

# Assessing effects of climate change on bird phenology at broad temporal and spatial scales

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# Phenology



# Bird Phenology and Climate Change

- Interest among ecologists and general public
- Birds often “first responders”
- Provide ecosystem services
  - Biological pest control
  - Pollination
- Inform decision makers of climate change impacts

# Past Work

- Birds arriving earlier in most places since 1960s
- Temperature, precipitation, North Atlantic Oscillation
- Variation by species- some earlier, some later, some unchanged
- Most work at narrow spatial scales



*The Auk* 122(4):1130–1148, 2005  
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Printed in USA.

LONG-TERM TRENDS IN SPRING ARRIVAL DATES  
OF MIGRANT BIRDS AT DELTA MARSH, MANITOBA,  
IN RELATION TO CLIMATE CHANGE

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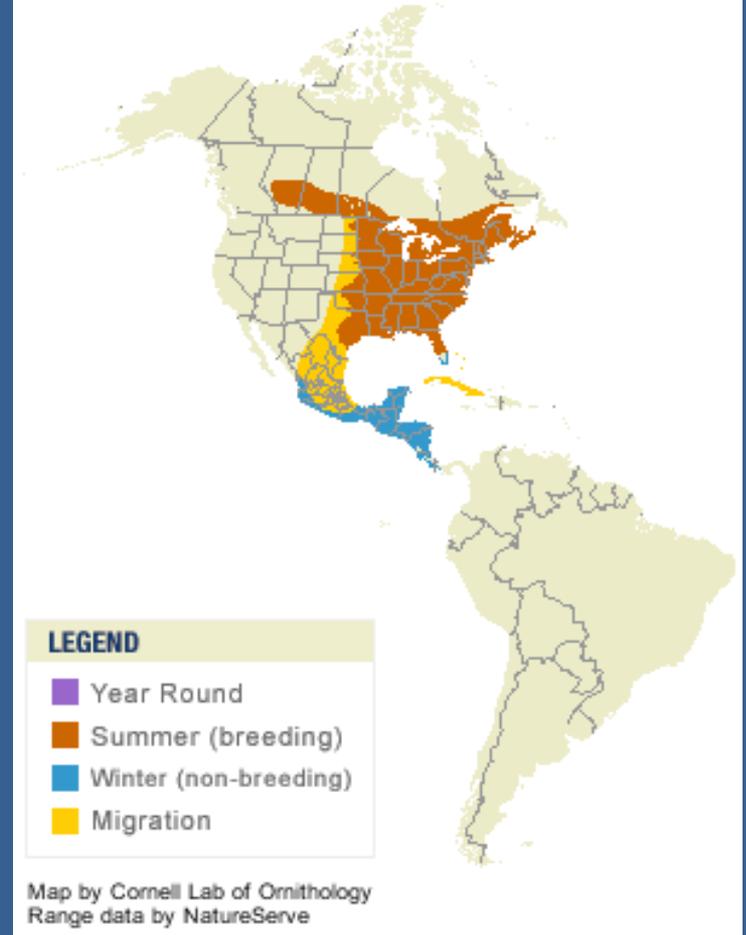
# Objectives

- **Compare arrival dates for Ruby-throated Hummingbirds in the Eastern United States between (1880-1969) and (1997-2010)**
- **Possible reasons for differences**
- **Challenges and benefits of using Citizen Science data to assess phenology**

# Ruby-throated Hummingbird



Ruby-throated Hummingbird  
*Archilochus colubris*



# First Arrival Data (1880-1969)

- N = 7,866

Name of Bird <i>Hummingbird, ruby throated</i>						Year
Locality <i>Spartanburg S. C.</i>						<i>1925</i>
Observer <i>Gabriel Cannon.</i>						
First seen	Number seen	Next seen	Became common	Last seen	Common or rare	Breeds
<i>Apr 26</i>					<i>C</i>	<i>Yes.</i>

