

Applying Volunteer-based Butterfly Monitoring Data Toward Understanding the Responses of Butterflies to Global Climate Change



Sarah Diamond

North Carolina State University

APNEP-STAC meeting, 27 April 2011

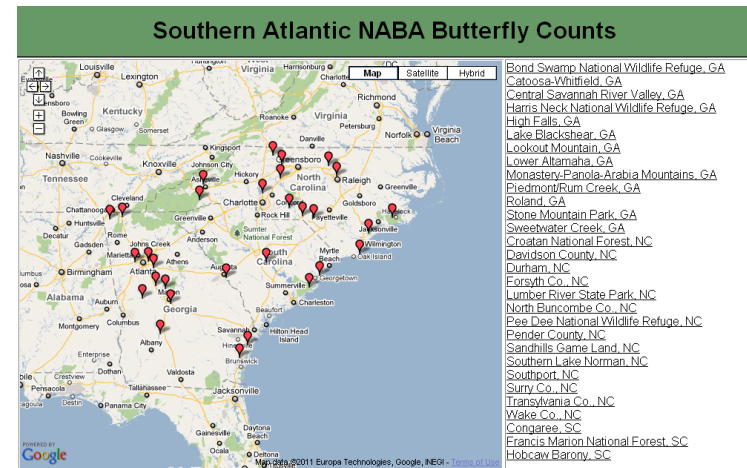
Roadmap

- Overview of volunteer-based butterfly monitoring
- The UK Butterfly Monitoring Scheme (UKBMS)
- Applying monitoring data to develop predictive models for butterfly species' responses to climate change



Volunteer-based butterfly monitoring

- Single-day counts
 - 4 July counts [June-July] (and potentially more times per year [spring/fall], depending on the site)
 - e.g., North American Butterfly Association (NABA)
- Recurring counts
 - Often involve once-per-week counts for the duration of butterfly activity
 - e.g., UK Butterfly Monitoring Scheme (UKBMS)



Volunteer-based butterfly monitoring

- Areas

- NABA: participants select a count area with a 15-mile diameter and conduct a one-day census of all butterflies sighted within that circle

- Transects

- UKBMS: participants walk transects (~1-4 km length x 5 m width) once-per-week starting 1 April through September, and census all butterflies along the transect (Pollard transects)



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Conservation in Action!

Limited to a single remaining population of less than 100 individuals, the Miami blue butterfly (*Cyclargus thomas bethunebakeri*) is one of the most endangered insects in the world. Once locally abundant and widespread throughout south Florida, the species lost ground rapidly over the last few decades. By the early 1990's, known populations were isolated and scarce. Fear that the butterfly had gone extinct escalated until November 19, 1999, when the butterfly was rediscovered in **Babia Honda State Park** in the Lower Florida Keys. This small island of 524 acres, a flagship of the Florida Park system for its popular white sandy beaches and deep turquoise waters, is now the focal point of conservation efforts to save the last remaining Miami blues.

A female (top) and male (bottom) Miami blue butterfly in UF's captive colony.

Owing to butterfly's tenuous current situation, the **Florida Fish and Wildlife Conservation Commission** added the Miami blue to the state's **endangered species list** in November 2003 providing the impetus for the start of an aggressive conservation and recovery effort.

Latest News

Florida Butterfly Festival - The Florida Museum of Natural History will host ButterflyFest: Oct. 23-24, 2010. This event will feature something for everyone. Throughout the weekend, all ages can participate in fun and educational activities, including take-away crafts for children, informative workshops, plant sales and ... [\[more\]](#)

The Butterfly Conservation Initiative - The Butterfly Conservation Initiative is dedicated to the conservation of threatened, endangered, and vulnerable North American butterflies and the habitats that sustain them, with a focus on recovery, research, and education. [\[more\]](#)

Coming Soon! - Downloadable Florida Butterfly ID Sheets [\[more\]](#)

North American Butterfly Association

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Butterfly Garden and Habitat Program

Create a paradise for butterflies while encouraging habitat restoration, no matter how large or small an area you have.



National Butterfly Center

Sponsor a garden

The National Butterfly Center is dedicated to education, conservation and scientific research on wild butterflies.



Butterfly Count Program

Special Requests to Compilers

4th of July Count (U.S.)
1st of July Count (Canada)
18th of Sept Count (Mexico)


Seasonal Counts

Memorial & Victoria Day Counts

American Butterflies Magazine

In the Fall 2010 Issue:

- Who Killed the Miami Blues
- Extinctions in South Florida
- Rio Grande Floods

NABA Corner

- Progress on National Butterfly Center

Welcome Current News

Epic trip to trace the remotest of our native butterflies (13 June 2009, The IUK Independent)

U.S. grants to help Oregon habitats, imperiled species (The Oregonian, 20 April 2009)

Darwin was right about those butterfly spots (courant.com Weblog, April 2, 2009)

Protective measures help drive down butterfly death rate in Taiwan (Taiwan News, March 21, 2009)

Painted lady butterfly migration hits Palo Alto (Palo Alto Online, March 27, 2009)

Butterflies I've Seen

Welcome to BIS, "Butterflies I've Seen", the web site that allows you to keep track of all of your butterfly sightings. Once you enter your sightings, you can retrieve them by location, by date, or by species. You can print out a list of all the butterfly species you've ever seen - a Life List, or you can print out a list of all the butterfly species you've ever seen at a particular location. At the same time, the sightings you enter provide important information that NABA, the major butterfly conservation organization in North America, will use to help answer scientists questions about butterfly distributions, abundance and conservation. Enjoy the site and the fact that your efforts are increasing our knowledge and helping butterfly conservation.

New Users may want to look at the step by step walkthrough available as [HTML here](#) or as a [MS Word document here](#).

A more advanced set of instructions about the site can be found as [HTML here](#) and as a [MS Word document here](#).

Send in a question or share your favorite experiences with butterflies in the [discussion area](#).

Registered Users Can:

- Enter and View Personal Butterfly Sightings
- Email Field Trips and Sightings Information
- Maintain Life Lists
- Submit Information or Links About Butterflies That May be of Interest to Others
- Read and Submit [News Articles](#)
- Participate in [Butterfly Group Discussions](#)

Non-registered Users Can:

- Read the Butterfly [News Articles](#) and [Group Discussions](#)

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Email the [Site-Administrators](#) with any suggestions or post your remarks in the designated [discussion area](#). Minimal recommended browser is [Internet Explorer 7.0](#) or Firefox 2.0.

This site developed for the [North American Butterfly Association](#) by [REDSHIFT TECHNOLOGIES, INC.](#)

Supported by grants from the [Geraldine R. Dodge Foundation](#)

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Mix of single-day, recurring, area, and transect butterfly monitoring in the US



Art Shapiro's Butterfly Site

Monitoring butterfly populations across Central California for more than 35 years...

