Long-term collection records reveal phenological misalignment between Northern California plants and their pollinators

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Background

- Climate drives phenology in plants and pollinators

snowmelt

Theobald et al. 2017, Stemkovski et al. 2020, Weaver and Mallinger 2022

soil moisture

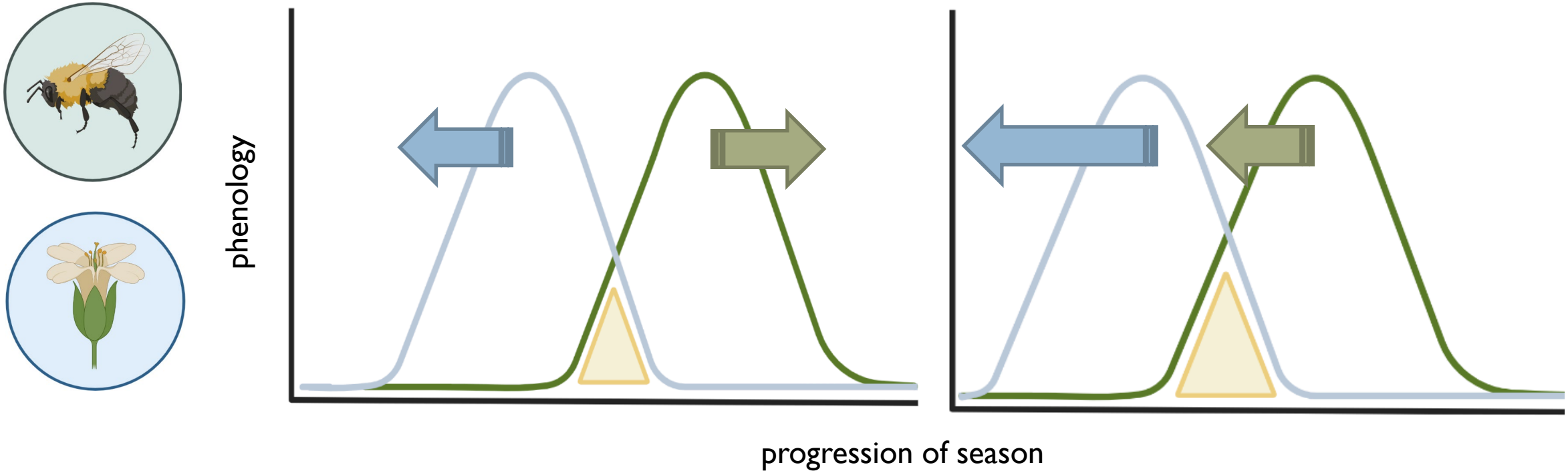
Olliff-Yang and Mesler 2018, Theobald et al. 2017

temperature

Buckley et al. 2022, Kehrberger and Holzschuh 2019, Ellwood et al. 2012

Background

- Differential climate-driven shifts in plant and pollinator phenology may cause development of mismatches in timing



Background

- Alpine and arctic habitats are especially sensitive to the warming effects of climate change.

- Intergovernmental Panel on Climate Change, 2014

Background

- Historically collected specimens can indicate long-term changes in phenology through their collection date

University of Idaho Stillinger Herbarium
Flora of the Payette National Forest
Advanced Field Botany 2016

Ipomopsis aggregata (Pursh) V.E. Grant ssp. *aggregata*
Det. by Laura Lampe, 14 Jul 2016. Fide: Flora of PNW.
Polemoniaceae

U.S.A., Idaho, Adams County:
Payette National Forest; Potato Knob; approximately 12 air miles west of Cascade; approximately 2 miles east of junction of Forest Road 243 and 214, on Forest Road 214. Elevation 1,753 m.

44.55529° N, 116.25816° W
Uncertainty: 100 m.; Datum: WGS 84; Source: GPS

Thin, dusty soil on basalt substrate; sparsely vegetated with ephemeral washes and dominated by Lomatium, Eriogonum, Allium, Sedum, and various Asteraceae.

