



The effects of climate change on phenology of wildflowers and pollinators in the Colorado Rocky Mountains

David W. Inouye, Jane Ogilvie
Dept. of Biology, Univ. of MD
Rocky Mtn. Biological Laboratory



Changing Environment

- **Changes in temperature**
- **Changes in precipitation**
- **Increased variation**

- **Changes can be global, regional, or local**

In short:

- **A changing ecological environment**

Changing Environment

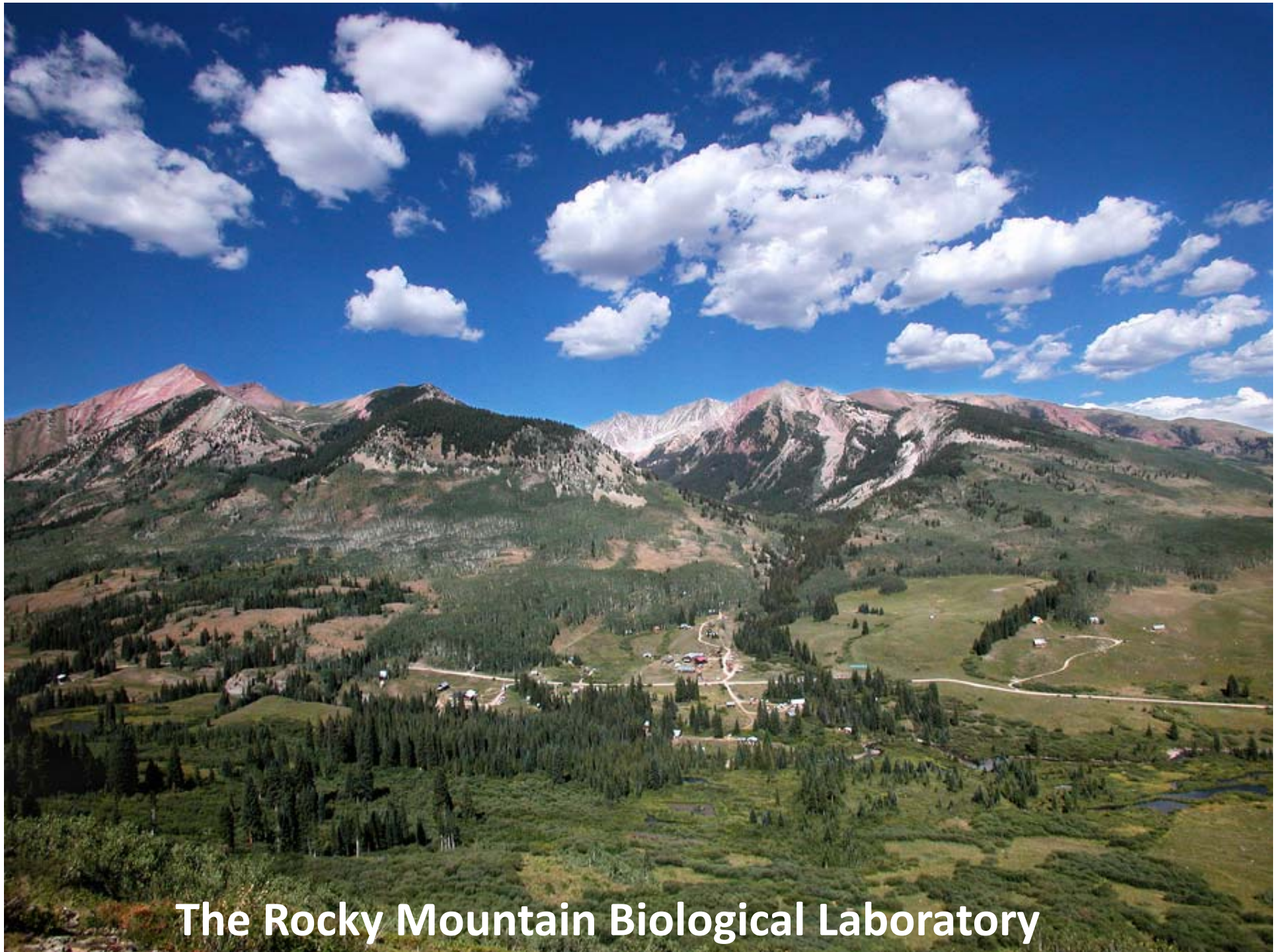
- Changes in temperature
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- Changes can be global, regional, or local

In short:

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Changes in phenology (timing of seasonal events)

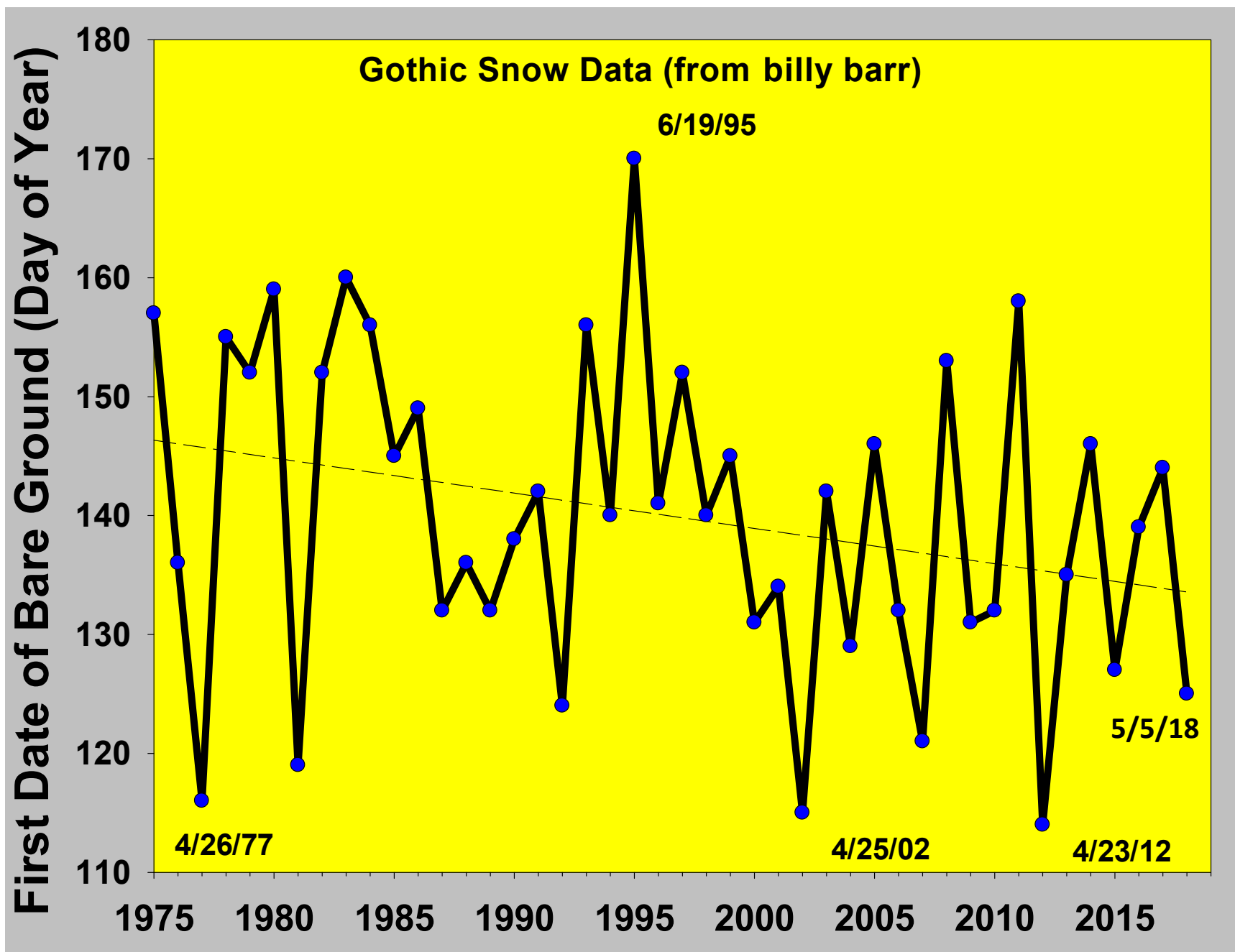


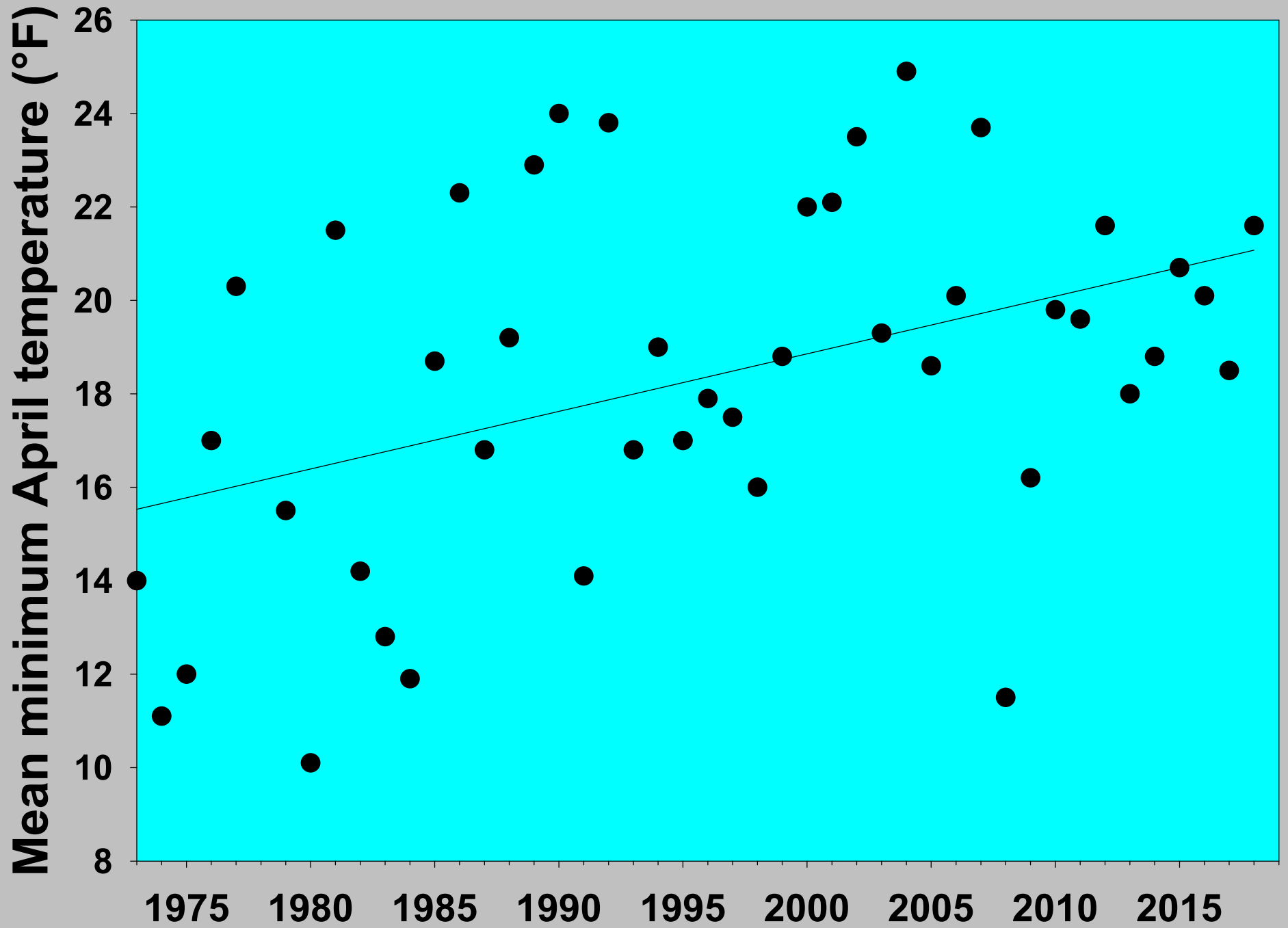
The Rocky Mountain Biological Laboratory

Mean snowfall (since 1975) = 10.7 m
Range = 4.7 – 16.4 m; 4.9 m in 2017-18



When does the snow melt?