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Welcome to Art's Butterfly World

This website describes over 34 years of data collected by Dr. Arthur Shapiro, professor of Evolution and Ecology at the University of California, Davis, in his continuing effort to regularly monitor butterfly population trends on a transect across central California. Ranging from the Sacramento River delta, through the Sacramento Valley and Sierra Nevada mountains, to the high desert of the western Great Basin, fixed routes at ten sites have been surveyed at approximately two-week intervals since as early as 1972. The sites represent the great biological, geological, and climatological diversity of central California.

As of the end of 2006, Dr. Shapiro has logged 5476 site-visits and tallied approximately 83,000 individual records of 159 butterfly species and subspecies. This major effort is continuing and represents the world's largest dataset of intensive site-specific data on butterfly populations collected by one person under a strict protocol. We have also collated monthly climate records for the entire study period from weather stations along the transect.

We built this website as a portal for Dr. Shapiro's data and observations, supported by National Science Foundation Biological Databases and Informatics Grant DBI-0317483. Much of the data is freely available (Please [Contact Us](#) for more information).

[Read more](#)

Donner Summit Historical Society Newsletter featuring Butterflies

Thu, 2011-03-31 09:37 — [dwaesjen](#)

This issue of the of the Donner Summit Historical Society Newsletter features Art's butterfly study, and focuses on the Donner Pass collection site.

1 attachment

Chlosyne hoffmanni



UC DAVIS

Data collection and deposition

- Quality control on data
 - NABA: minimum four adult observers, and 6 party-hours per count
 - Data not conforming can still be submitted to Butterflies I've Seen (BIS)
 - UKBMS: transect walks are undertaken between 10:45am and 3:45pm and only when weather conditions are suitable for butterfly activity: dry conditions, wind speed less than Beaufort scale 5, and temperature 13°C or greater if there is at least 60% sunshine, or more than 17°C if overcast
 - Online field guide resources for identifications
 - Submission of butterfly photographs with count data for confirming identifications
- Most volunteer butterfly monitoring data are freely available from the web or upon request

Why monitor butterflies?

Butterfly phenology as an indicator of climate change

- **Phenology:** “recurring plant and animal life cycle stages, such as leafing and flowering, maturation of agricultural plants, emergence of insects, and migration of birds”
- With climate warming, phenologies of many organisms shifting
 - Empirical evidence for earlier spring events & later fall events
 - Asynchronies in timing of events as taxa have different phenological responses to warming
- Phenology identified by the Intergovernmental Panel on Climate Change (IPCC) as a key indicator of biological responses to climate change



HOME

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The UK Butterfly Monitoring Scheme (UKBMS)

Welcome to the United Kingdom Butterfly Monitoring Scheme (UKBMS), a recently formed merger of the long-running Butterfly Monitoring Scheme (BMS) with Butterfly Conservation's co-ordination of 'independent' transects. The resulting UKBMS dataset is one of the most important resources for understanding changes in insect populations... [[more](#)]

The scheme has monitored changes in the abundance of butterflies throughout the United Kingdom since 1976. Over the 32 years of the scheme, recorders have made over 170,000 weekly visits to 1500 separate sites, walking over 375,000 km and counting over 12.5 million butterflies!

The UKBMS is based on a well-established and enjoyable [recording method](#) and has produced important insights into almost all [aspects of butterfly ecology](#).



Volunteer-based
71 species
1500 sites
~ 26 sampling events / yr
Sampling 1976 to present

Latest News

The [Wider Countryside Butterfly Survey](#) is in full swing this summer.

[2009 Summary of Changes Table now available online](#)

[2010 National Butterfly Recorders' Meeting](#) Full programme now online.

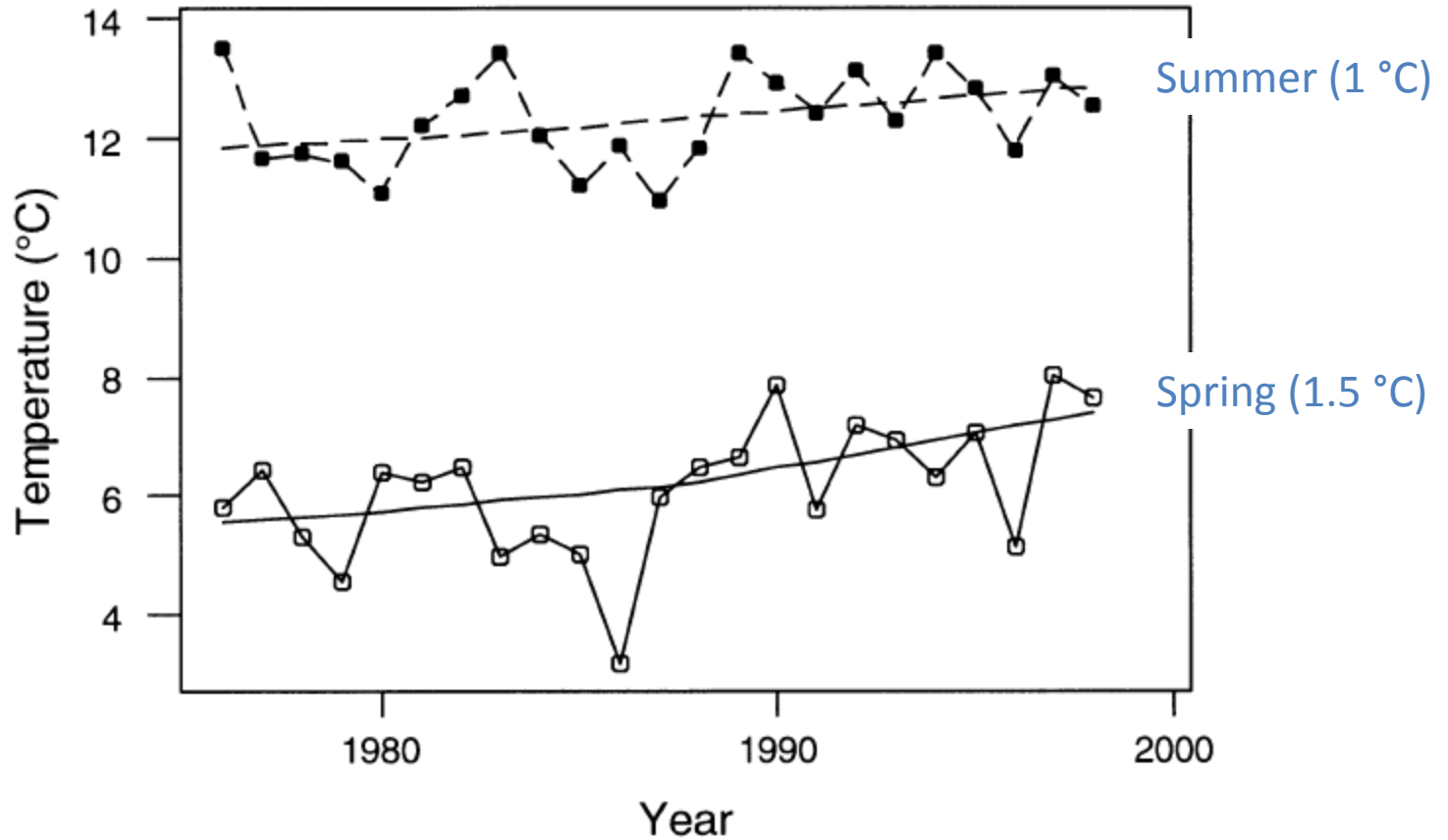
[2008 Annual Report](#) To download [High Res](#) (38.2 MB, PDF) [Low Res](#) (3.1 MB, PDF)

