Variation in ecosystem carbon allocation patterns among different vegetation types in Western Ghats, India

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Introduction

- A major global challenge is the urgent need to bend the curve of rising atmospheric carbon dioxide (CO_2) concentration which stands at 421 ppm as on March 2023[1].

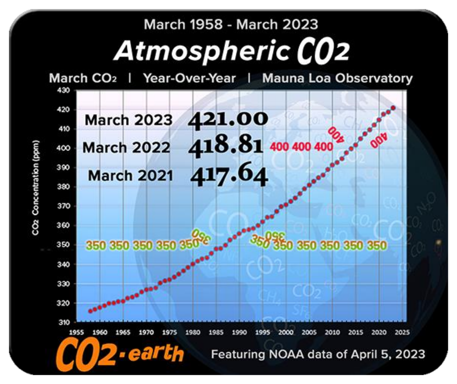


Fig. 1: Rising atmospheric CO_2 concentration (*CO_2 Earth*)

- Carbon (C) pools in forests play an important role in regulating the regional and global C cycles[2].
- Studies on partitioning of C allocation patterns in different C pools offer crucial insights to either maximize the C sequestration or maintain the existing C sinks.

Objective

This study aims to assess C stocks of all the pools {*live biomass* (trees and non-tree vegetation), *detritus* (deadwood and forest floor litter), and *soil*} from different vegetation types in Kanyakumari Wildlife Sanctuary (KWLS), Western Ghats, India.

Study area

Kanyakumari Wildlife Sanctuary (KWLS), southern Western Ghats, India

Six vegetation types {3 natural forests, tropical dry deciduous (TDD), semi-evergreen (TSE) and evergreen (TEF) and 3 plantations, teak (TP), rubber (RP) and areca nut (AP)} were selected in KWLS, southern Western Ghats, India. (Fig. 1).

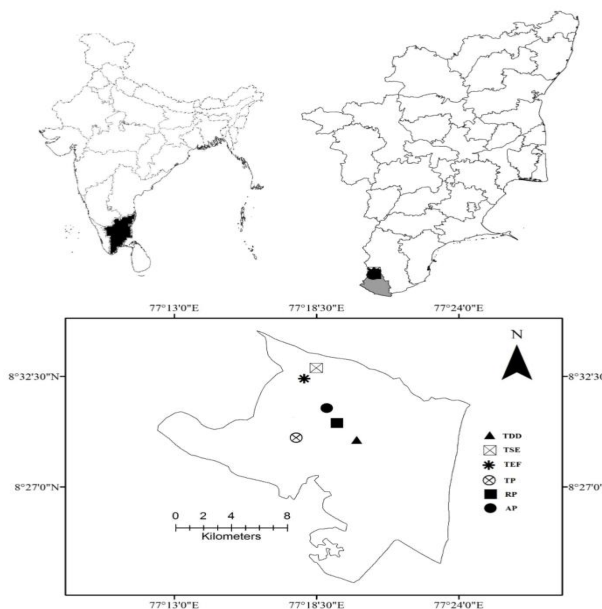
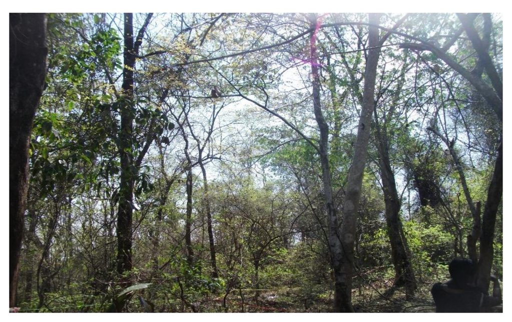


Fig. 2: Location of the six vegetation types in KWLS, Tamil Nadu, India

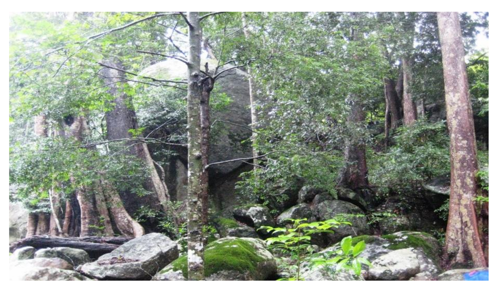


TDD

TP

TSE

RP



TEF

AP

Methodology

- A total of 60 (20 m × 20 m) square sample plots were laid in the selected vegetation types (ten sample plots in each type).