Dust on snow events







Dust storm approaching Phoenix, AZ, July 5, 2011, photo by Daniel Bryant

Frost can significantly reduce flower abundance

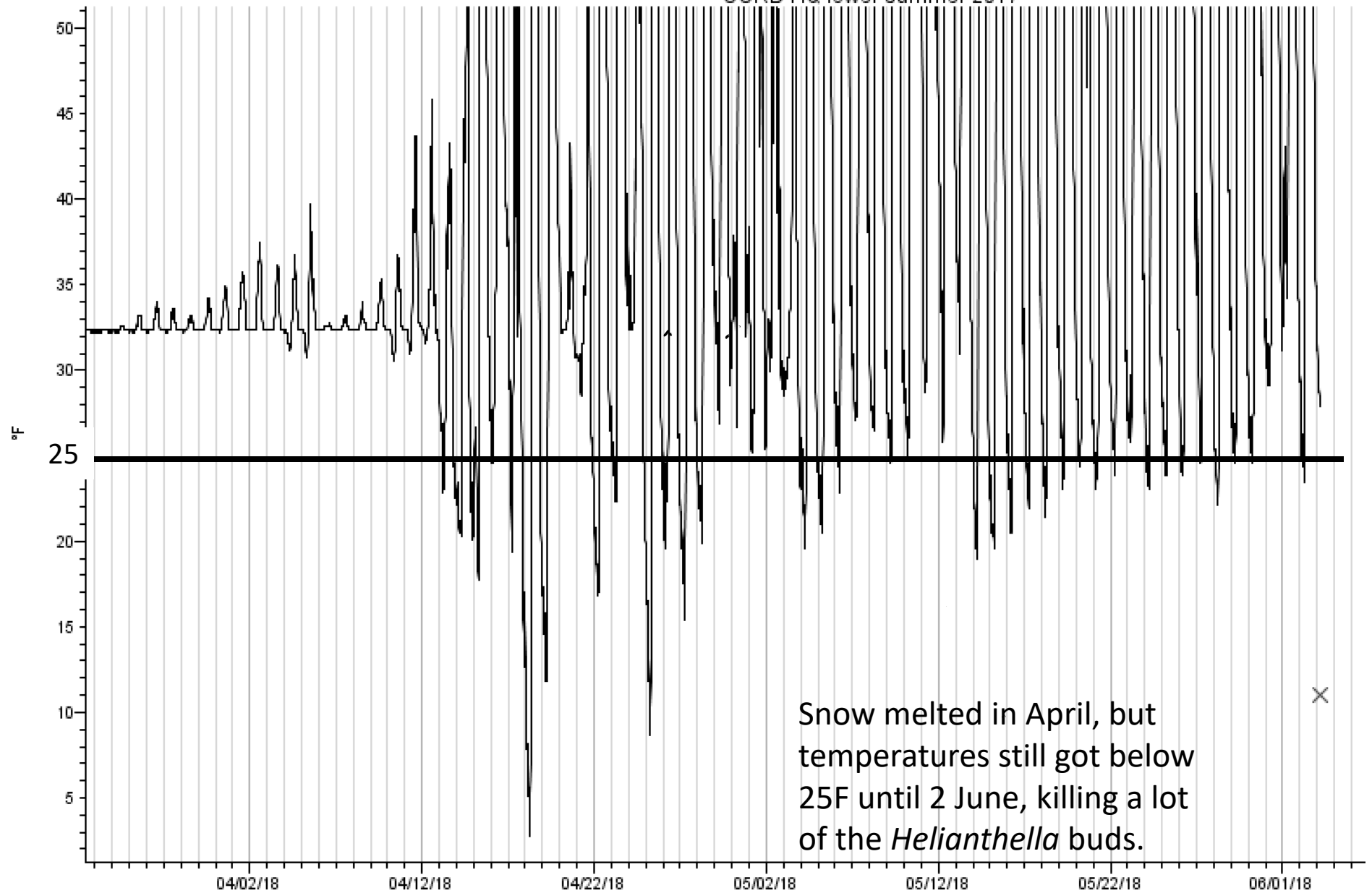




13 June 2001

21.55 (F) -5.81 (C)

CCRD HQ lower summer 2017

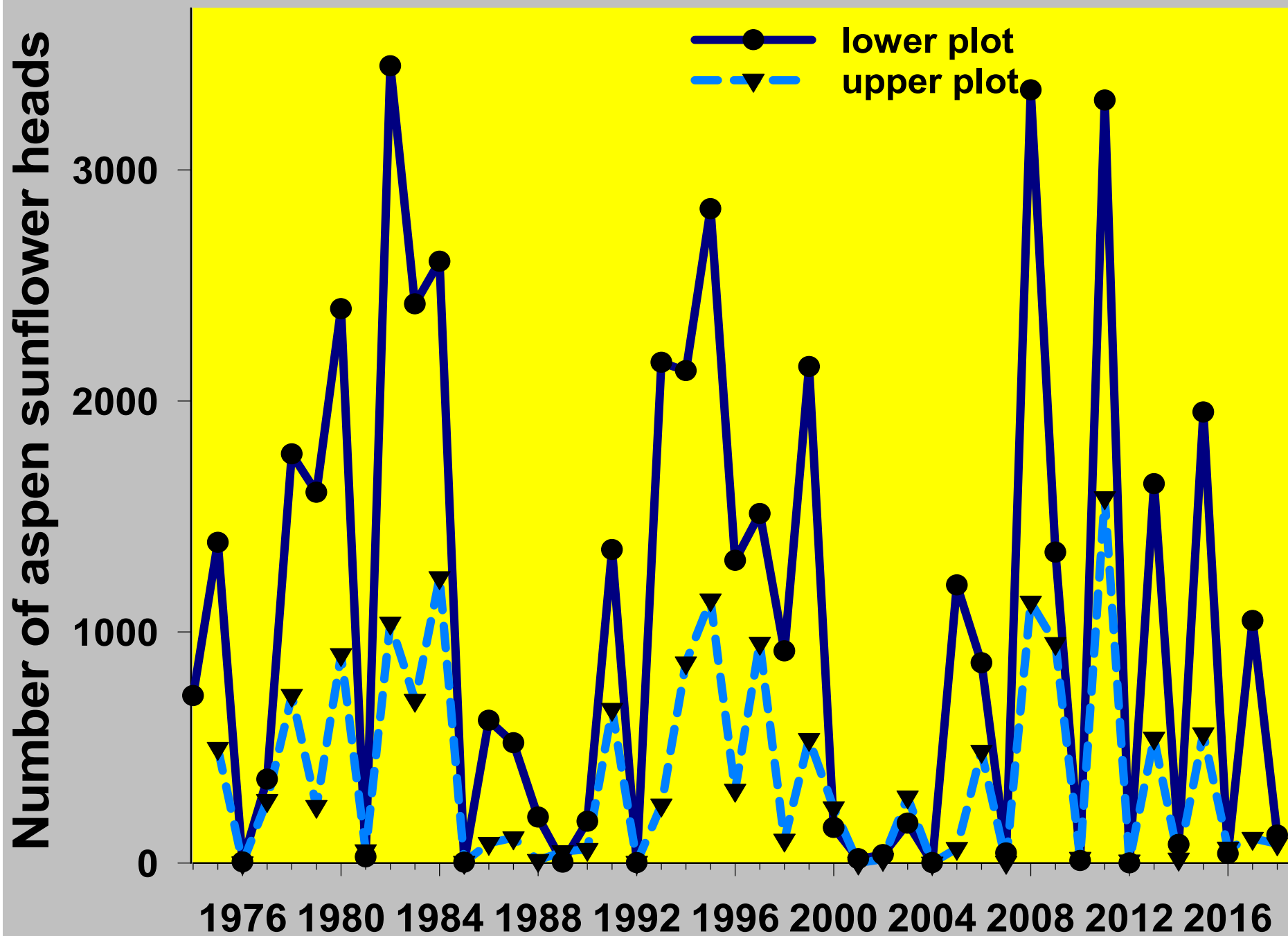


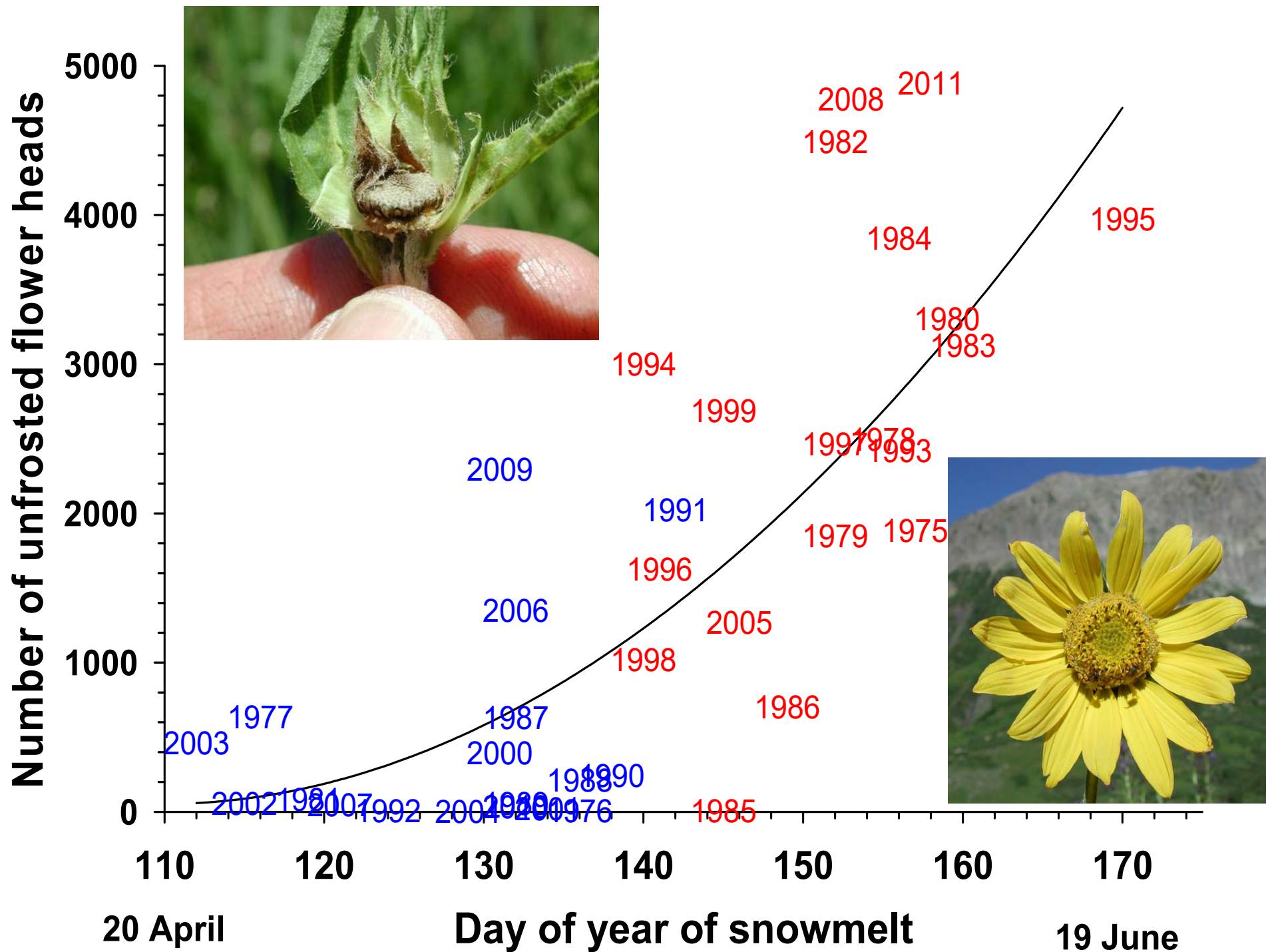


Helianthella quinquenervis (aspen sunflower)









Over 4 million flowers counted



Need data?

120+ species
45 years
3X week
10 yrs bee data

The RMBL Phenology Project

David Inouye, Principal Investigator (RMBL)
Rebecca Irwin (North Carolina State University)
Brian Inouye (Florida State University)
Nora Underwood (Florida State University)
Aimee Classen (University of Vermont)
Jane Ogilvie (RMBL)
billy barr (RMBL)

