Using citizen science to determine the future of forests through digitized herbaria

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Oak specimen from Linnaean collections

http://linnean-online.org

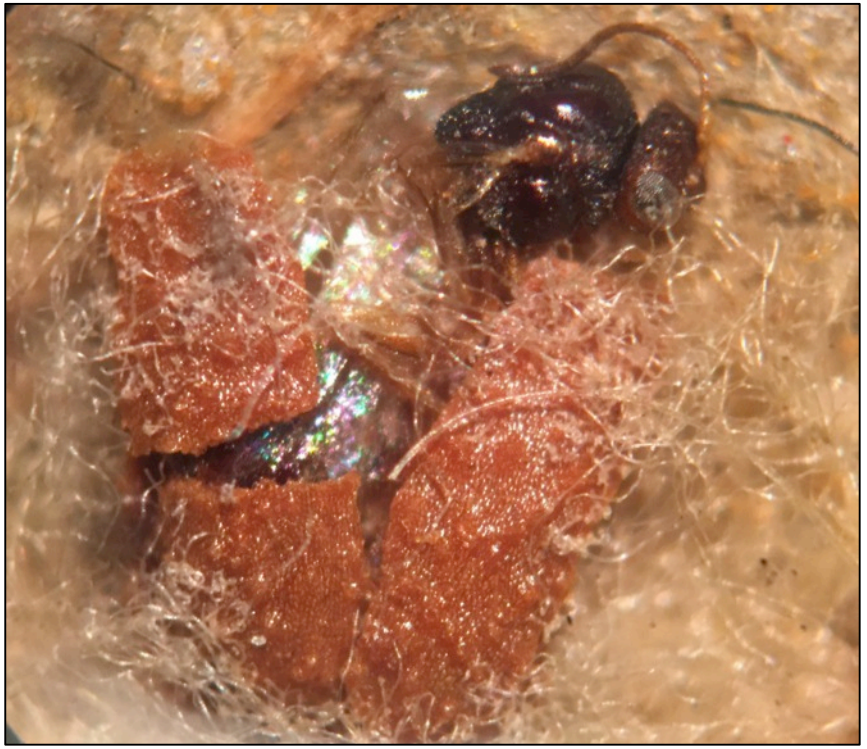
Herbivory surveys at Harvard University Herbaria

Leafcutter bee

Stippling

Herbivory surveys at Harvard University Herbaria

Leaf miner, 1900



Gall wasp, 1899

Insect herbivory drives ecological processes.

Potato aphids (Macrosiphum euphorbiae) on lettuce

- **Plant growth and vigor (Zvereva et al. 2012. *Oikos*)**
- Decomposition (Chapman et al. 2003)
- Tree carbon storage (Kurz et al. 2008. *Nature*)

Insect herbivory drives ecological processes.

Colorado State University

Bugguide.net

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Insect herbivory drives ecological processes.

news.ubc.ca

UC Boulder

- Plant growth and vigor (Zvereva et al. 2012. *Oikos*)
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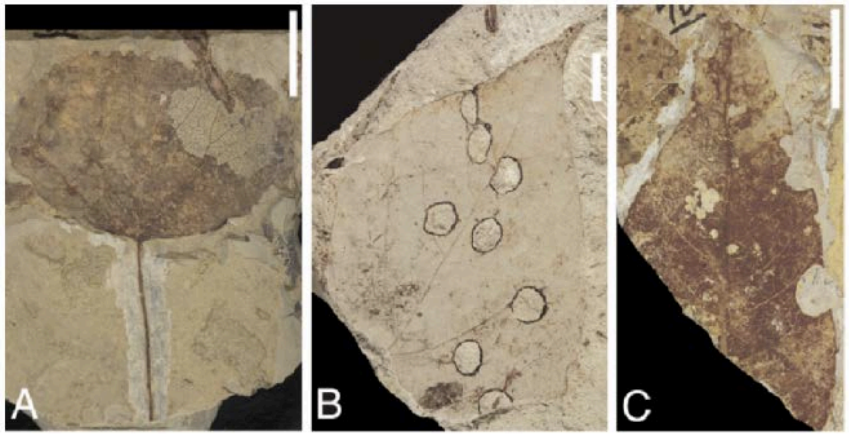
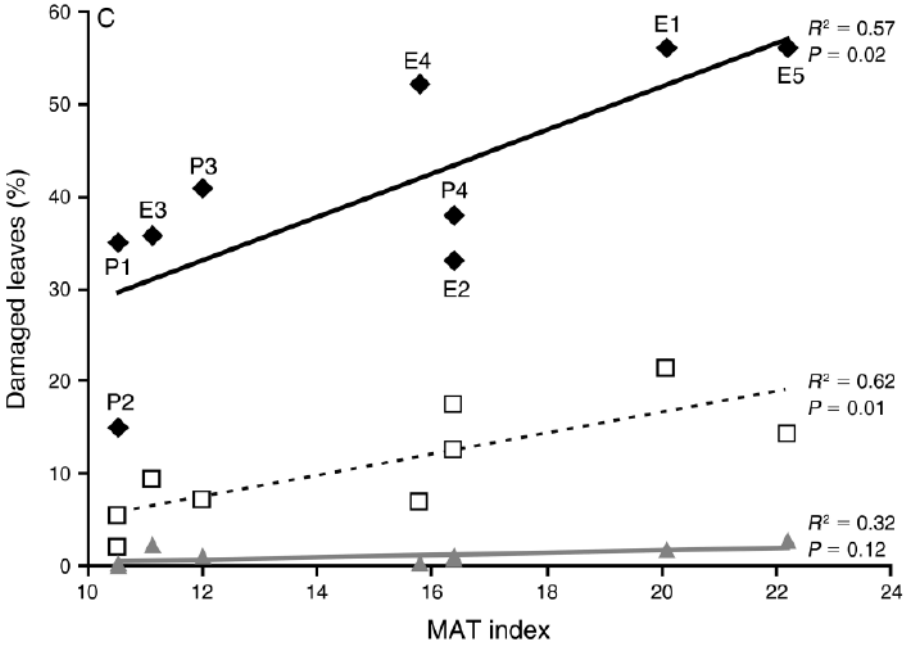
- **Tree carbon storage (Kurz et al. 2008. *Nature*)**