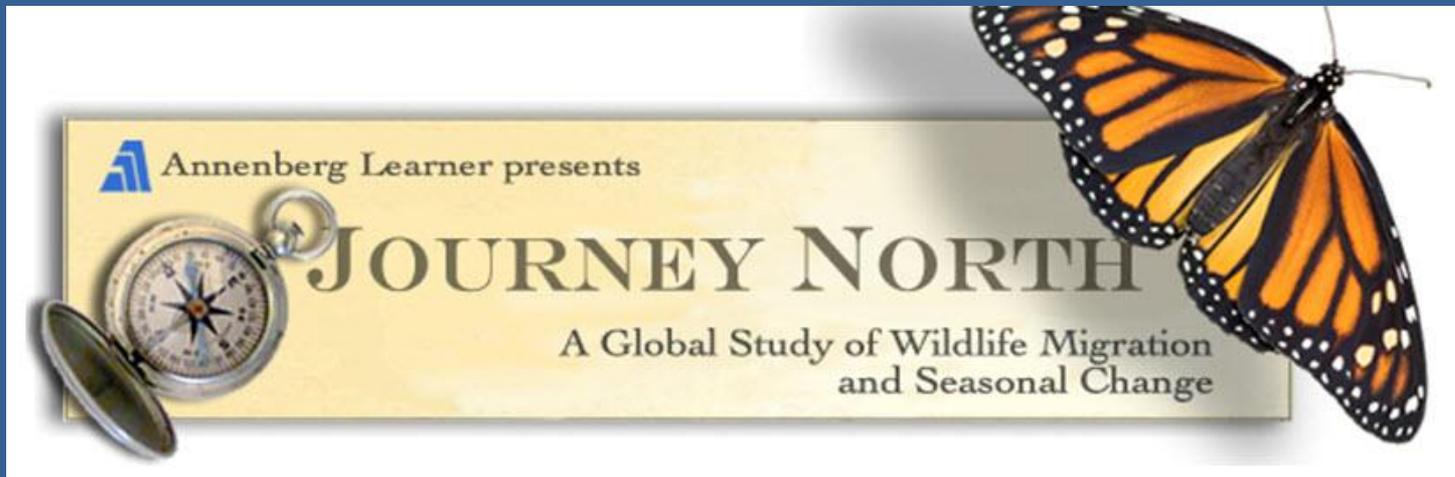


North American  
Bird Phenology Program



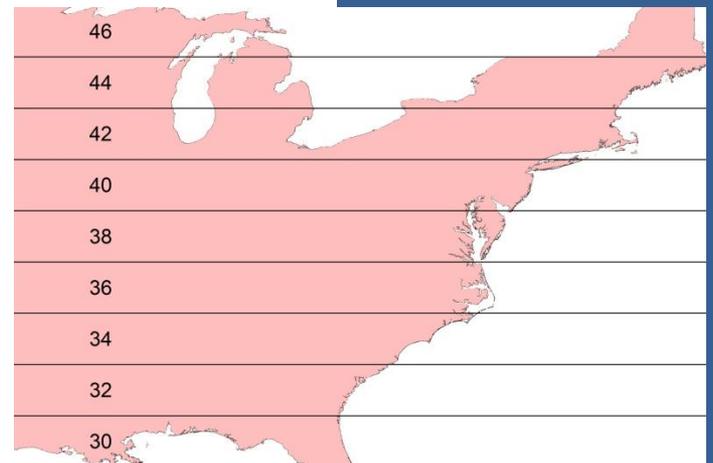
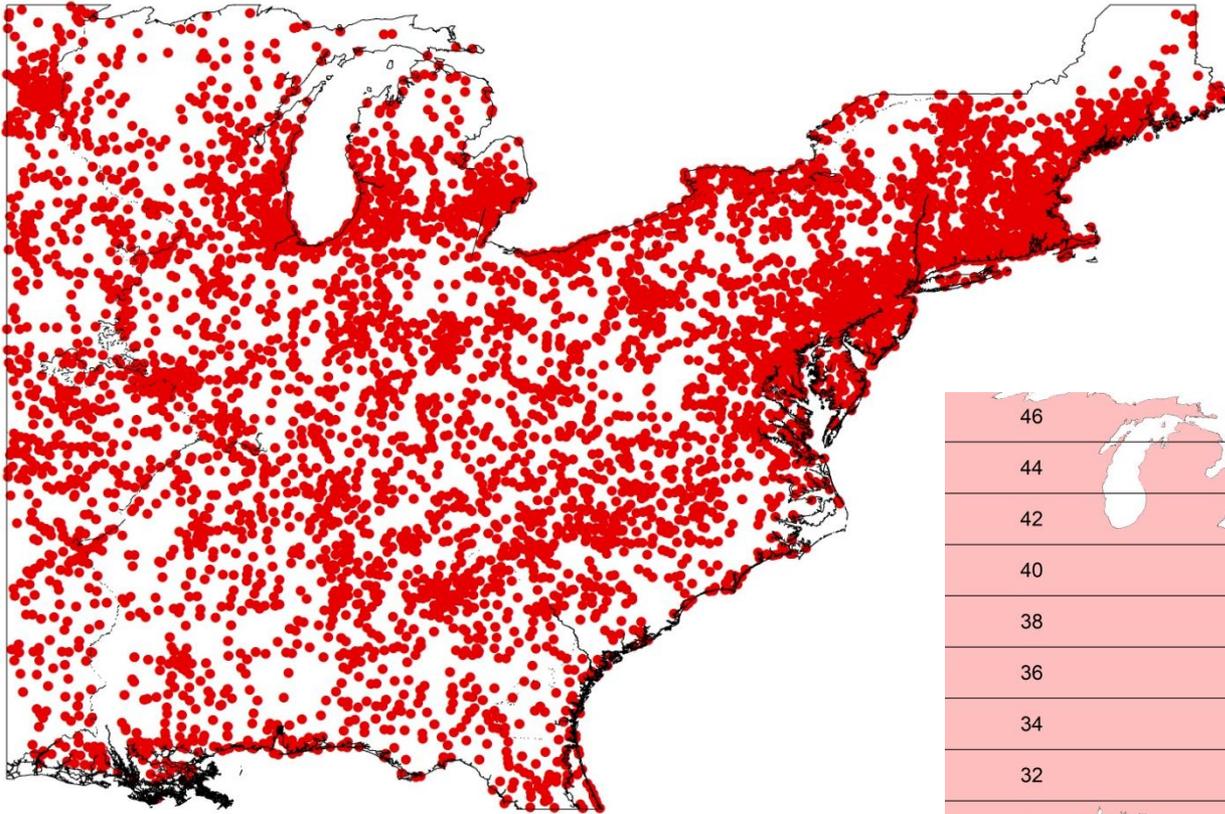
# First Arrival Data (1997-2010)

