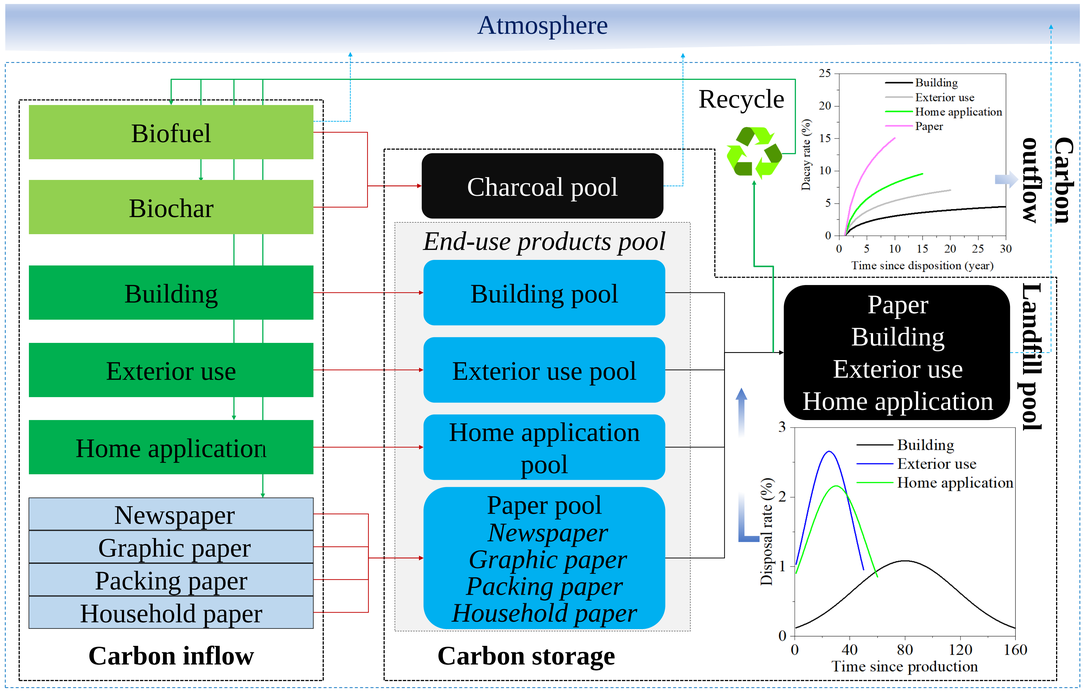

Figure 2. The Wood Products Carbon Storage Estimator (WPsCS Estimator) used to quantify the wood products carbon pool. Note that the biochar is non-energy use biochar.