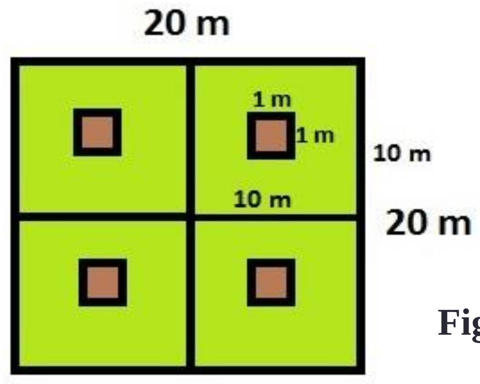


Fig. 3: Study design

- The aboveground biomass (AGB) and belowground biomass (BGB) of trees and lianas were estimated using standard allometric equations[3-5].
- Detritus and soil sampling was done following standard protocols[6,7].

Results

- A total of 233 species were enumerated from 222 genera and 73 families.
- The mean total vegetation biomass C (BC; AGB + BGB) varied from 29.8 Mg C ha^{-1} (AP) to 445.7 Mg C ha^{-1} (TEF).
- The mean total detrital C (DC) ranged from 1.1 Mg C ha^{-1} (TDD) to 3.2 Mg C ha^{-1} (TEF).
- The mean soil organic C (SOC) varied from 58 Mg C ha^{-1} (TEF) to 123.6 Mg C ha^{-1} (TDD).
- The total ecosystem C stock averaged 262.7 ± 56 Mg C ha^{-1} and ranged between 94.7 Mg C ha^{-1} (AP) and 506.8 Mg C ha^{-1} (TEF).