Evidence predicting how herbivory will respond to recent climate change: **Fossil evidence**





Fossil evidence shows insect herbivory was more abundant in warmer epochs.

Currano et al. 2010. *Ecol. Mono*.
Wilf & Labandeira. 1999. *Science*

Evidence predicting how herbivory will respond to recent climate change: **Space for time studies**

Photo by Matt Bertone

<u>Some</u> studies show insect herbivore abundance or/and herbivory increase with increasing temperatures over space.

Kozlov et al. 2015. *Gl. Ch. Biol.*
Kozlov et al. 2015. *Gl. Eco. Biogeo.*
Youngsteadt et al. 2014. Gl. Ch. Biol.
Dale et al. 2014 Ecol. Appl.

Evidence predicting how herbivory will respond to recent climate change: **Observations of insect herbivore abundance**

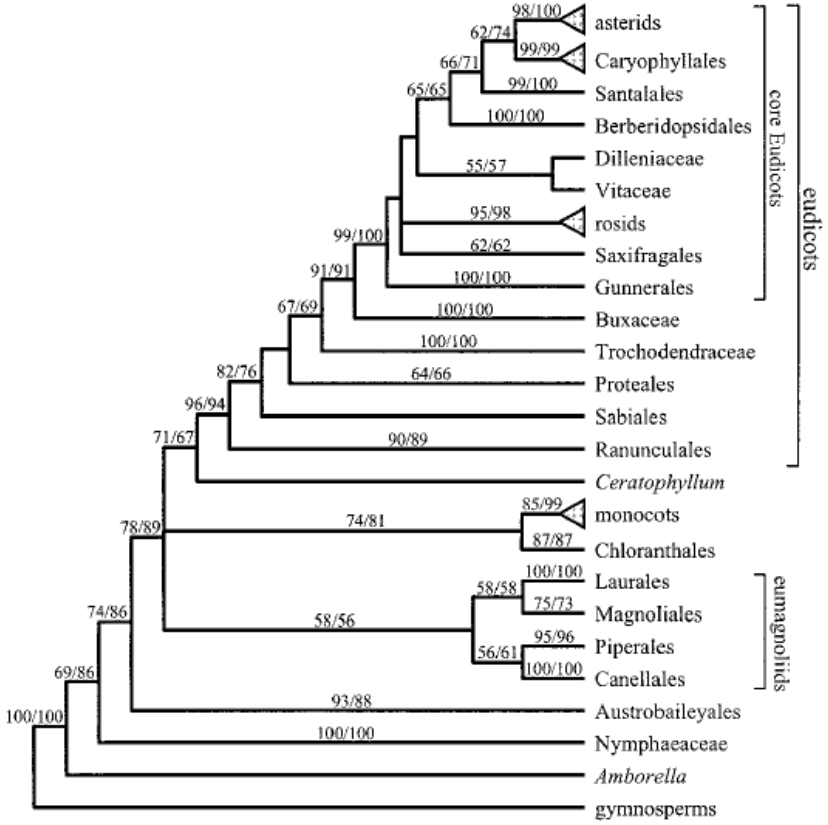
Wooly aphid Eriosomatinae, photo by Alex Wild

In actual surveys, insects show widely varying responses to recent climate change.

Aphids:
Bell et al. 2014. *J. of An. Ecol.*

Butterflies:
Sheppard et al. 2016. *Nat. Clim. Ch*.
Harrington et al. 2007. *Gl. Ch. Biol.*
Warren et al. 2001. *Nature*