The Rocky Mountain Biological Laboratory
(RMBL) Gothic, CO

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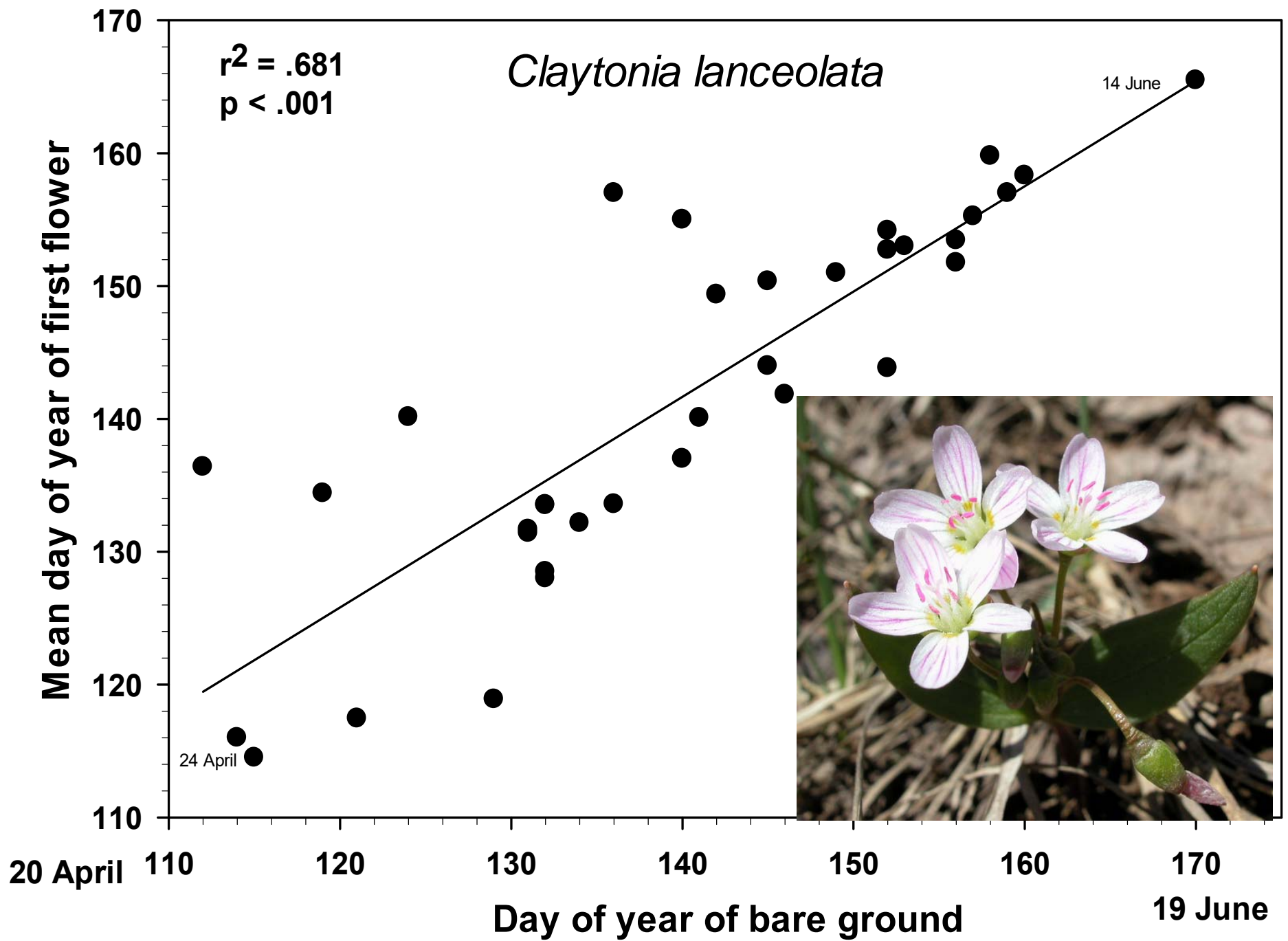


59 publications
4800 citations

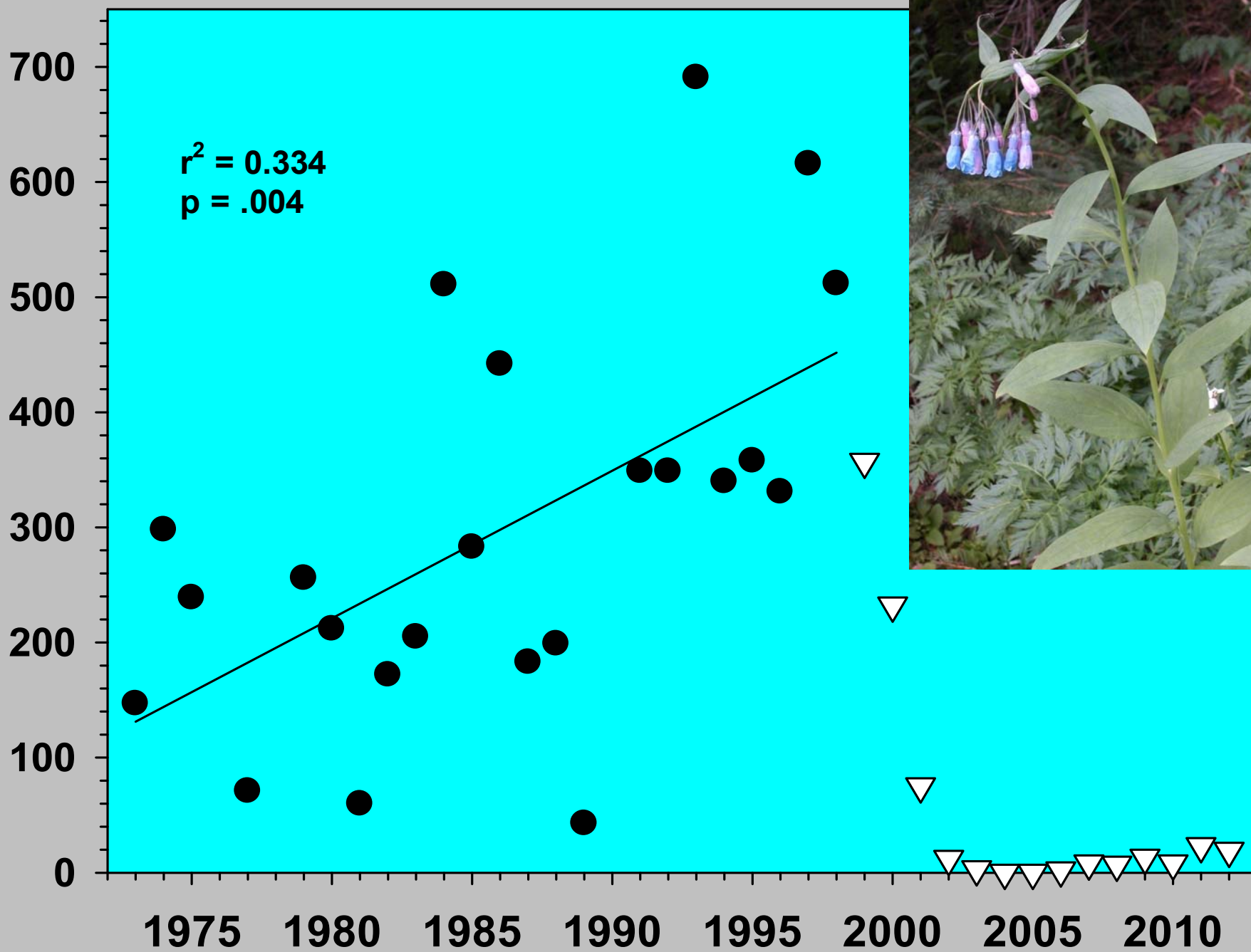
Data request
form

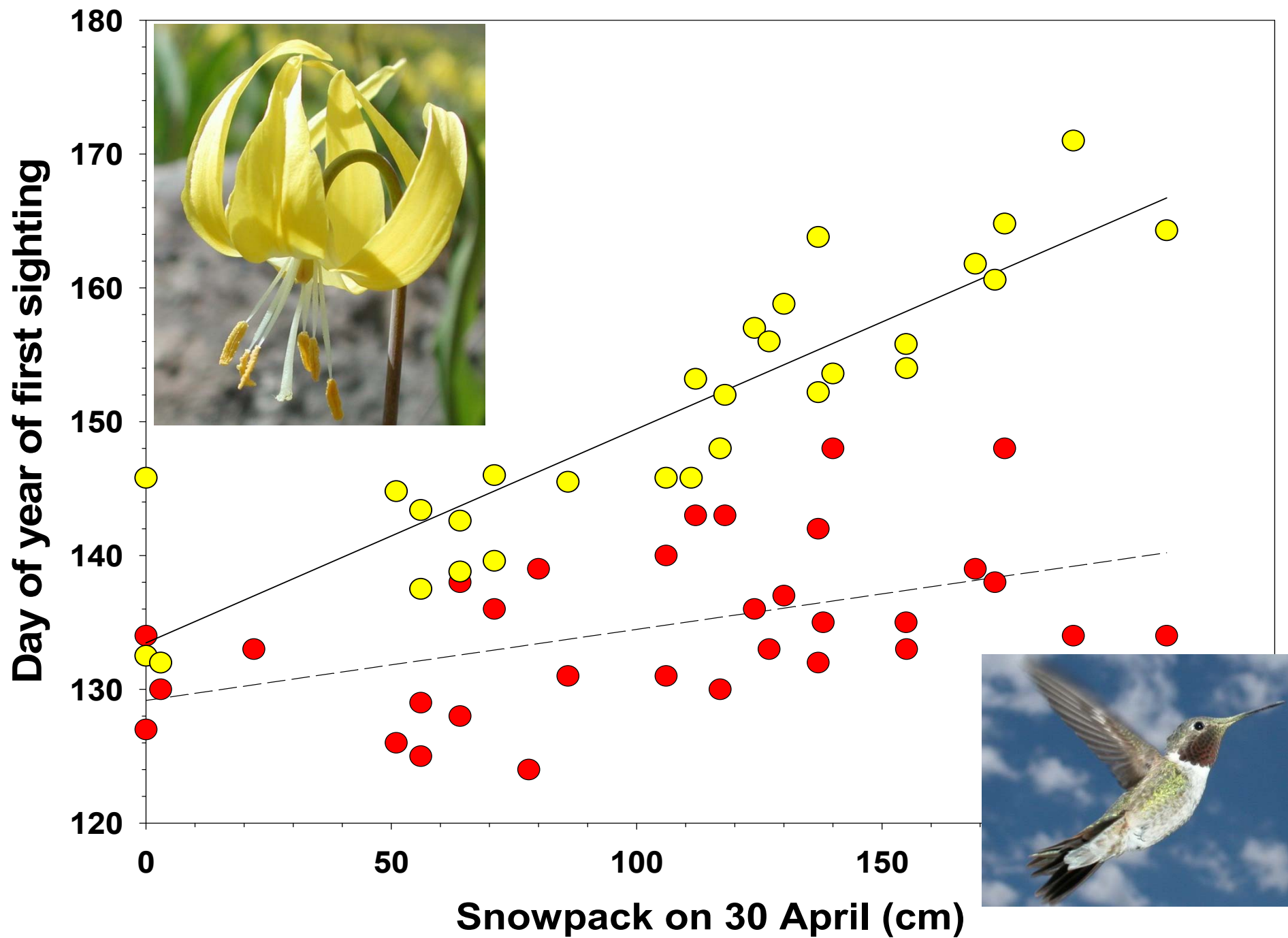
Daily snowfall +
snowpack

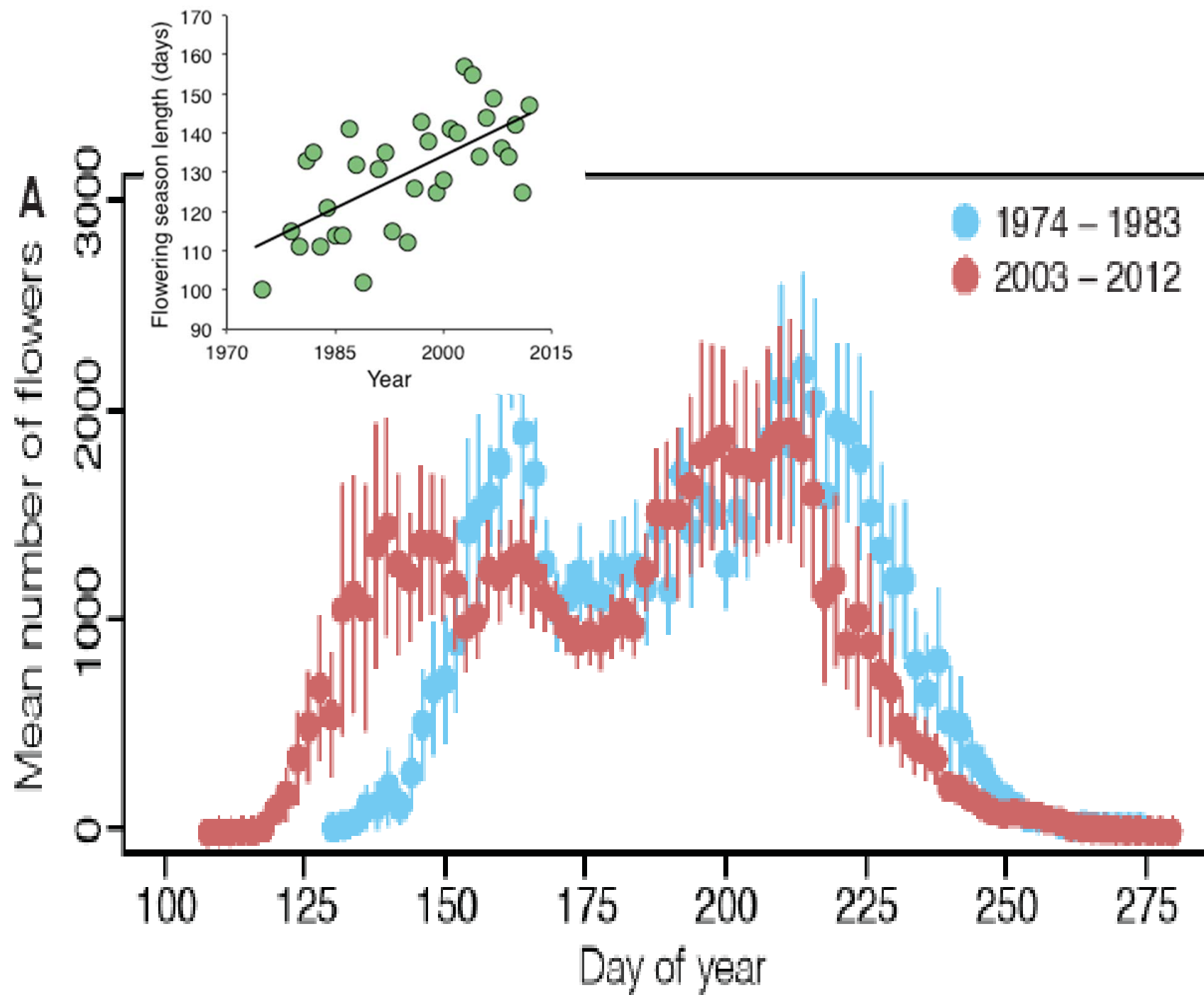
This project is based high in the Colorado Rocky Mountains at the Rocky Mountain Biological Laboratory ([RMBL](#)), in Gothic, Colorado, USA. The project brings together long-term studies on



