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BlueCarbon R package: Estimation of Organic Carbon Stocks and Sequestration Rates From Soil Core Data

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Summary

BlueCarbon facilitate the estimation of organic carbon stocks and sequestration rates from soil/sediment cores of depositional environments. It contains seven main functions to estimate core compaction, correct core compaction, estimate sample thickness, estimate organic carbon content from organic matter content, estimate organic carbon stocks and sequestration rates and visualize the error of stock extrapolation.

Statement of Need

Coastal blue carbon ecosystems have earn a large attention for their role as sinks of organic carbon. In the last decade, publications about blue carbon research have grown exponentially, including many studies reporting soil organic carbon stocks and sequestration rates Quevedo, Uchiyama, & Kohsaka (2023). Although there are many soil sampling strategies, estimation methodologies are fairly homogeneous, following the protocol published by the Blue Carbon initiative Howard, Hoyt, Isensee, Pidgeon, & Telszewski (2014). However, and although many blue carbon researchers work in R and it is becoming more common to publish the code used, there is no specialized R library. This library aims to standardize and automate the main estimations to get soil/sediment blue carbon stocks and sequestration rates from raw field and laboratory data.

Design

The BLueCarbon library contains seven main functions (Fig. 1) to deal with core compaction (estimate the compaction of cores and mathematically correct core compaction), transform laboratory data (estimate sample thickness and estimate organic carbon content from organic matter content) and estimate organic carbon stocks and sequestration rates (estimate organic carbon stocks and sequestration rates and visualize the error of stock extrapolation).

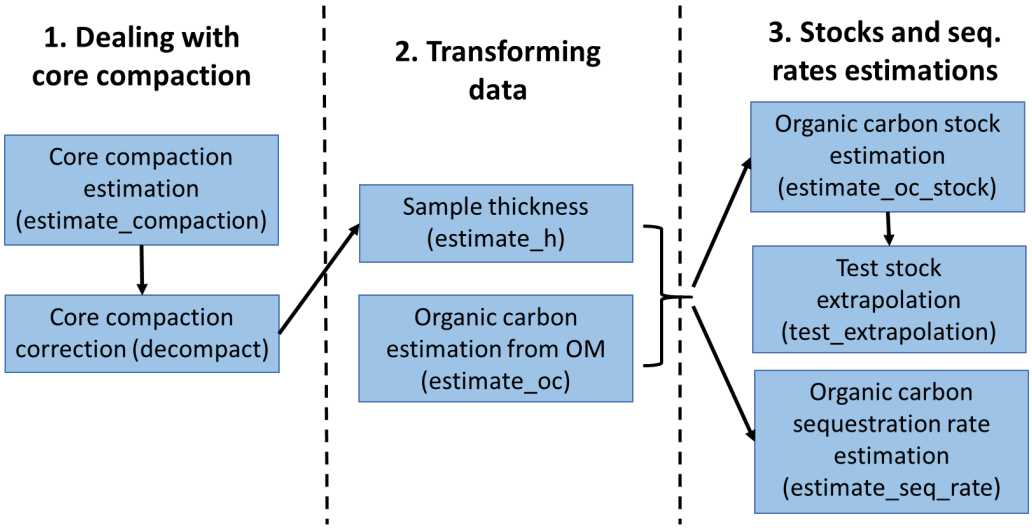

Figure 1: Blue Carbon library workflow

estimate_compaction - Estimate Core Compaction

Sampling soil cores by manual percussion usually leads to the compaction of the material retrieved. This function estimates the percentage of compaction from measurements taken after inserting the corer tube and before extracting it (Fig. 2): length of the corer tube (sampler_length), distance between the surface of the soil and the top of the tube in the outside (external_distance) and distance between the surface of the soil and the top of the tube in the inside of the tube (internal_distance).

decompact - Calculate sediment properties after decompaction

This function applies a linear correction (all the core material is assumed to have been compacted equally) to correct sample depth and, if provided, dry bulk density.

estimate_oc - Organic carbon content estimation from organic carbon data

There is linear correlation between organic carbon and organic matter content. This correlation can change between ecosystems and sampling sites due to changes in organic matter composition among other factors. This function models a linear correlation between organic matter and organic carbon content in your samples and predict the content of organic carbon for those samples were there is no organic carbon values. Estimation of organic carbon is done by means of linear regressions on log(organic carbon) ~ log(organic matter). It gives back a organic carbon value for each organic matter value provided. If there is a organic carbon value for that sample it return the same value, else, generates a model for that site, else, model for specie, else, model for that ecosystem. If a model can not be created due to the low number of samples (<10) it uses the equations in Fourqurean et al. (2012) for seagrasses, Maxwell et al. (2023) for salt marshes and Piñeiro-Juncal et al. (under review) for mangroves to estimate the organic carbon. It is unlikely, but possible, that a model will predict a higher organic carbon than organic matter content. This is not possible in nature. If this is the case the function will give a warning and it is recommended to discard that model.

