Differences in leaf and wood traits predict phenological sensitivity to daylength more than temperature

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Introduction

1. General intro—climate change changing ecological communities
   (a) Climate change—evident in the changes in species
   (b) Includes changes in species phenologies—timing of life history events—most species advancing
   (c) But across species see high variability in phenological responses—poor understanding of the physiological or environmental factors causing this variation
   (d) Phenology is just one of many traits shaped by environmental cues—relatively poor understanding of the complexity and interdependencies between phenology and other traits
   (e) Identifying the mechanisms driving this variation = important if we are to accurately predict future changes in community composition, including species invasions, range expansions.
2. Traits—what shapes them?
   (a) To understand trait variation—must understand the drivers at both the proximate and ultimate scales
   (b) Proximate drivers = environmental factors—temperature, soil moisture, daylength
   (c) E.g. cooler temperature cues can delay timing of species growth and select for larger body size (Bergmann's rule)
   (d) But environmental factors also change within a growing season—for example can impose greater abiotic stress early in the season = high risks frost events versus the greater biotic stress later in the season = high competition
   (e) these ultimate drivers = how species niches shape species assemblages and community dynamics'
   (f) Collectively—these drivers shape species overall phenotypes
3. Functional trait ecology and LES?
   (a) Species phenotypes correlate with their growth strategies and responses to environments
   (b) The consistency in these relationships across communities allowed the quantification of certain traits to = inferences of growth strategies/community processes to be made independently of species identity (McGill2006)
   (c) Plants = development of the leaf economic spectrum—trait values = distinct gradients that range from acquisitive growth strategies—cheaper tissue and faster growth—to conservative strategies—invest in long-lived tissue but slower growth rates

   (d) These traits serve as proxies for difficult to measure physiological processes and responses to biotic interactions

4. Limitations if LES
   (a) Drawing on these relationships—can better understand how plant communities assemble and the promote species coexistence
   (b) But general focus on community level responses—ie use of metrics of functional diversity or community weighted means (eg Diaz2013)—fails to account for causes of trait variation
   (c) Highly variable nature of phenology = given as the reason it is excluded from these functional trait frameworks
   (d) Phenological variation likely to correlate with other functional traits and be driven by the same cues that promote acquisitive versus conservative growth strategies.
   (e) But still considerable variation in traits and phenology not explained by environmental cues alone

5. But other sources of variation = geography
   (a) In addition to spp level variation—expect to see variation between populations
   (b) Latitudinal gradients—differences in daylength and temperature
   (c) Traits may also vary in response to biotic interactions weaker at higher latitude—longer colder winters lead to reduced herbivore pressures
   (d) Differences in competition and species assemblages = further potential to drive local adaptation in traits

6. Introduce tree budburst as a system
   (a) Here we use spring budburst in woody plants to study the relationship between cues and traits
   (b) Spring conditions can create strong abiotic and biotic gradients—-abiotic: frost risk, nutrient availability, and light levels—biotic: decreasing herbivore apparency, increasing competition
   (c) Predict these trade-offs between early and late season conditions will correlate with other traits
   (d) Early species = bb before canopy closure = acquisitive growth = shorter, small DBH, low SSD, low LMA, high LNC
   (e) Late species = canopy species = conservative growth = tall trees with large DBH, high SSD, high LMA, low LNC
   (f) Good understanding of budburst cues—but not whether their strength is mitigated by other traits

7. What we did in this study:
   (a) Our aim = combine the decades of research on bb phenology with = trait literature = understand how other traits relate to environmental cues that drive phenology
   (b) Combined measures of individuals traits with their observed bb in a controlled environment experiment
   (c) Take a community-wide approach—understory and canopy species—that dominate deciduous forest communities in North America
   (d) Measuring six leaf and structural traits and three budburst cues—tested for spatial variation in traits and their correlation with budburst cues—chilling, forcing, photoperiod
   (e) Using joint-modeling approach—can use trait values to partition phenological responses to cues and from species level differences—potential to predict species growth strategies and phenological responses