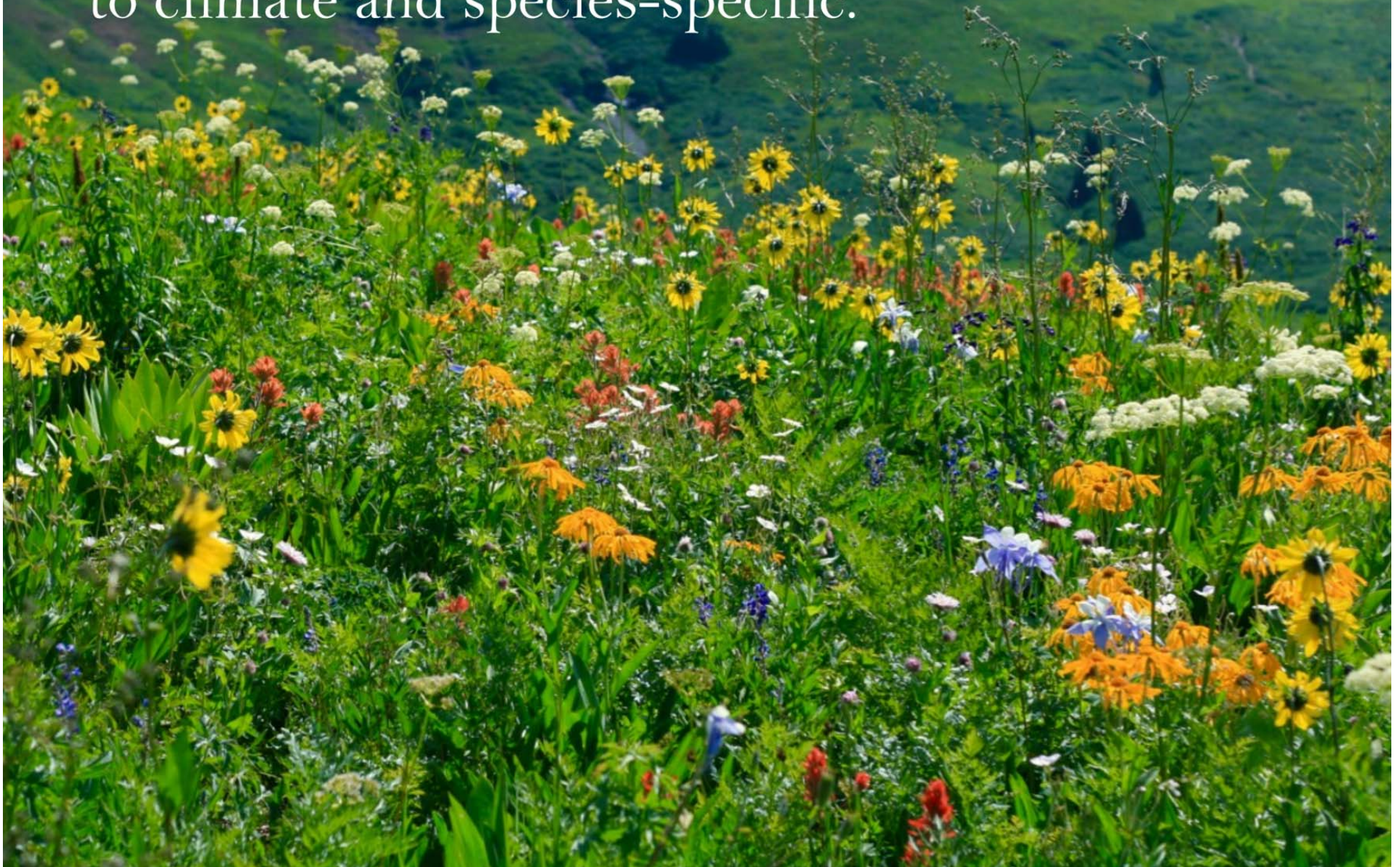
Maximum number of flowers in bloom







Plant flowering is often responsive to climate and species-specific.



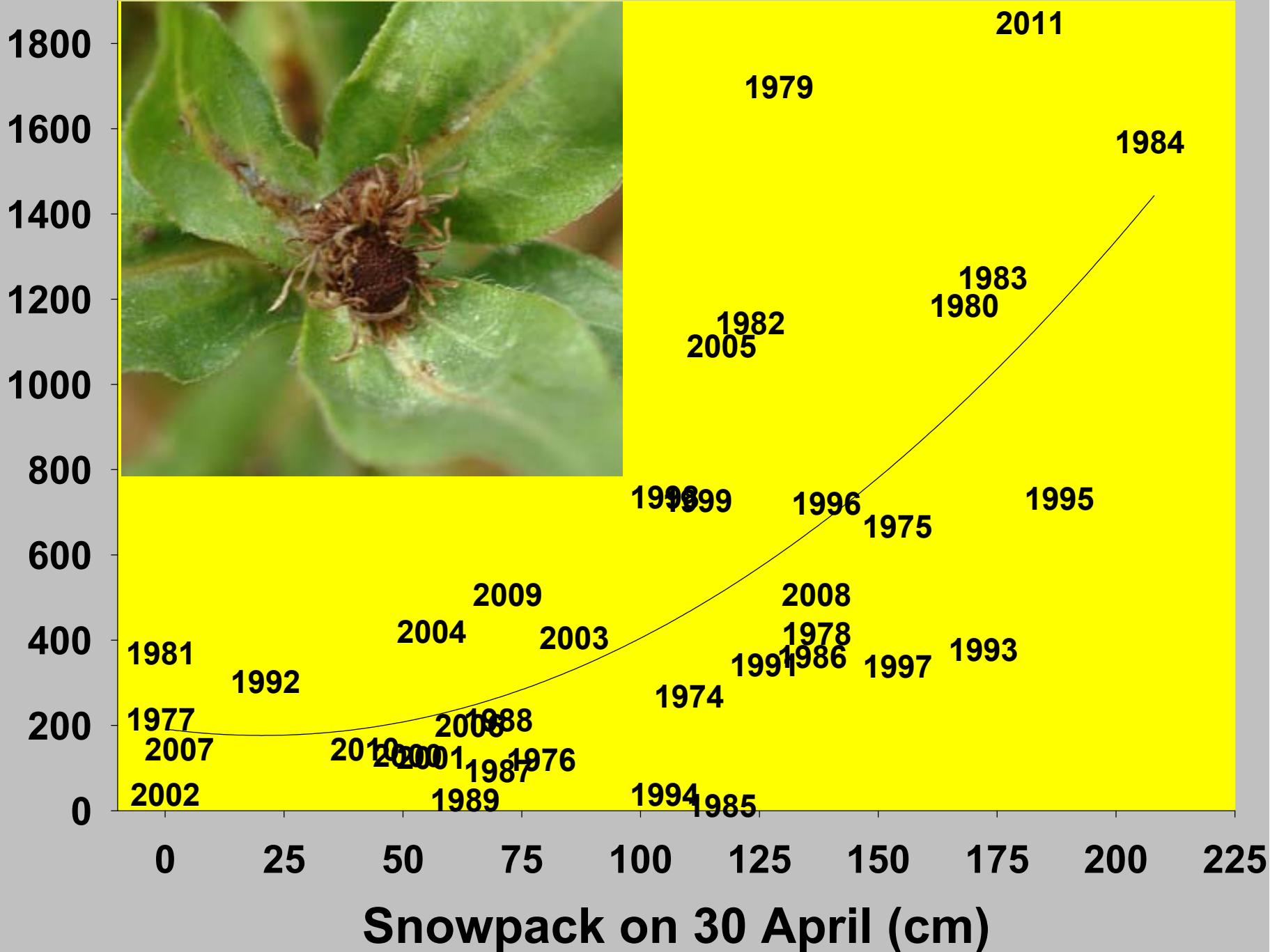
Are pollinators being affected?

