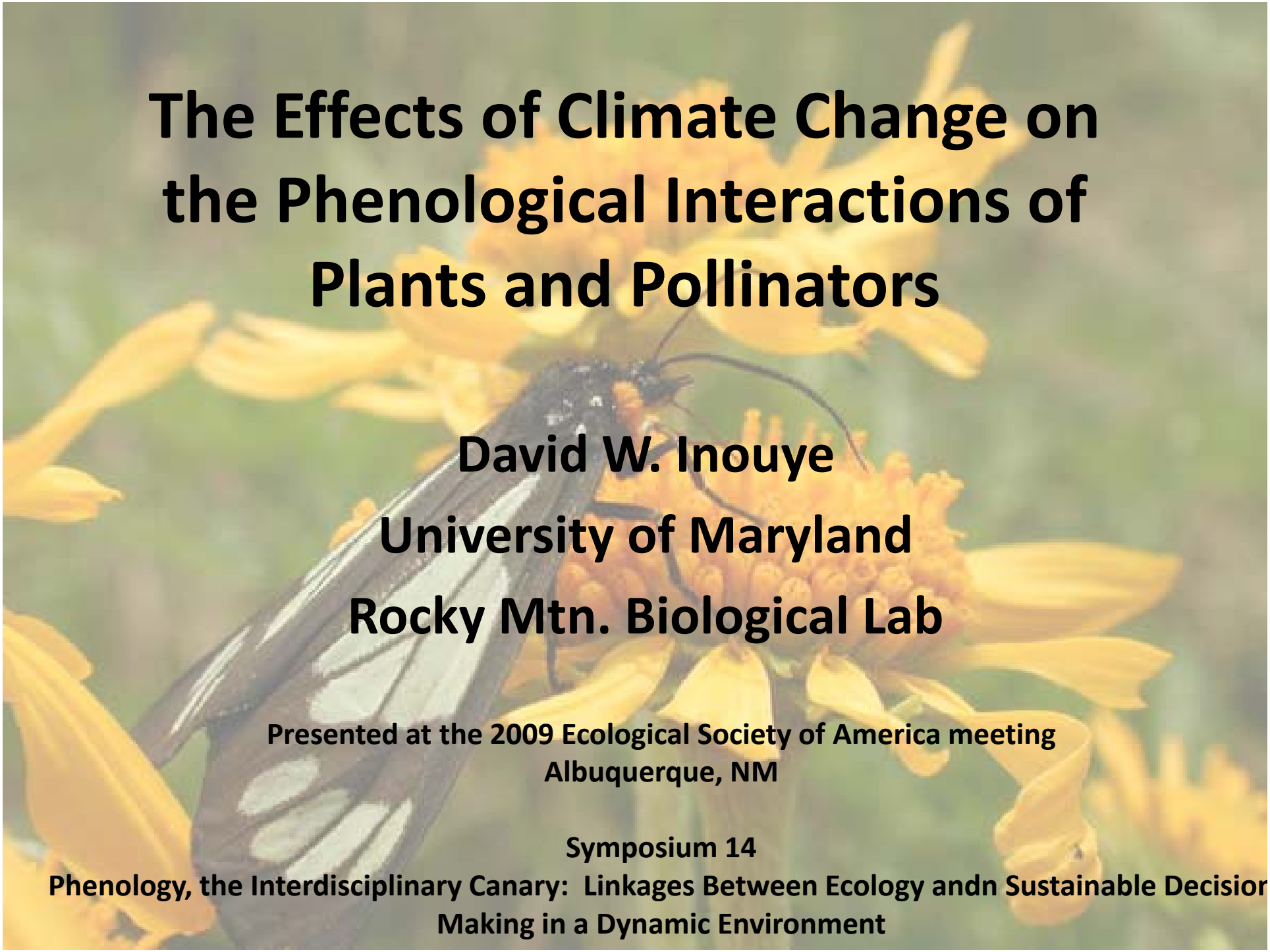
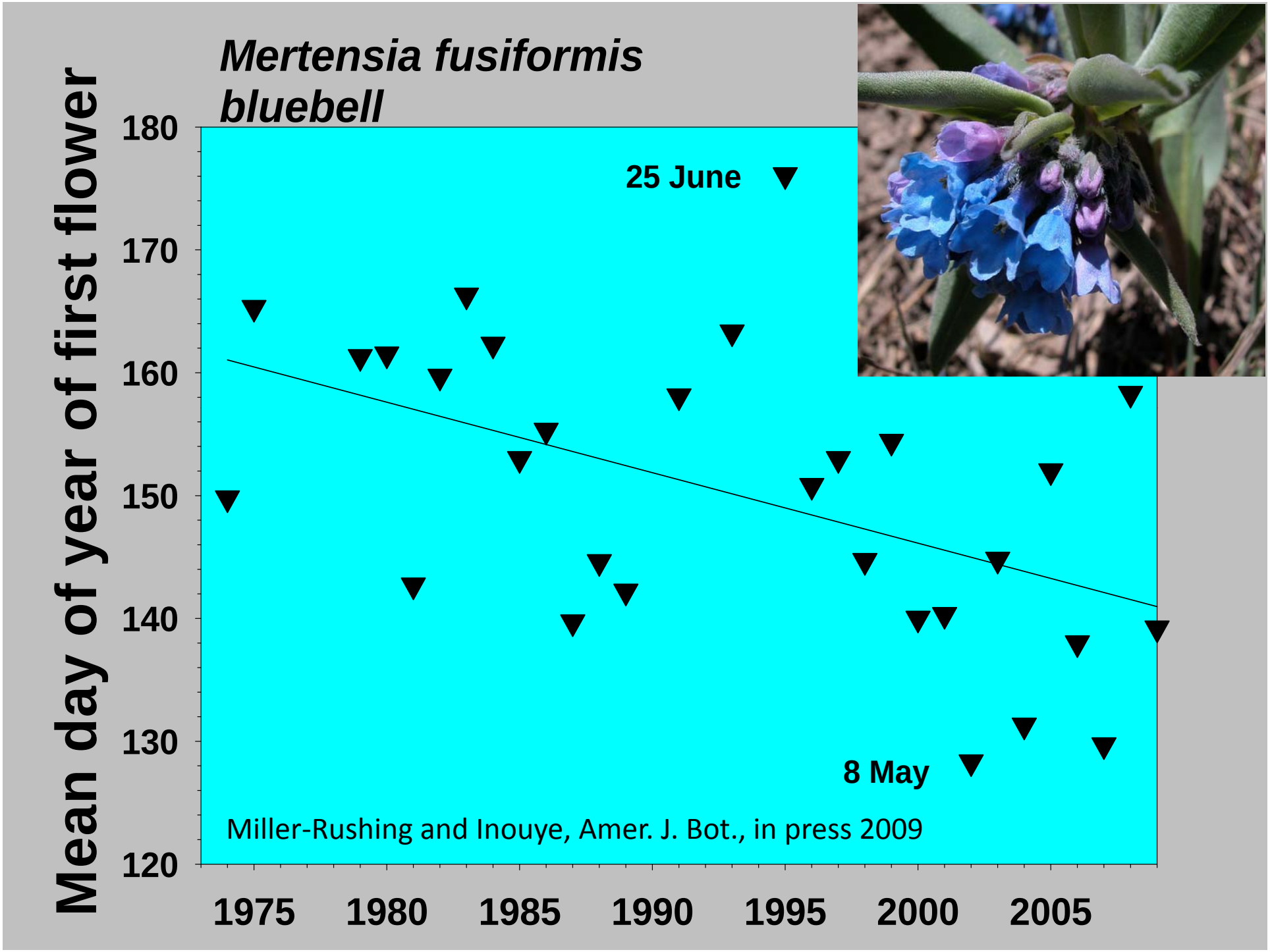


The Effects of Climate Change on the Phenological Interactions of Plants and Pollinators

David W. Inouye
University of Maryland
Rocky Mtn. Biological Lab

Presented at the 2009 Ecological Society of America meeting
Albuquerque, NM

Symposium 14
Phenology, the Interdisciplinary Canary: Linkages Between Ecology andn Sustainable Decision Making in a Dynamic Environment



