Project title

Recent changes in tree demographic rates in European forests: patterns and possible causes

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1. Aim (for EnvEurope and LTER)

a) Determine whether systematic changes in tree demographic rates (mortality and recruitment) have recently occurred in European forests.

b) Identify possible causes of those changes, mainly exogenous environmental drivers (changes in climate and soil fertility) vs. endogenous structural drivers (increases in tree density and competition for resources).

2. Research questions and Hypothesis (500 words)

Recruitment, growth and mortality are the main processes driving the dynamics of plant communities (Shugart 1984, Oliver & Larson 1996). Understanding how these processes have changed in the last decades has become increasingly important due to the many disturbances to which forests are being subjected. In fact, tree demographic rates have been shown to be altered by virtually every global change driver, including climate warming (Allen et al. 2010, Carnicer et al. 2011), alterations of the forest N status (Bedison & McNeil 2009), land use shifts causing stand densification (Vilá-Cabrera et al. 2010, Gómez-Aparicio et al. 2011), or an interaction of them (Linares et al. 2009, 2010, Lines et al. 2010).

Understanding how global change could be affecting the balance between recruitment and mortality in forest systems is particularly relevant, since this balance determines tree turnover rates, biomass accumulation, and ultimately ecosystem function and productivity (Jones & Lawton 1995, Stephenson & van Mantgem 2005). However, spatially extensive analyses of changes in the recruitment-mortality balance are still extremely rare. To the best of my knowledge, only two outstanding studies can be considered the exception to this rule: the work conducted by O.L. Phyllips et al. in tropical forests (Phyllips & Gentry 1994, Phyllips et al. 2008), and the work conducted by S. van Mantgem et al. in conifer forests of Western United States (van Mantgem et al. 2010). Interestingly, the two studies differed strongly in their conclusions on recent changes in forest demographic rates. In the tropics, stem turnover and aboveground biomass seem to have risen in the last decades due to a simultaneous increase in mortality and particularly on recruitment rates. In Western US, however, the increase in tree mortality rates have not been followed by an increase in recruitment rates, causing a decrease in basal area. These contrasting results highlight the fact that we are still far from reaching a consensus about the impacts of recent global changes on forest dynamics. More large-scale studies in other parts of the globe are clearly needed in order to improve our ability to forecast how forests will change in the future.

The main objective of this proposal is to conduct a large-scale assessment of recent changes in the recruitment-mortality balance of tree species in European forests, and to identify the main environmental factors driving these changes. I hypothesize that:

1) Background mortality rates have increased rapidly in recent decades in European forests, as found for tropical and temperate forests across large areas in Southamerica (Phyllips et al. 2008) and Western US (van Mantgem et al. 2010).

2) Recruitment rates do not necessarily have paralleled the increase in mortality rates, potentially causing a decrease in turnover rates. This decrease is more likely to occur in those European forests where species are already growing at the limit of their physiological tolerance (e.g. *Pinus sylvestris* forests in Spain, Vilá-Cabrera et al. 2010).

3) Changes in demographic rates of tree species is probably the consequence of abiotic (e.g. climate, soil properties) or biotic changes (e.g. stand densification) in the environment of European forests over recent decades.

3. Spatial and temporal coverage

Spatial coverage: Forest ecosystems across Europe

Temporal coverage: At least two demographic censuses are needed in order to calculate recruitment and mortality rates. However, the larger the number of censuses and the time scale covered the better.

4. Parameters used/needed* (if not only aquatic habitat are to be selected then the parameter group could be enlarged)

Parameter group (theme)	Selected parameter	Details about the parameter	Should be taken from existing data (yes/no)	Feasibility/constraints regarding existing data	Should be recorded in field (A5 work) (yes/no)	feasibility/ constraints regarding field sampling
1) Climate and physical variability	Mean monthly temperature Mean monthly precipitation Landscape characteristics	Monthly values for as many years as possible Monthly values for as many years as possible Altitude, slope, aspect, topographic position	yes	No problems foreseen	no	
2) Biogeochemistry data	Soil water content/potential Soil organic matter Soil nitrogen and phosphorus concentration Soil pH and cation concentration	Annual values for as many years as possible Annual values for as many years as possible Annual values for as many years as possible Annual values for as many years as possible	yes	Each soil variable can be estimated using different methods. However, several of the methods available are roughly comparable and can offer similar information on spatiotemporal trends in soil conditions.	no	
3) Structure and function of the ecosystems, communities and populations	Repeated censuses (at least two) of tree species in permanent plots Abundance and composition of the forest understory	Information for each individual tree in the permanent plots: species, ontogenetic stage (e.g. seedling, juvenile, adult), spatial location (e.g. XY coordinates), size (e.g. DBH), health status (e.g. standing dead, alive, defoliated) Information on each individual shrub in the permanent plots (e,g. species, size, spatial location)	yes	Data at the individual level are desirable but not essential. Data at the plot level (e.g. basal area or density of the different species) is also welcome. Data at the individual level are desirable but not essential. Data at the plot level (e.g. density or cover of shrubs) is also welcome.	no	

	Pest (i.e. insects, pathogens) abundance/presence/outbrakes			This information is important to separate biotic-driven catastrophic mortality events from background (noncatastrophic) mortality rates		
4) Human population and economy	Forest management	Evidences of forest management (e.g. thinning, cutting) during the time interval of the demographic data	yes	Not accurate data are needed. Just some information that can help to separate unmanaged from managed plots	no	

5. METHODS USED

1) Analysis of recent changes in recruitment and mortality rates across European forests
Generalized non-linear mixed models (GNMMs) will be used to calculate annual rates of recruitment and mortality. Maximum likelihood will be used to estimate model parameters producing the most likely annual demographic rates that, when compounded by the length of the census intervals, best corresponded to the rates observed in the data. Temporal autocorrelation will be accounted for with a first order autoregressive autocorrelation function. Models will be first run for all species together, and then separating by tree species and genus. Other potential classifications (e.g. by forest type, by diameter stem class, by elevation class) will be explored and models run when enough data are available.

2) Assessing possible endogenous and exogenous causes of changing demographic rates
I will first explore the evidence for recent changes in exogenous abiotic (e.g. mean temperature, mean annual rainfall, soil properties) and endogenous biotic conditions (e.g. tree density or basal area, understory density or cover) across European forests using linear mixed models and time series analyses. I will then model demographic rates as a function of those environmental variables for which trends of change have been previously identified. I will explicitly look for potential interactions among environmental variables in their effects on demography. If information on biotic-driven catastrophic mortality events is available (e.g. pest outbrakes), it will be taken into account when assessing potential causes of changes in demographic rates.

6. EXPECTED RESULTS

a) Explore temporal trends in two key demographic rates -recruitment and mortality- of tree species in European forests. I expect to show that ongoing, large-scale changes in tree demographic rates are not limited to the tropics and Western US.

b) Detect potential changes in forest turnover due to a mismatch among the incorporation (recruitment) and loss (mortality) of tree individuals into European forests.

c) Explore which tree species/genus and forest types in Europe have suffered stronger changes in tree demographic rates in recent decades.

d) Analyze the evidence that the physical, chemical and biological environment that trees grow in has been altered over recent decades across large areas of Europe.

e) Link changes in tree demographic rates to causal environmental drivers across Europe. This link is essential to understand the magnitude of the consequences of global change for the stability of European forest ecosystems.

7. REFERENCES

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