[Amendment to the 2008 Annual Report](#)

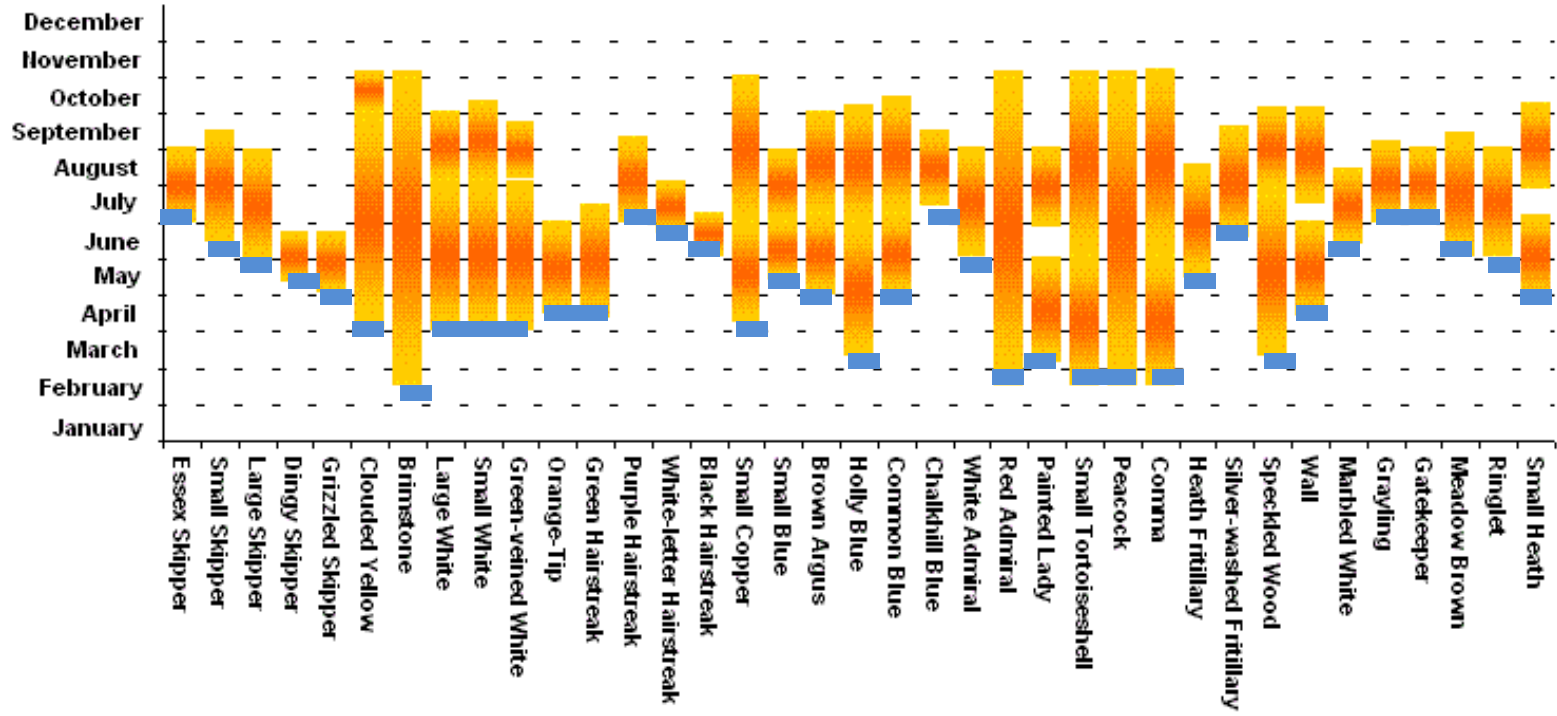


A new publication, "[The State of Butterflies in Britain and Ireland](#)", was launched on May 15th. This book is a follow-up to the hugely successful [Butterflies for the New Millennium atlas](#), and is available to purchase from the publishers, [Nature Bureau](#) (price: **£14.50 inc. p&p**)