Kyrstan Hubbel 2016-36 11 Jul 2016
with David Tank, Maribeth Latvis, Suzie Parker, Sara Winzer, Dayle Funka, Laura Lampe, Sarah Herzog, Marisa Anderson, Megan Ruffley, Grahm Johnson, Ian Gilman, Niels Mitchell

leaf material preserved in silica gel

Are there differences in the potential of alpine and lowland habitats to develop plant-pollinator phenological mismatches?

Hypothesis: *phenological shifts, and therefore potential for mismatches, are unique in the climatically-sensitive alpine communities of Northern California.*

Methods: The Data

Plants

Collection records from Northern California counties spanning up to 156 years

Well-collected taxa with short flowering periods

Consortium of California Herbaria (CCH2)

Erigeron pygmaeus

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Pollinators

Collection records from Northern California counties spanning up to 117 years

Bee taxa known to pollinate selected plants

Symbiota Collections of Arthropods Network (SCAN)

Lasioglossum sp., Image: Hennige

Methods: The Data

Records constrained by elevation:

Alpine: *minimum* 2700-3200 meters

Yosemite region, Tahoe region, Mt. Lassen, Mt. Shasta, Mt. Eddy

Lassen Peak

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Lowland: *maximum* 1500 meters

Foothills, valleys, and coastal regions of Northern California

Mt. Tamalpais

Methods: The Data

Records constrained by elevation:

Alpine: *minimum* 2700-3200 meters

Yosemite region, Tahoe region, Mt. Lassen, Mt. Shasta, Mt. Eddy

Plants: 339 specimens

Pollinators: 73 specimens

Lassen Peak

Lowland: *maximum* 1500 meters

Foothills, valleys, and coastal regions of Northern California

Plants: 963 specimens

Pollinators: 3,208 specimens

Mt. Tamalpais

Methods: Modeling Phenological Change

Collection DOY
(proxy for phenology)

explained by

→ **collection year**
→ latitude
→ elevation

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Habitat-wide models pool data across taxa
Compare slopes across habitats and plants and pollinator groups