Possible Effects on Interactions

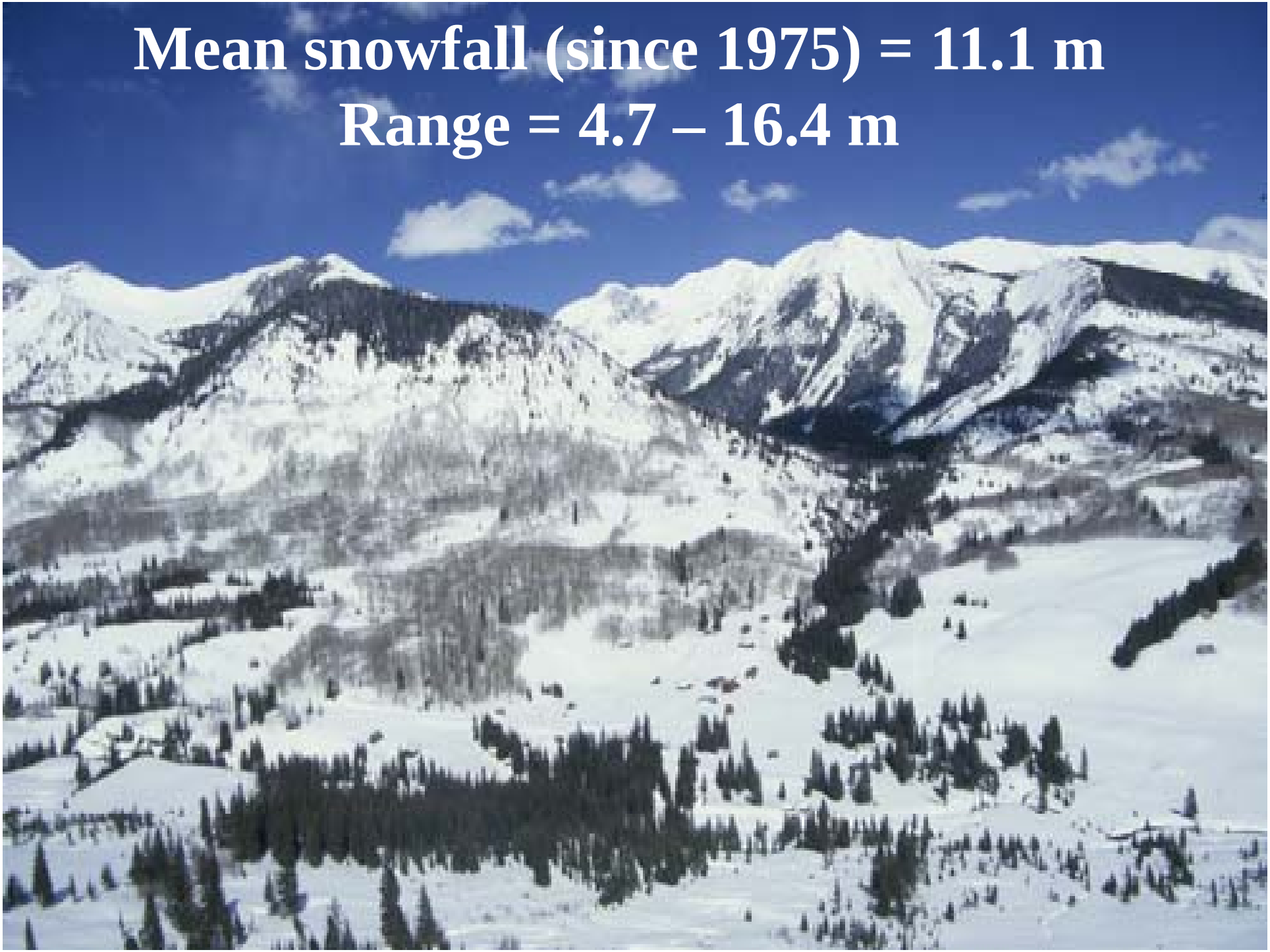
- Plants and pollinators use the same environmental cues for phenology
  - Phenology remains synchronized
- They use the same cues, but respond at different rates to changes in the cues
  - Uncoupling of historical phenological relationships
- Rare and common species respond differently
  - Uncoupling of historical phenological relationships

More Possible Effects

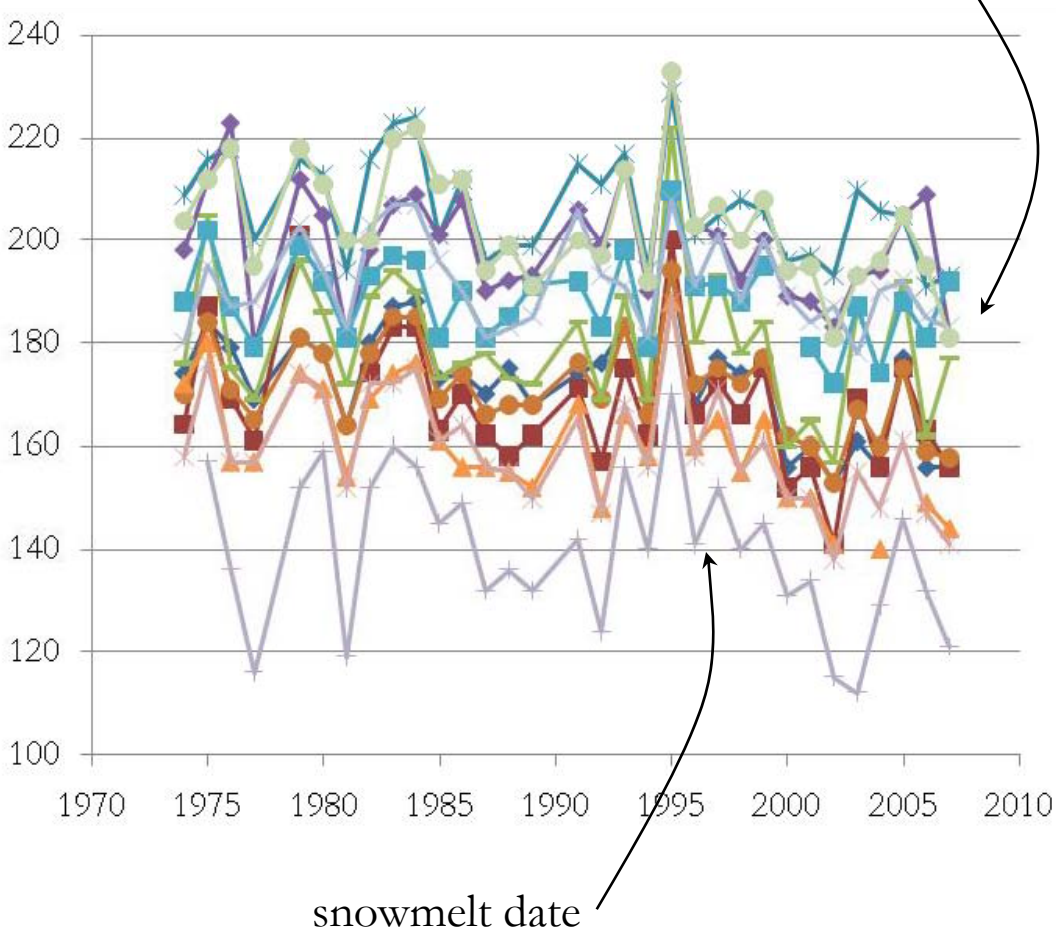
- Phenology and abundance are linked
  - Increases variability of demographic parameters
- Differential changes across gradients
  - Pollinators move up mountains faster than plants
  - Pollinators change latitude faster than plants

Consequences

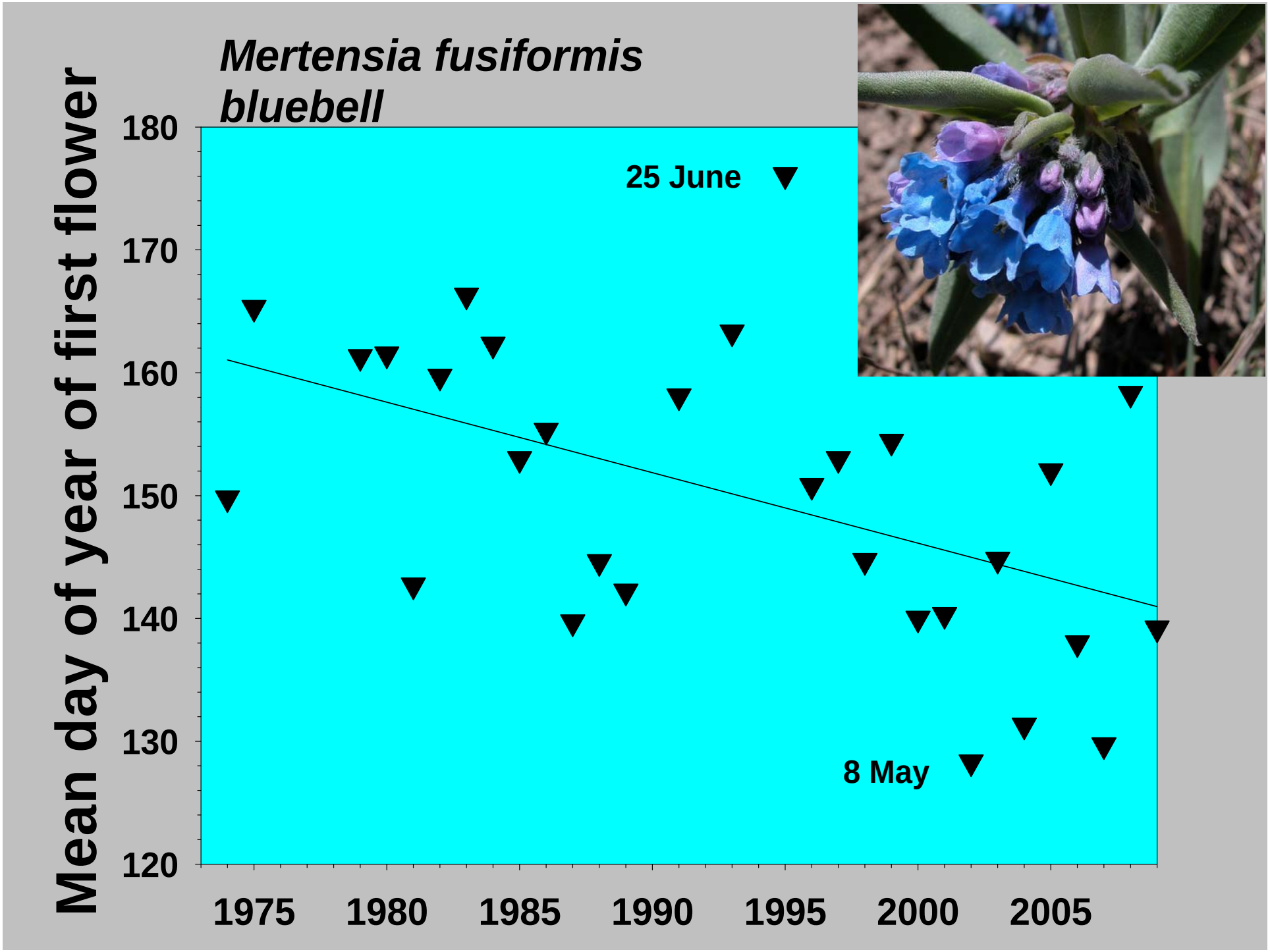
- Trophic mismatches
- Changes in interaction webs
- Range changes
- Local extinctions
- Global extinctions
- Evolution
  - New interactions

