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Landscape-scale And Spatially Explicit Representation (LASER) of tropical vegetation dynamics and ecosystem carbon stocks in a hyperdiverse tropical forest ecosystem

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Background

Albeit the fact that tropical forests harbor exceptionally high biodiversity and store large amounts of carbon (C) in vegetation biomass, the mechanistic controls on ecosystem C stocks remain poorly resolved. This is due to the fact that multiple interacting factors, such as climatic drivers (i.e., temperature, precipitation, climate seasonality), edaphic factors (i.e., soil fertility, topographic diversity) and diversity-related parameters (i.e., species composition and associated plant functional traits) in concert determine ecosystem functioning and therefore affect tropical forest C sink-strength.

Methodology

To account for the environmental (and spatial) variability twenty 1ha permanent monitoring plots have been established across environmental gradients on the Osa peninsula, Costa Rica (**Fig. A**). Recently, these forest plots have been surveyed by conducting a light detection and ranging (LiDAR) remote sesning campaign along regionally replicated transects located within different forest ecosystem types; (i) hilltop (ridge) positions, (ii) slope positions, and (iii) valley bottom (ravine) positions, as well as in (iv) secondary forests ranging in different successional stages and disturbance regimes (**Fig. B**).

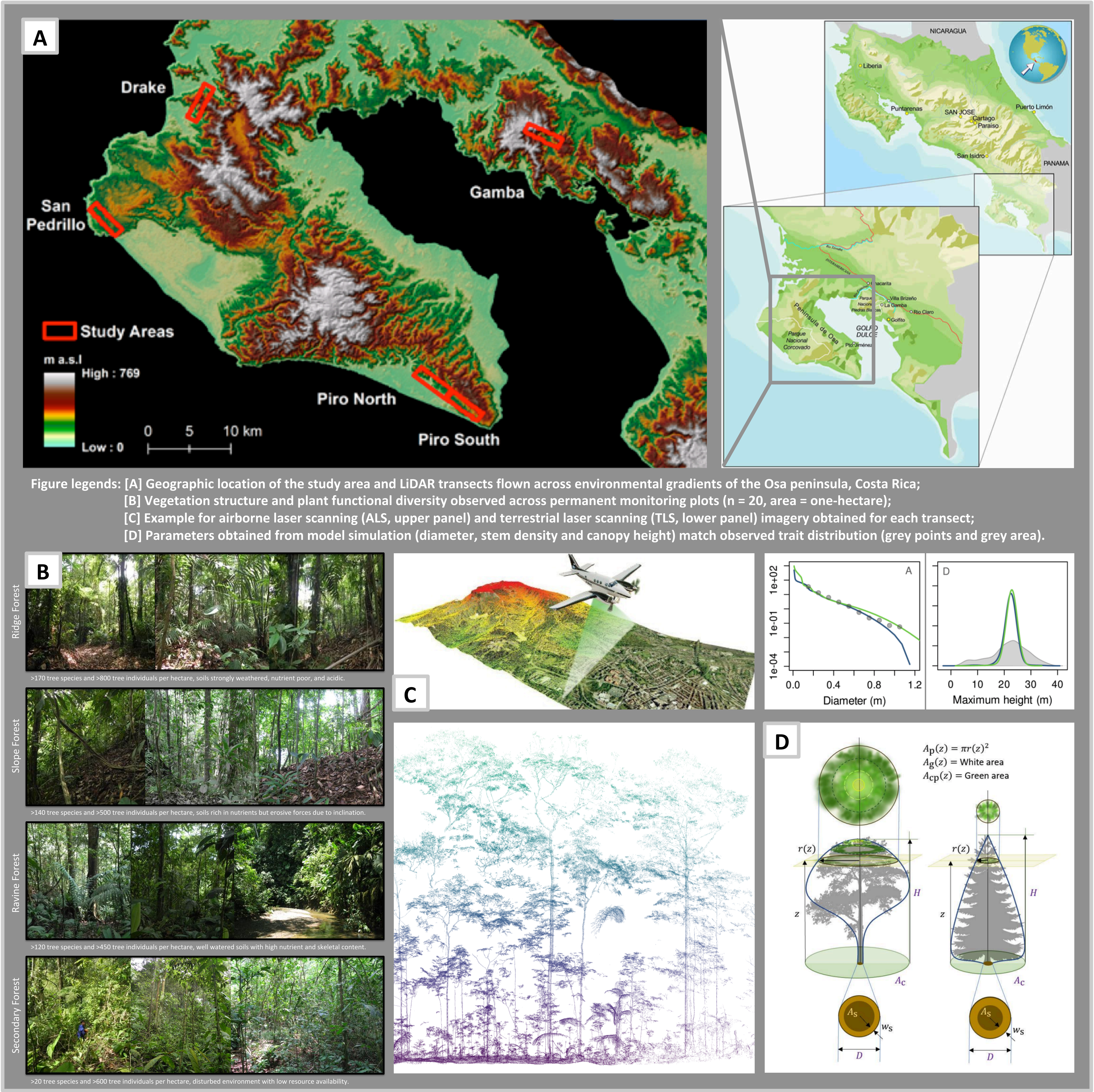

Figure legends: [A] Geographic location of the study area and LiDAR transects flown across environmental gradients of the Osa peninsula, Costa Rica;
[B] Vegetation structure and plant functional diversity observed across permanent monitoring plots (n = 20, area = one-hectare);
[C] Example for airborne laser scanning (ALS, upper panel) and terrestrial laser scanning (TLS, lower panel) imagery obtained for each transect;
[D] Parameters obtained from model simulation (diameter, stem density and canopy height) match observed trait distribution (grey points and grey area).

Approach

Here, we propose a novel framework designed for integrating in-situ observations of local plant species diversity with remote sensing estimates of plant functional traits, with the goal to deduce parameters for a recently developed trait- and size-structured demographic vegetation model. Plant-FATE (Plant Functional Acclimation and Trait Evolution) captures the acclimation of plastic traits within individual plants in response to the local environment and thus simulates shifts in species composition through demographic changes between coexisting species, in association with plant life-history strategy.

Outlook

Based on the identification of 11.786 tree individuals and the observed distribution of vegetation structure (i.e., diameter at breast height, and maximum tree height) obtained from the high-resolution imagery (**Fig. C**) and the associated plant functional trait characteristics (i.e., growth rate and stem mortality) obtained from in-situ monitoring (**Fig. D**), we derive parameters for calibrating our trait-based and size-structured vegetation model. Hence, by simulating the forest ecosystem response based on the emerging plant functional trait space we will be able to project ecosystem C sink-strength under different biodiversity and climate change scenarios.

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