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Collection DOY
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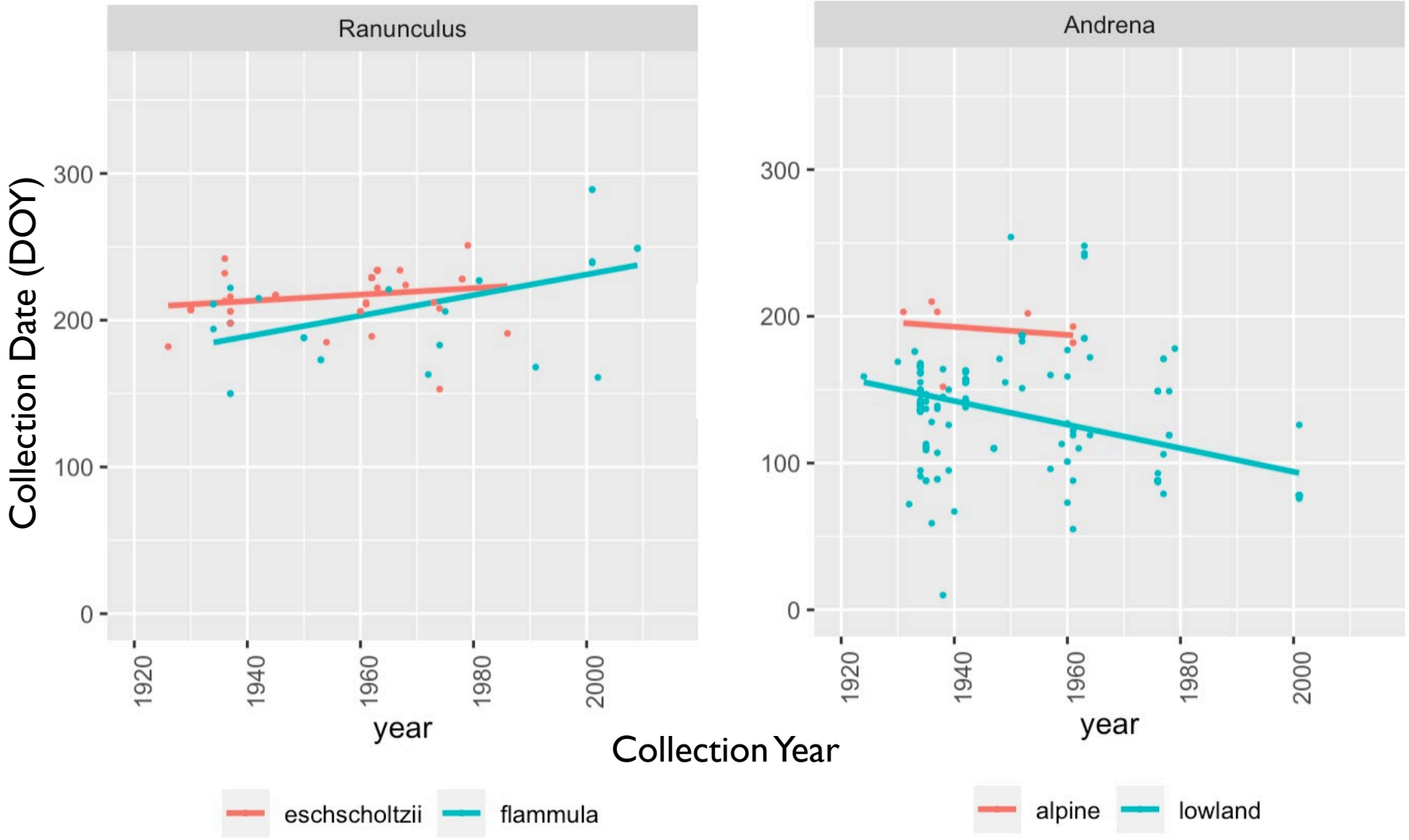
Habitat-wide models pool data across taxa
Compare slopes across habitats and plants and pollinator groups

Interspecific models compare trends among taxa
Including testing for independent contrasts

Methods: Modeling Phenological Change



Results: Comparing Phenological Change

95% CIs of slopes, or **shift in collection dates** (phenology) in **days per year**

	Alpine	Lowland
Plants	[-0.102, 0.074] **No phenological change**	
Pollinators		

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95% CIs of slopes, or **shift in collection dates** (phenology) in **days per year**

	Alpine	Lowland
Plants	[-0.102, 0.074] **No phenological change**	
Pollinators	[-0.034, 0.624] **No phenological change**	

Results: Comparing Phenological Change

95% CIs of slopes, or **shift in collection dates** (phenology) in **days per year**

	Alpine	Lowland
Plants	[-0.102, 0.074] **No phenological change**	[-0.142, -0.010] **Phenological advances** (21 – 2 days over 156 years)
Pollinators	[-0.034, 0.624] **No phenological change**	

Results: Comparing Phenological Change

95% CIs of slopes, or **shift in collection dates** (phenology) in **days per year**

