Are increases in tree fecundity greater than increases in productivity on the temperate-tropical latitudinal gradient?

Globally, tree fecundity exceeds productivity gradients

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Why might tree fecundity differ over a latitudinal gradient? What processes might be driving fecundity differences? The authors investigated whether tree fecundity varied with latitude. A previous study indicated that seed mass density is higher in the tropics and decreases with latitude. In the current study, the researchers investigated whether seed mass in the tropics was higher because trees in the tropics are larger and therefore produce more seeds, or because trees of a given size produce more seeds in warmer wetter areas. They quantified seed production by tree and unit area to examine individual and community fecundity.

Do individual fecundity, community fecundity, and primary production all increase with latitude?

- Individual seed production, community seed production and net primary productivity all increase across latitude with maximum values in the tropics but the increases in individual and community seed production are far larger than the three-fold increase in net primary productivity.

How much larger are individual and community fecundity increases? And are fecundity differences with latitude driven by changes in individual fecundity?

- Seed production for a given tree size is 100 times higher in the tropics than at higher latitudes. This increased seed production is the primary driver for increased community seed production, which is 250 time higher in the tropics.

Is latitude the largest driver for overall fecundity observed in the study?

- Variation in overall fecundity is influenced to a greater extent by between-tree and within-tree fecundity variation than by the effect of latitude.

- Standardized individual production is highest in the tropics, which is driven by the seed production for a given size tree. For seed production, temperature is more important than moisture. At high temperatures moisture level amplifies the response to temperature.

Why might individual and community fecundity increase so much more than productivity?

- Increased seed production in the tropics could be caused by trees producing seeds for a longer period to take advantage of the longer growing season or by increased reproductive allocation in response to higher intensity species interactions in the tropics.
- The smaller increase in net primary production than fecundity with latitude could be caused by mechanical and hydraulic constraints as well as tree mortality.

Is tree diversity indicative of seed resource diversity? How might this impact food web dynamics?

- Diversity of the seed resource is lower than that of trees in warm climates. This will impact food web dynamics because frequency-dependent consumer pressure is related to seed resource diversity.

How might climate change impact tree fecundity globally?

- Impacts of climate change on tree fecundity will be determined by changes in seed production as well as changes in populations of consumers and dispersers in response to climate change.

What additional areas of research would help us further understand global tree fecundity and related food web dynamics?

- The new understanding of individual and community fecundity drivers can be used to improve modeling of global vegetation and climate, by directly incorporating individual and community fecundity. Models have previously considered fecundity a set portion of net primary production.
- Further research could investigate whether increased tree fecundity in the tropics is a result of reproductive allocation and its biophysical constraints or an adaptive response to density- and frequency-dependent consumer pressures. This would improve our understanding of tropical forest food web dynamics.

Research Approach/Methods

- The authors used crop count (tree) and seed trap (community) data from the MASTIF project, which included individual standardized production estimates, in a state-space, auto-regressive model to produce an estimate of mean fecundity for each tree in each year. Mean fecundity is the product of conditional fecundity and maturation probability.
- Crop count observations include the number of fruiting structures that were counted scaled by fruit per structure and the fraction of the crop counted.
- Seed trap observations include counts and locations for seed traps on an inventory plot where every tree is measured and mapped and dispersal is taken into account.
- The model included individual predictors including: crown class, climate, soil, diameter, and terrain covariates, and environmental predictors including: temperature norms and anomalies from the previous year and soil moisture from the previous and current year.

- The researchers used regression to compare variation in individual and community productivity estimates across temperature and moisture surplus.
- The authors obtained net primary productivity data from the Moderate Resolution Imaging Spectroradiometer (MODIS) and used regression to investigate whether it varied with temperature and moisture surplus.

Keywords climate, competition, forest regeneration, seed consumption, species interactions, tree fecundity

Images

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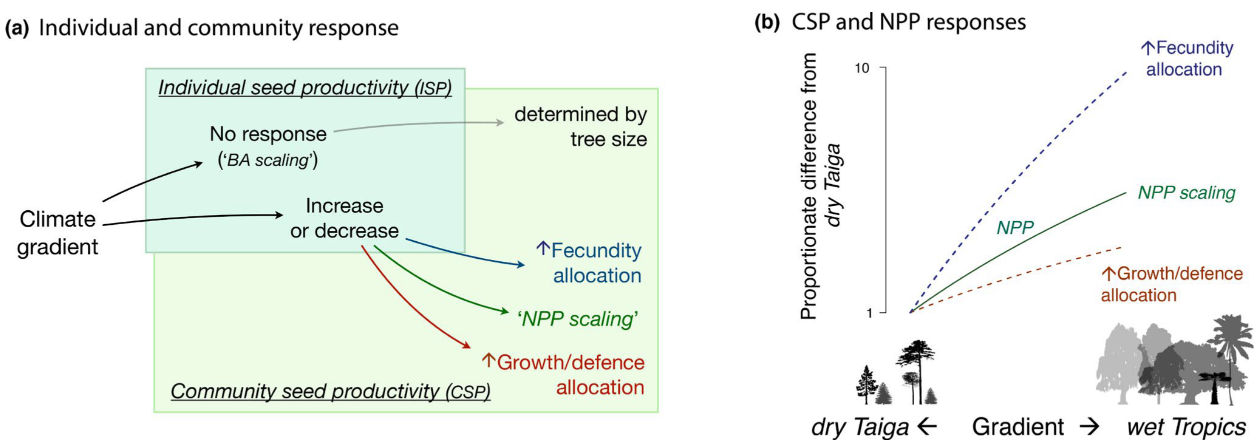

Figure 1 in Journé et al. 2022. (a) Individual seed productivity (ISP, seed mass per tree basal area) might not vary with latitudinal climate gradients, in which case community seed productivity (CSP, seed mass production per forest area) depends on variation in tree size. Alternatively, responses could depend on net primary productivity (NPP), increasing if allocation in warm climates shifts preferentially to fecundity or decreasing if allocation in warm climates shifts to growth and defences. (b) Proportionate differences in fecundity hypothesised for the three scenarios in (a) shown as differences from the climate gradient in NPP. The NPP scaling scenario means that NPP and CSP follow the same proportionate trajectory (green line).