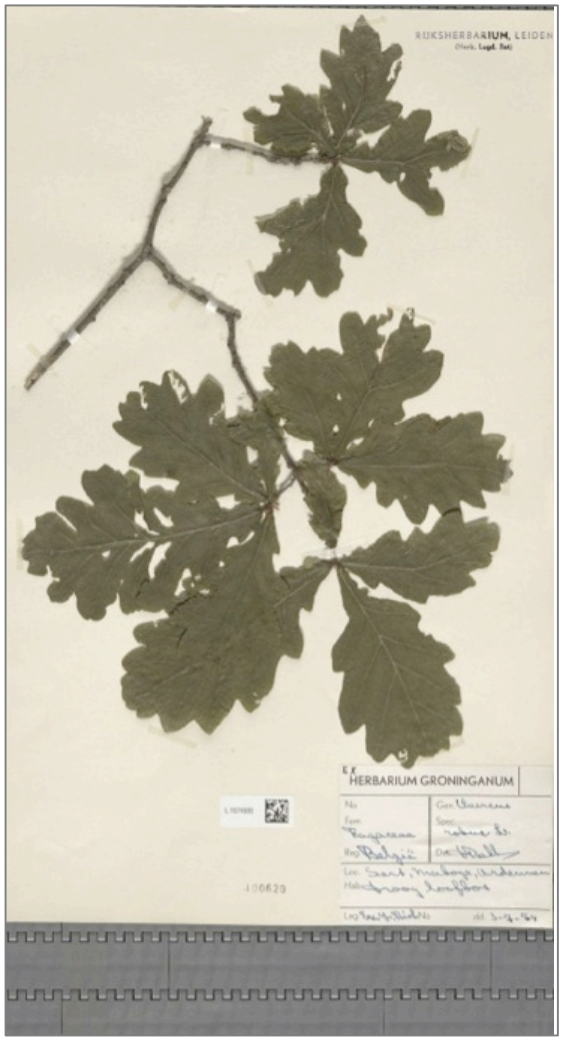
Herbaria may offer unprecedented opportunities to understand what factors drive herbivory rates.



Hilu et al. 2003. *Am. J. Bot*.

- Across time (from 1800s)
- Across space
- Across the plant phylogeny
- Across the insect phylogeny

Insect herbivory rates on herbaria



- How prevalent is herbivory on herbarium specimens?
- How has herbivory changed over time?