- N = 8,804



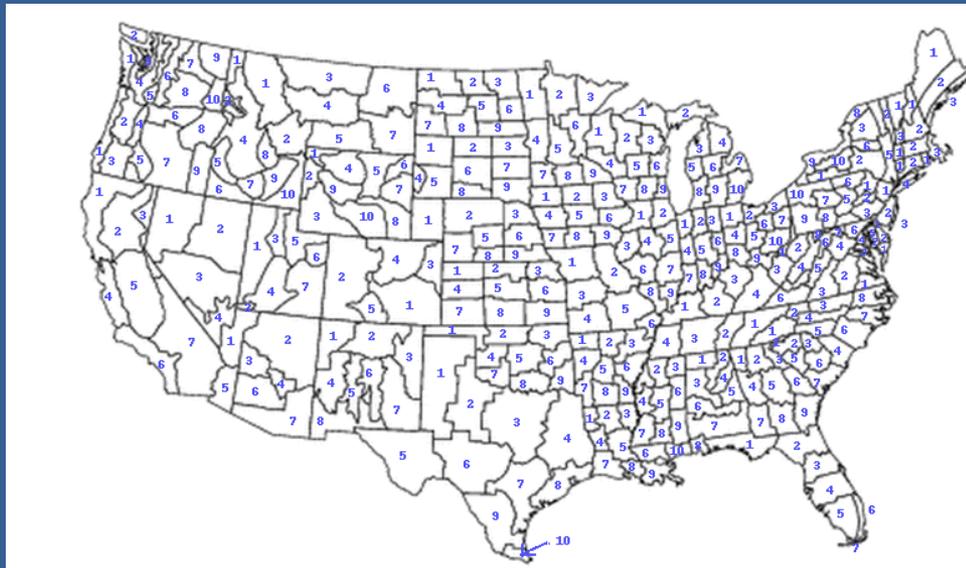
# Study Region

- N = 16,670 first arrival points
- Added latitude, longitude, altitude, Julian arrival date, day of week



# Climate Data

- Assigned climate variables by year and climate division (1895-2010)
  - Winter and spring temperature in breeding grounds
  - Precipitation in breeding grounds
  - Winter temperature in non-breeding grounds prior to departure



NCDC Climate Divisions (TIME BIAS CORRECTED DIVISIONAL TEMPERATURE-PRECIPITATION DROUGHT INDEX)