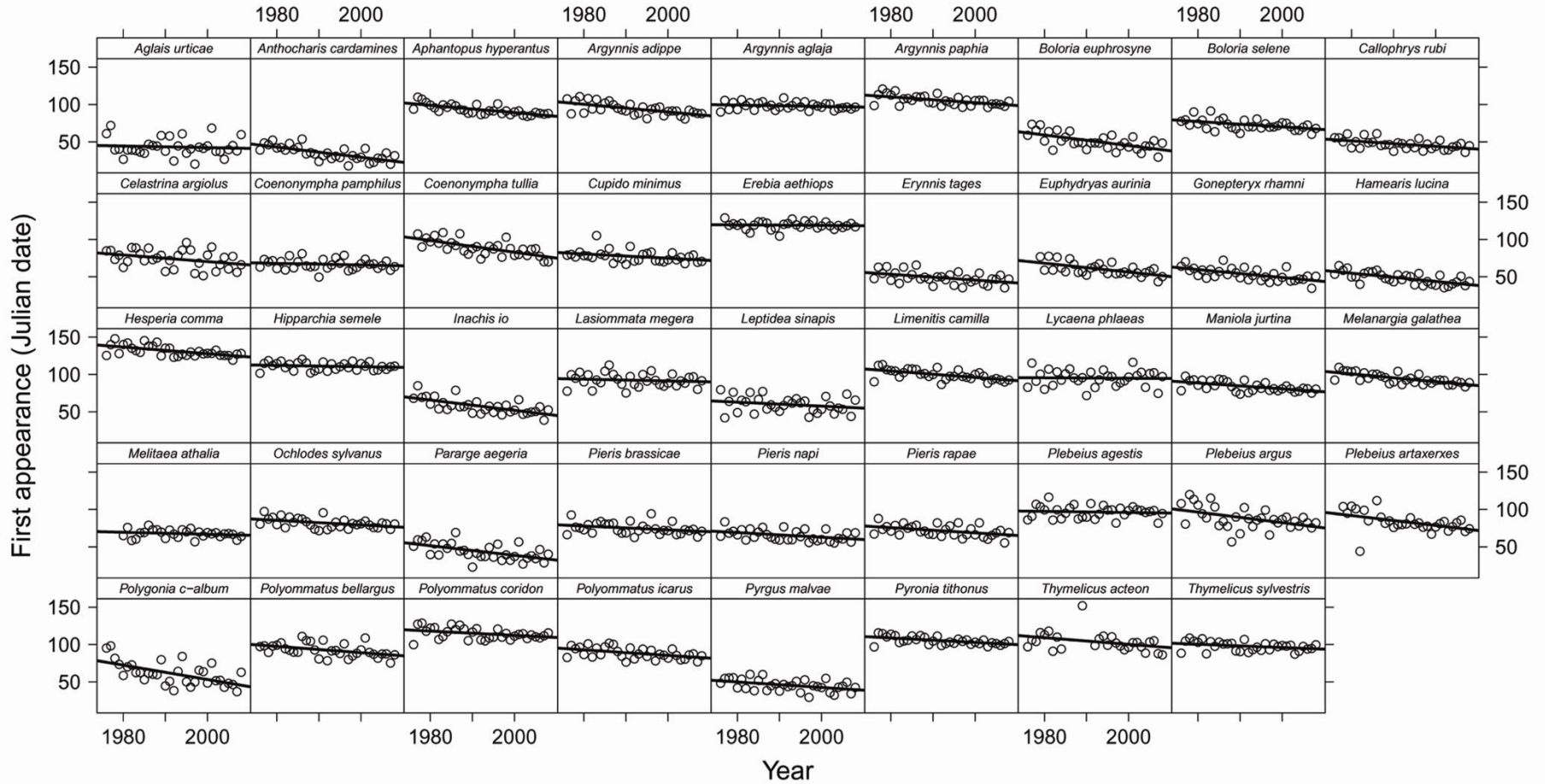
Increase in UK air temperature



Flight phenology of UK butterflies: Date of first appearance

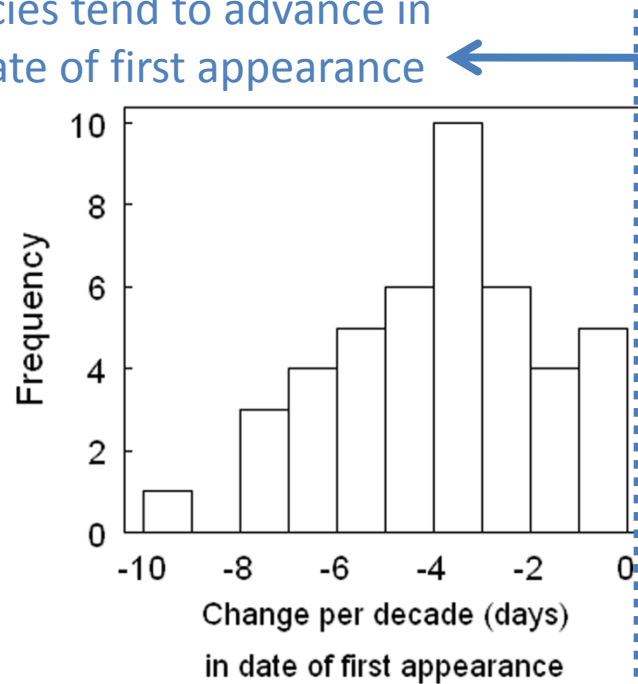


Phenology of UKBMS species (1976-2008)



Phenological change per decade

All species tend to advance in their date of first appearance



Can species' traits and shared evolutionary history explain the degree of phenological advancement?

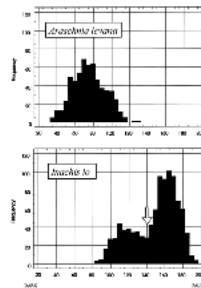
Diet breadth



Overwintering stage



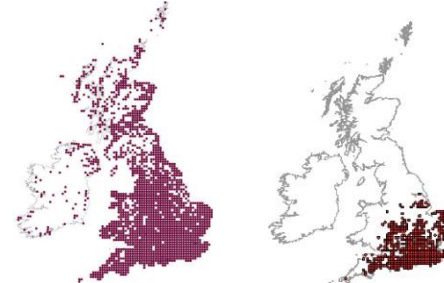
Voltinism



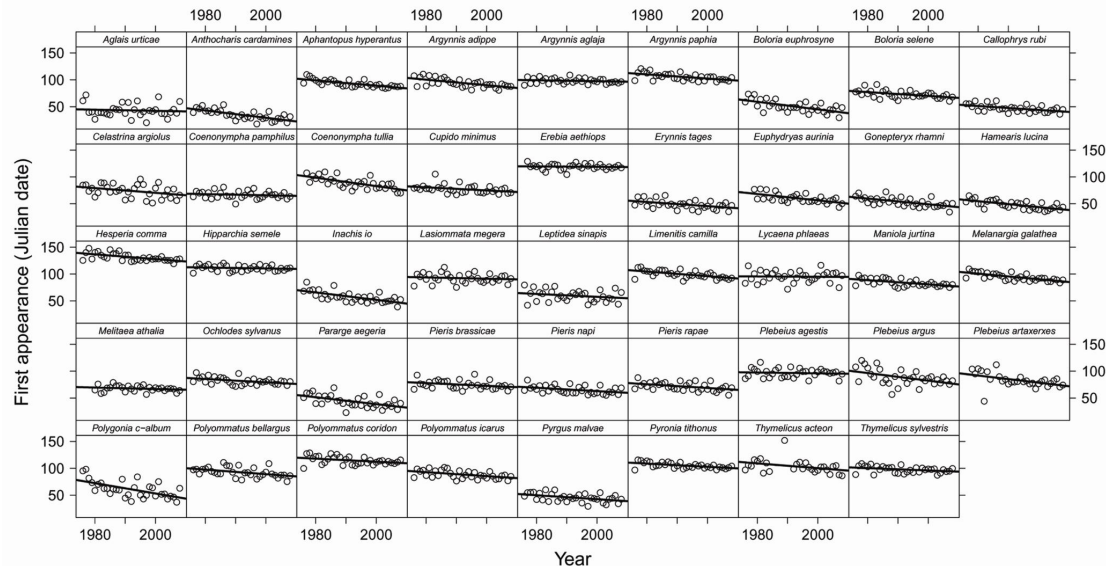
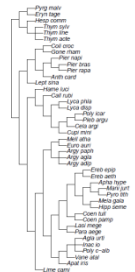
Dispersal



