

Phenology Working Group Report

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Organizers: Johanna Schmitt and Jack Mustard

The phenology breakout group traversed a wide range of interests in discussing research opportunities in phenology. The overview presentations set a context for the range of research currently under way. From a remote sensing perspective, major properties of phenology are readily measured, and over large spatial scales. At the detailed plot and plant level controls on phenology by environmental variables and genetics are becoming more widely understood. Yet there is a tremendous amount of research that is possible.

The breadth of research in phenology can be broken down to two major efforts: 1) empirical measurements and models designed to explain them; 2) first-principles or process-based models that predict phenology. The basics of terrestrial plant phenology are readily measured either in the field or remotely. These can be considered dependent variables and include:

- Germination or seedling emergence
- Bud burst
- Leaf out
- Flowering
- Fruiting
- Senescence

It is widely thought that these phenological events are driven by independent variables arising from the physical environment, including:

- Temperature
- Growing degree days
- Cooling degree days
- Frost period (beginning and end)
- Photoperiod

Provenance and common garden studies have demonstrated striking differences between populations in their phenological response to common cues, and these differences are most likely the result of local adaptation through genetic differentiation. New research is linking genetic variation to phenological response in certain model systems, but the generality of these models across species and phenological events/traits remains unclear.

While a number of phenology models exist, many of these are empirical, for example designed to predict phenology in agricultural systems. Empirical models have historically shown high predictive success in local environments. However, recent research indicates that there are many surprises in store, particularly as systems scale from local to regional to continental and larger. As many more climate and phenology datasets -- including some long-running studies of particular species or locations -- are becoming available, the area of phenology modeling is ripe for further development and interdisciplinary research.

The expertise in the Brown-MBL community encompasses:

- Ecosystems

- Biogeochemistry
- Ecology
- Plant physiology
- LULCC (Land-use and land-cover change)
- Remote Sensing
- Reconstruction of paleoclimates

From this foundation there are a number of avenues that could be pursued. A small working group would be beneficial to explore the dimensions of future research. The main task would be to develop a concrete plan around the basic question:

What are the major questions and what data sets exist to address the questions?

Specific questions raised in the initial breakout session included:

- How often in a single organism or species are different aspects of phenology regulated by different environmental cues? Does this lead to decoupling of response in these traits? What effects will future non-analogue climates then have on the life cycles of these organisms?
- When species in a community assemblage use different environmental cues to determine phenology, will changing climates cause mismatches in community interactions? What consequences might this have for population cycles and ecosystem processes?
- How can changing climates and phenologies disrupt the concerted functioning of different physiological processes such as photosynthesis and respiration? How would this affect carbon and nitrogen cycles?
- To what extent can phenological models developed using land plants be applicable to phenological traits in other systems such as marine algal blooms or insect diapause?
- Are there discernible signatures of human activity on phenology, i.e. differences among urban, rural and wild settings? How will shifting and growing human populations affect phenology?