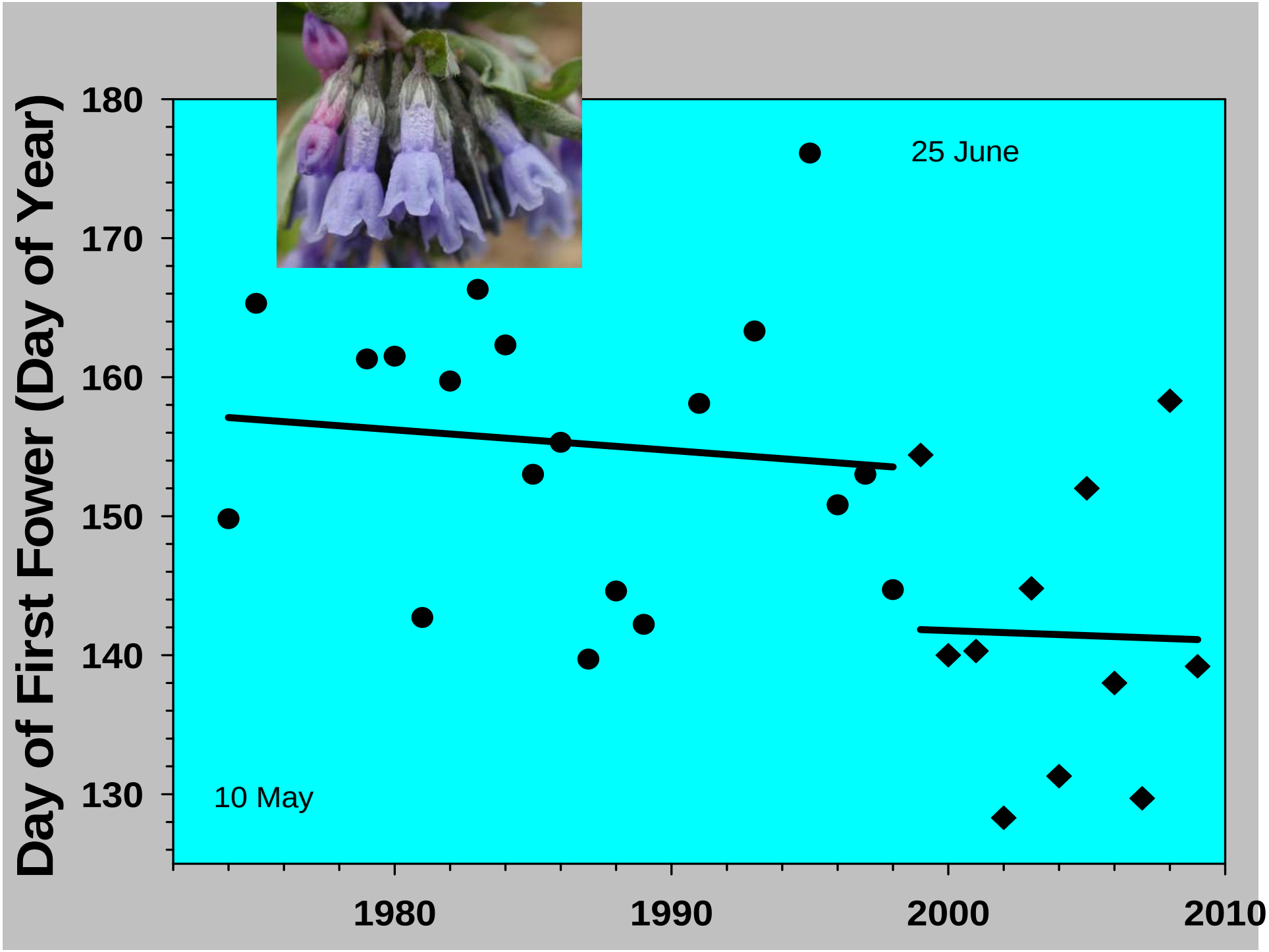


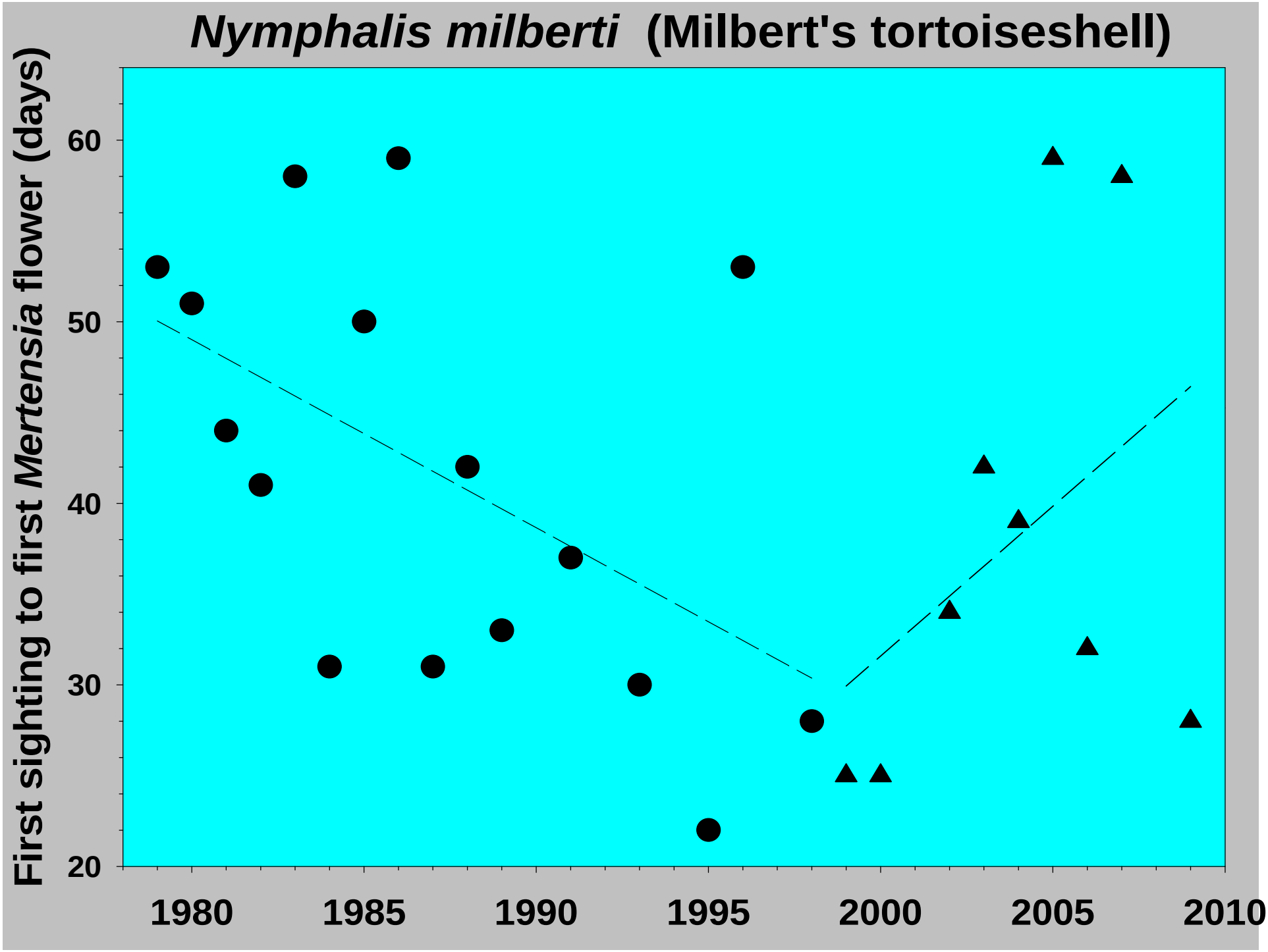
Snowmelt date is a good predictor of flowering time in subalpine wildflowers