	Alpine	Lowland
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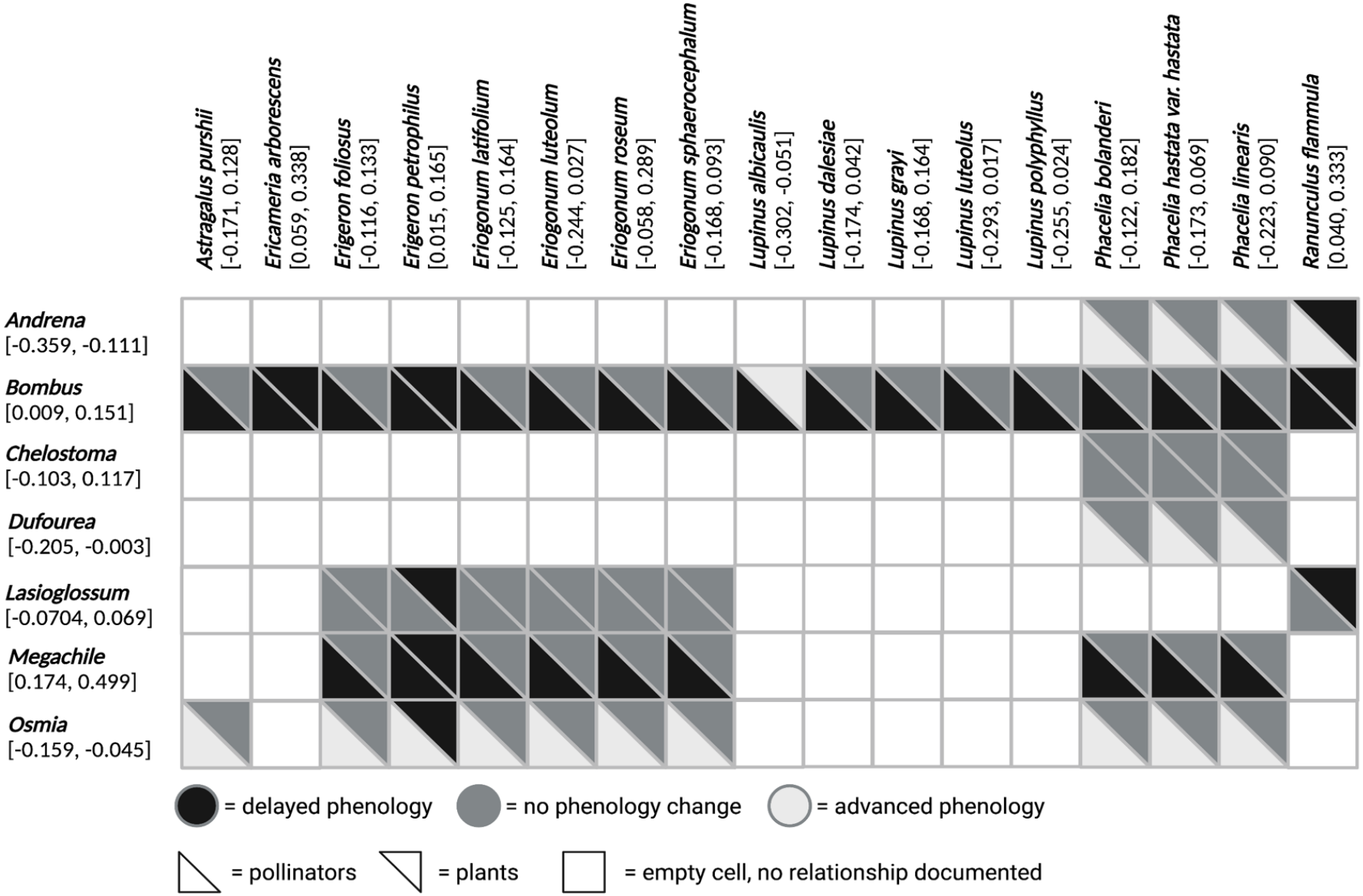
Pollinators	[-0.034, 0.624] **No phenological change**	[-0.476, -0.330] **Phenological advances** (56 - 39 days in 117 years)