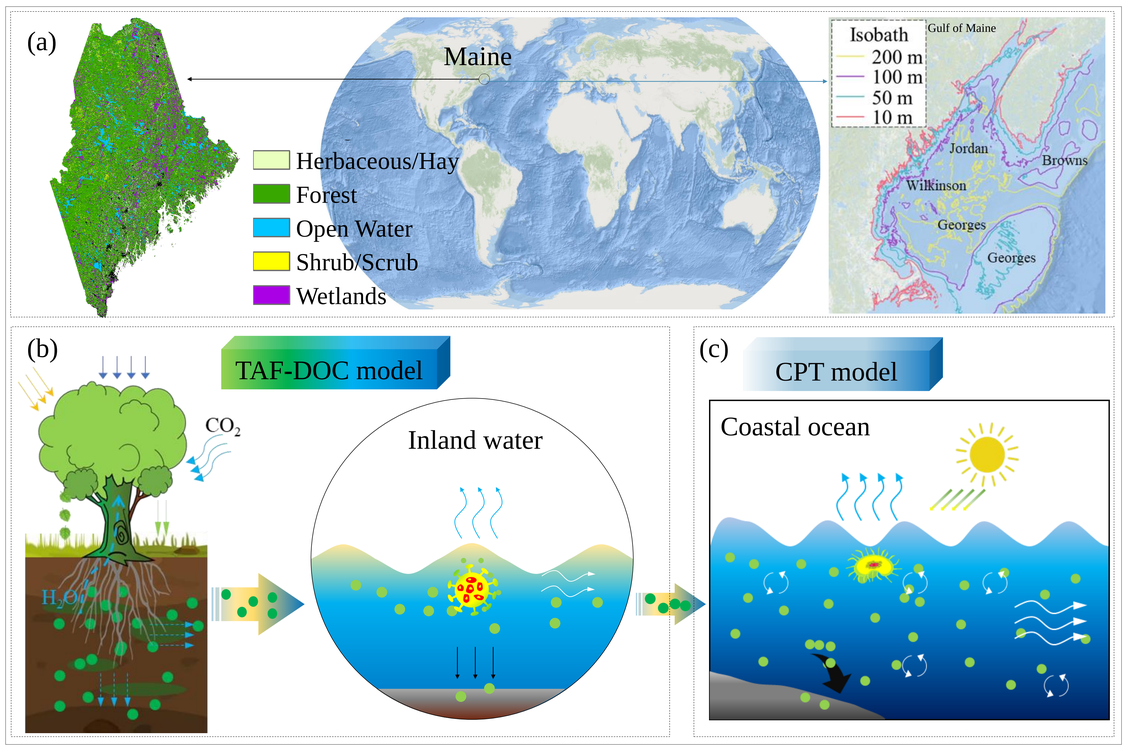

Figure 3. The framework used to account for the lateral DOC flux. The study area (a). The leaching process of terrigenous dissolved organic carbon (tDOC) from soils to inland waters and its delivery to the Gulf of Maine are modeled by the Terrestrial-aquatic DOC Fluxes model (TAF-DOC) (b). The potential fates of tDOC in the GoM is simulated by the Coastal Particle Tracking model (CPT) (c).

Results

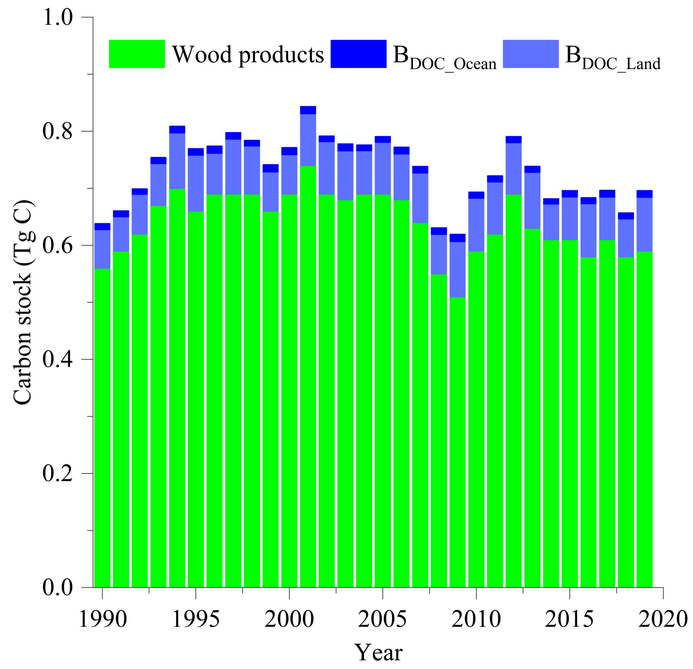

Figure 4. The annual carbon sink in harvested wood products produced from timber harvested in Maine, as well as the annual amount of dissolved organic carbon (DOC) buried in inland water sediments (B_{DOC_Land}) and the Gulf of Maine (B_{DOC_Ocean}).

1) The wood products carbon pool accrued to 19.2 Tg C from 1990 to 2019, with an annual increment rate of 0.64 Tg C per year.
2) The annual DOC loading from forested areas was 0.36 Tg C per year, with 0.08 Tg C per year and 0.01 Tg C per year buried in inland waters and marine sediments, respectively. Ultimately, 2.79 Tg C was sequestered in sediment over this time period, functioning as a long-term sink for atmospheric carbon.

Conclusions

1) The State of Maine's carbon budget, 2006–2016 indicates the annual carbon sink is 2.68 Tg per year.
2) The total carbon sink (0.73 Tg C per year) attributed to these lateral carbon fluxes comprises 27% of the total carbon sink increment in live forest biomass in Maine (2.68 Tg C per year).
3) Ignoring these lateral carbon fluxes would lead to underestimation of the forests' role in sequestering atmospheric carbon.