Range & distribution



Phylogeny



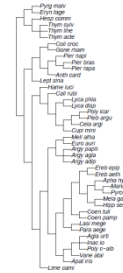
Analytical approach: phylogenetic glm

- linear model controlling for phylogenetic non-independence
- strength of the phylogenetic signal controlled by altering the parameter λ
 - $\lambda = 0$ is equivalent to a standard linear model, with all shared phylogenetic history reduced to zero
 - $\lambda = 1$ uses the original covariance matrix
 - pglm scales the covariance between data points as the product of this shared history and λ (estimated using ML)

$$\Sigma = \begin{pmatrix} \sigma_{11} & \dots & \sigma_{1n} \\ \sigma_{21} & \sigma_{22} & \dots \\ \vdots & \dots & \vdots \\ \sigma_{n1} & \dots & \sigma_{pp} \end{pmatrix}$$

The goal: build a predictive model for butterfly phenological responses to climate warming based on species-level traits

Phylogenetic autocorrelation

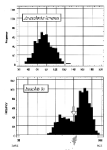


Overwintering stage
(egg, larva, pupa, adult)

Change in day of first appearance
(per decade)



Voltinism



Dispersal ability



Number of larval host plant species

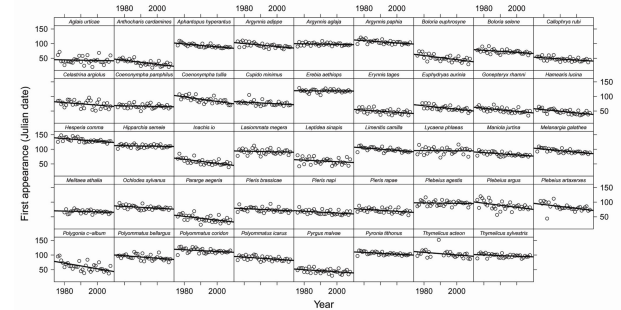
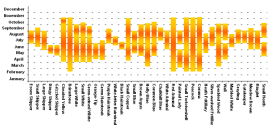


Latitudinal extent
(amount of UK mainland occupied)



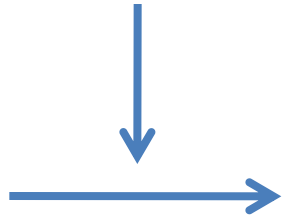
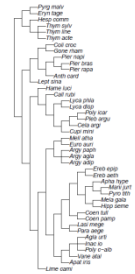
Percent national 10km grid cells occupied

Julian day first appearance (1975)



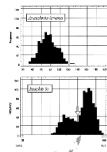
$\lambda \sim 0$ (full model pglm); Moran's I = -0.02, p = 0.41
 Virtually no phylogenetic signal in phenological advancement

Phylogenetic autocorrelation



Overwintering stage
(egg, larva, pupa, adult)

Change in day of first appearance
(per decade)



Voltinism

Dispersal ability

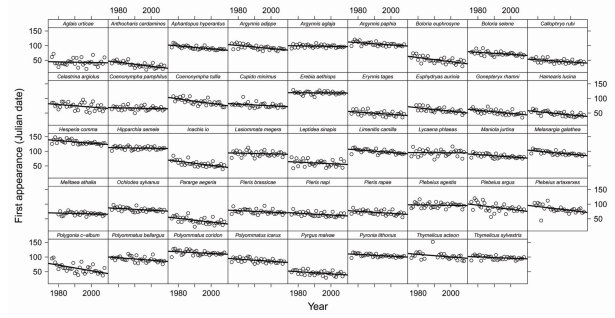
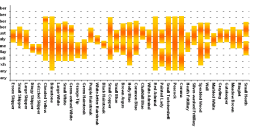
Number of larval host plant species

Latitudinal extent
(amount of UK mainland occupied)



Percent national 10km grid cells occupied

Julian day first appearance (1975)



Model selection approach:

what combination of parameters best predicts the degree of phenological advancement?

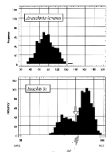
(all main and two-way interactions)



Overwintering stage
(egg, larva, pupa, adult)



Change in day of first appearance
(per decade)



Voltinism



Dispersal ability

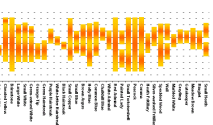


Number of larval host plant species

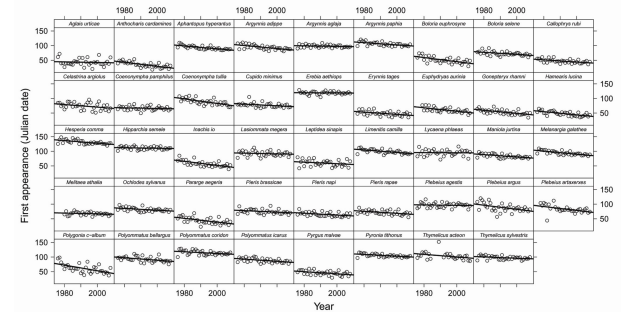


Latitudinal extent
(amount of UK mainland occupied)

Percent national 10km grid cells occupied



Julian day first appearance (1975)



Best-fitting models ($\Delta AICc < 2$)

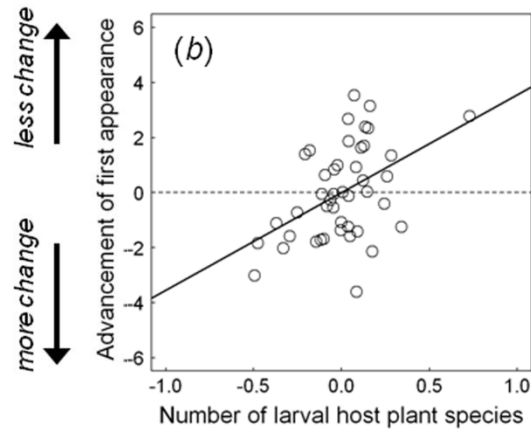
Dispersal and voltinism absent from best-fitting models

Models with strongest empirical support contain: annual day of first appearance, overwintering stage, diet breadth, and range/distribution

Model no. (<i>i</i>)	Model wt. (w_i)	First app. ^b	Overw. Stage	No. Plants	Per. Nat.	Lat. Ext.	No. Plants* Per. Nat.	No. Plants* Lat. Ext.	Per. Nat.* Lat. Ext.
1	0.394		•	•	•	•		•	•
2	0.250	•	•	•	•	•		•	•
3	0.144	•	•	•	•	•	•		•
4	0.111	•	•	•	•	•		•	•
5	0.101		•	•	•	•	•		•
w_{+i} ^a	1.000 (cum. w_{+i})	0.505	1.000	1.000	1.000	1.000	0.245	0.755	1.000

