PREDICTING LONG–TERM FOREST DYNAMICS AT REGIONAL SCALES

Emily Lines
University of Cambridge
erl27@cam.ac.uk

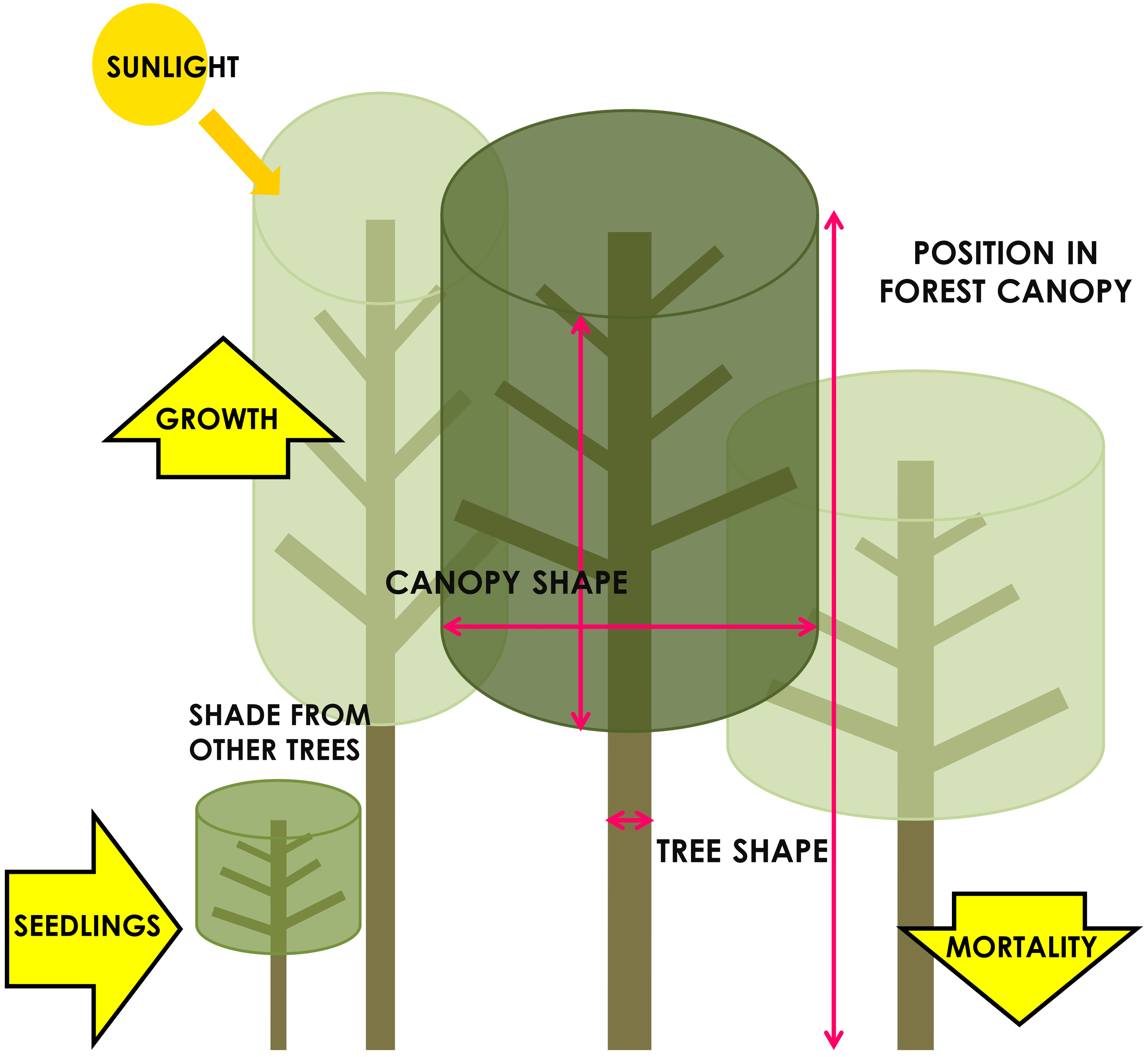
Supervisors:
Dr David Coomes
Dr Drew Purves
(Microsoft Research)

Forest ecosystems store more carbon than the atmosphere and contain $^{2}/_{3}$ of the world's biodiversity but their response to changing climate and role in mitigating the effects of human–induced greenhouse gases is highly uncertain.

Landscape–level predictions of forest–climate dependency can be made by scaling from key tree–level processes using individual–based forest models (e.g. SORTIE[1], PPA[2]).

No existing forest models have yet created simulations which explicitly model all parameters for all tree species as functions of climate and soil at large scales.