Nationaal Herbarium de Nederland digital collection

Images at 600 ppi

Quercus robur

Europe, 1871-2001

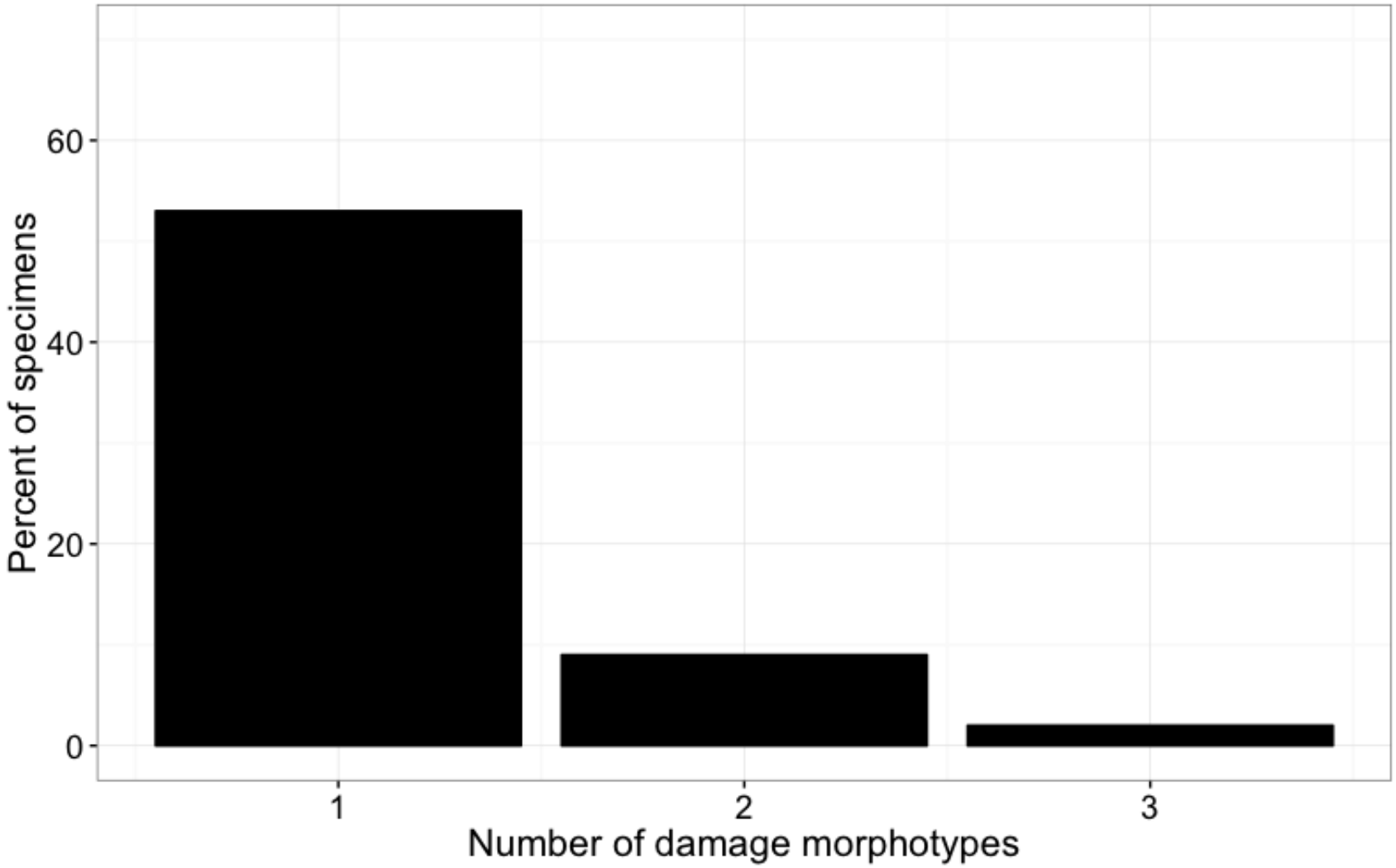
n_{Total}= 56 specimens

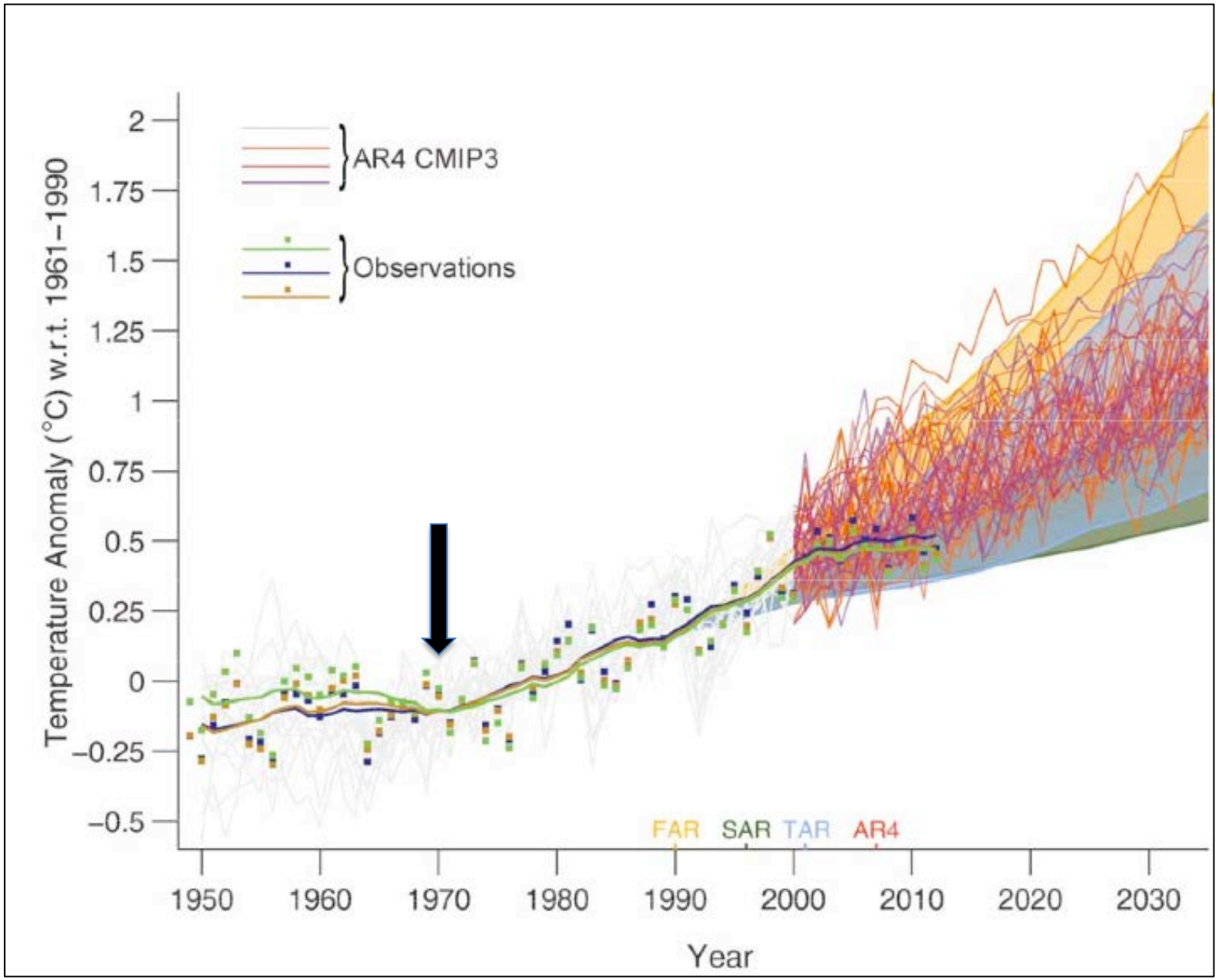
Leaf mines

Chewing damage

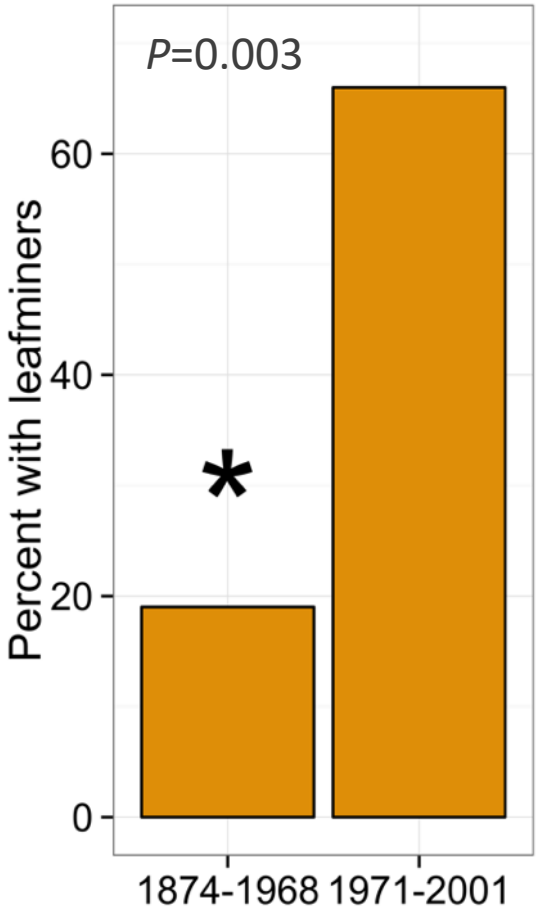
Galls

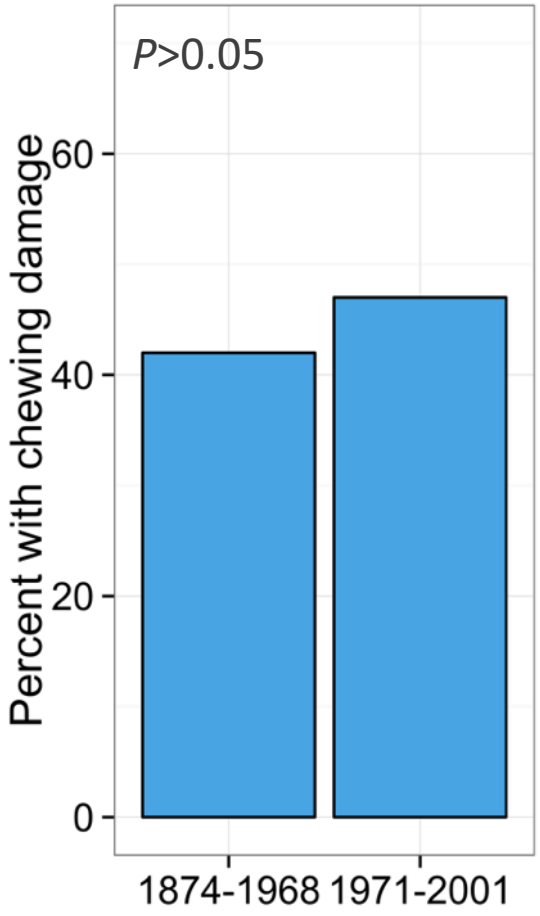
Over 60% of specimens harbor some kind of insect damage.

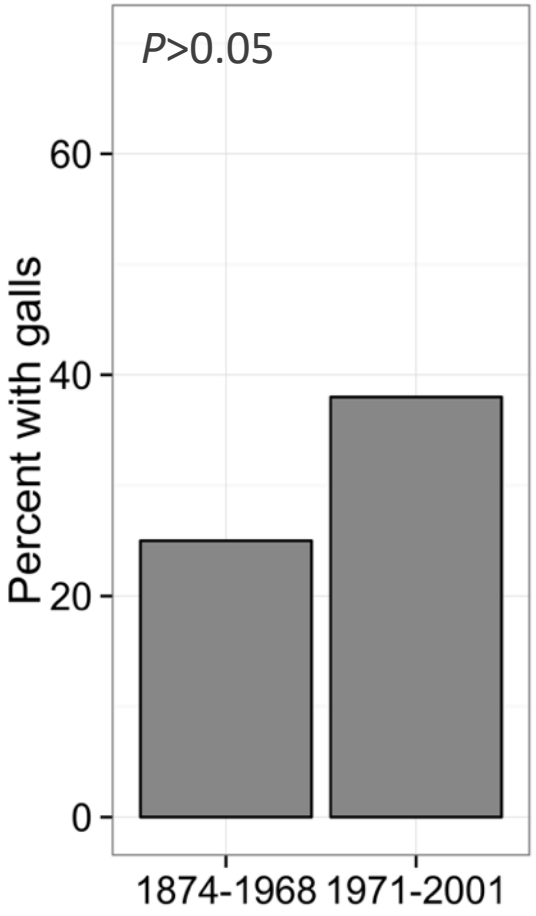



AR4 CMIP3
Observations
Temperature Anomaly (°C) w.r.t. 1961–1990
2
1.75
1.5
1.25
1
0.75
0.5
0.25
0
−0.25
−0.5
FAR
SAR
TAR
AR4
1950
1960
1970
1980
1990
2000
2010
2020
2030
Year

IPCC 2014


P=0.003
Percent with leafminers
60
40
20
0
*
1874-1968
1971-2001


P>0.05
Percent with chewing damage
60
40
20
0
1874-1968
1971-2001


P>0.05
Percent with galls
60
40
20
0
1874-1968
1971-2001

Herbivory became more prevalent on *Q. robur* after climate warming.

Next steps:

1. In-depth herbivory surveys at the Harvard University Herbaria

2. Citizen science to expand to a worldwide survey

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Herbivory surveys at Harvard University Herbaria