Partial regression plot

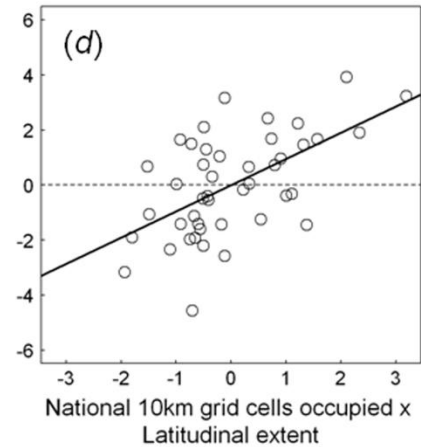
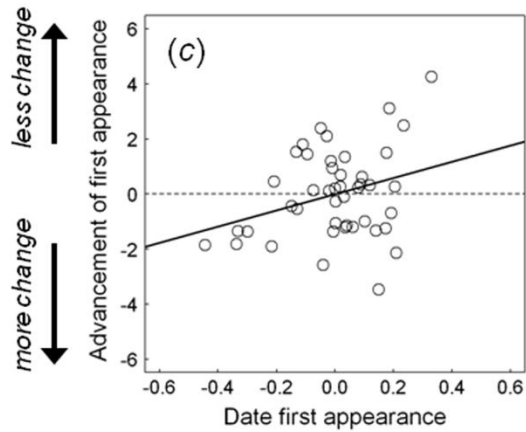
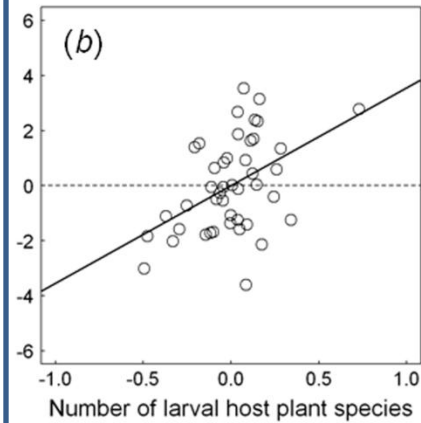
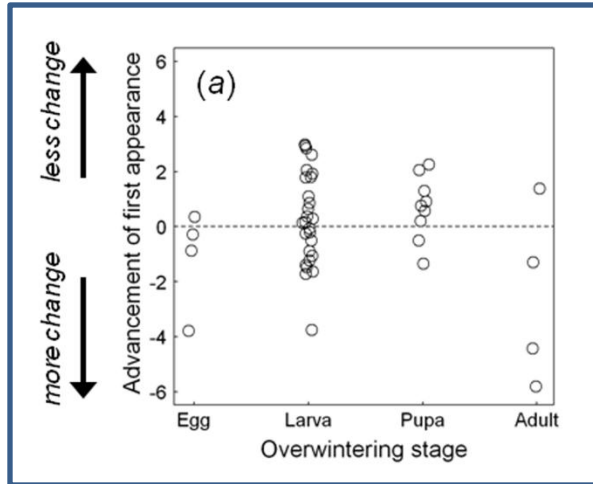
Residuals of
 $y \sim x_1 \dots x_n (-x_*)$



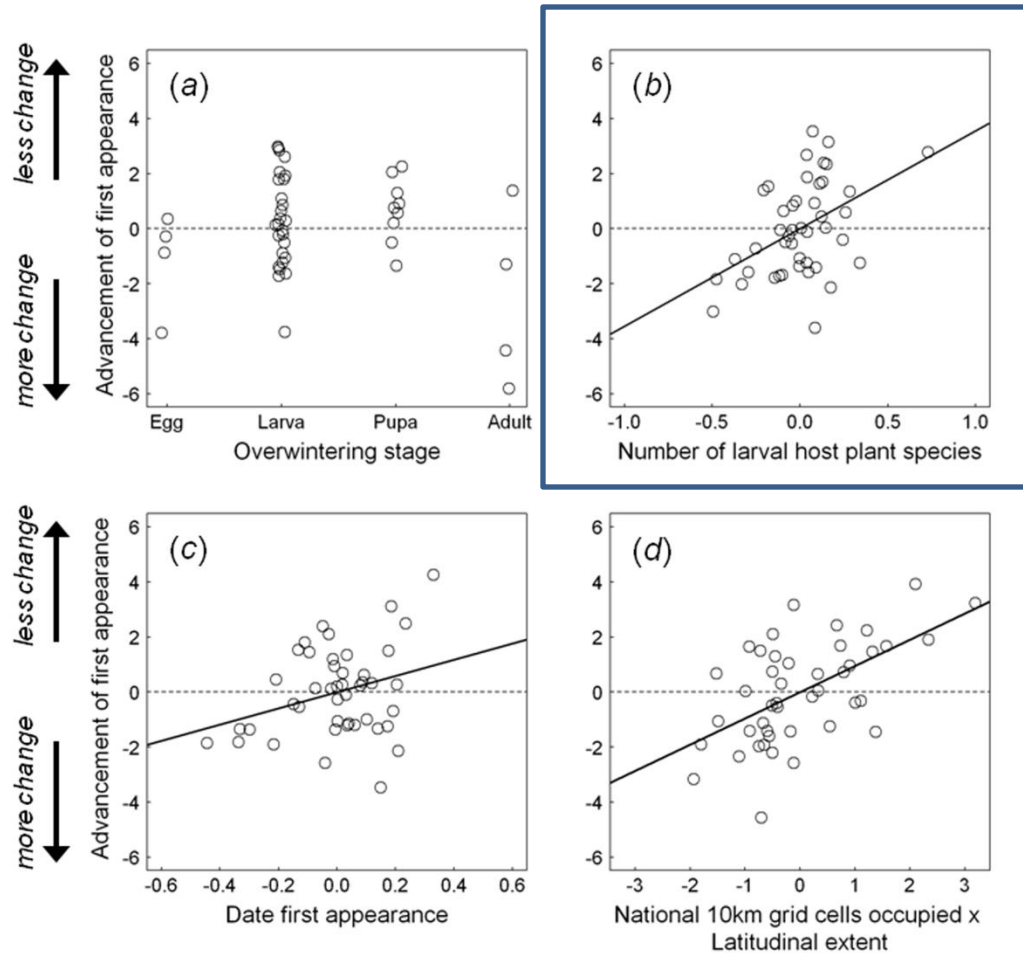
Residuals of
 $x_* \sim x_1 \dots x_n$

'Significant' predictors ($p < 0.05$, full model of all terms from best-fitting models; type III SS)