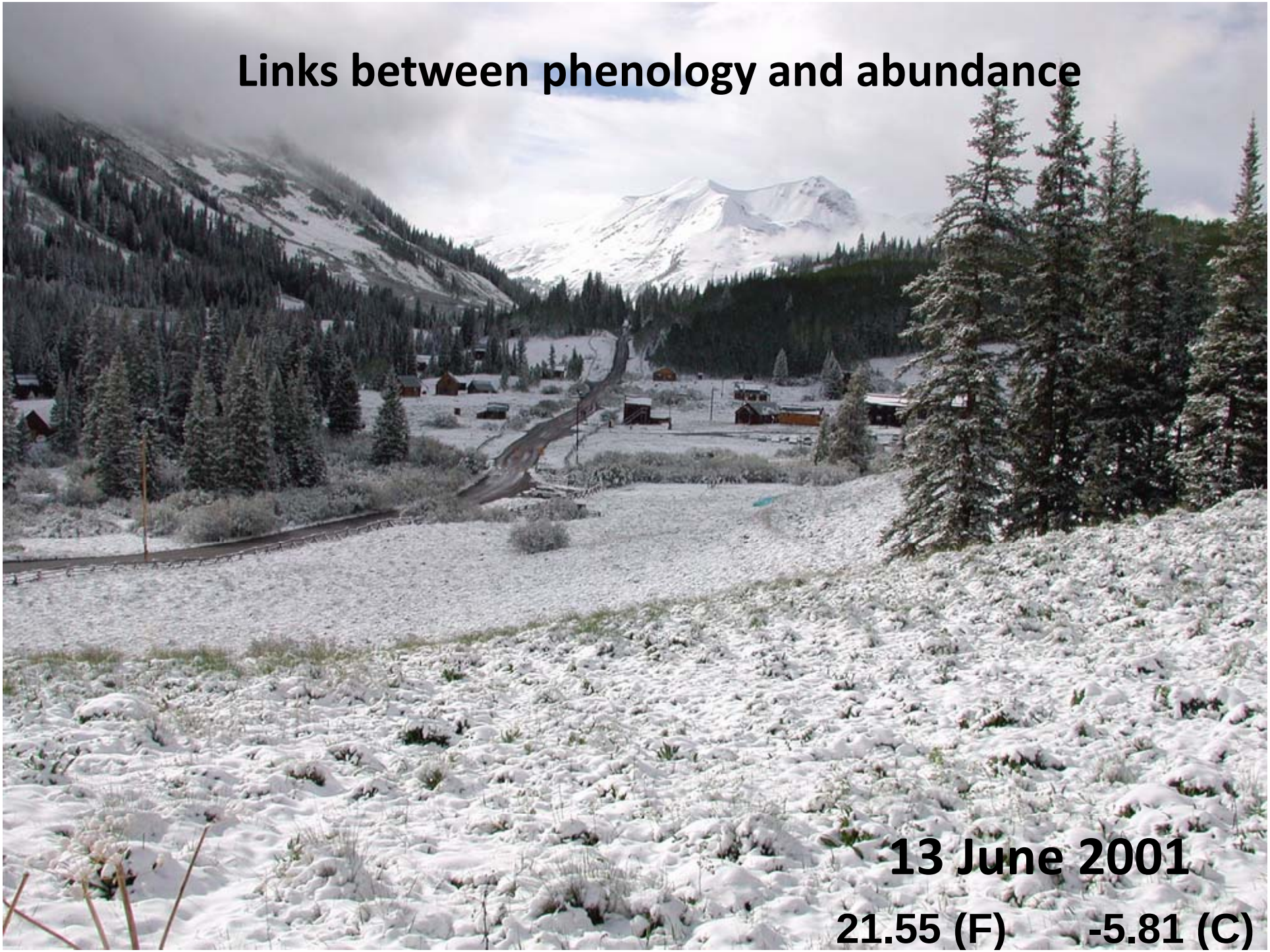


Data: D. Inouye
Slide by Jessica Forrest



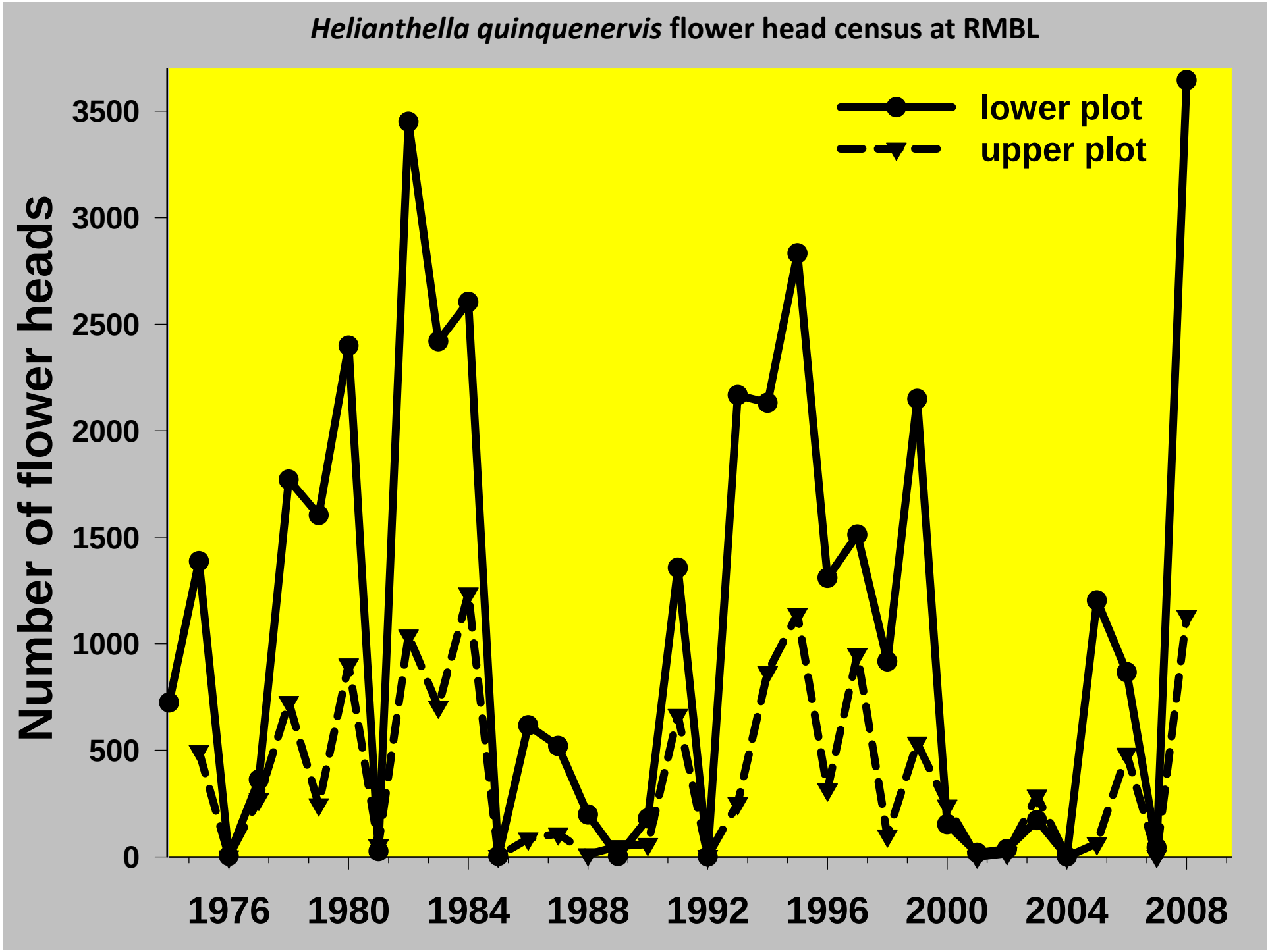


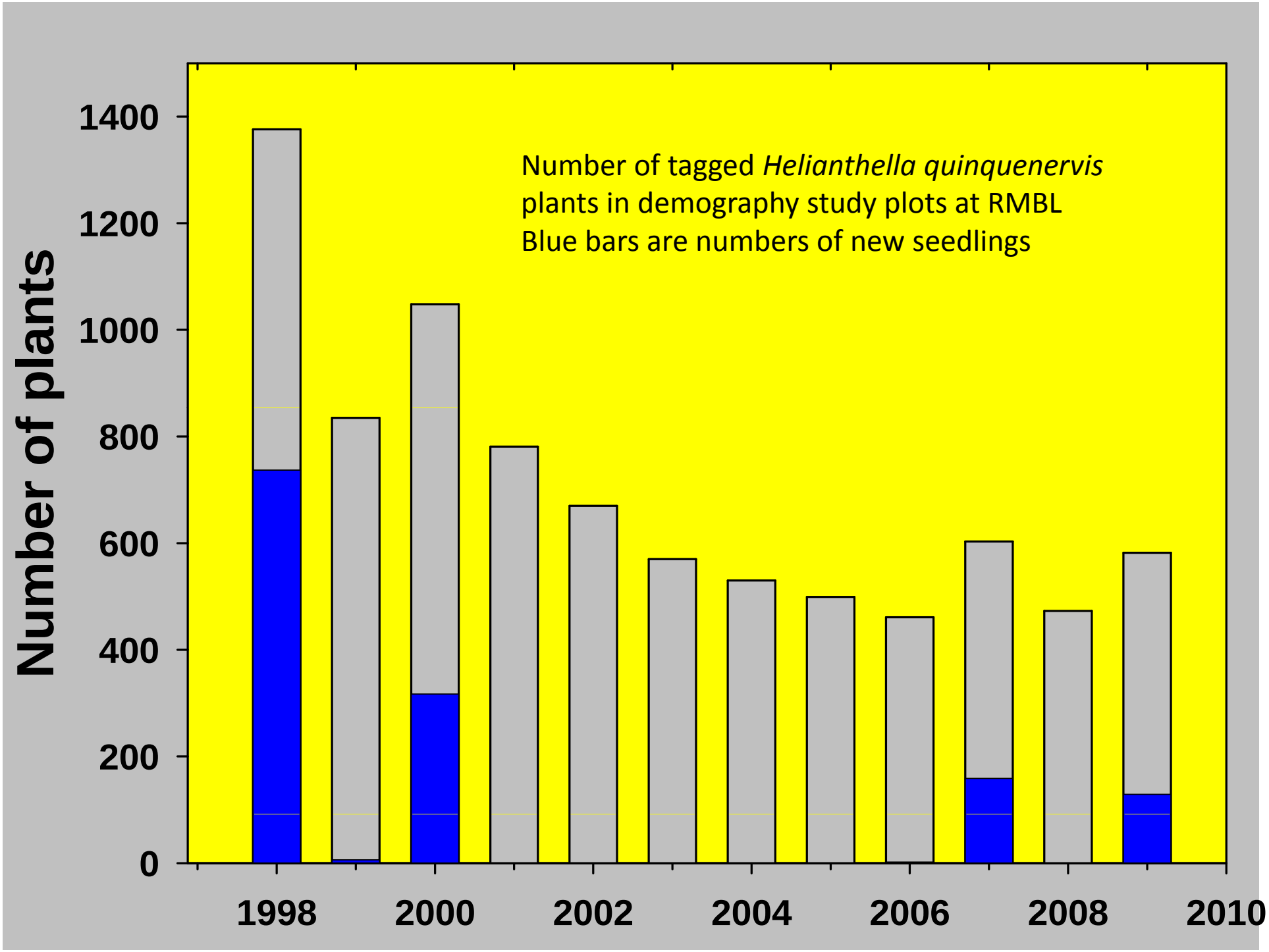


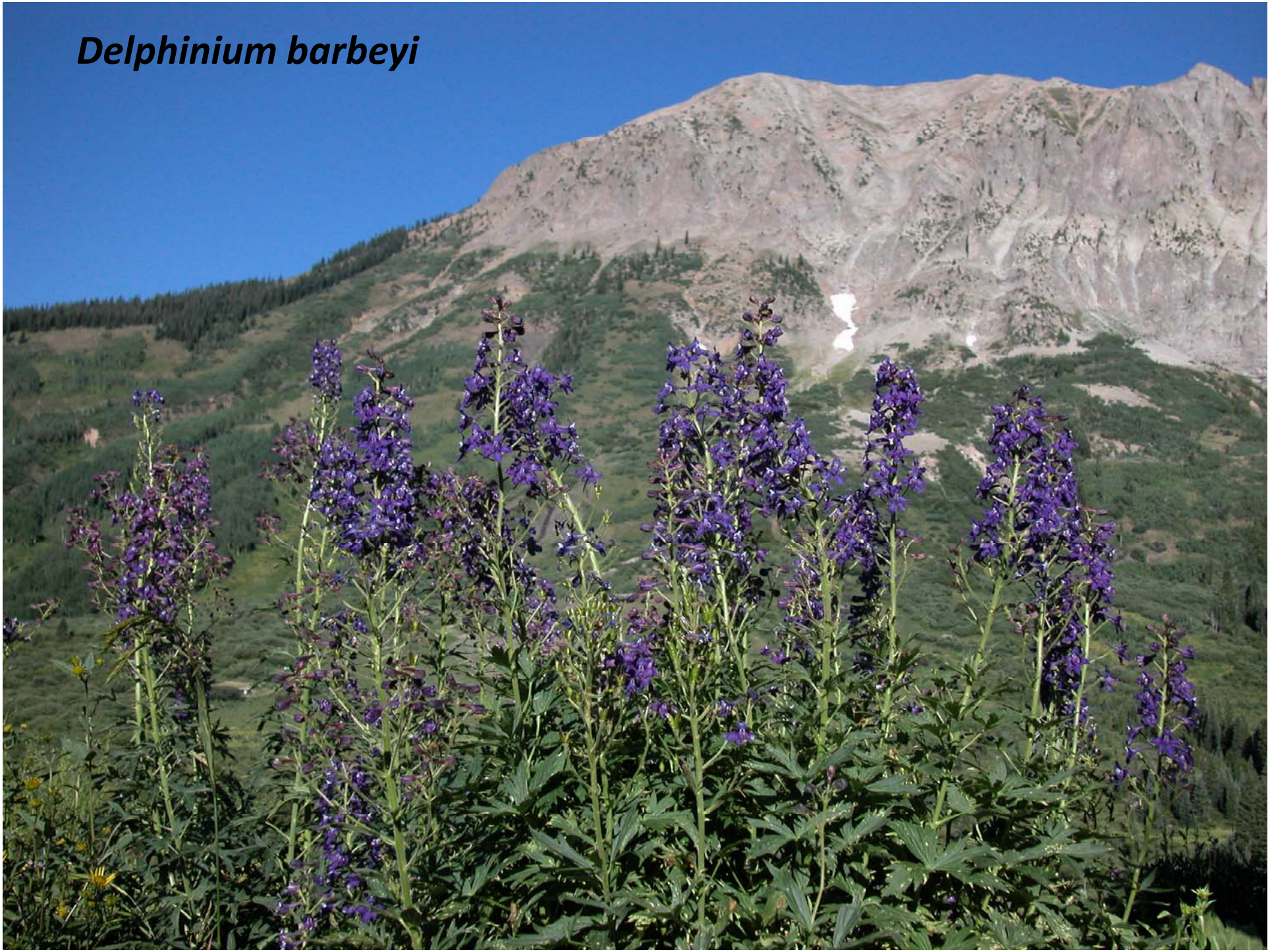


Flowers and a frost-killed bud of *Helianthella quinquenervis* at RMBL

