NABA Butterfly Count Column

Connecting Climate to Butterfly Count Data

by Leslie Ries

Any long-time butterfly enthusiast knows that weather can have a profound impact on the timing, distribution and abundance of butterflies. These impacts can either be direct, through influences on adult activity levels or caterpillar development, or indirect, through influences on host or nectar plant resources. To further complicate things, weather impacts may be immediate, such as when the sun finally shines through on a cloudy day – what a great time to see butterflies! Or they may accumulate throughout the season, as juveniles need a certain amount of energy resources to develop into adulthood. While these connections are intuitive, establishing the relationships empirically and actually determining the extent to which weather and climate drive butterfly dynamics can be much more challenging. But the importance of being able to answer these types of questions is imperative as we seek to understand how our changing climate may be influencing butterfly distribution patterns now, and even into the future based on projected climate scenarios. The NABA count data have the potential to be an invaluable resource to explore these relationships.

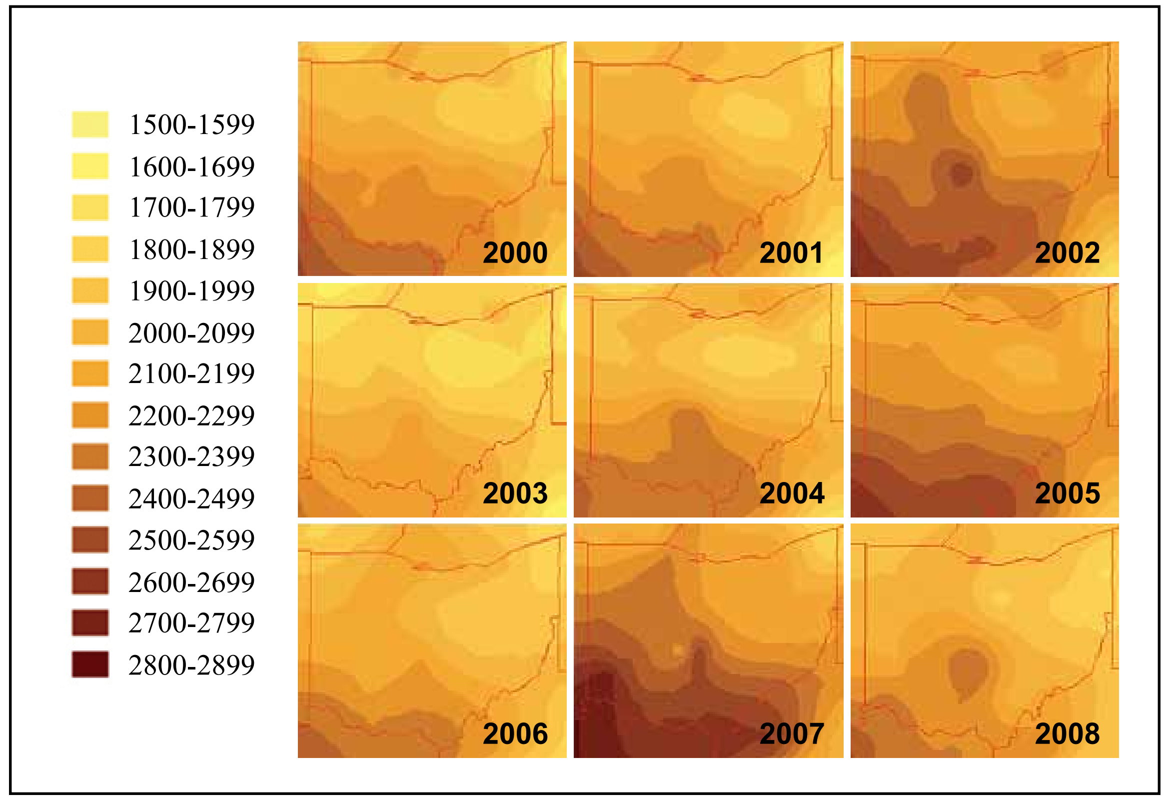
There are so many aspects of local weather and climate that impact butterfly biology and it is unrealistic to tackle all of them. My goal is to determine the key drivers of large-scale, long-term patterns. To do this, I am focusing on two general metrics of local weather: the amount of heat available for caterpillar growth and patterns of precipitation. Both of these measures capture dynamics that vary spatially and build over time (and the spatial variation also builds over time), and so the challenge is to determine the best metric to be tied to a particular observation at a place and date where a butterfly count occurred. Even more challenging is not only to use the right metric, but to figure out how far back in time to go (relative to the date of each survey) to best capture the most important seasonal climatic effects. In today's column, I am going to briefly introduce you to the key climate metrics I am working with and then, in future columns, I will show you how, in collaboration with many other researchers, I am working to relate these climate variables to butterfly development, emergence, and distribution.