Results: Comparing Phenological Change: *Lowland Taxa*



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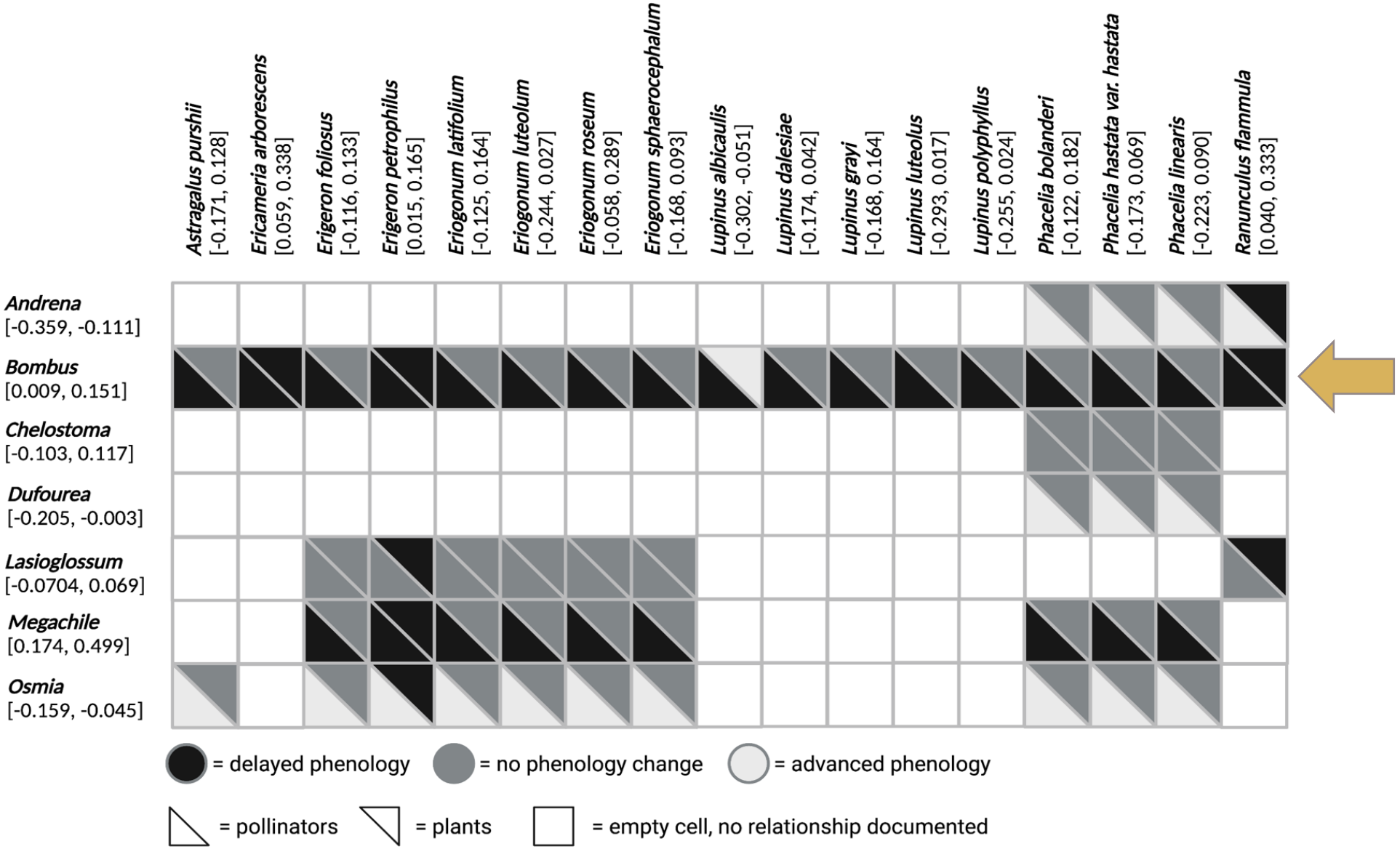

Field Validation of Model Results

- Models accurately predicted peak flowering for 13 **(72.2%)** of the 18 plant taxa visited
- Eight taxa could not be visited due to COVID-19 travel restrictions, 2021 wildfires, alpine thunderstorms, etc.

Conclusions in Context

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Hypothesis: phenological shifts, and therefore potential for mismatches, are unique in the climatically-sensitive alpine communities of Northern California.

→ Contrary to the hypothesis, there is no evidence for unique Northern Californian alpine phenology changes;

→ Lowland habitats show greater potential for mismatches.