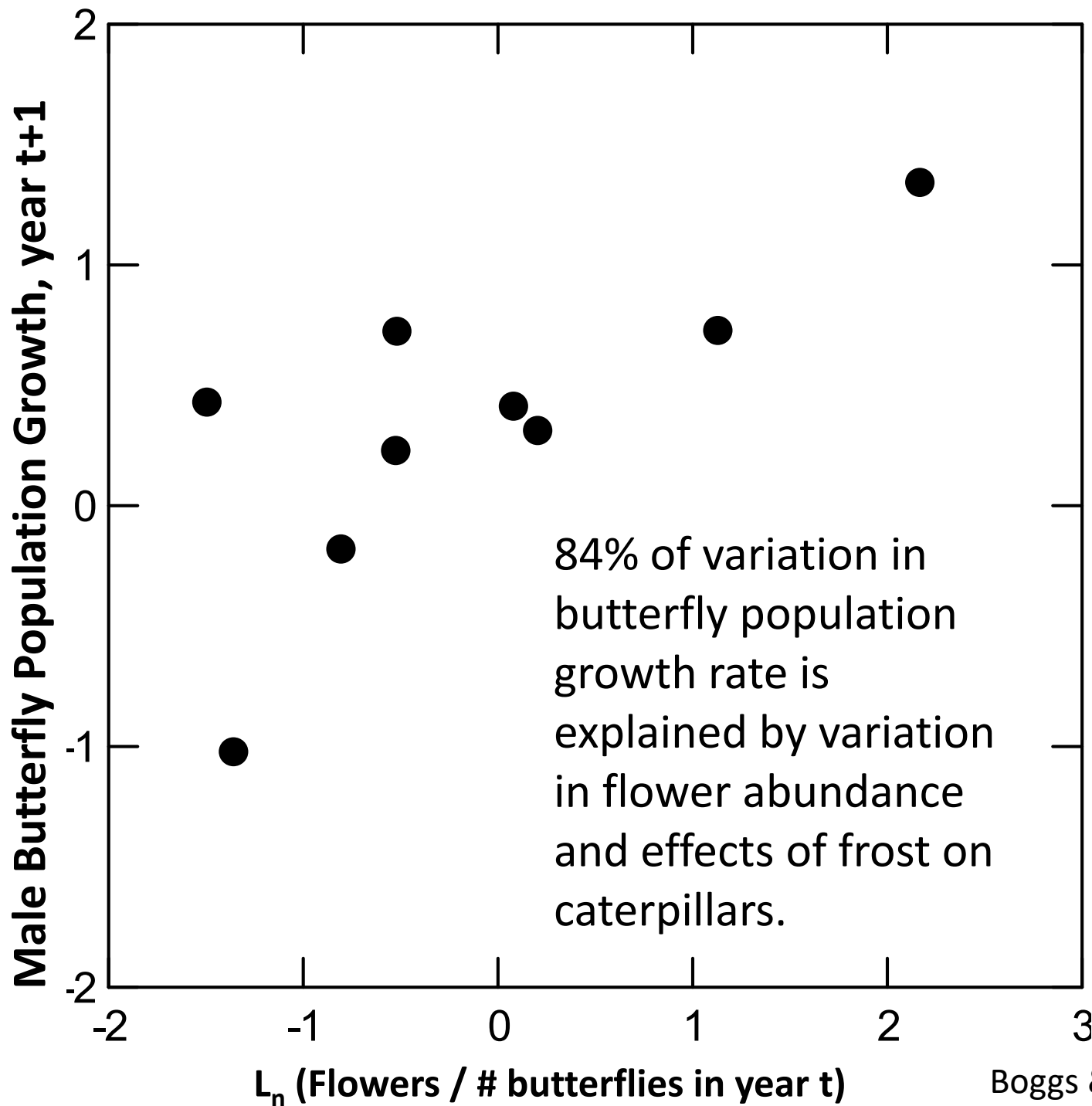


Speyeria mormonia and *Erigeron speciosus*



Maximum Number of Flowers Counted





The *Erigeron* – *Speyeria* story

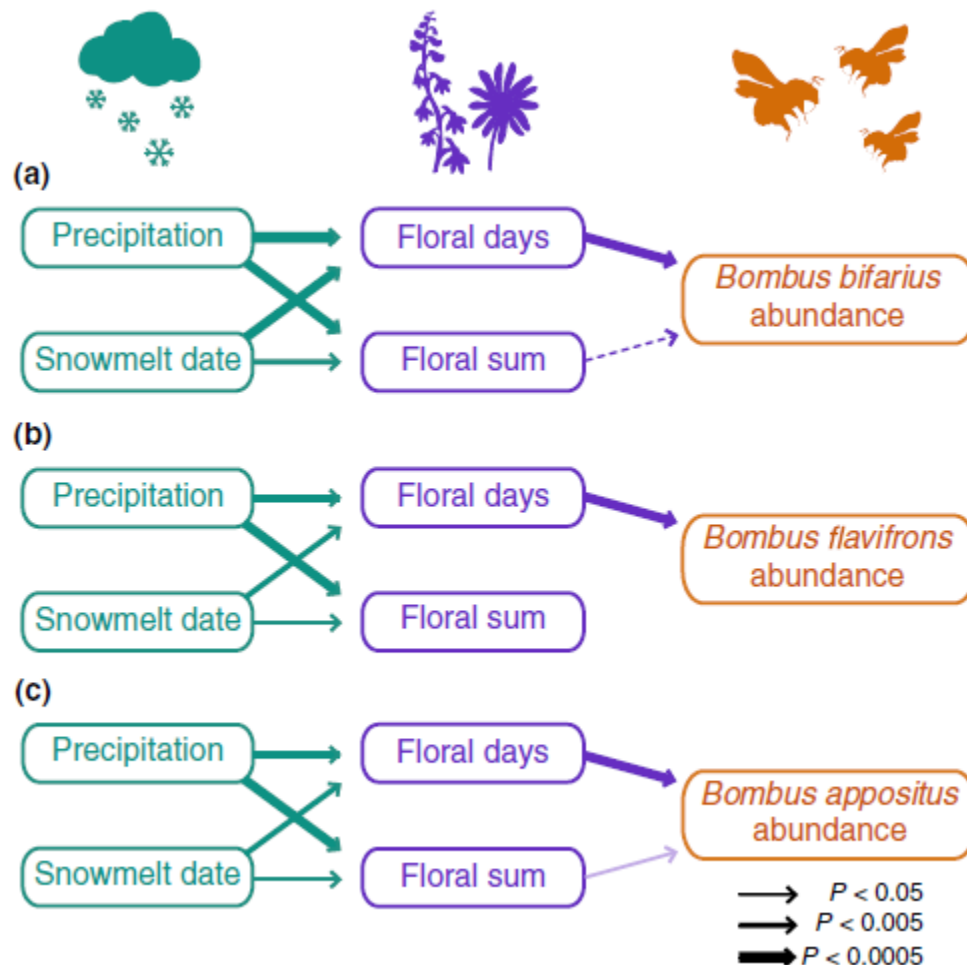
- **Decreasing snowpack**
- **Warmer springs**
- **Earlier snowmelt**
- **Increased incidence of frost damage**
- **Fewer flowers (less nectar) for butterflies**
- **Fewer butterflies**

Queens of 8 bumble bee species moved up 230m from 1974 - 2007



LETTER

Interannual bumble bee abundance is driven by indirect climate effects on floral resource phenology



Jane E. Ogilvie,^{1,2*} 

Sean R. Griffin,^{1,3}

Zachariah J. Gezon,^{1,4,5}

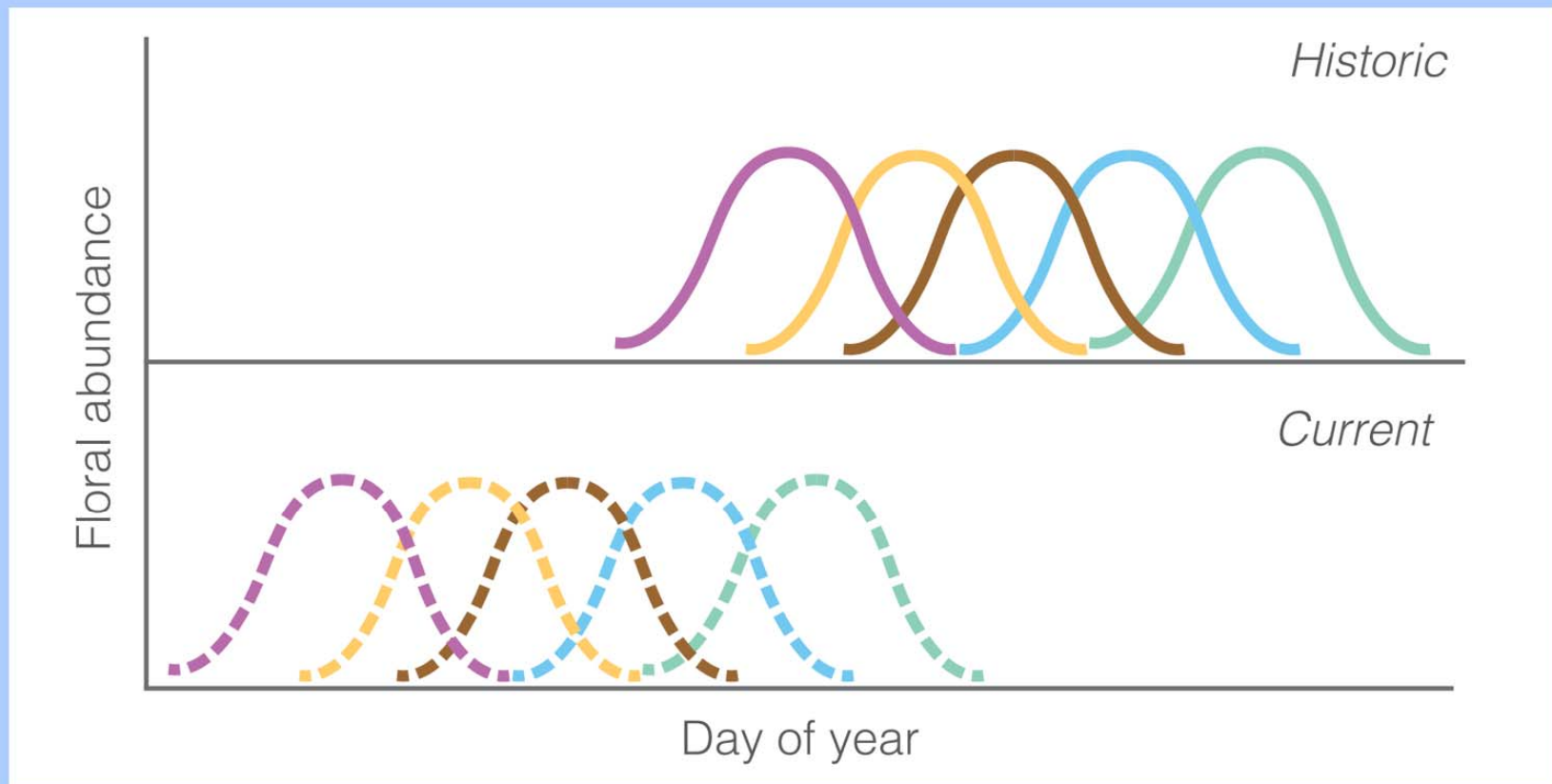
Brian D. Inouye,^{1,2}

Nora Underwood,^{1,2}

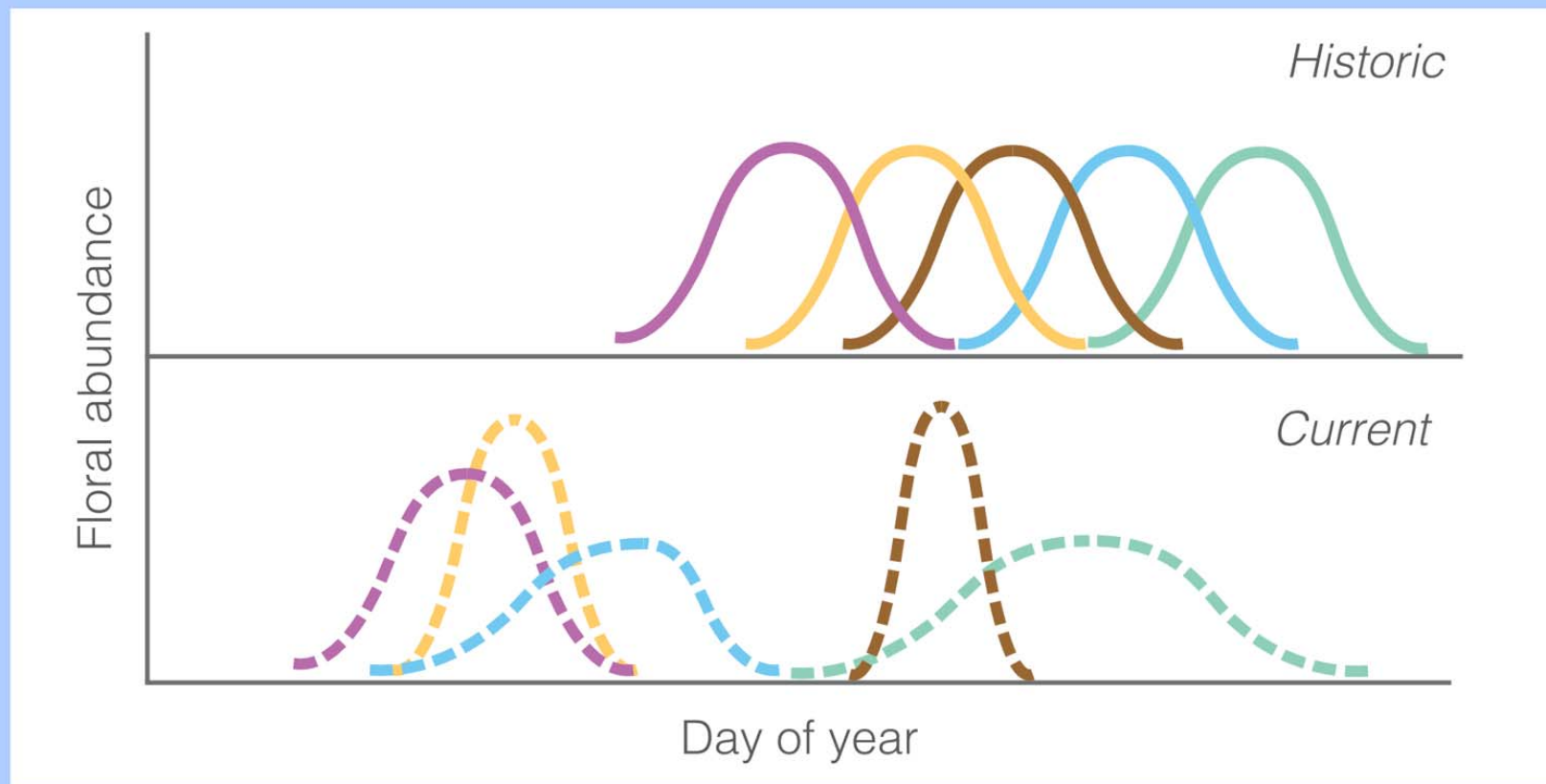
David W. Inouye^{1,6} and

Rebecca E. Irwin^{1,3}

Assemblage-level patterns of flowering



Assemblage-level patterns of flowering



Floral guilds may change in abundance, richness, diversity—resource metrics important for pollinator foraging and abundance.