# Questions

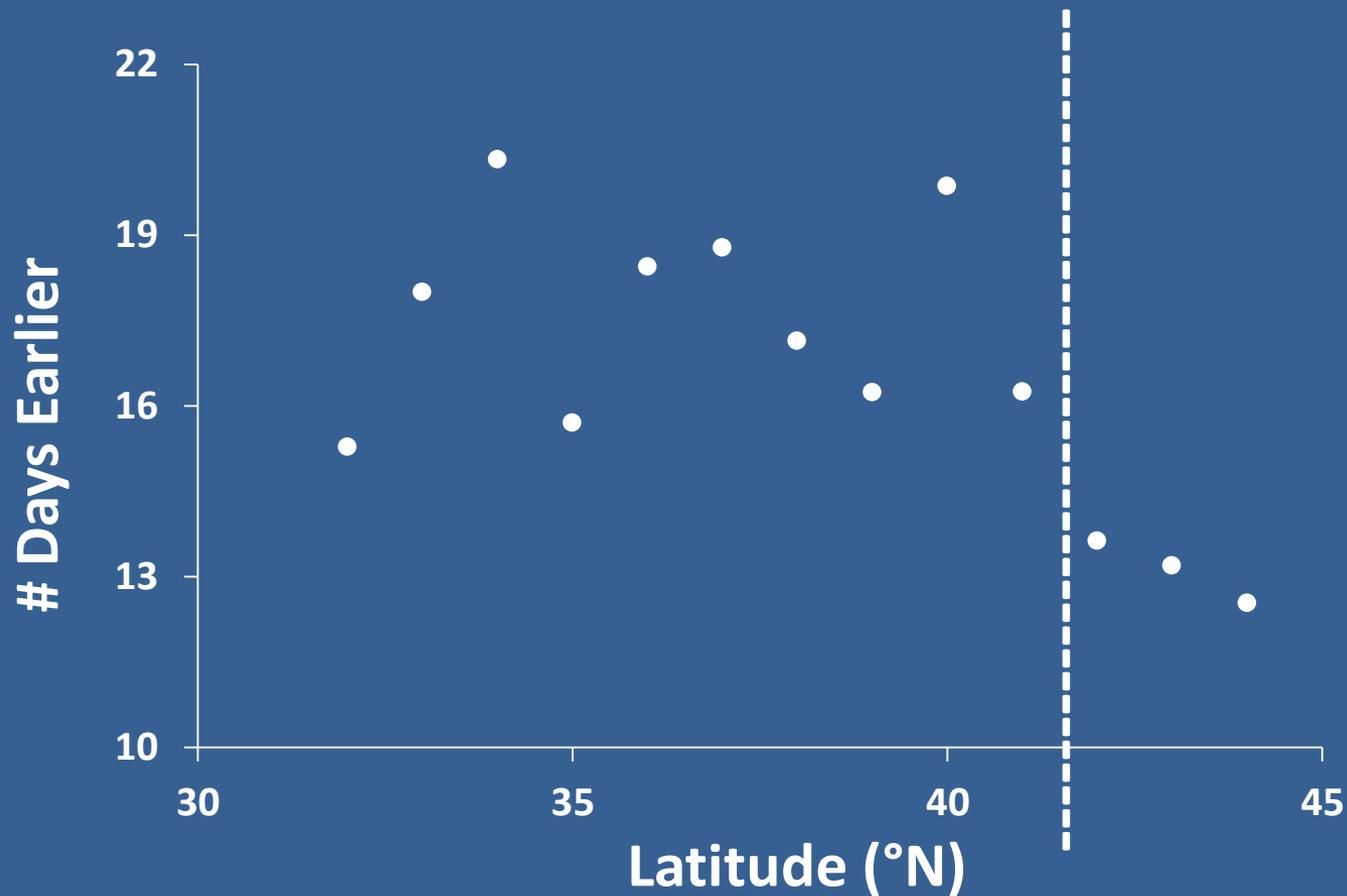
- Are birds arriving earlier across North America?
- Is change correlated with environmental variables?
- Which variables describe differences?
- T-tests and stepwise linear regression (JMP 9)

