Project title:

Environmental factors as drivers of mast seeding in tree species across Europe - EUROMASTING

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1. Aims (for EnvEurope and LTER)

- To describe temporal changes in tree seed production across Europe using long-term data from LTER sites.
- To identify which environmental factors or resources better explain the interannual variation in seed production (i.e., mast seeding) along a wide gradient of environmental conditions across Europe.
- To test the adaptive (the "resource matching") *vs*. the nonadaptive (the "economy-of-scale") hypotheses for masting for each of the selected sites.
- To evaluate the magnitude of variation in seed production among sites as a function of their resource availability.
- To detect recent changes in tree seed production that could be related with global change drivers (climate change, land use change, air pollution).

2. Research questions and Hypothesis (500 words)

Mast seeding - the highly variable seed production among years - (Silvertown 1980; Kelly 1994) is very common in tree species, but there is no consensus about its main causes and the main environmental factors affecting it.

Resource supply and environmental conditions are clearly involved in mast seeding, but the exact nature of this involvement is not completely understood (Kelly and Sork 2002). On one hand, the resource-matching hypothesis states that plants adapt their reproductive effort to the current available resources (strongly dependent upon climate conditions), with no need of adaptive value (Kelly 1994). In contrast, the authors supporting masting as a selective response to processes such as wind pollination or predator satiation (the economy-of-scale hypothesis) postulate that environmental factors or resources only act as synchronizing cues for individual plants, driving high and low seed crops at regular periods of time (Janzen 1971; Norton and Kelly 1988). The best demonstration that mast seeding is an evolved reproductive strategy and not only the result of the available resources for the plant is the presence of "switching" between growth and reproduction (Kelly and Sork 2002), that is, the diversion of resources toward reproduction in some years and toward vegetative growth in others (Norton and Kelly 1988). In the case that a masting plant species is merely responding to the variable and unpredictable environment ("putative" masting), both reproduction and growth should be favored in good years, whereas both processes would be depleted in years with limiting resources (Monks and Kelly 2006). However, there are very few published examples that test strictly resource switching in order to contrast the adaptive *vs.* the non-adaptive hypotheses for masting (but see Pérez-Ramos *et al.* 2010).

On the other hand, resource supply could also drive mast seeding at a higher spatial scale. Thus, we hypothesize that interanual variability in seed production is stronger in poorer habitats (such as

semiarid or arid sites) due to the need for a longer period of time for tree recovery after the strong resource exhaustion of a massive reproductive event (Kelly and Sork 2002; Espelta *et al.* 2008).

In this project, we are interested in analysing long-term data set on reproductive and vegetative growth of European tree species (mainly *Quercus* spp. and other widespread tree species) along a wide gradient of environmental conditions in order to determine whether mast seeding is more consistent with the resource-matching hypothesis or the economy-of-scale hypothesis. In addition, we will test whether this phenomenon is more severe in sites with more limiting resources.

3. Spatial and temporal coverage

Tree seed production is very variable with time and it is essential to have long-term data to infer ecological and evolutionary processes. For this project we need long-term data (at least 10-15 years) on seed production and tree growth (such as radial stem growth or leaf litter production) in dominant tree species located in forest sites across Europe. These biotic data will be used in conjunction with environmental data - climate and soil conditions - of the LTER sites.

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	- Air temperature - Rainfall - Wind velocity (when possible). - Net radiation	Mean, maximum and minimum monthly values (standard meteorological methods)	yes		Not necessary	
2) Biogeochemistry data	Parameters related with soil fertility and water availability throughout the year	Soil availability of N, P, K, Ca and Mg. Soil acidity (pH) and organic matter. Water retention.	yes			

3) Structure and function of the ecosystems, communities and populations	- Seed production - Vegetative growth (in terms of radial stem growth or leaf litter production).	- Seed production: in $g.m^{-2}$, in number of $seeds.m^{-2}$, or relative to individual trees. - Radial stem growth (annual increment in DBH or in dry wood biomass per unit of area). - Leaf litter production: in $g.m^{-2}$ or in $g.tree^{-1}$	yes		yes	For estimating seed production, we could use data from both field sampling (using seed traps) and the visual method.
4) Human population and economy						

5. METHODS USED

To identify environmental factors that may be useful predictors of annual seed production, we will fit linear and nonlinear models (separately by tree species and site) using maximum likelihood techniques.

To test whether mast seeding is an evolved reproductive strategy (economy-of-scale hypothesis) or only results from the available resources for the plant (resource matching hypothesis), we will explore the presence of switching by examining the relationship between the reproductive effort (seed production) and the vegetative growth (such as radial stem growth or leaf litter production).

This model approach will be used in conjunction with meta-analyses techniques to evaluate the influence of climate on mast seeding along a wide gradient of environmental conditions across Europe.

6. EXPECTED RESULTS

We expect to find:

- Differences between northern and southern forests in the temporal trends of seed production and the main environmental drivers.

- Temperature and precipitation as main drivers of mast seeding, but with a very different contribution of these two factors as a function of the site characteristics.

- A higher interannual variation in seed production in those sites with more limited resource availability, such as semiarid or arid habitats.

- A stronger influence of resource availability on mast seeding (i.e., agreeing most closely with the resource-matching hypothesis) in these poorer sites.

Expected output:

- At the end of the project we expect to produce a multi-authored paper for an indexed journal.

7. REFERENCES

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