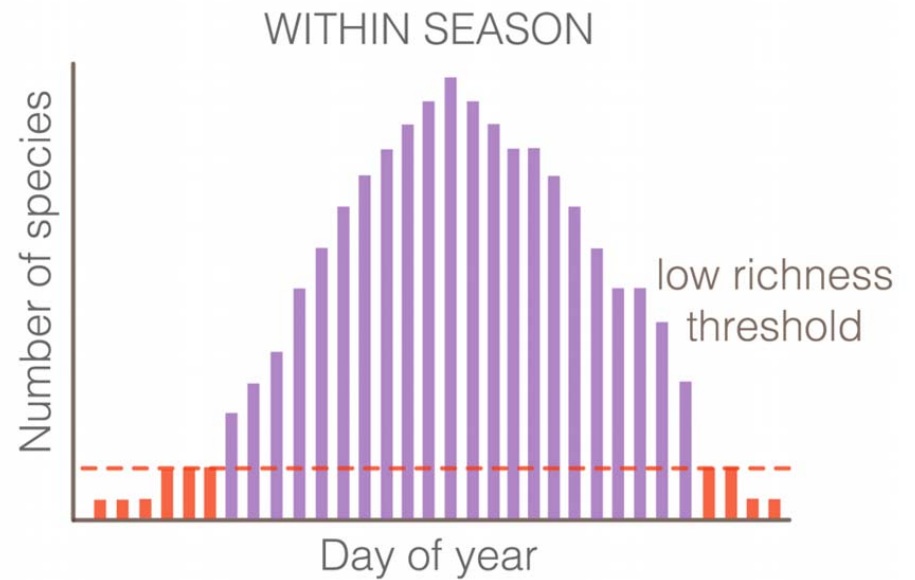
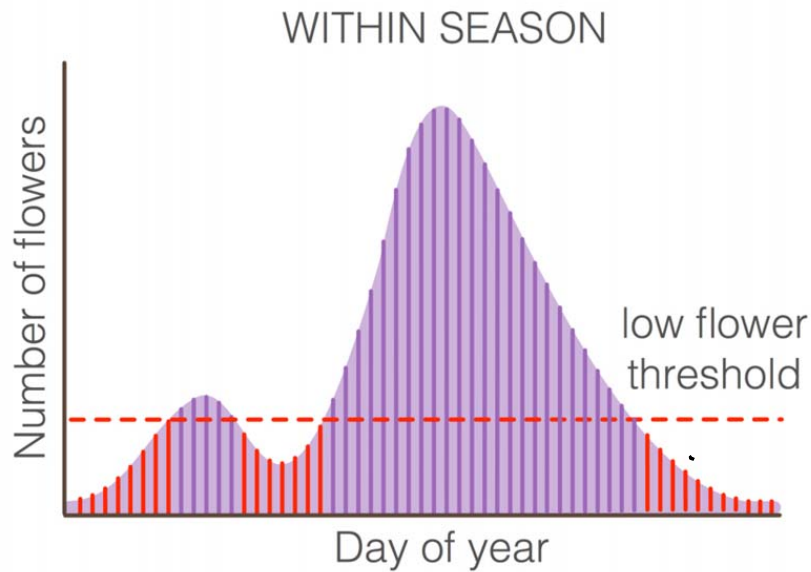


Photo: PJ CaraDonna

Sufficient & Poor floral richness days

Floral resource abundance

Floral resource richness



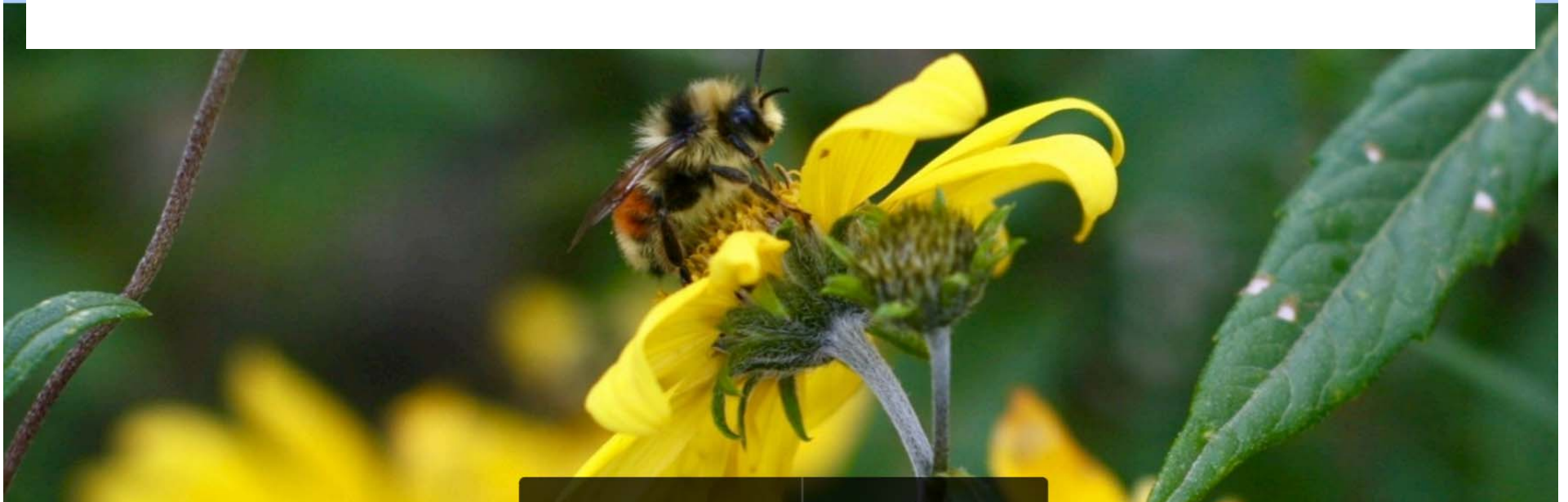
A close-up photograph of a bumblebee with black and yellow fur, positioned on a cluster of vibrant purple flowers. The bee is facing right, with its head buried in the petals. The background is a soft, out-of-focus green, suggesting a natural outdoor setting. The overall image has a slightly grainy texture and a naturalistic feel.

Research questions

1. What are the long-term trends in climate?
2. Do the floral resource guilds of different pollinator species have divergent responses to time and climate?
3. Do across and within-season floral metrics show divergent responses to time and climate variables?

Long-term Trends in Resource Guilds

- Compiled floral guilds for species in pollinator functional groups: bumble bee, solitary bee, fly, butterfly, hummingbirds
- Across-season metrics: floral sum, duration, richness, diversity
- Within-season metrics: sufficient floral abundance and richness days, poor floral abundance and richness days

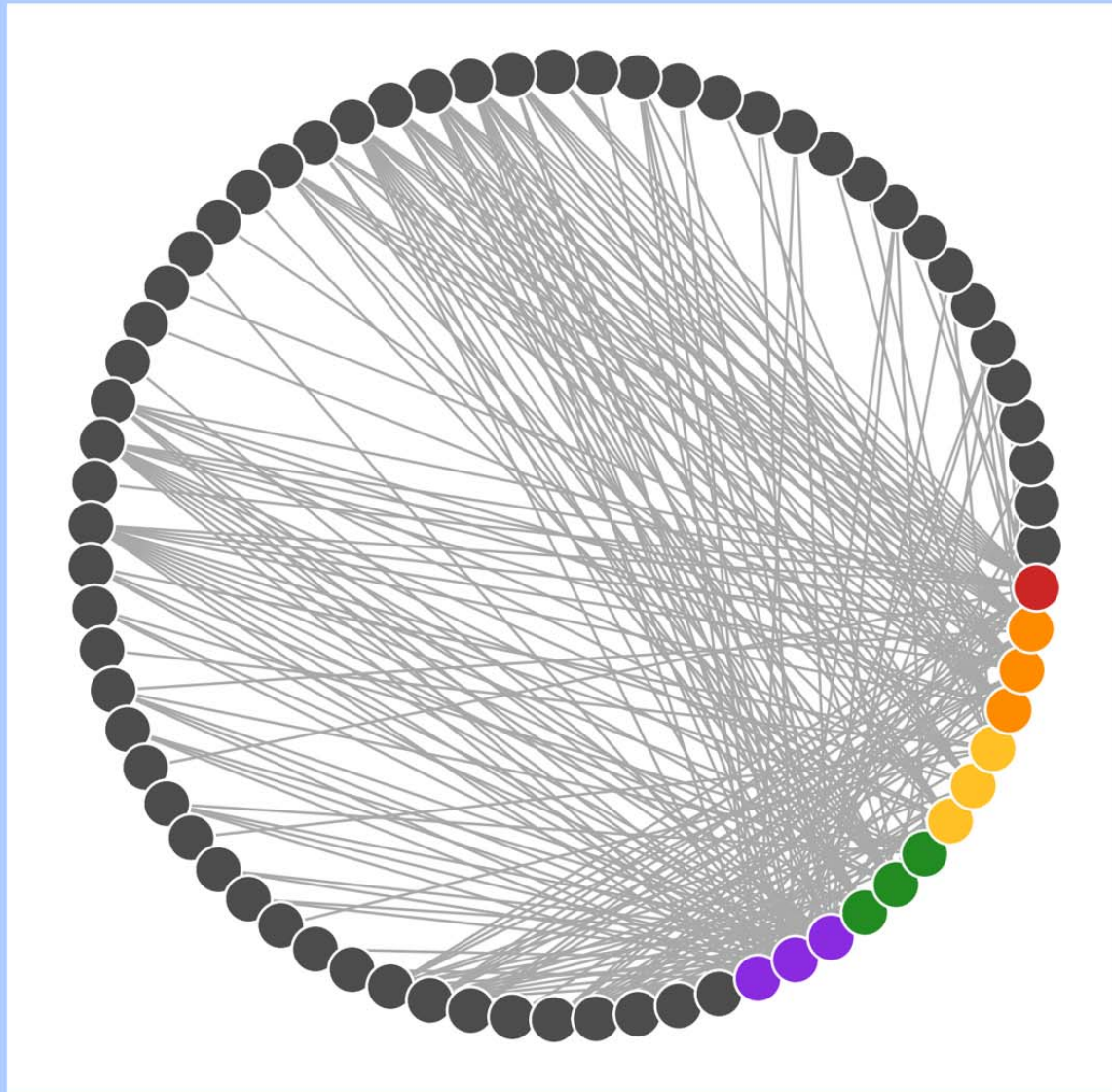


Focal pollinator species

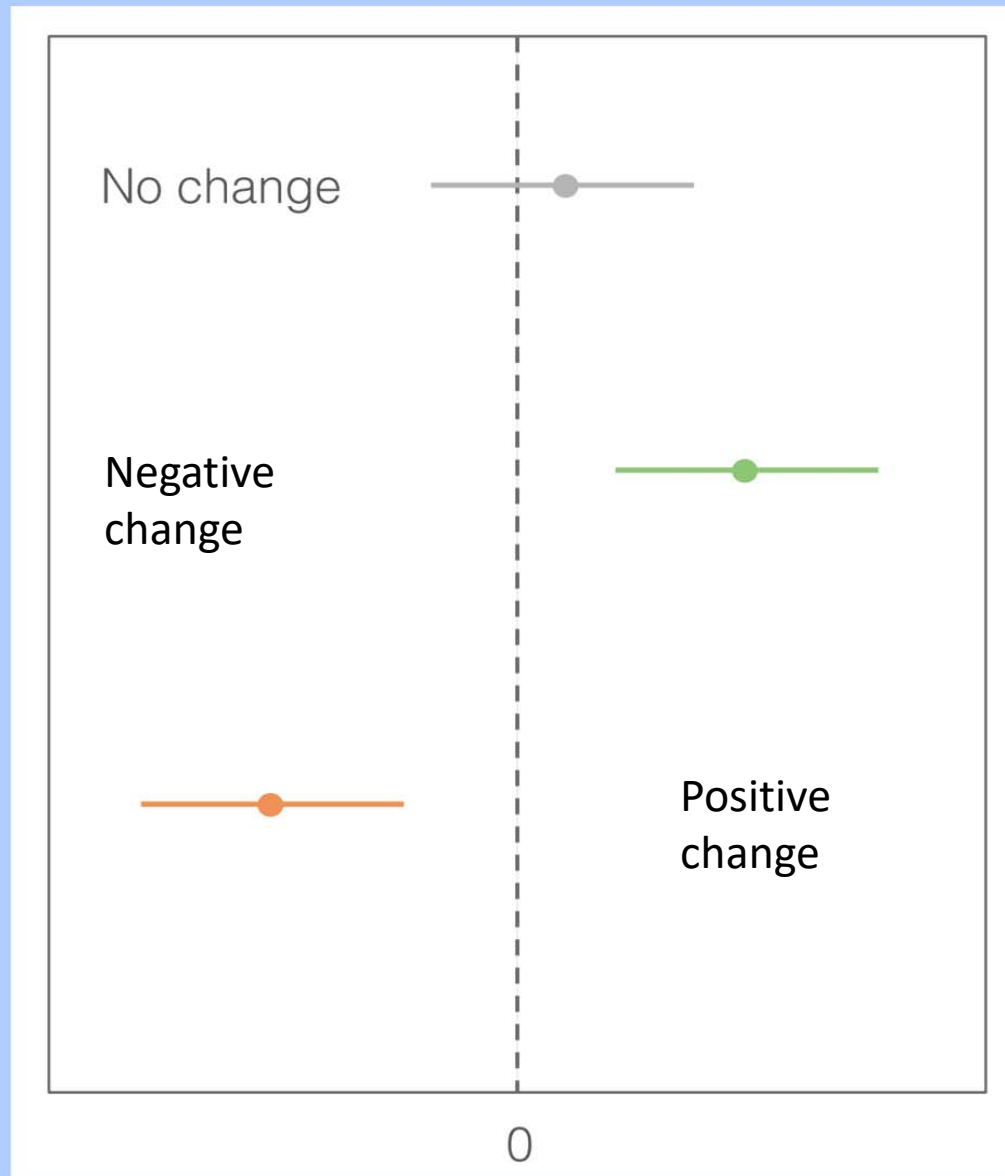
Species	Family	Functional group	No. of plants
<i>Bombus appositus</i>	Apidae	Bumble bee	19
<i>Bombus bifarius</i>	Apidae		30
<i>Bombus flavifrons</i>	Apidae		27
<i>Halictus rubicundus</i>	Halictidae	Solitary bee	18
<i>Megachile melanophea</i>	Megachilidae		10
<i>Osmia montana</i>	Megachilidae		12
<i>Sphaerophoria philanthus</i>	Syrphidae	Fly	23
<i>Systoechus vulgaris</i>	Bombyliidae		20
<i>Thricops septentrionalis</i>	Muscidae		23
<i>Glaucopsyche lygdamus</i>	Lycaenidae	Butterfly	12
<i>Ochlodes sylvanoides</i>	Hesperiidae		11
<i>Speyeria mormonia</i>	Nymphalidae		13
<i>Selasphorus platycercus</i>	Trochilidae	Hummingbird	11