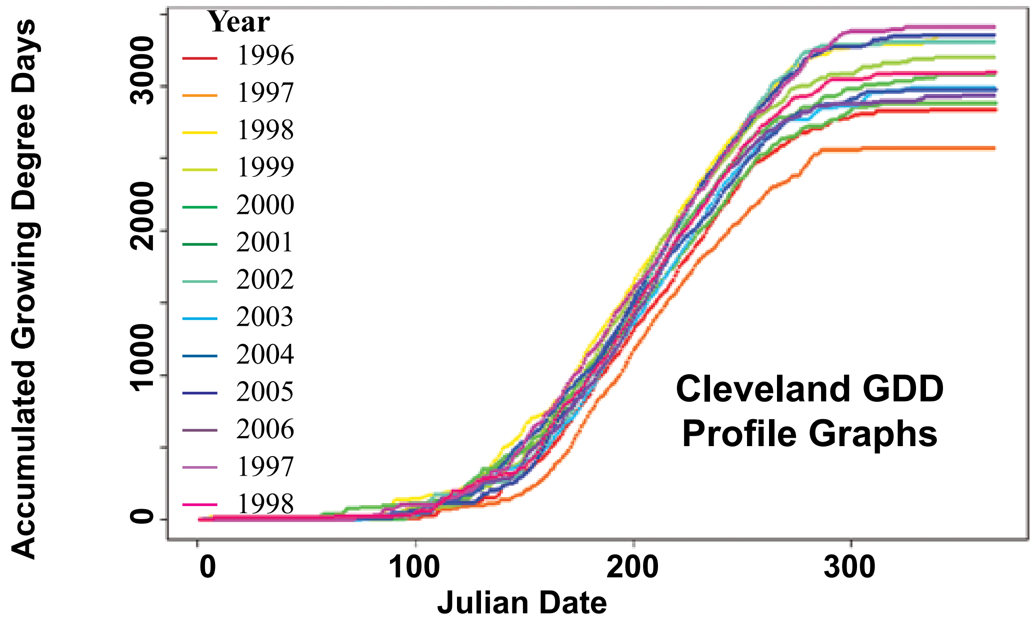
As noted above, ambient temperature (and cloud cover) can have an immediate impact on adult activity levels (and thus detectability), but this is not my current focus. Instead, I am using temperature data to calculate the amount of energy available for caterpillar growth throughout the season. The most common metric used to evaluate this is Growing Degree Days (GDD). The idea behind GDD is that growth and development for many organisms, including plants and insects, is limited by daily temperature. Temperatures must exceed some minimum threshold before growth can occur and the hotter the temperature the more energy is available for growth. To calculate GDD on a daily basis, simply take the day's mean temperature (or the average of the minimum and maximum) and subtract that minimum threshold temperature (often called the "base" temperature). For instance, if a certain species' caterpillars can only develop when temperatures are greater than 50F, then a day with a mean temperature of 70F adds 20 GDD (note that the Celsius scale can be used as well). Of course, after a certain upper temperature is reached, no additional benefit for growth is accrued, so some GDD calculations include a maximum number of degree days that can be accumulated during a single day. One dynamic that is not currently captured by most GDD formulations is that caterpillar development can actually slow as temperatures get too hot, and temperatures can even become lethal at some point. This is a key area where I am working with collaborators to improve GDD models.

As the season progresses, the number of GDD accumulates each day. For instance, during a typical year the number of GDD in the Midwest ranges from 2000 to 3000 based on the 50F cutoff, but varies both spatially and from year to year (see maps, this page.). Further, the pattern of accumulation at any one site also varies yearly (see graph on page 42). For those studying development, it is often possible to tie the timing of events (first emergence of adult butterflies or flowering of key plants) to a particular GDD value even more successfully than day of the year. The number of accumulated GDD over the season may even allow for more generations for some species resulting in larger populations. For well-studied species such as Monarchs, we know how many GDD it takes to get through each stage of development. GDD has been successfully tied to the emergence, abundance, and range of several butterfly species.