***Helianthella quinquenervis* – Aspen sunflower (good flowering year)**



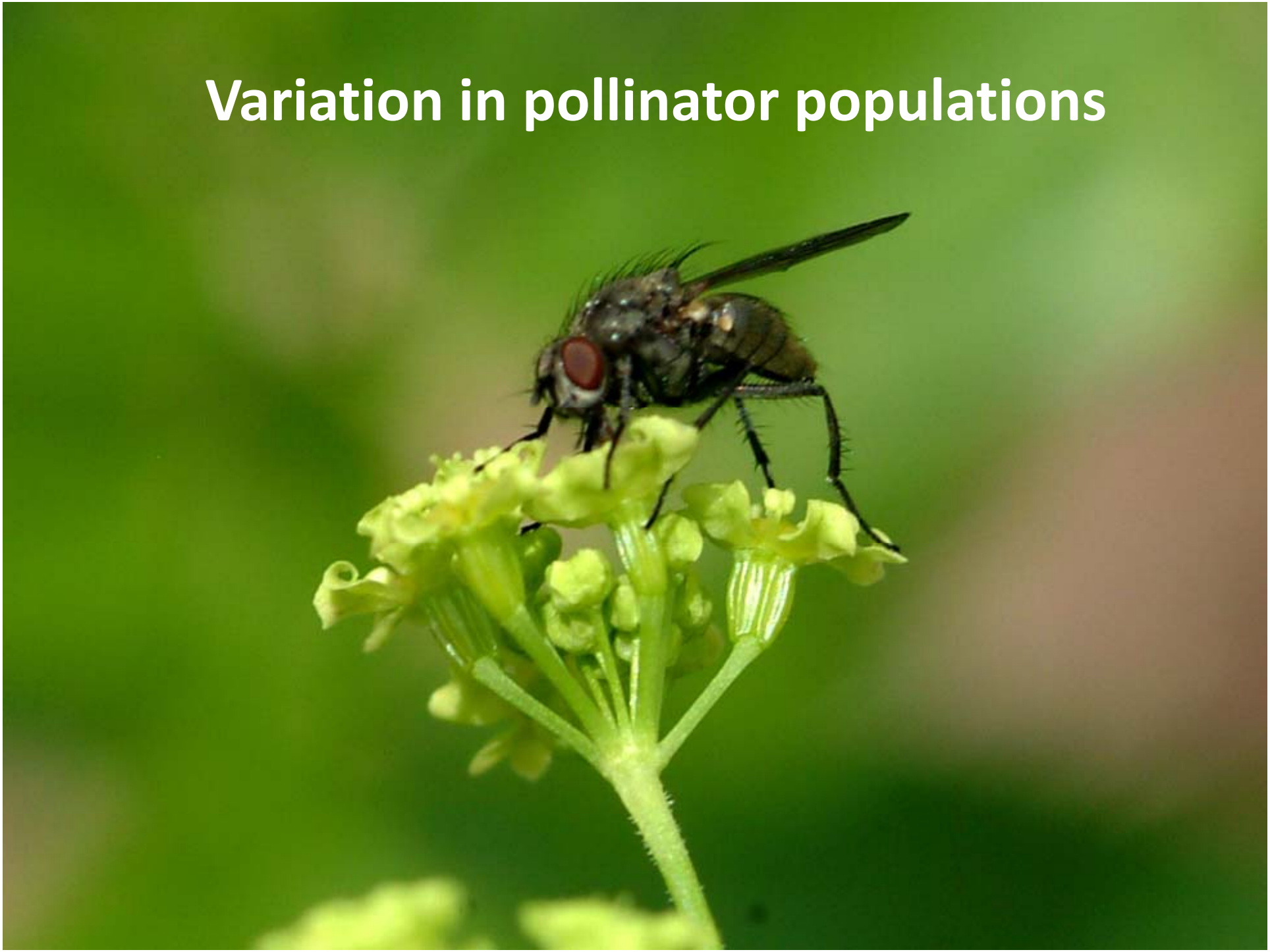




Frost-killed buds of *Delphinium barbeyi*

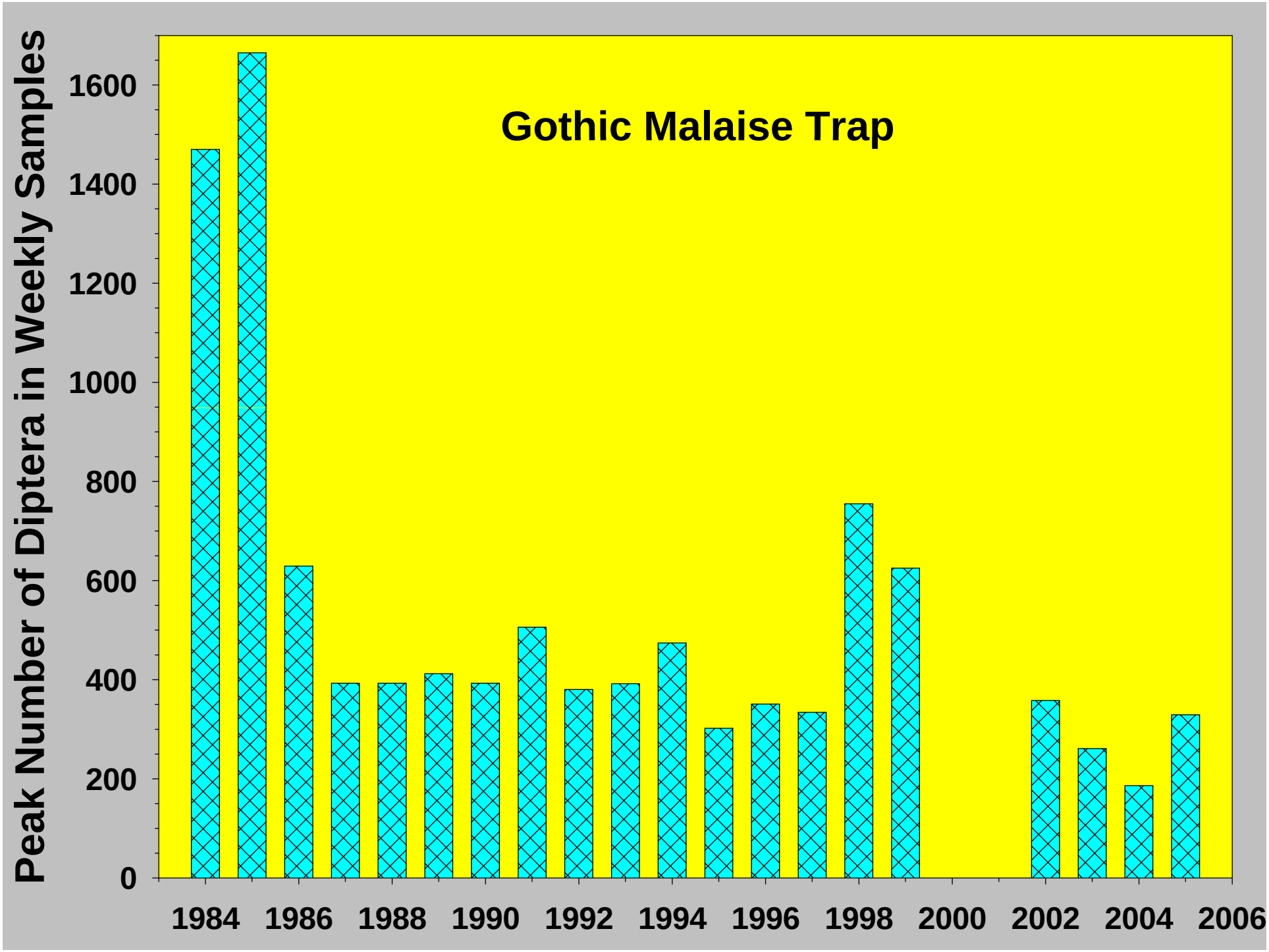
Nature Precedings : doi:10.1038/npre.2009.3583.1 : Posted 8 Aug 2009