# Changes in Arrival Dates

Latitude	Mean First Arrival			Mean First Arrival			Days Earlier	S.E.	P-Value
	N	(1880-1969) <sup>1</sup>	S.E.	N	(1997-2010) <sup>1</sup>	S.E.			
32	60	95.02	1.38	357	79.74	0.40	15.28	1.43	<.0001
33	82	105.04	1.10	495	87.04	0.38	17.99	1.16	<.0001
34	75	111.22	1.01	593	90.90	0.32	20.32	1.06	<.0001
35	169	111.86	0.69	781	96.17	0.28	15.69	0.74	<.0001
36	119	117.57	0.87	671	99.13	0.31	18.44	0.93	<.0001
37	128	122.02	0.80	674	103.24	0.30	18.77	0.86	<.0001
38	193	125.60	0.73	848	108.46	0.29	17.14	0.79	<.0001
39	310	128.96	0.58	823	112.73	0.32	16.23	0.66	<.0001
40	579	135.08	0.42	783	115.23	0.33	19.86	0.53	<.0001
41	933	135.67	0.30	1004	119.43	0.27	16.24	0.41	<.0001
42	1043	136.40	0.26	1214	122.78	0.23	13.62	0.35	<.0001
43	589	138.00	0.32	782	124.81	0.27	13.20	0.42	<.0001
44	515	139.46	0.30	618	126.93	0.26	12.53	0.40	<.0001

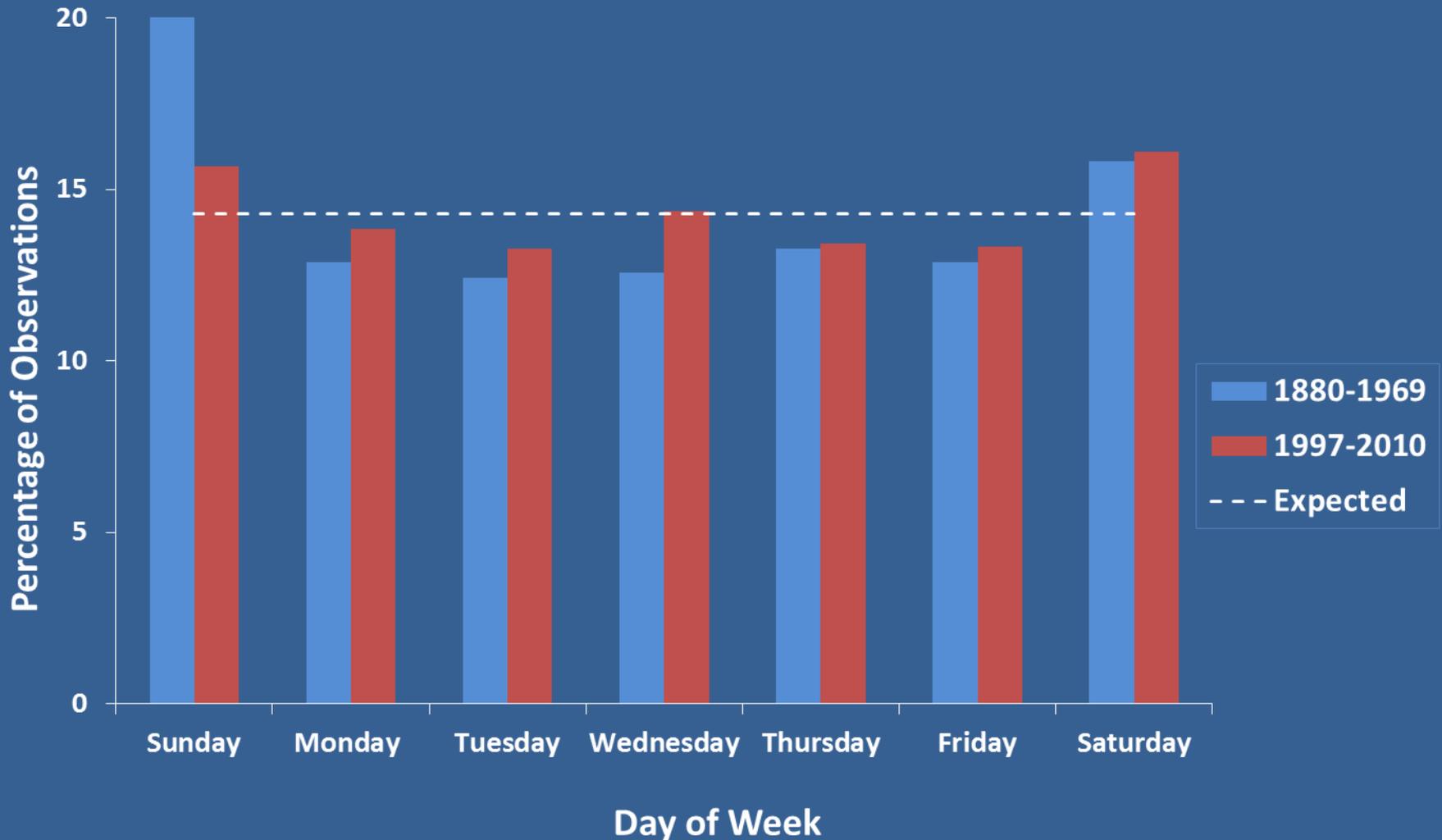
<sup>1</sup>Arrival dates are expressed in Julian calendar dates and corrected for leap years; for example, '95' is equivalent to April 5.