estimate_h - Sample thickness estimation

For those cores were only selected samples were measured it is necessary to assign a carbon density to the empty spaces before the estimation the total stock. This function checks

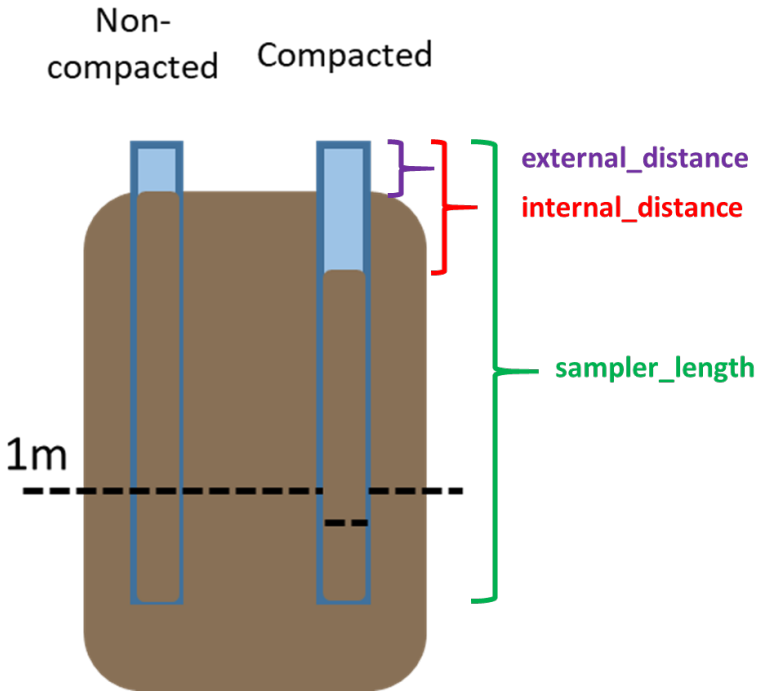

Figure 2: Soil compaction from field sampling

for gaps between samples and, if any, divide this space between the previous and next sample to return sample thickness without gaps in the core (Fig. 3). The middle point between one sample and the next is estimated from the bottom of the previous sample to the top of the next sample, and not form the middle point of one sample to the middle part of the next, as this would inequality distribute the gaps between samples if the samples have different thickness. The stock and sequestration rate estimation functions (estimate_oc_stock and estimate_seq_rate) have this function incorporated and it is not necessary to run it beforehand.

estimate_oc_stock - Organic carbon stock estimation

Estimates carbon stocks from soil core data down to a specified depth, 100 cm by default. If the core does not reach the desired depth, it extrapolates the stock from a linear model between accumulated mass of organic carbon and depth.

test_extrapolation - Visualize the error of stock extrapolation

This function subset those cores that reach the desired depth, estimates the stock (observed stock), estimate the stock from the linear relation of organic carbon accumulated mass and depth using the 90, 75, 50 and 25% top length of the indicated desired depth. Compares the observed stock with the estimated stocks by extrapolation. This function requires that some of your cores do reach the desired depth.

estimate_seq_rate - Organic carbon sequestration rates estimation

Estimate the average organic carbon sequestration rate to the soil in a indicated time frame (by default last 100 years) from the organic carbon concentration and the age of the samples.

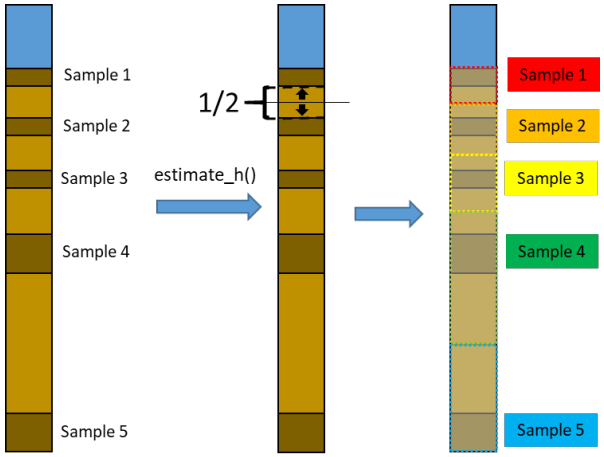

Figure 3: Gap distribution between samples to estimate accumulated organic carbon mass.

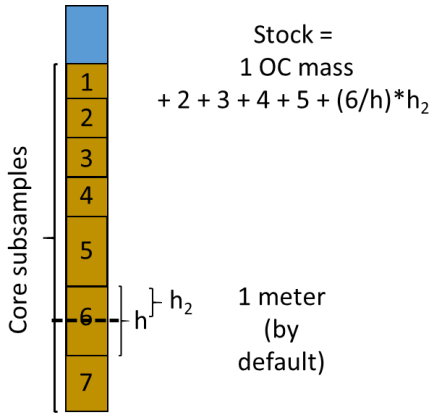

Figure 4: OC stock estimation diagram

Availability

The library is available xxxx. Browse the source core. To install it… The library and tutorials can be accessed here and a workshop recording and a step-by-step tutorial walk through are available here.

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