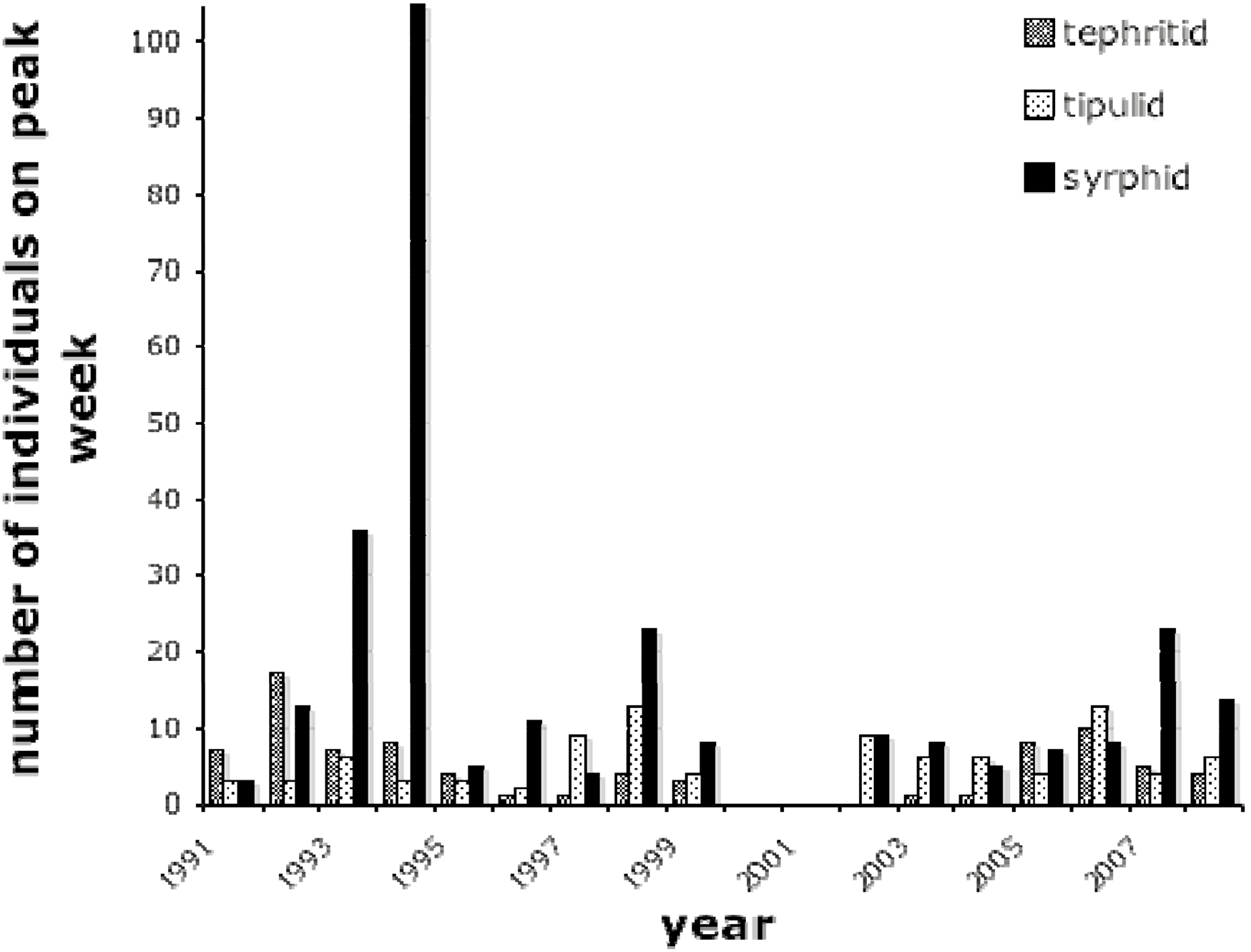
Frost-damaged buds



Nature Precedings : doi:10.1038/npre.2009.3583.1 : Posted 8 Aug 2009

Nature Precedings : doi:10.1038/npre.2009.3583.1 : Posted 8 Aug 2009



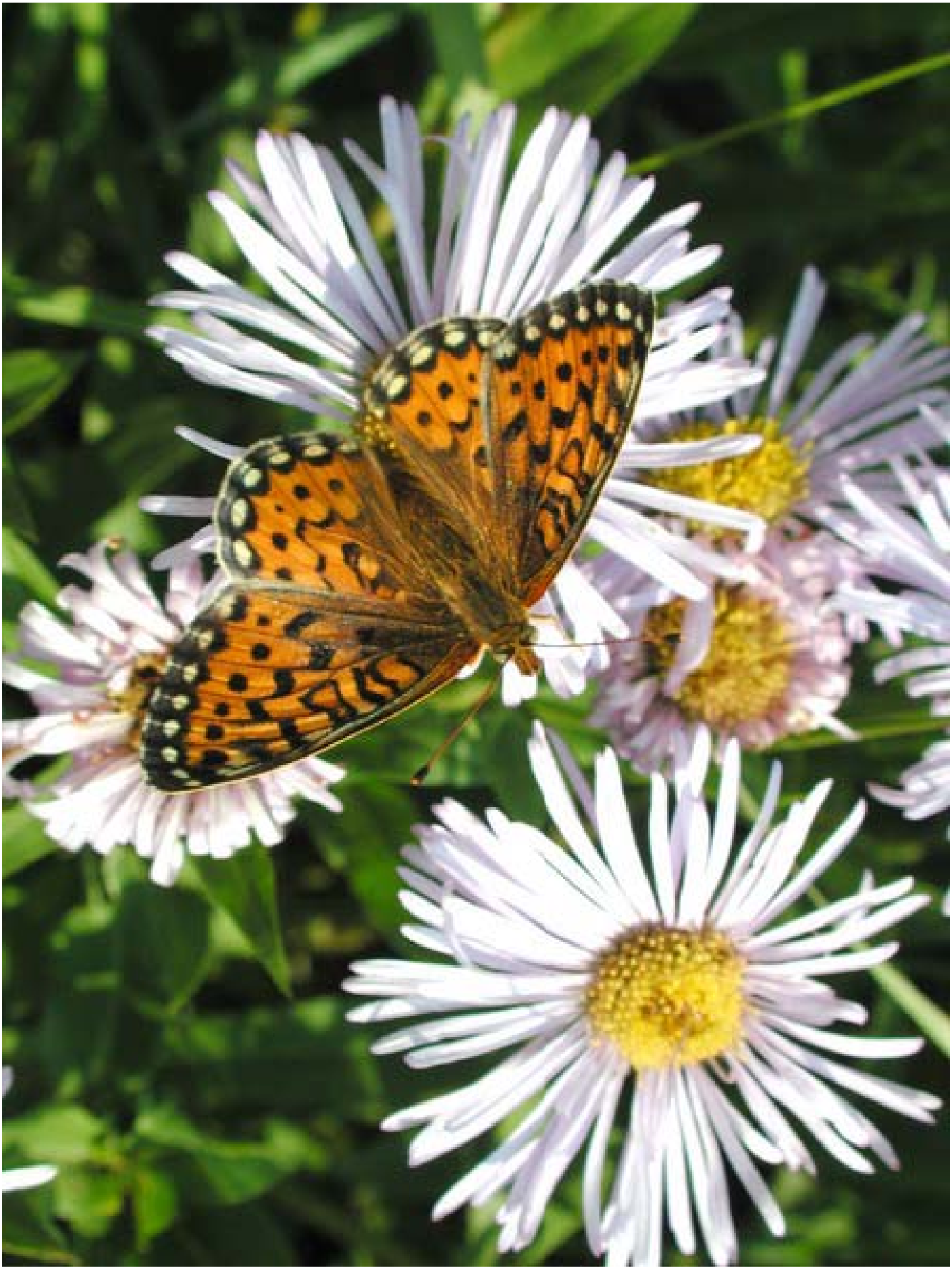


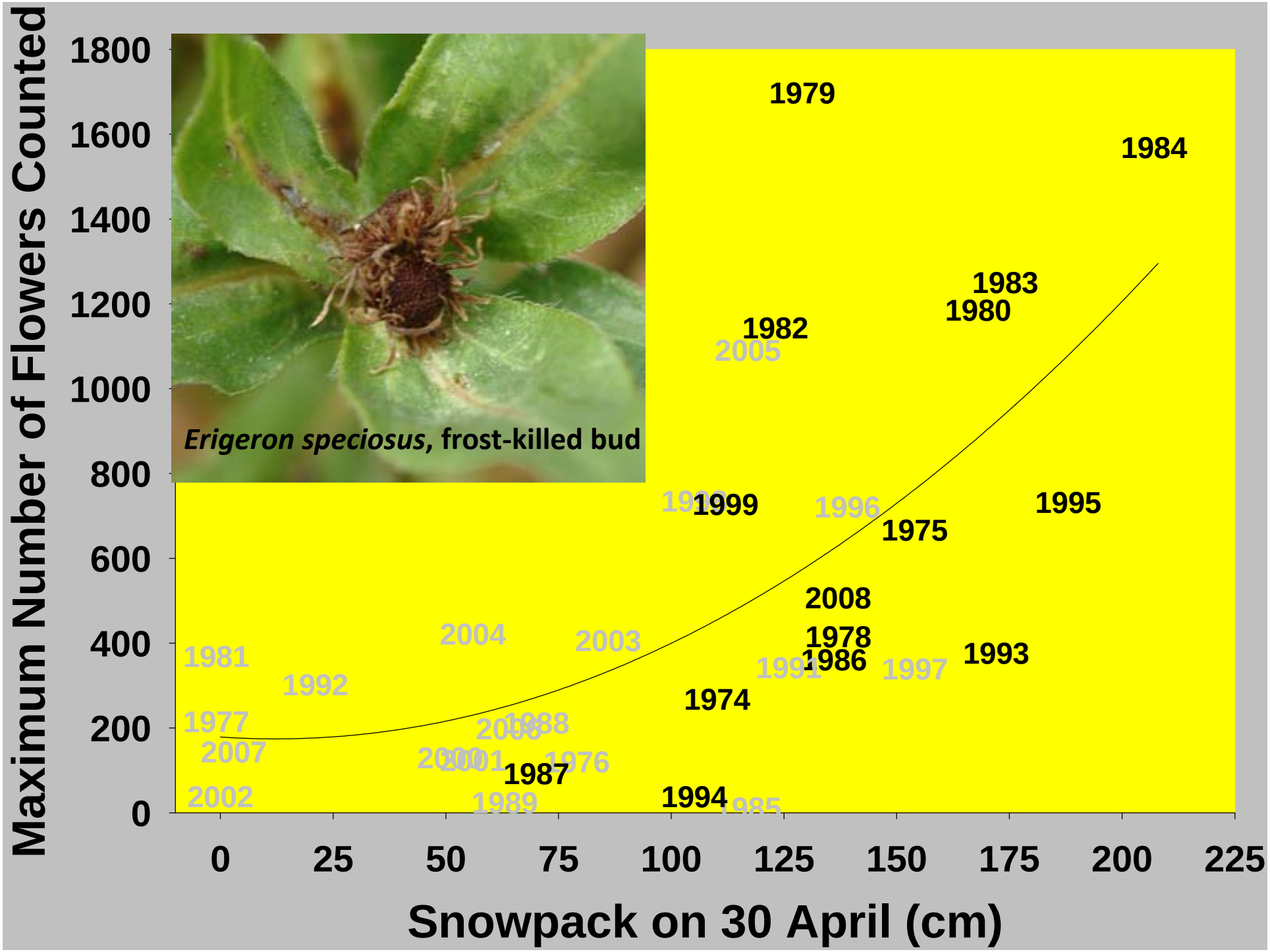
Nature Precedings : doi:10.1038/npre.2009.3583.1 : Posted 8 Aug 2009

Are pollinators being affected?