# Difference in First Arrival Dates (1880-1969) vs. (1997-2010) by Latitude



# Hummingbird First Arrivals Reported

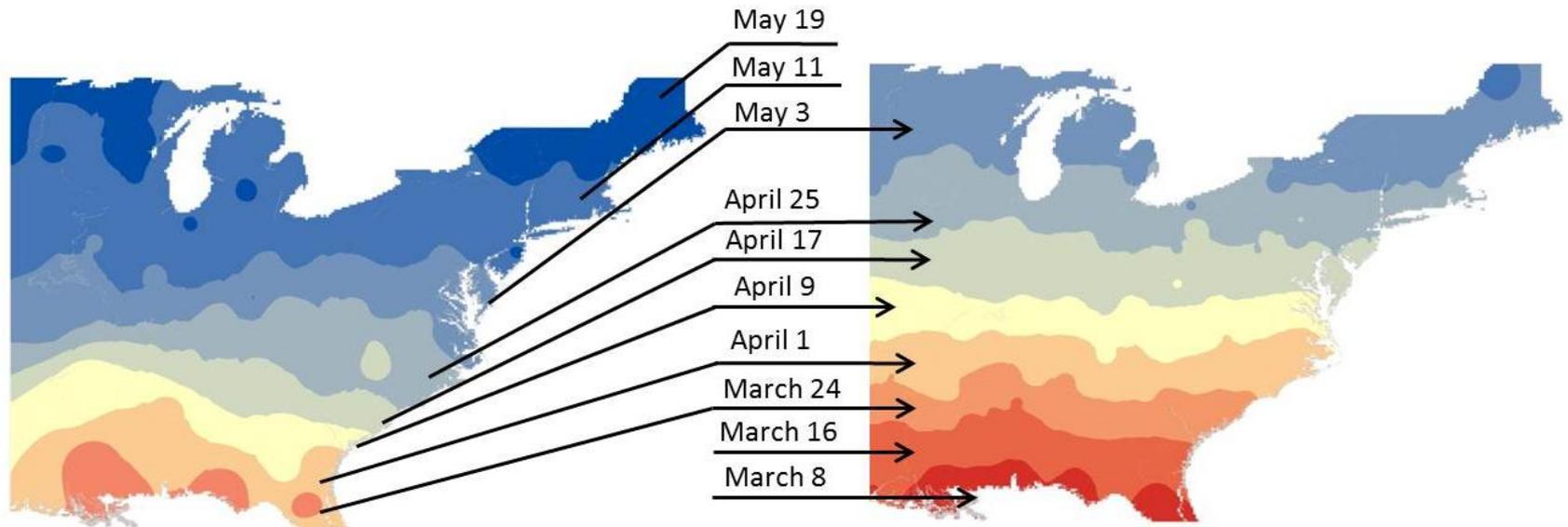
N = 16,670



# Hummingbird First Arrival Dates

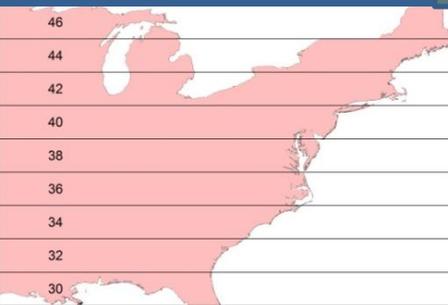
1880-1969

1997-2010



# Environmental Correlates

Winter Temperature			Spring Temperature		Spring Precipitation	
Latitude	P-Value	Description	P-Value	Description	P-Value	Description
32	0.96		0.08		0.08	
33	0.27		0.30		0.01	Dryer Springs
34	0.03	Colder Winters	0.26		0.15	
35	<.0001	Warmer Winters	<.0001	Warmer Springs	0.00	Dryer Springs
36	<.0001	Warmer Winters	<.0001	Warmer Springs	0.16	
37	0.27		0.01	Warmer Springs	0.61	
38	<.0001	Warmer Winters	<.0001	Warmer Springs	0.03	Wetter Springs
39	<.0001	Warmer Winters	<.0001	Warmer Springs	0.02	Wetter Springs
40	<.0001	Warmer Winters	<.0001	Warmer Springs	<.0001	Wetter Springs
41	<.0001	Warmer Winters	<.0001	Warmer Springs	<.0001	Wetter Springs
42	<.0001	Warmer Winters	<.0001	Warmer Springs	<.0001	Wetter Springs
43	<.0001	Warmer Winters	<.0001	Warmer Springs	<.0001	Wetter Springs
44	<.0001	Warmer Winters	<.0001	Warmer Springs	<.0001	Wetter Springs



# Regression-based Predictors

Latitude	Winter Temperature		Spring Temperature		Spring Precipitation		Wintering Grounds Temperature	
	1997-2010	1880-1969	1997-2010	1880-1969	1997-2010	1880-1969	1997-2010	1880-1969
32			↑temp, earlier				↑temp, earlier	
33	↑temp, later		↑temp, earlier					
34			↑temp, earlier				↑temp, earlier	
35			↑temp, earlier				↑temp, earlier	
36			↑temp, earlier					
37								↑temp, earlier
38					↑precip, later		↑temp, earlier	
39	↑temp, later				↑precip, later	↑precip, earlier	↑temp, earlier	
40	↑temp, later	↑temp, later					↑temp, earlier	
41	↑temp, later				↑precip, later	↑precip, earlier	↑temp, earlier	
42	↑temp, later						↑temp, earlier	
43							↑temp, earlier	
44				↑temp, earlier			↑temp, earlier	

Dormancy; Mechanism?

