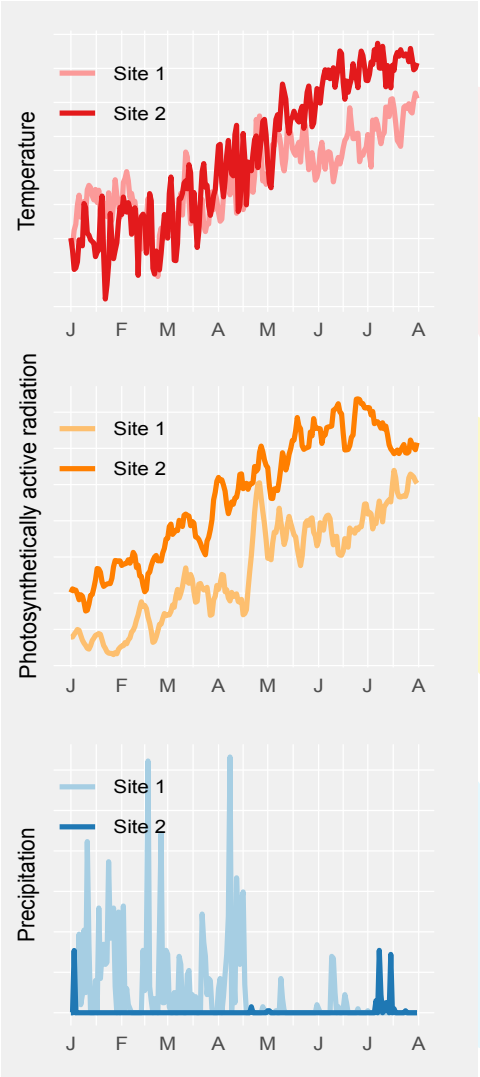
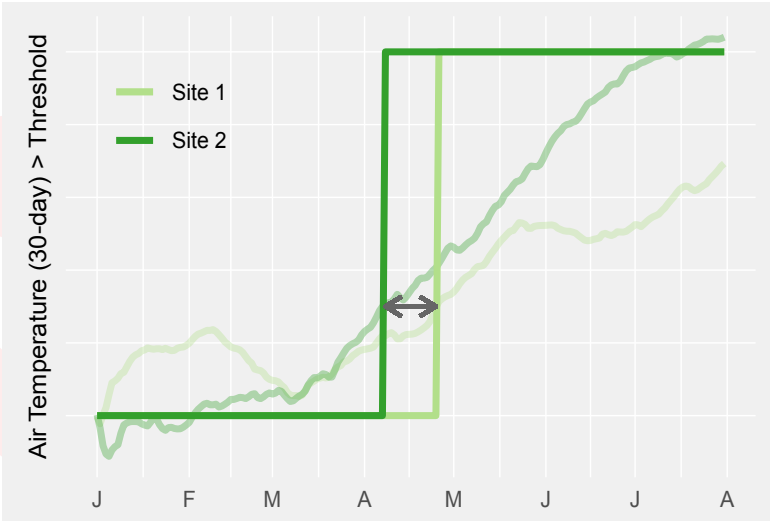
Multivariate Environment



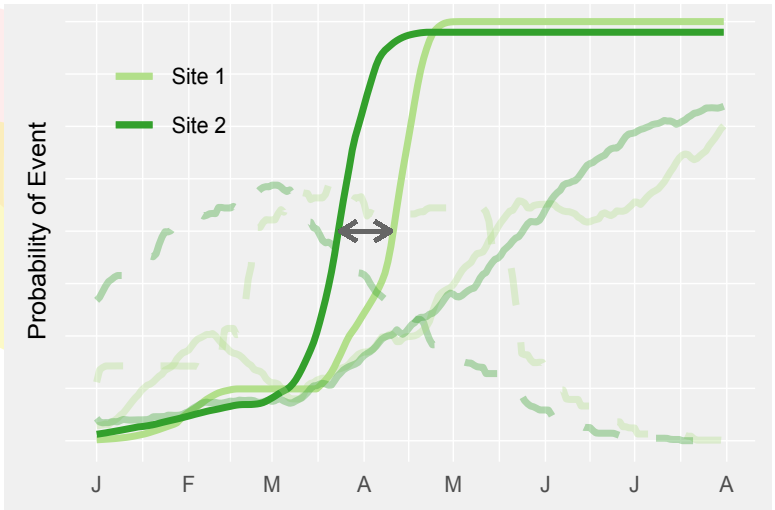


Measured Environmental Tracking

Ecologists often use simple measurements to estimate tracking. Here, a running average of 30-day air temperature is used to identify a threshold response, which is predicted to be earlier in Site 2.

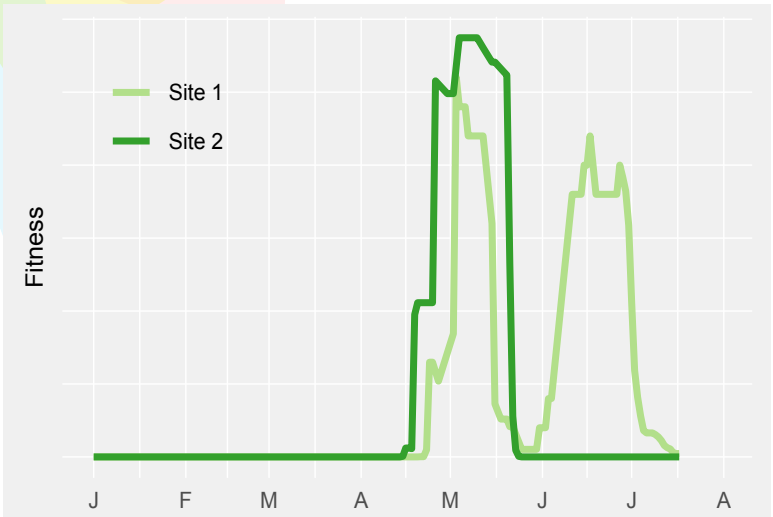
Environmental Tracking

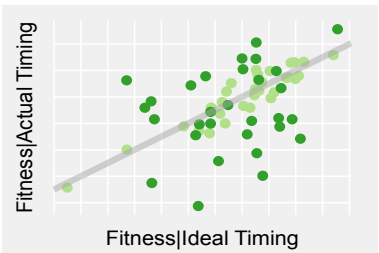
However, an organism's cue system may respond to multiple environmental variables. Here, the probability of a phenological event (solid line) depends on accumulated heating and chilling hours (dashed lines). The organism's environmental tracking is only partly captured by the ecologist's 'measured' environmental tracking.



Fundamental Tracking

Ultimately, fitness is determined by the joint distribution of many environmental variables. Here, end-of-season fitness (e.g., seed set) is a function of the timing of a start-of-season life history event (e.g., germination date) and the changing environment through the season. Fitness depends on growth—a function of temperature, light, and soil frost and summer heat stress.





Cue Reliability

Of ultimate value to the organism—especially under a changing climate—is cue reliability. i.e., the correlation between fitness given the actual timing of a life history event and fitness given the ideal timing.