Speyeria mormonia and ***Erigeron speciosus***

Nature Precedings : doi:10.1038/npre.2009.3583.1 : Posted 8 Aug 2009



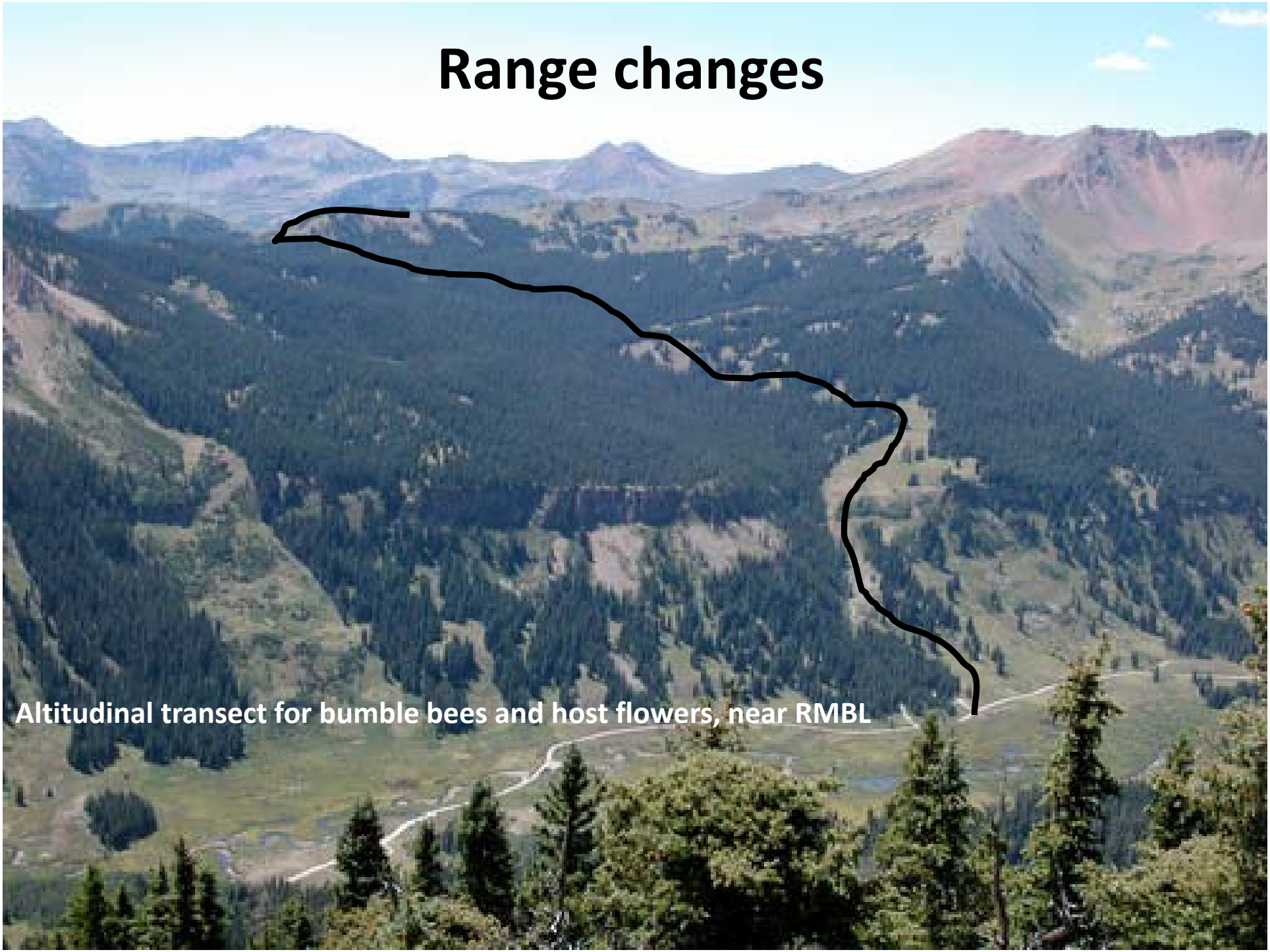


The *Erigeron – Speyeria* story

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

Butterfly population data from Carol Boggs, Stanford University

Range changes

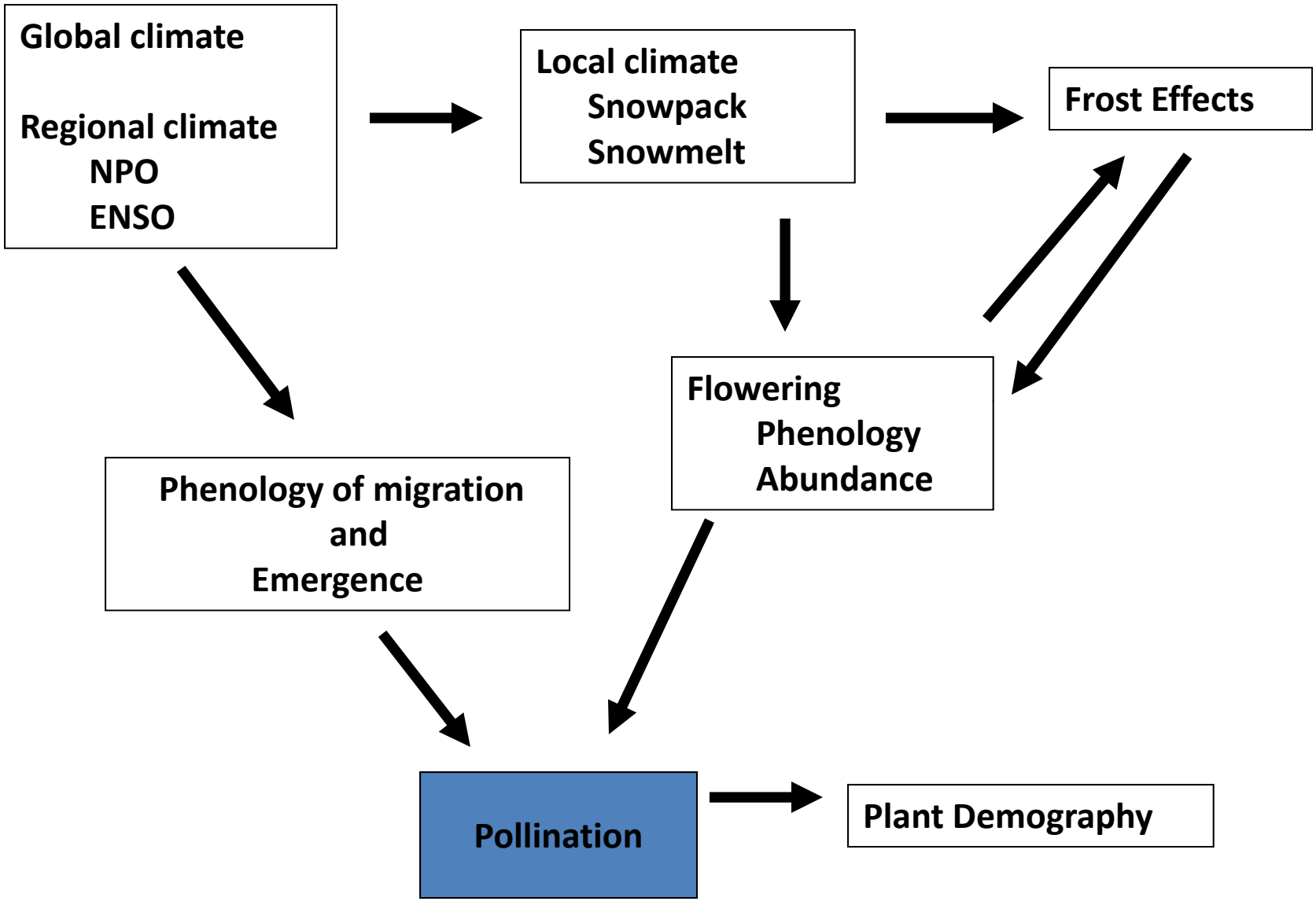


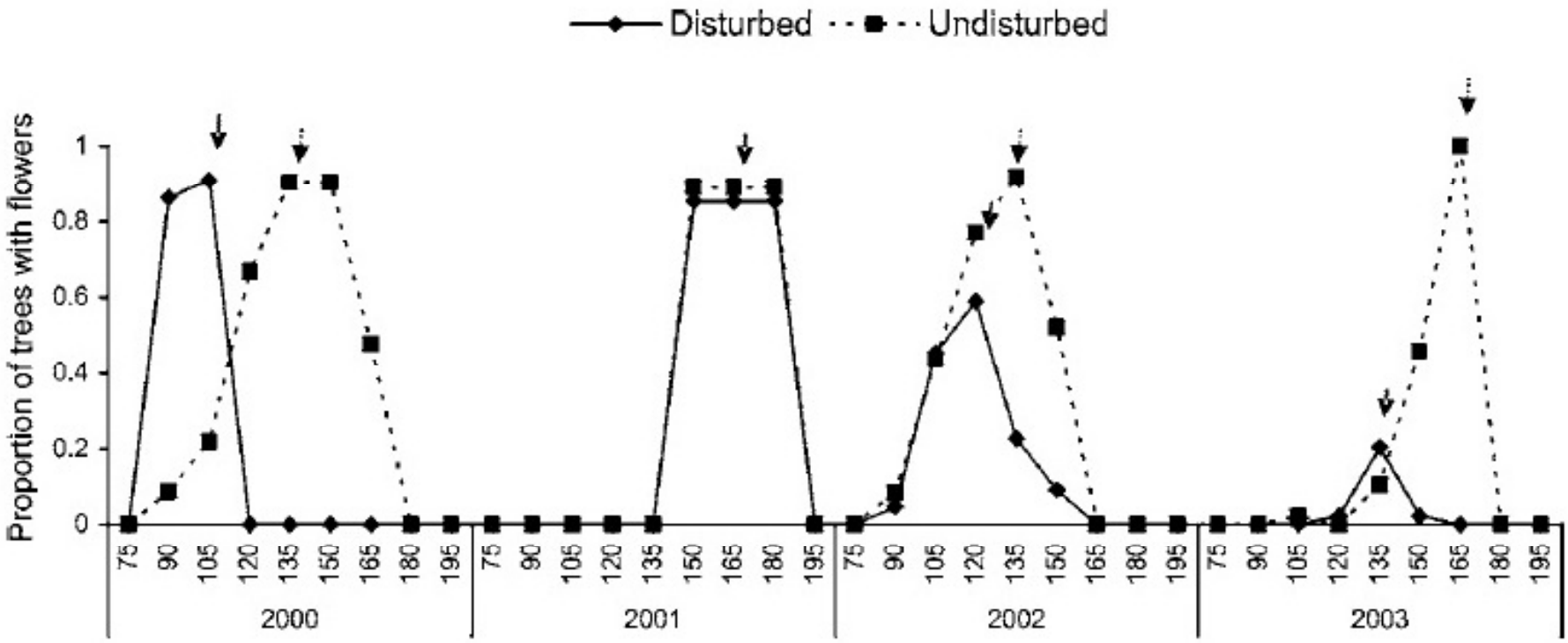
Altitudinal transect for bumble bees and host flowers, near RMBL

New factors affecting snowmelt

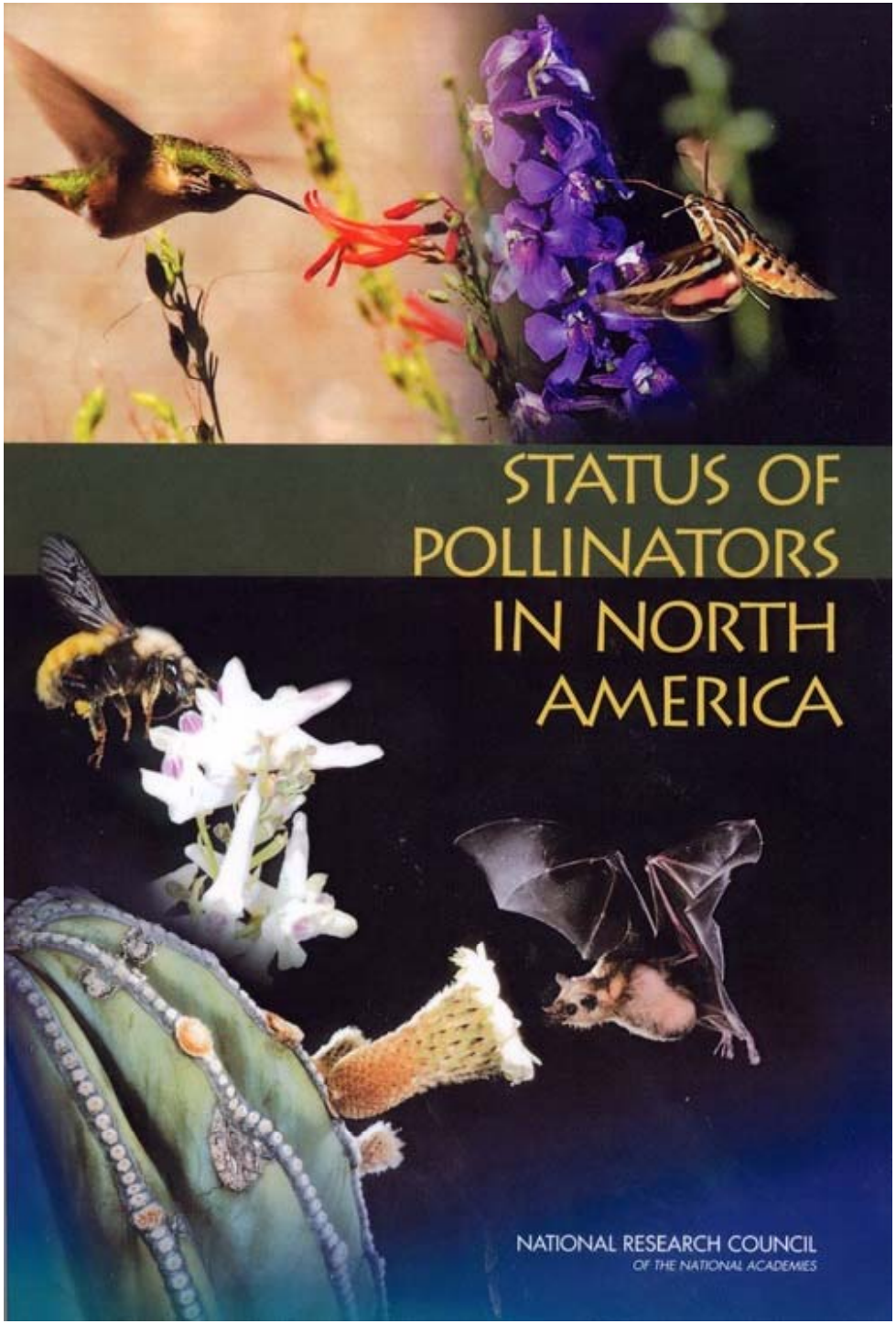
Photo of dust layers in the snowpack, spring 2009. Photo from the San Juan mountains, Colorado, by Chris Landry.

Photo Courtesy of Center for Snow and Avalanche Studies, Silverton Colorado





Herrerías-Diego, Y., M. Quesada, K. E. Stoner, and J. A. Lobo. 2006. Effects of florest fragmentation on phenological patterns and reproductive success of the tropical dry forest tree *Ceiba aesculifolia. Conservation Biology* ***20:1111-1120.***



We need data on:

Pollinator distributions

Pollinator abundance

Pollinator phenology

Floral resource phenology

Floral resource abundance

Range changes

Phenology of interactions

Evolutionary trap

- In an environment that has been altered suddenly by human activities, an organism makes a maladaptive behavioral or life-history choice based on formerly reliable environmental cues, despite the availability of higher quality options.

- Schlaepfer, Runge & Sherman 2002.