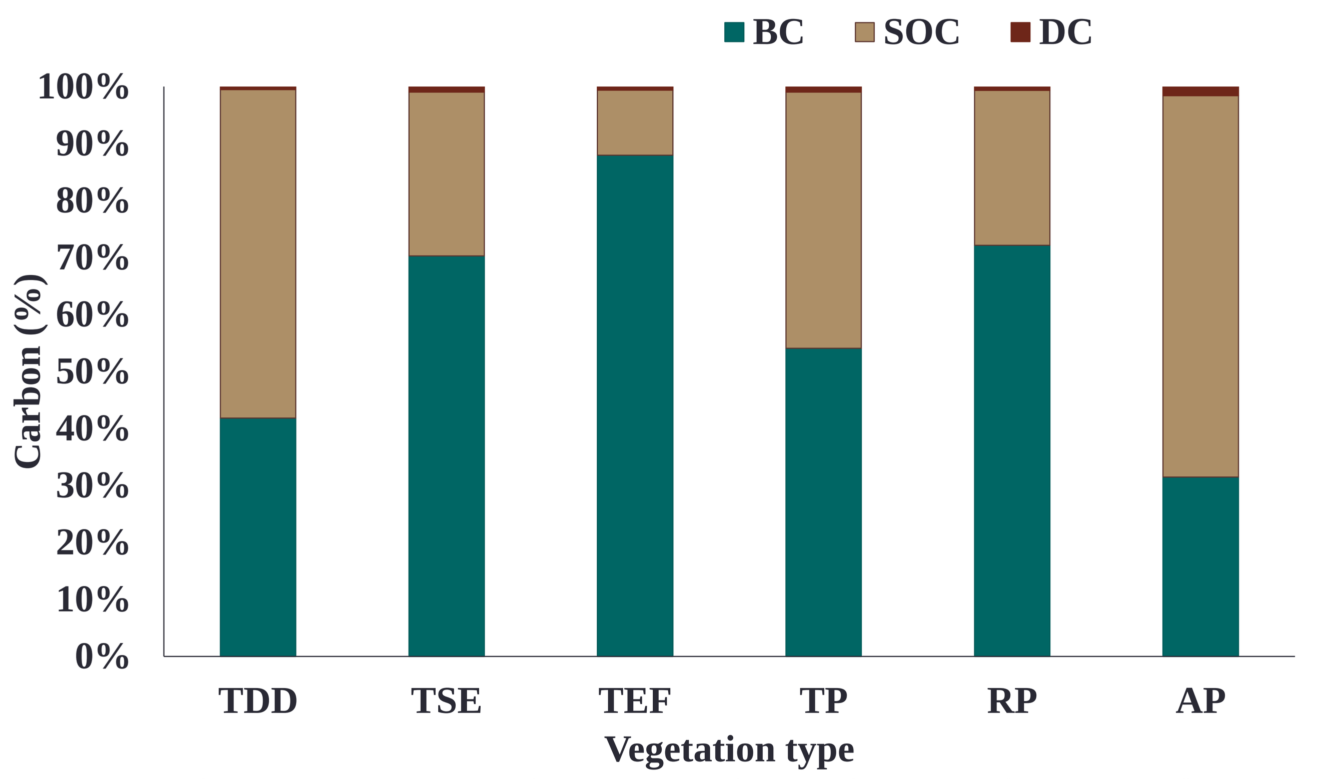


Fig. 4: Carbon allocation patterns in the six vegetation types of KWLS

- Overall, around 86.8% of the total woody biomass is constituted by aboveground biomass and the rest by belowground biomass.
- The total ecosystem-level carbon stocks were noted to be in the following hierarchy: TEF (506.8 Mg C ha^{-1}) > RP (284.4 Mg C ha^{-1}) > TSE (272.2 Mg C ha^{-1}) > TDD (214.5 Mg C ha^{-1}) > TP (203.6 Mg C ha^{-1}) > AP (94.7 Mg C ha^{-1}).

Table 1: Top contributors to biomass carbon in natural forests of KWLS

Vegetation type	Species	% contribution to BC
TDD	*Terminalia paniculata*	40.2
TSE	*Pterocarpus marsupium*	38.4
TEF	*Hopea parviflora*	61.7

- The mean diameter at breast height (DBH) value across the six vegetation types ranged from 23 to 28.1 cm.
- Large trees (≥ 70 cm DBH) contributed 6.8 (TSE) to 28.4% (TEF) of biomass.