Species that overwinter as adults advance more than other stages

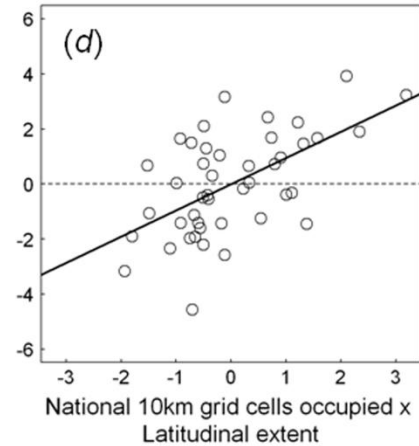
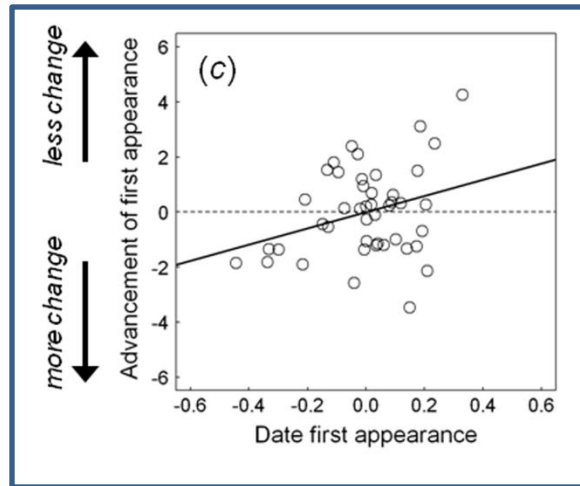
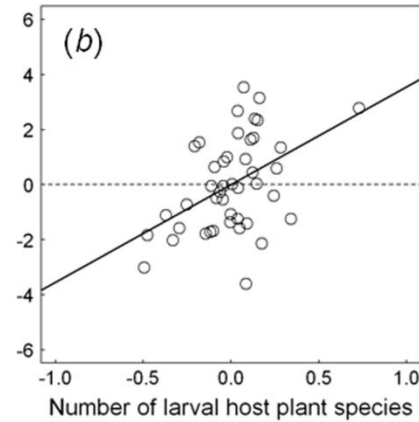
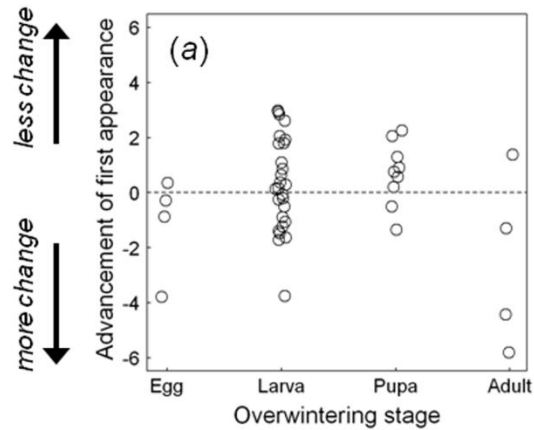


'Significant' predictors ($p < 0.05$, full model of all terms from best-fitting models; type III SS)



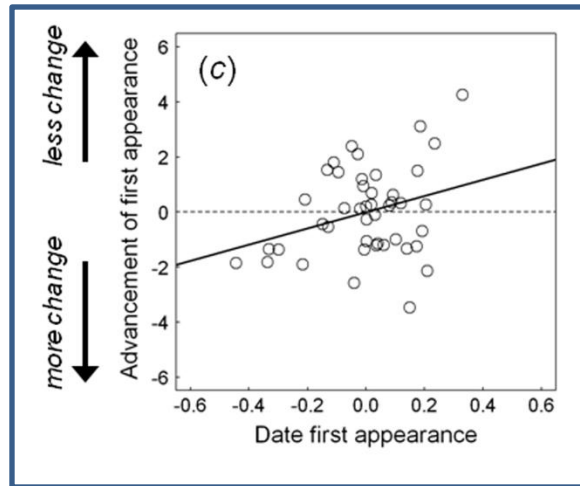
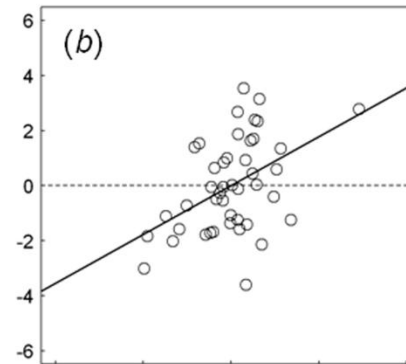
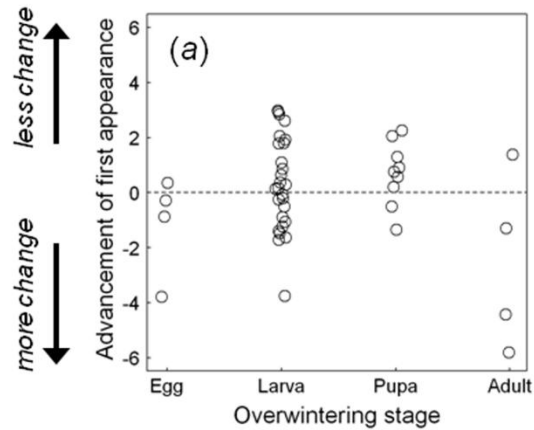
Species with narrower diet breadths advance more

'Significant' predictors ($p < 0.05$, full model of all terms from best-fitting models; type III SS)