Key Model Processes:



These are split into four submodels:

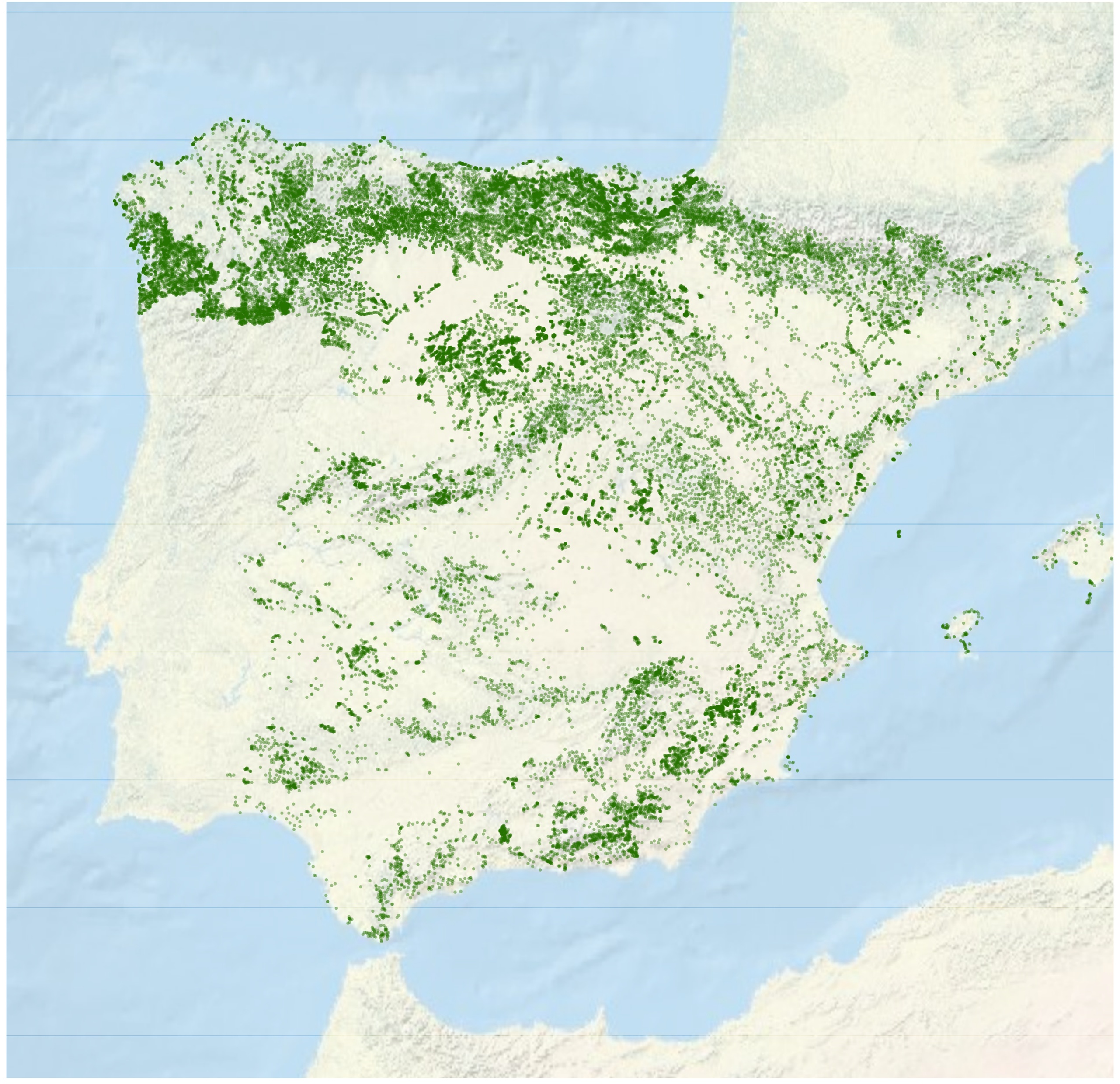
Recruitment: Determines the number, species and location of new seedlings.

Allometry: Tree height, canopy width and depth are calculated from stem size. These are used to calculate the amount of light the tree receives, and the amount of shade it casts on its neighbours.

Growth: Annual growth rate calculated as a function of the amount of light (key resource) the tree receives.

Mortality: Annual probability of mortality calculated as a function of growth/position in the canopy.

However, the climate and soil dependency of each of these processes is **uncertain**. Each process needs to be investigated individually to determine how it varies along climatic and environmental gradients for each species.



Forest cover map of the main study area, **Spain** (Inventario Forestal Nacional 1986–1996).

▪ Spain is the most heavily forested country in Southern Europe; 28% of the land is partially or completely forested.

▪ Most of the forest is in hilly areas with high precipitation.

▪ Unusually, Earth Systems Models agree on the future of Spain: that it will become hotter and drier with climate change (IPCC, 2001), which makes analysis of forest responses to climate change more straightforward.

Model construction methods

Two forest inventories give data from every km^2 of forested land in the main study area, **Spain**. Specially modified adaptive Metropolis–Hastings MCMC techniques allow parameterisation of the submodels for common species.

Additional techniques are needed to parameterise the model for rare species:

- **Phylogenetic analysis**: more closely related species will have more similar parameters[3]. A phylogenetic distance matrix can be used to constrain parameters.
- **Dimension reducing parameter analysis**: there are strong correlations between individual species' parameters, e.g. slower growing, shorter species are more tolerant of shade[4]. A parameter manifold created using more common species can exploit this non–independence to estimate parameter values for rare species.

Key Research Questions:

How do each of the model processes vary along climate and soil gradients?

How much do species differ in their response to changing environment?

What is the impact of this climate dependency on forest processes, and what does this mean for the future of Spanish forests?

References
1 Pacala, S. *et al.*, 1996. *Ecological Monographs*, 66, pp.1-43.
2 Purves, D. *et al.*, 2008. *PNAS*, 105(44), p.17018–17022.
3 Harvey, P. *et al.*, 1995. *Ecology*, 83(3), pp.535-36
4 Falster, D. & Westoby, M., 2005. *Journal of Ecology*, 93(3), pp.521-35.

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