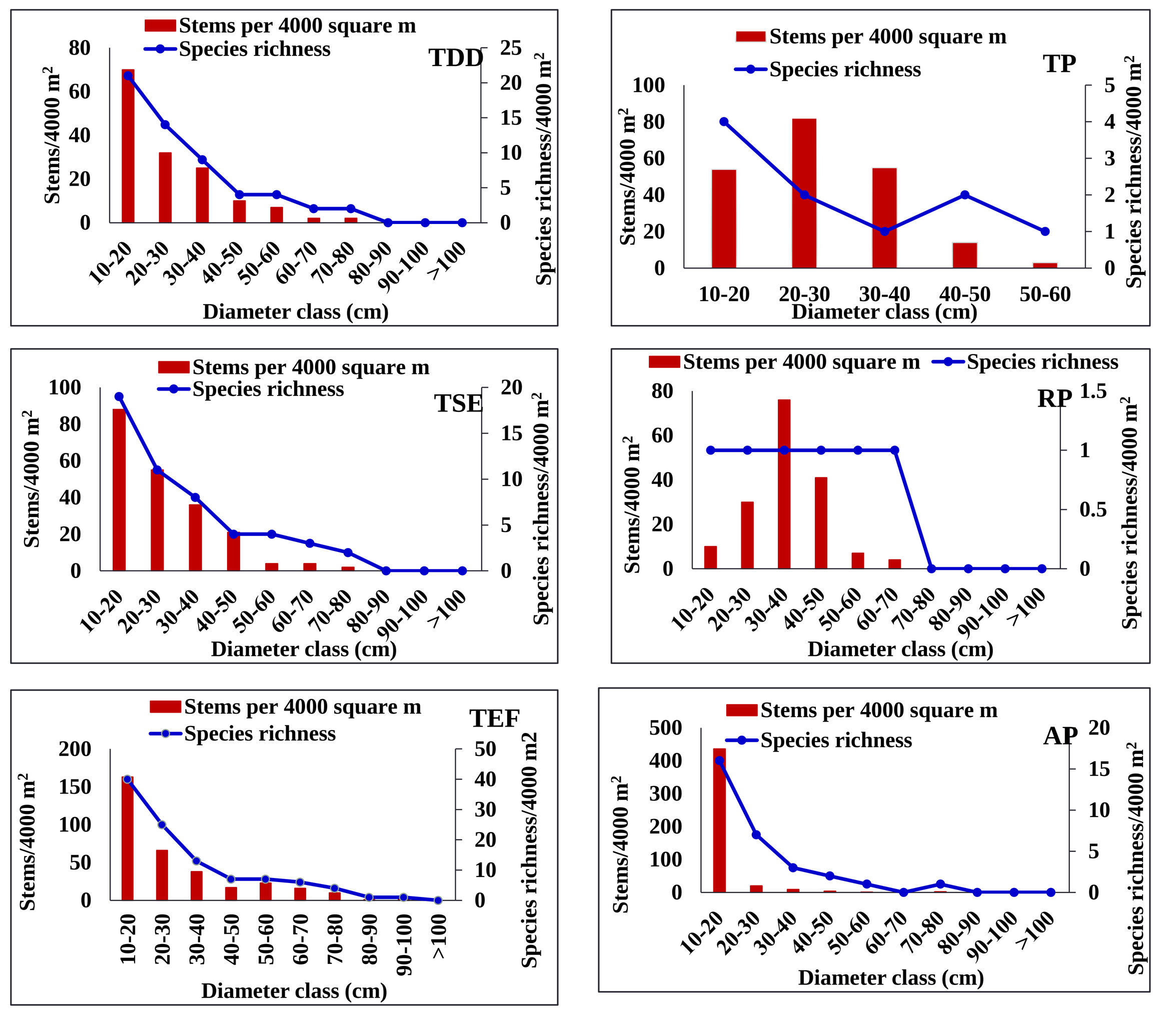


Fig. 5: Diameter class-wise distribution of tree adults

- The C stocks were significantly positively correlated with stand density, basal area, mean annual precipitation and elevation, whereas it was negatively correlated with mean annual temperature.

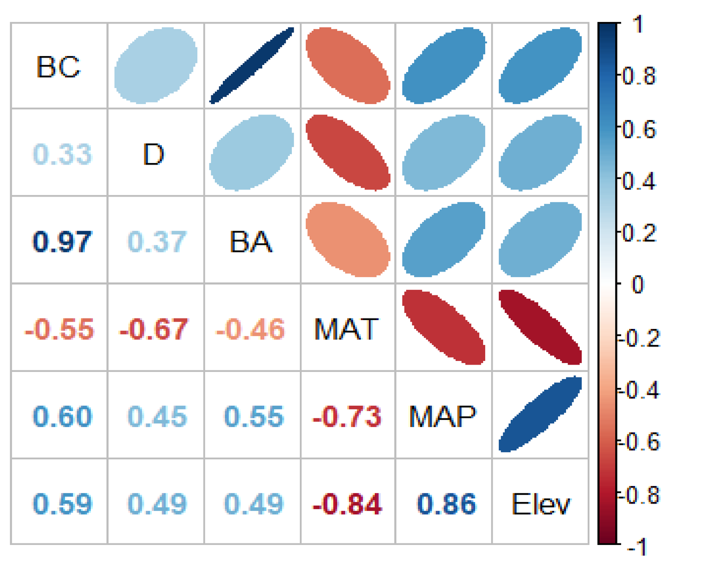


Fig. 6: Correlogram showing the relationship of biomass C (BC) with density (D), basal area (BA), mean annual temperature (MAT), mean annual precipitation (MAP) and elevation (Elev)

Key takeaways

- Different vegetation types had different C allocation patterns. Soil was the major C pool in tropical dry deciduous forest and areca nut plantation, whereas biomass was the largest pool in other vegetation types.
- The site conditions, species composition, size class of trees and management practices play key roles in the partitioning of carbon stocks among the pools.
- The C stocks of teak and rubber plantations were comparable with those of dry deciduous and semi-evergreen forest types respectively.
- The present study would improve our understanding on C allocation patterns at ecosystem-level in different vegetation types of Western Ghats, and can be used for ecosystem restoration and forest management programmes to enhance C sequestration.

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