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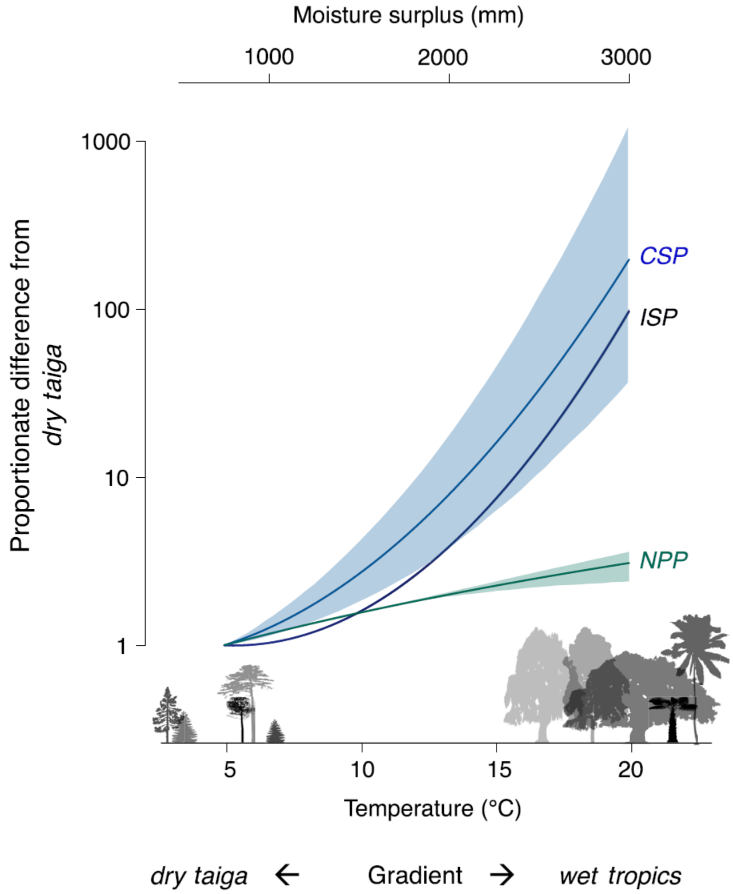

Figure 5 in Journé et al. 2022. (a) Two order of magnitude increases from cold/dry to warm/moist for individual (ISP) and community (CSP) seed production relative to NPP. Curves are sections through surfaces (dashed lines) in Figure 4, with scales for moisture surplus (above) and temperature (below). Curves are in proportion to values in cold, dry conditions. Confidence intervals (95%) are not visible for ISP due to the large number of trees. Confidence intervals are wider for CSP due to limited inventory plots at high temperatures (Figure 2).

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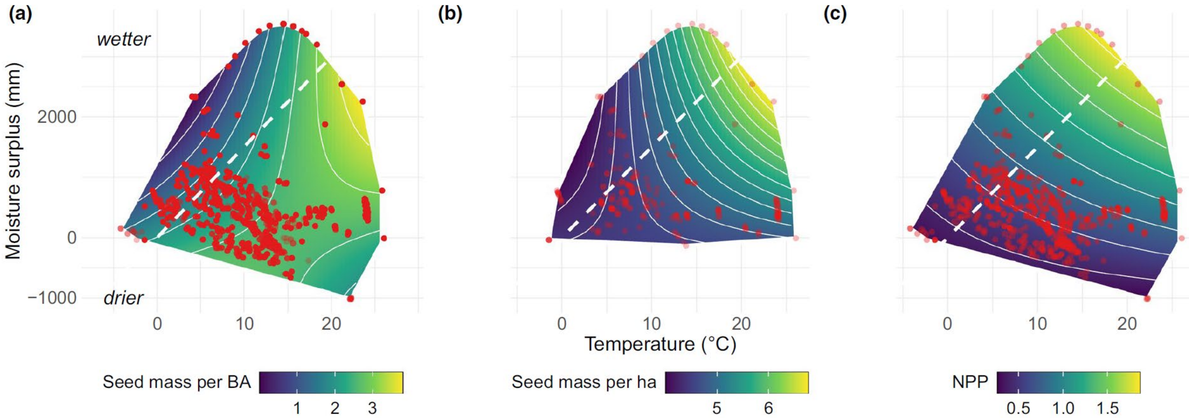

Figure 4 in Journé et al. 2022. (a) Climate responses for (a) ISP (seed production per tree basal area, log10 g m−2 y−1), (b) CSP (seed mass per ha forest floor, log10 g ha−1 y−1) and (c) NPP (kg C m−2 y−1). Dashed lines indicate the transect from dry taiga to wet tropics in Figure 5b. The scales for contours are linear for (c) and log10 for (a) and (b). Convex hulls are defined by observations (red), including individual trees (a, c) and inventory plots (b). Surface predictive standard error are reported in Figure S3. Coefficients are reported in Table S3.