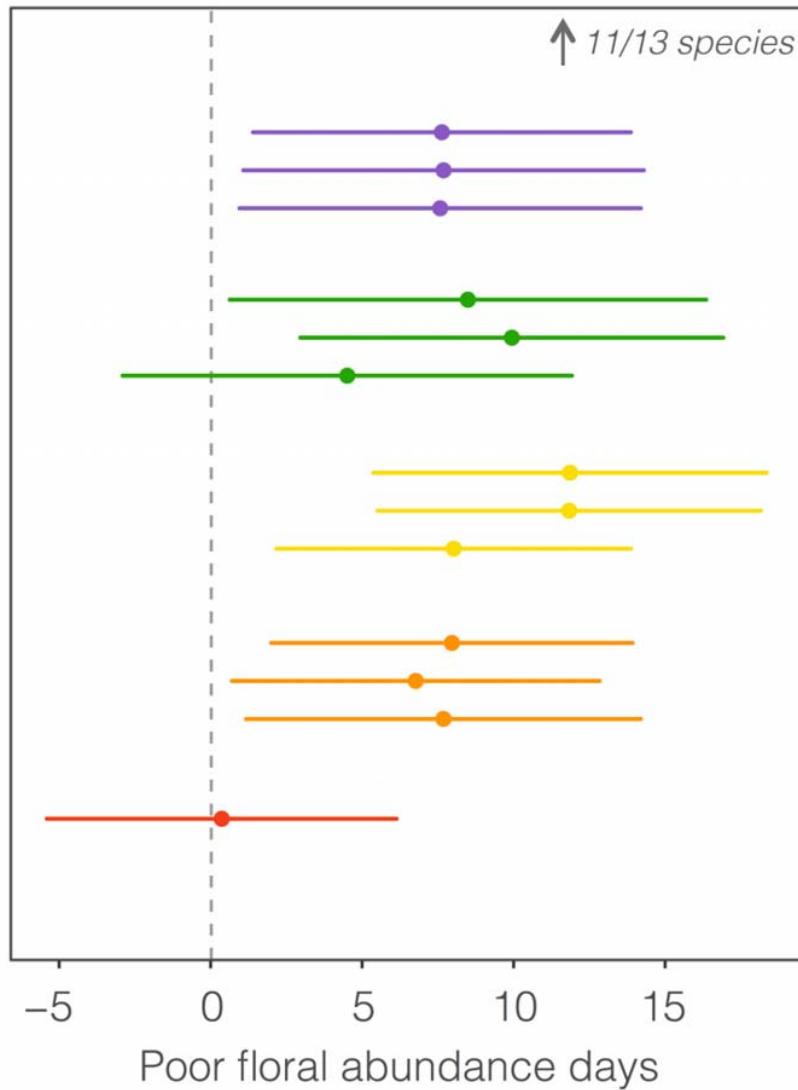
Network-derived resource lists



Change over Time



Poor floral abundance days increasing



Results

- *Floral sum is not changing directionally*
- *Floral duration is changing over time*
 - *Not uniformly for all groups of pollinators*
- *Floral richness is changing for some*
- *Sufficient floral abundance days are increasing for some groups*
- *Poor floral abundance days increasing*
- *Poor floral abundance days are related to snowmelt date*

A close-up photograph of a hummingbird in flight, hovering and feeding from a red flower. The bird's wings are blurred due to rapid movement. It has a long, thin beak that is inserted into the flower. The background is a soft, out-of-focus green.

Floral resource metrics
are changing divergently
for different pollinator species.

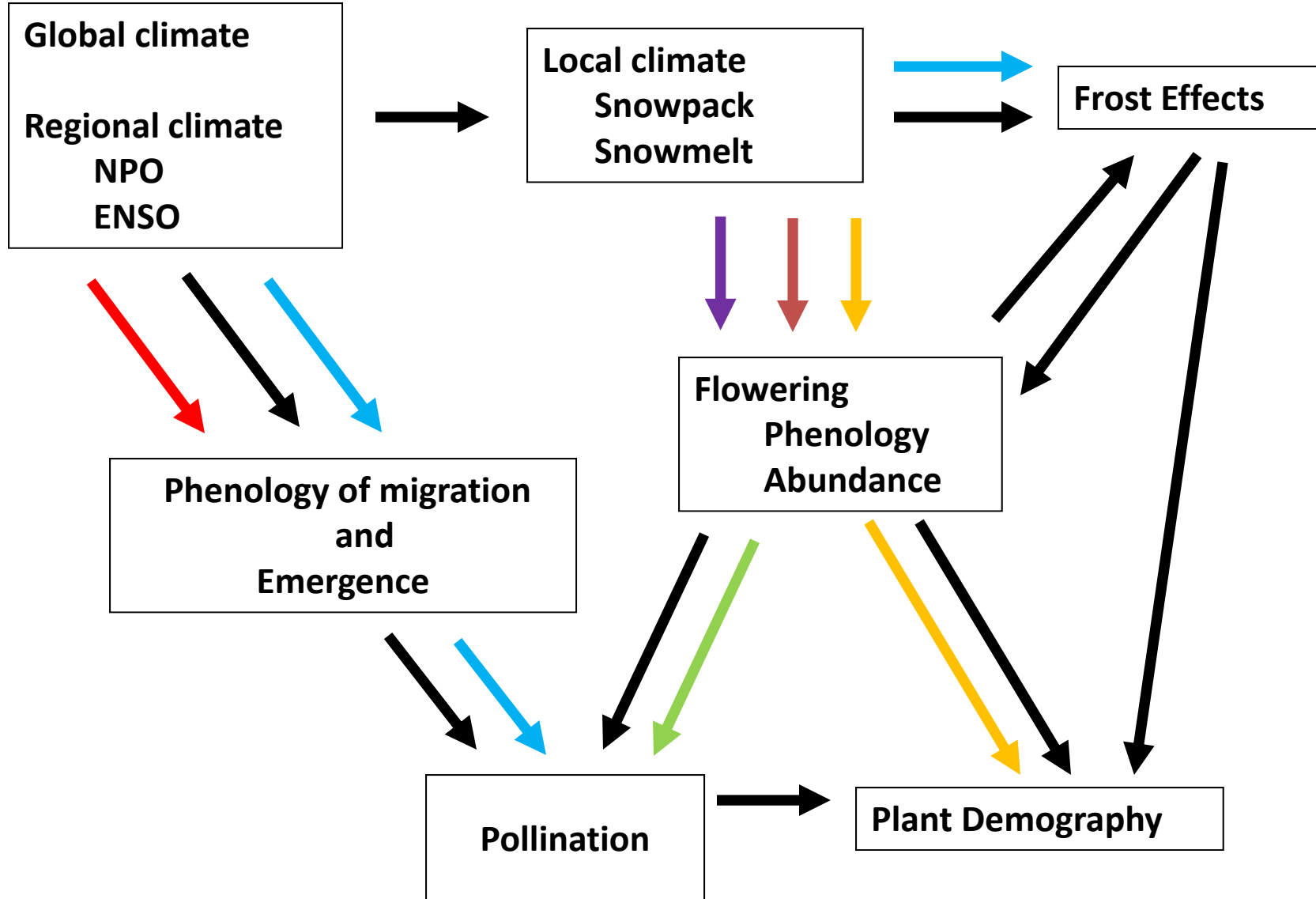
Photo: DW Inouye

Conclusions

- **The climate is changing**
- **Snowmelt dates are getting earlier**
- **Flowering is starting earlier**
- **Frequency of frost damage is increasing**
- **Pollinators may be affected, but not uniformly**
- **Variation in species responses may lead to altered and new interactions**

15(?) More years of data collection



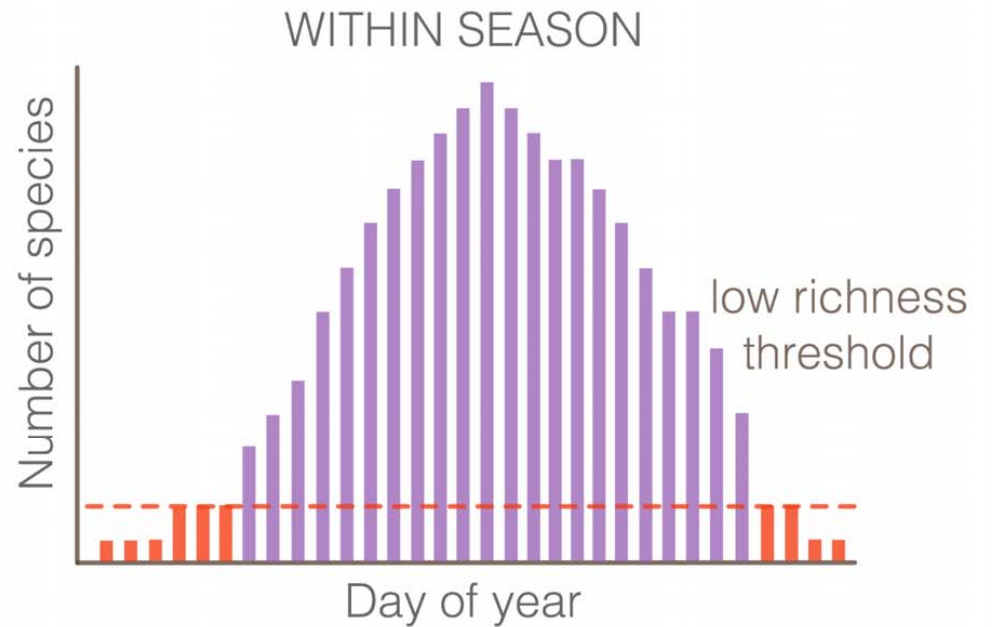
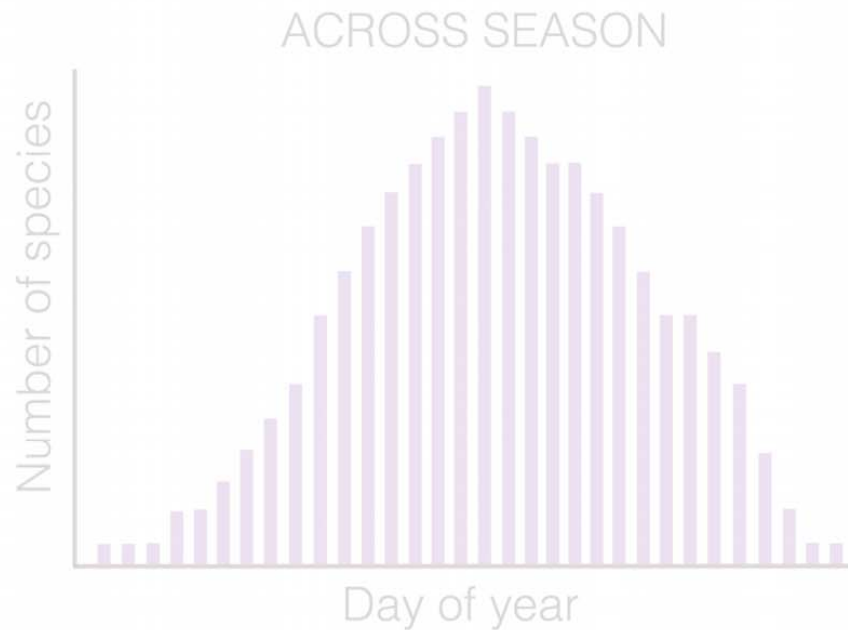