20 plant species, 3 done so far

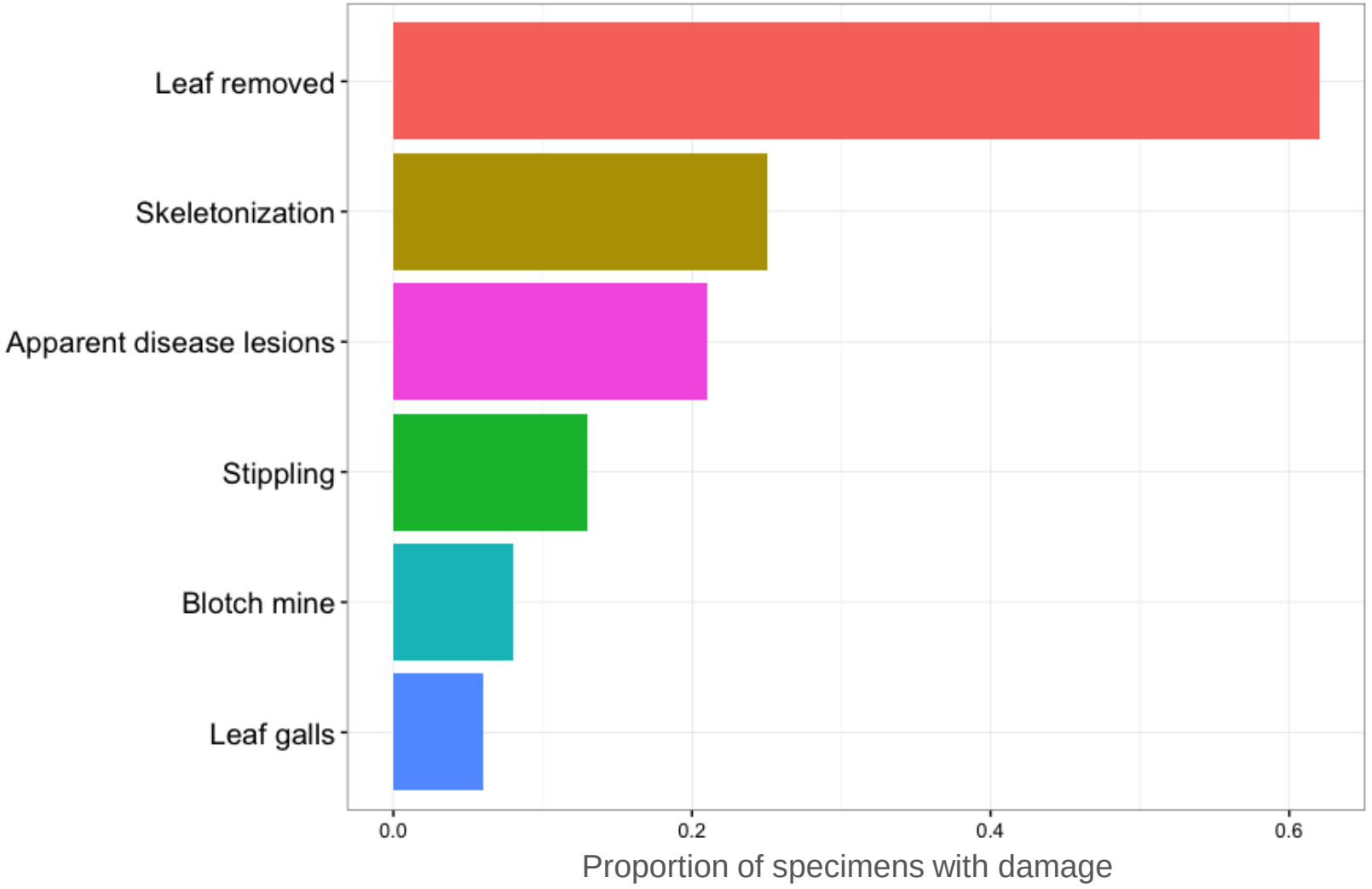
New England, 1895-2015

Herbivory surveys at Harvard University Herbaria

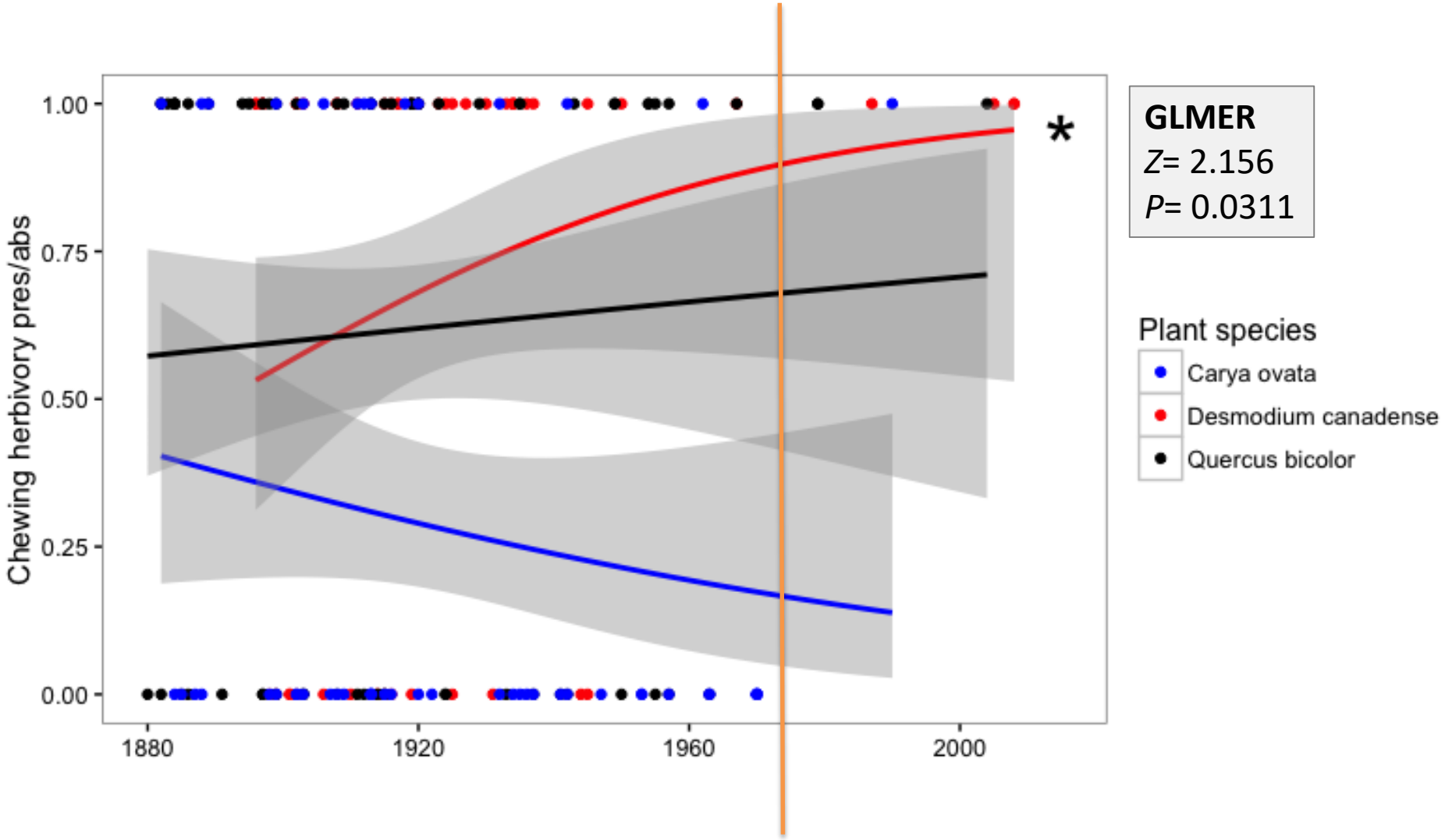
20 plant species

Native to New England, 1895-2015

Chewing is by far the most prevalent type of damage.

