• Can we see the effects of climate change in Massachusetts?

• Richard Primack
Warming temperatures; and ice-out at Walden

Mean annual temperature (°C)

Data from Blue Hill Meteorological Observatory
• What is happening in Massachusetts?

• Why should we care?

Large-flowered trillium
(Trillium grandiflorum)
Phenology matters!

From Both et al. 2006. *Nature*. 

English oak 
(*Quercus robur*)

EARLIER
English oak
\((Quercus \text{ robur})\)

Winter moth
\((Operophtera \text{ brumata})\)

From Both et al.
English oak  
(Quercus robur)

EARLIER

Winter moth  
(Operophtera brumata)

EARLIER

Pied flycatcher  
(Ficedula hypoleuca)

SAME TIME
EACH YEAR

Finding old records
Henry David Thoreau kept detailed records

“I want to go away soon and live away by the pond… But my friends ask what I will do when I get there? Will it not be employment enough to watch the progress of the seasons?”
- Thoreau, 1841
Flowering times in Concord; Thoreau, Hosmer, Miller-Rushing & Primack

Rhodora  Bird’s foot violet
Earlier flowering times

Photographs and climate change

Example: Fringe tree

American Fringe Tree
Chionanthus virginicus

20 June 1926

7 May 2003

Photographs from Lowell Cemetery

30 May 1868

22 May 2010

Miller-Rushing et al. 2006
New Sources of Data; Herbarium specimens

Intensive search for bird data

Are the birds responding to climate change?

Is their response similar to that of plants?
Insects are the missing link!
Species lost

• 27% of Thoreau’s species now extinct

• 36% now rare (one or two populations)

• Most loss over last 40-50 years - due to many factors

Purple fringed orchid
(*Habenaria psychodes*)

Primack et al. 2008 Biological Conservation
What we have learned:
Management is needed
Flowering times predict which species are most successful

Purple loosestrife

Willis et al. 2010 PLoS One
Conclusions

• Spring is arriving earlier; and further changes are coming.
• Interactions are changing.
• Climate is just one cause of changes.
• Management is essential.
• Experiments are needed, including assisted migrations.
• We need to inform and involve the public and students.
Climate change is here in Massachusetts already, and we need to adapt to these changes!