Conclusions in Context

Lowland Phenology

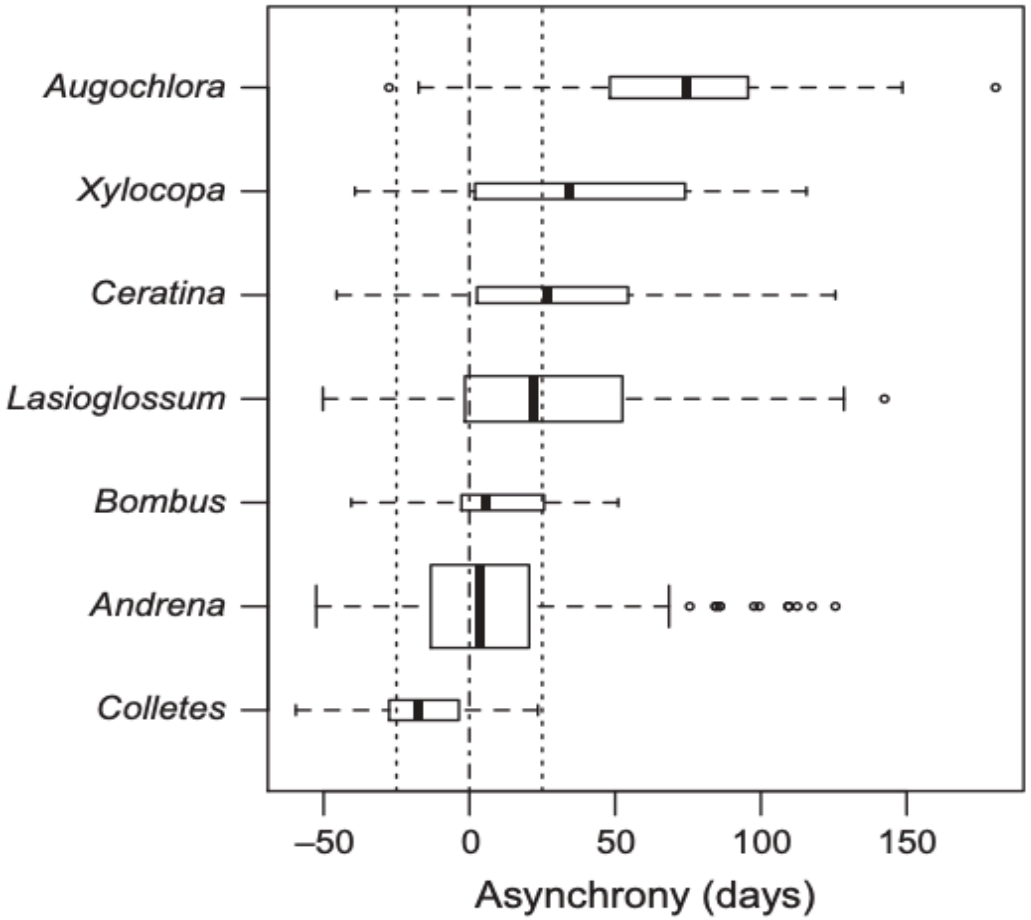
- Lowland habitats of Northern California show greater potential for phenological mismatches
- Specialists or taxa dependent on generalist taxa such as *Bombus* (out of synchrony with most plant taxa studied) may be at particular risk
- High lowland biodiversity may buffer mismatch effects

Phacelia bolanderi

Conclusions in Context

Buffering via Biodiversity

Bartomeus 2013



Phacelia bolanderi

Conclusions in Context

Alpine Phenology

- No evidence for phenological change or risk of mismatch in Northern California's alpine habitat
- Contrary to existing studies, which have found alpine phenological advances with climate change
- Greater availability of alpine collection records would allow for comparison of phenological changes among alpine taxa

Astragalus purshii

Conclusions in Context

Future Directions

- Monitoring effects of climate change in California's White Mountains began have begun
- Other existing studies that compare long-term plant and pollinator phenology changes across habitats are limited
- Understanding climate-related community reorganization will help predict ecological consequences

Near Gardisky Lake

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