# Regression-based Predictors

Latitude	Winter Temperature		Spring Temperature		Spring Precipitation		Wintering Grounds Temperature	
	1997-2010	1880-1969	1997-2010	1880-1969	1997-2010	1880-1969	1997-2010	1880-1969
32			↑temp, earlier				↑temp, earlier	
33	↑temp, later		↑temp, earlier					
34			↑temp, earlier				↑temp, earlier	
35			↑temp, earlier				↑temp, earlier	
36			↑temp, earlier					
37								↑temp, earlier
38					↑precip, later		↑temp, earlier	
39	↑temp, later				↑precip, later	↑precip, earlier	↑temp, earlier	
40	↑temp, later	↑temp, later					↑temp, earlier	
41	↑temp, later				↑precip, later	↑precip, earlier	↑temp, earlier	
42	↑temp, later						↑temp, earlier	
43							↑temp, earlier	
44				↑temp, earlier			↑temp, earlier	

# Migratory Changes- Why?

- **Climate change**
  - Some effects predictable, others not
  - Emerging cues?
  - Effects vary spatially- 40°N?
- **Other factors?**
  - Increased backyard bird feeding
  - Bird population changes



# Summary

- **Climate influences hummingbird migratory patterns**
- **Climate change likely one of several factors**
- **Broad networks of citizen volunteers can contribute to meaningful ecological research**

# Acknowledgments

- Clemson University Department of Forestry and Natural Resources
- Elizabeth Howard and Journey North with funding from the Annenberg Foundation, Lanny Chambers ([www.hummingbirds.net](http://www.hummingbirds.net)), and hundreds of citizen volunteers
- Jessica Zelt, Sam Droege, and hundreds of program volunteers, North American Bird Phenology Program- Patuxent Wildlife Research Center-USGS, Dr. Jake Weltzin, Alyssa Rosemartin, USA-National Phenology Network
- Committee Members, Dr. Rob Baldwin and Dr. Bill Bowerman
- Clemson University Creative Inquiry students- Kasey Auman, Corissa Boaman, Jon Burroughs, Brett Crawford, Evan Kaiser, Matt Kynoch, Brian Lang, Claire Stuyck, Selina Taylor
- Paul Leonard, Dr. Amber Pitt, Sam Essewein, David Stone, Hutch Collins
- Dr. Ali Arab, Georgetown University