Like GDD, patterns of precipitation vary

Maps of Ohio show accumulated Growing Degree Days (GDD) from 2000 through 2008. Note that spatial pattern varies somewhat from year to year and some years accumulate more GDD than others. In addition, the pattern of accumulation throughout the year can vary, as shown by the accumulated GDD profile for one site in Cleveland . GDD values were based on a 50F cutoff and developed using NOAA weather station data.





These graphs were developed by Heather Lessig using the same data used to generate the Ohio images on pg. 41.

both spatially and temporally and so can be extremely tricky because it is both the timing and amount of precipitation that can have substantive effects, especially on host and nectar plant resources. Further, each species' resources likely respond differently to different precipitation patterns. Rather than try to fine-tune these dynamics species by species, I am working with drought indexes that indicate whether it was a particularly wet or dry year based on that location's norms (so a "dry" year in the Southwest will have a different precipitation profile compared to a "dry" year in the Southeast). There are several of these indexes, of which the Palmer's Drought Severity Index and its variants are the most common. These are calculated on several time scales, and each gives a sense of how prolonged dry or wet conditions persist back for different periods of time. I won't go into details here, but an excellent summary of the various indexes, selected references, and animated maps showing how drought patterns can change through time can be found at the National Oceanic and Atmospheric Administration's (NOAA) website: (http://www.ncdc.noaa.gov/oa/climate/research/prelim/drought/palmer.html).

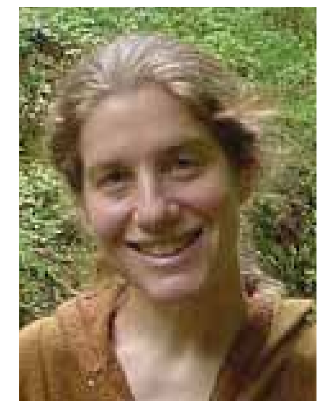
Since the NABA count data are collected at continental scales and stretch back to 1975, one of the additional challenges is acquiring, processing and analyzing these huge climate data sets. One solution is to use summaries that are available from organizations like NOAA and US Department of Agriculture (USDA) that summarize the data, but often averaged over coarse spatial scales and over several years. Using GDD summaries also constrains you to accept typical cutoffs (like 50F or 60F) even when we have detailed developmental data for some species. To be as flexible as possible, I have found that beginning with the raw data is the best approach. In future columns, I will show how we are using these vast stores of climate data at increasingly fine scales of both spatial and temporal resolution to understand the connection between butterfly dynamics and climate.

Contributors (continued from page 48)

Ornithological Society meeting in south Florida. Sally received her biology degree from Emory University and advanced biology training from the University of California at Davis. She has worked at the Florida Natural Areas Inventory, the natural heritage program for the State of Florida, for 18 years. As the Conservation Lands Biologist for Florida Natural Areas Inventory, she has developed a comprehensive map-based database on federal, state, local, and private conservation lands throughout Florida. Sally helps Dean coordinate the statewide butterfly grant from the Florida Fish and Wildlife Conservation Commission.

Berry Nall has Masters' degrees in Physics Education (The University of Texas-Pan American) and in Divinity (Southwestern Baptist Theological Seminary). He now resides in Starr County, Texas, where he pastors a small church and teaches high school science. He grew up chasing butterflies and moths over the hills of Maryland and Virginia. As an adult that pursuit was neglected until he obtained a digital camera and discovered the joys of digital collecting. A simple effort to identify the butterflies passing through his yard soon grew into a passion for butterfly photography, a butterfly garden (open to the public), a website, and a desire to raise as many kinds of butterfly as possible. His website, www.leps.thenalls.net, currently includes life histories of over 60 butterfly species and adult photographs of an additional 110 species that have been found in Starr County, TX.

Mike Reese updates the NABA Recent Sightings web pages. He enjoys photographing wild flowers, birds, dragonflies, and, of course, butterflies. He is an educator in Wautoma, Wisconsin and has been recording and documenting the butterflies that are found there for over 15 years. He also maintains a website on the Butterflies of Waushara County, Wisconsin.



Leslie Ries is a conservation biologist who has worked largely on the impacts of landscape structure on habitat quality. All of her past field work has focused on butterflies. Leslie was an undergraduate at University of Maryland (Zoology). She received an M.S. in Ecology, Evolution and Behavior from Iowa State University and a Ph.D. in Biology from Northern Arizona University. She is currently a post-doctoral associate at the University of Maryland where she is working on the 4th of July dataset.