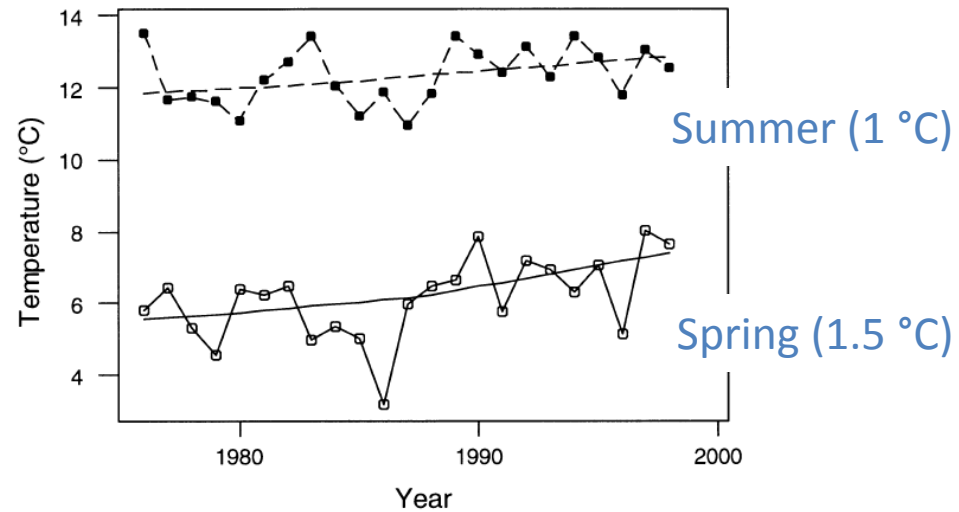


Species that have earlier annual dates of first appearance advance more

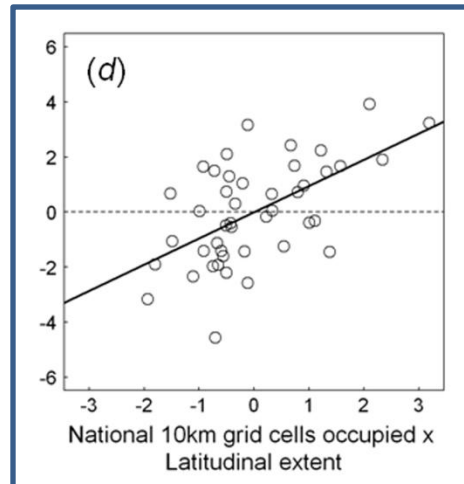
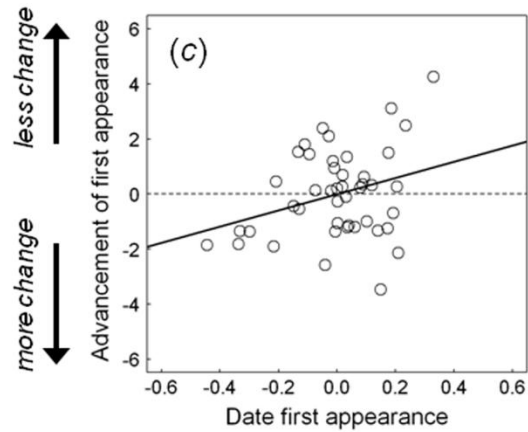
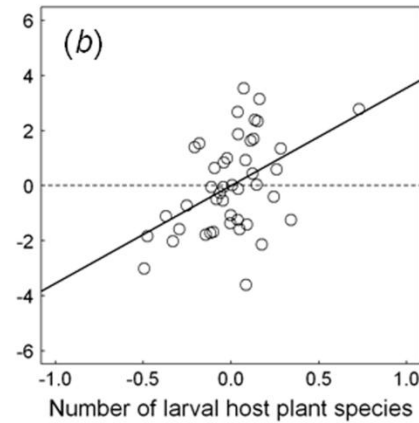
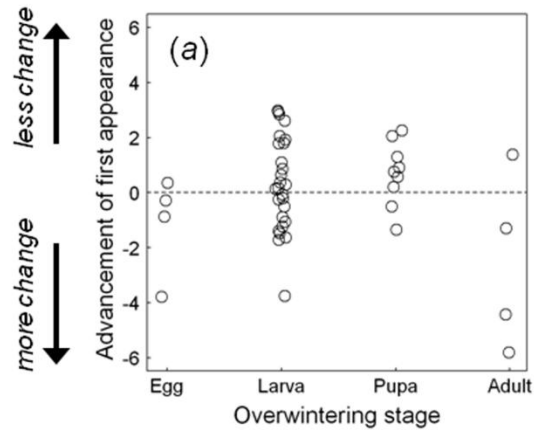
'Significant' predictors ($p < 0.05$, full model of all terms from best-fitting models; type III SS)



Species that have earlier annual dates of first appearance advance more

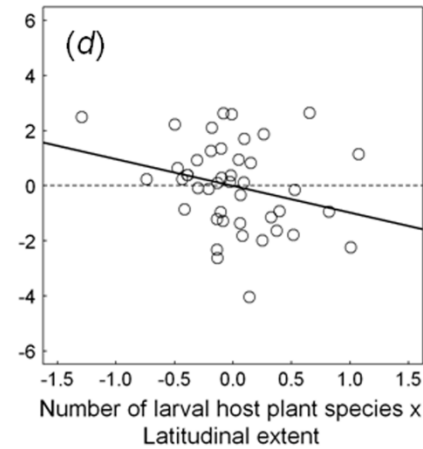
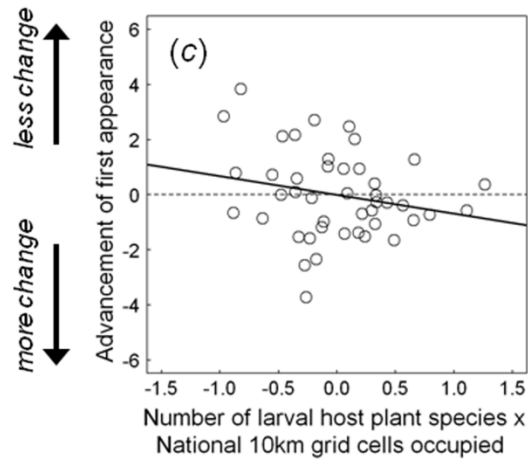
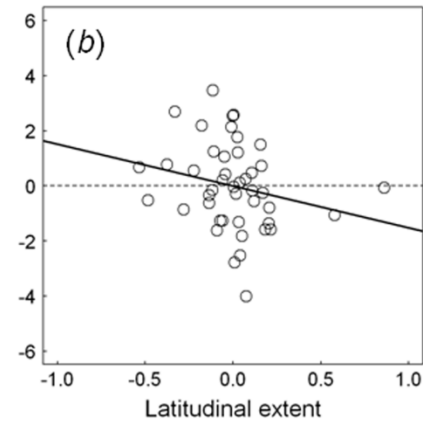
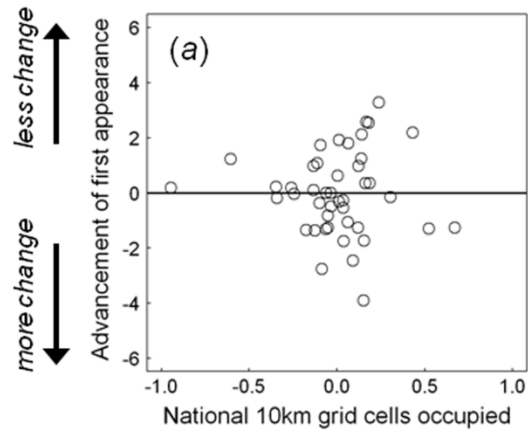


'Significant' predictors ($p < 0.05$, full model of all terms from best-fitting models; type III SS)



Species that
occupy less
habitat advance
more

'Non-significant' predictors ($p < 0.05$, full model of all terms from best-fitting models; type III SS)



Implications

- Basic research
 - Identifies patterns between phenology & life history / species-level traits
 - Suggests testable hypotheses for the bases of these patterns
 - Especially need to link magnitude of phenological response with performance
- Applied research & Conservation
 - Identify those species that will respond most strongly to climate change
 - UK butterflies
 - Other species with particular life histories

Acknowledgements

- Univ. North Carolina collaborators
 - Alicia Frame, Ryan Martin, Lauren Buckley
- UKBMS and volunteers



Volunteer-based ant sampling

- North Carolina State University
 - Rob Dunn lab / Andrea Lucky (alucky@ncsu.edu)
- ‘Ants in your Backyard’ / citizen science program
 - Baiting for ants in your yard and house
 - Sending samples to be processed in the Dunn lab