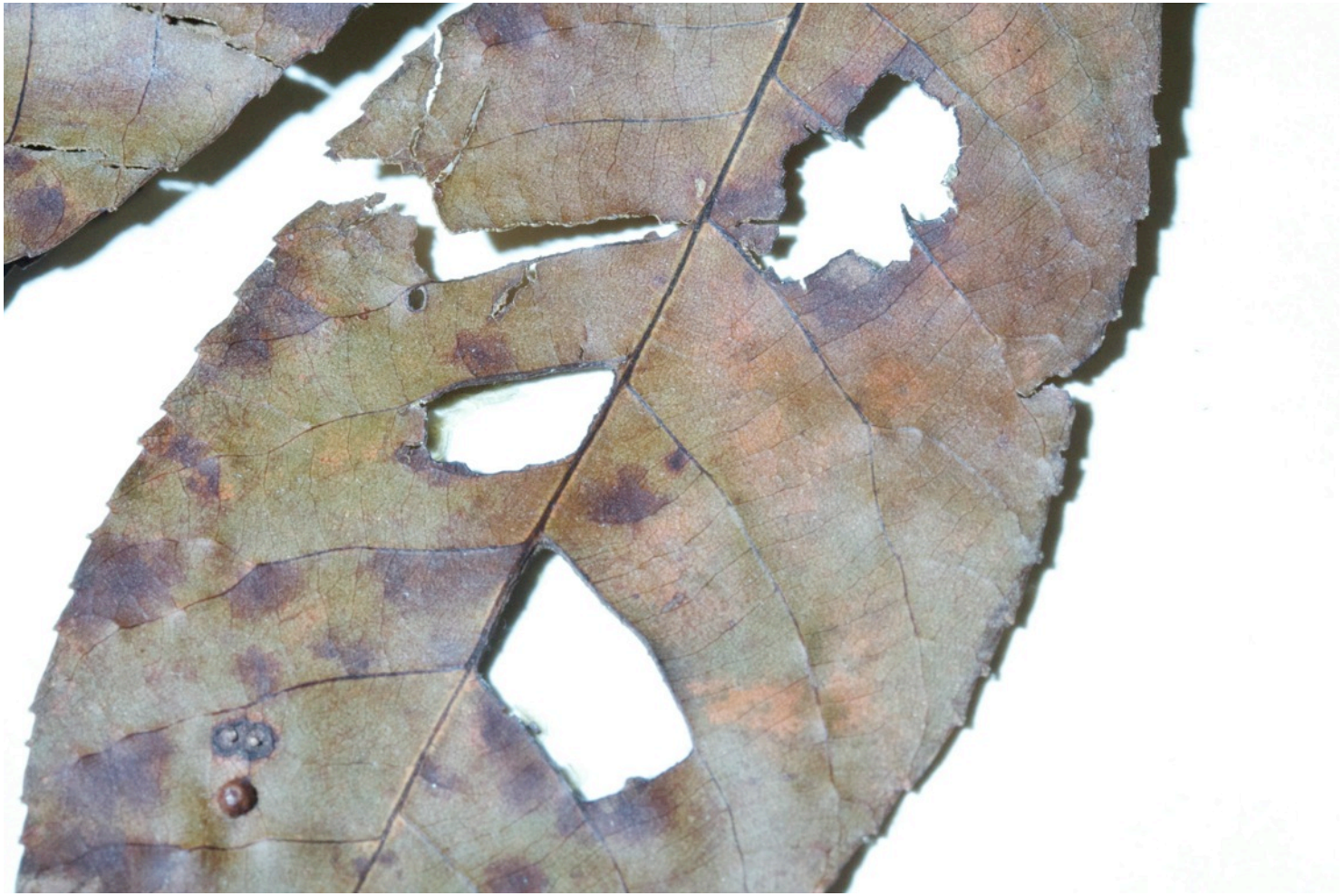


Results from 3 species



Challenges

Challenges



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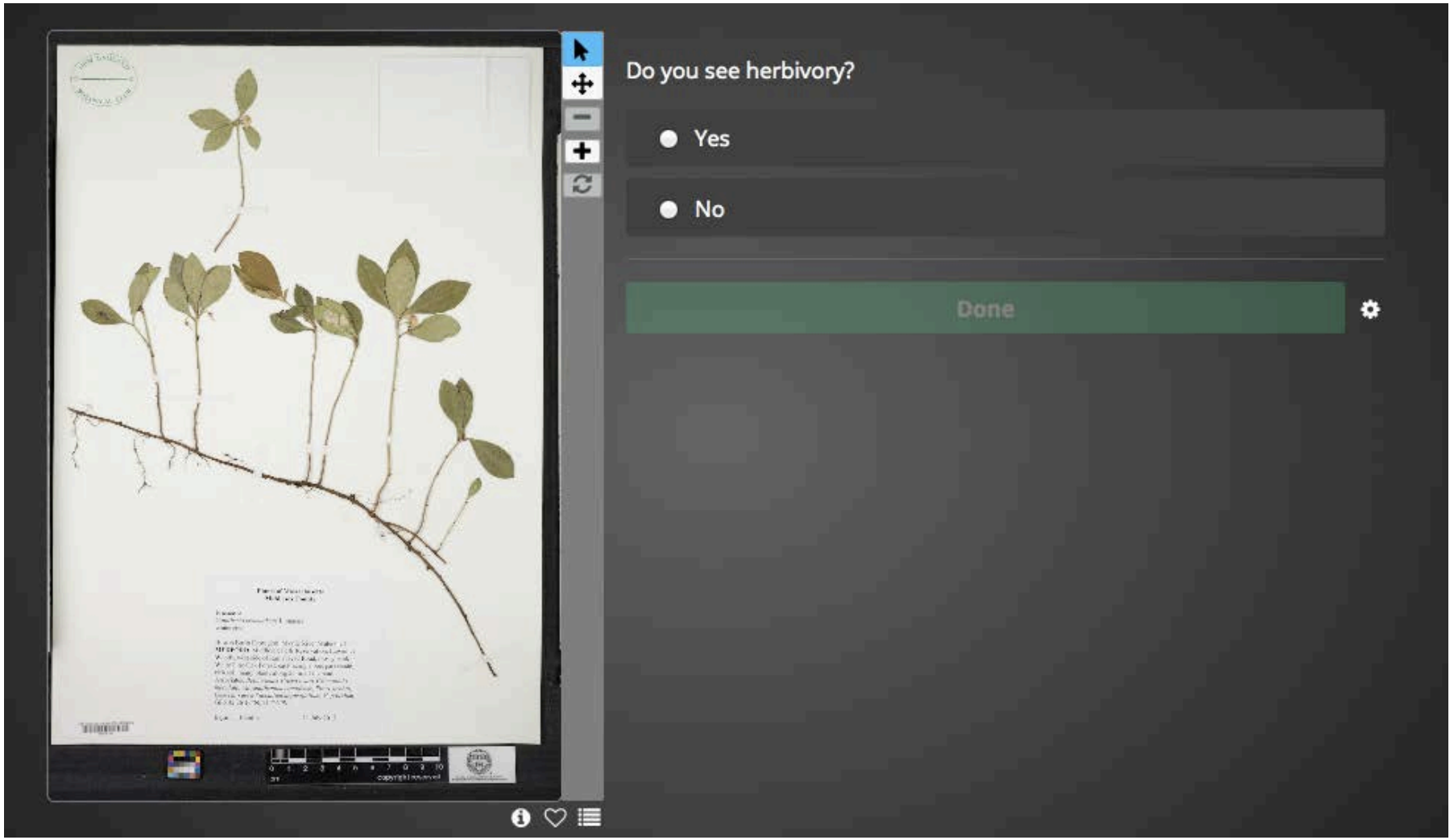
Natural history collections offer unique opportunities to connect people to natural history, the process of science, and climate change.

Source: naturalsciences.org

New Project based in Zooniverse: **Bite Marks**



Your Wild Life projects explore natural history on, in, and around humans.

Photos by Lauren Nichols


HERBARIUM OF CHARLES EDWARD FRIES
Galium circaezans Mx
Rhus Hill, Milton, Mass
copyright reserved


GRAY HERBARIUM
HARVARD
UNIVERSITY
Harvard University, Gray Herbarium (GH)
PLANTS OF MASSACHUSETTS
Ulmus americana L.
ULMACEAE
Tree 70ft tall, trunk diameter 3ft, crown-spread about 80ft, cultivated. Specimens made from fallen branches. Growing in sandy loam (Merrimac - urban-land complex, 0-8% slopes; sandy, mixed, mesic Typic Dystrudepts), in the northwestern portion of the Old Yard, Harvard University. Cambridge, Middlesex Co. Elev. about 26ft. 42° 22' 30.6"N, 71° 07' 01.8"W. UTM 19 325693E, 4693599N (NAD83/WGS84).
Coll. Doug Goldman #3780
24 April 2006
cm
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Collaborators

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Nate J. Sanders