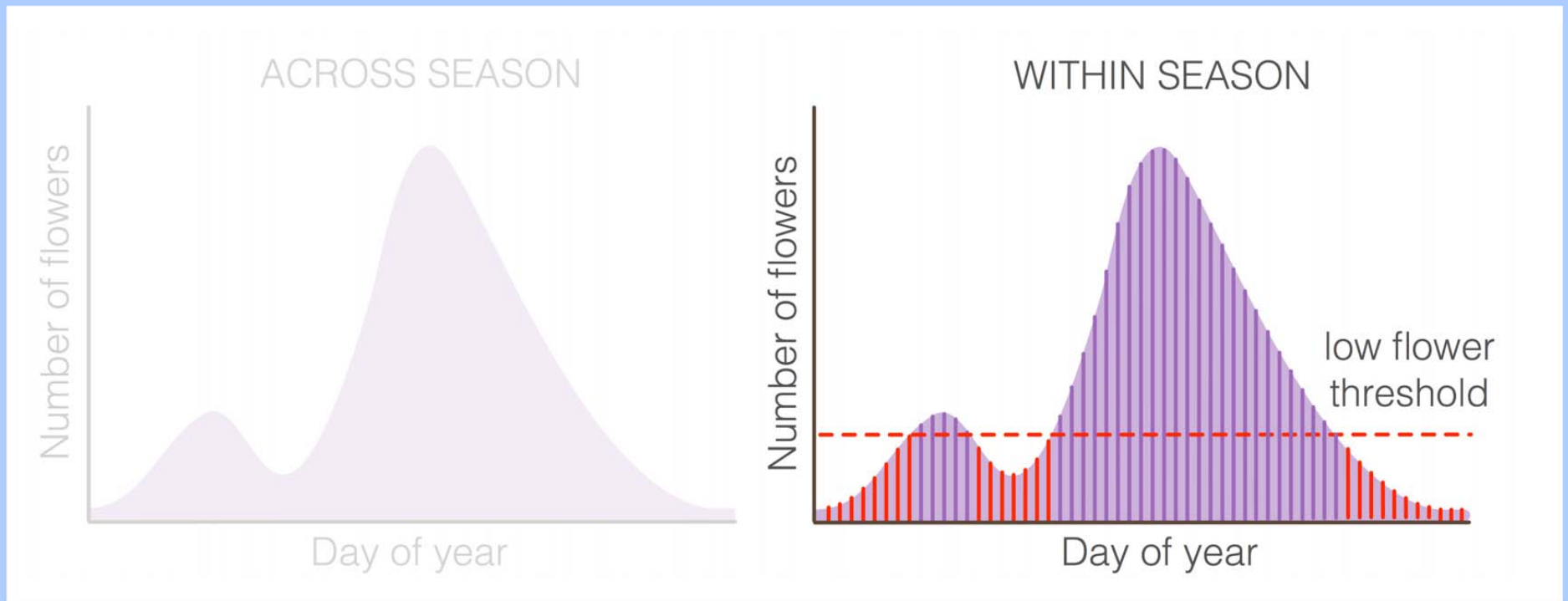
Across vs. within-season metrics

Floral resource richness

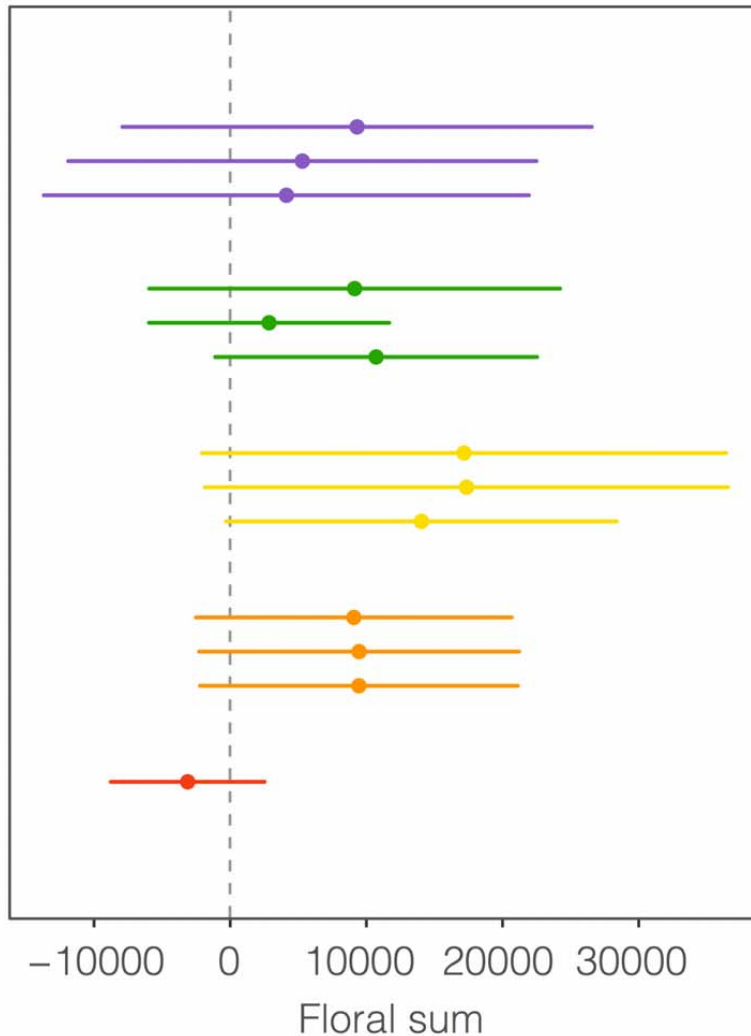


Across vs. within-season metrics

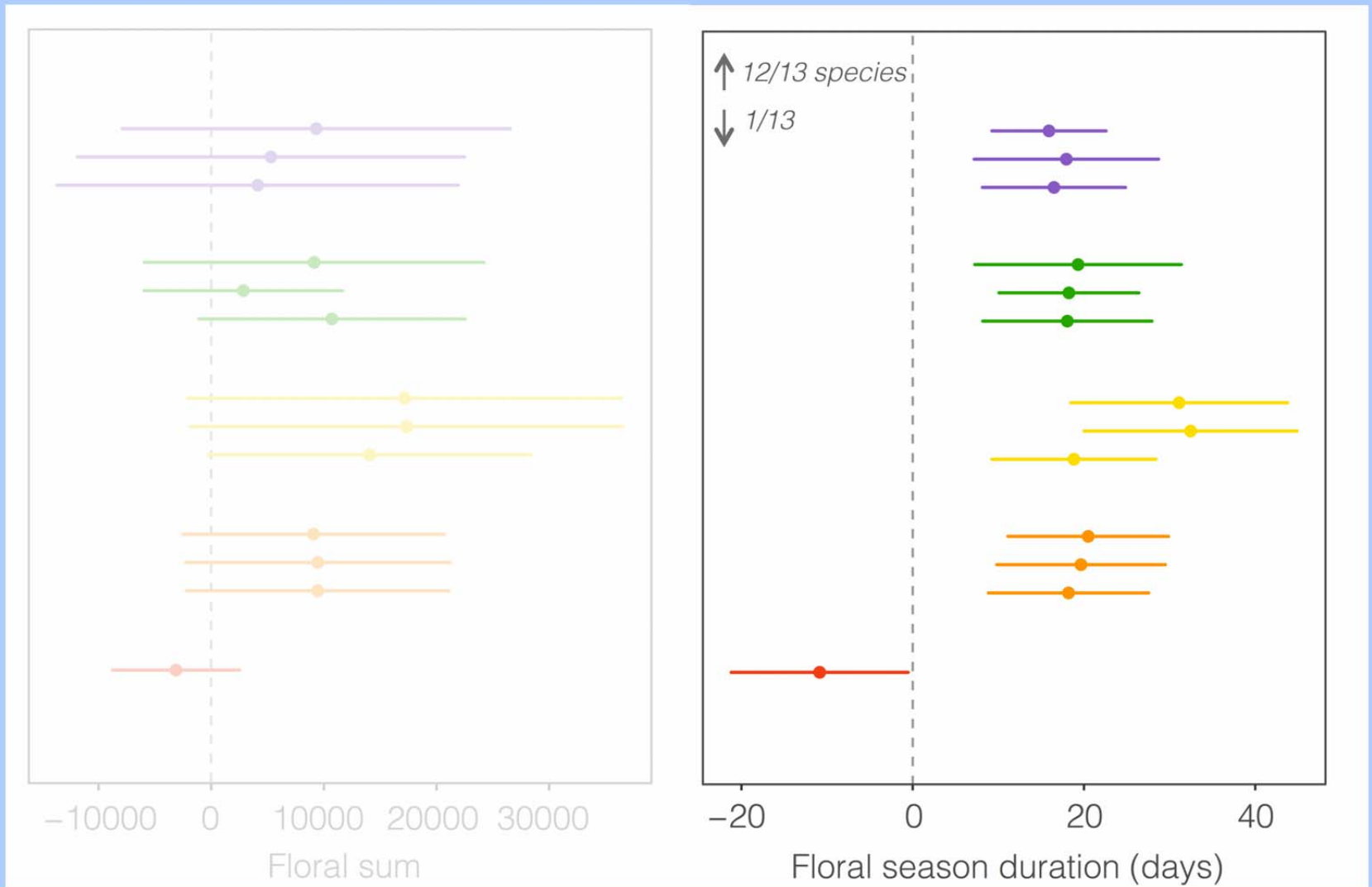
Floral resource abundance



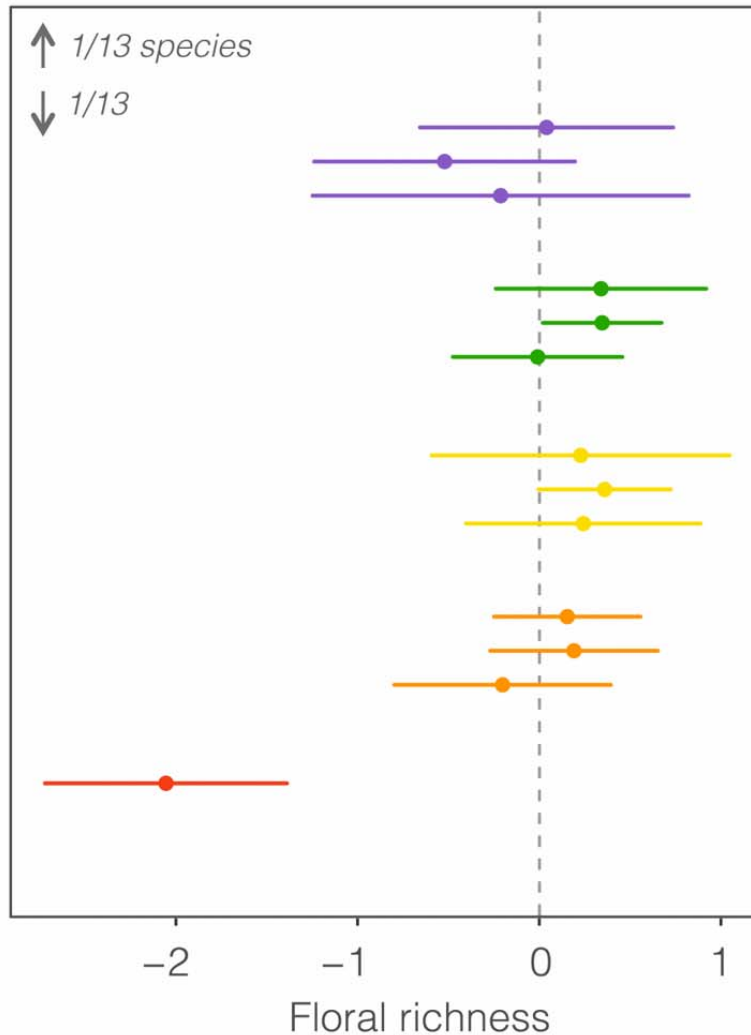
Floral sum is not changing directionally



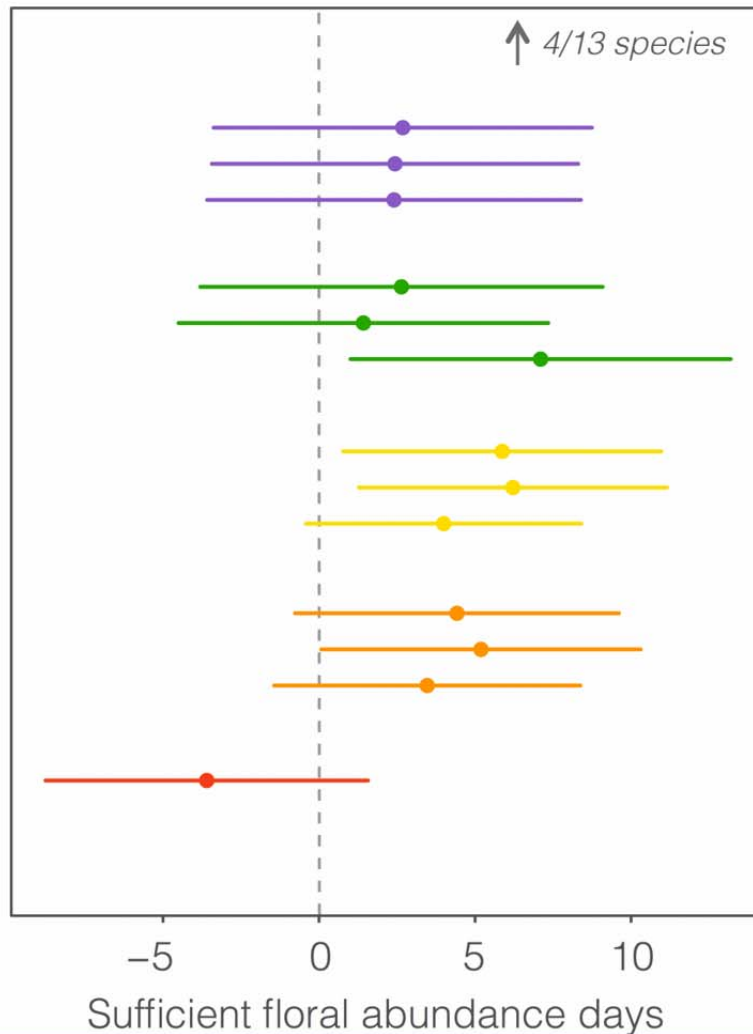
Floral duration is changing over time



Floral richness is changing for some



Sufficient floral abundance days are increasing for some groups



Poor floral abundance days are related to snowmelt date

