Flowering phenology response to climate warming in the Pacific Northwest

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Global climate warming (Sockler 2013) corresponds to shifting phonologies across many organisms during the past century.

- Spring phenologies have advanced 2.3 days per decade (Parmesan & Yohe 2003)
• Shifts depend on temporal and geographic positions
• Greater advances at high latitudes
• Earlier flowering species more sensitive to warming

Plant Responses

![Graph showing change in spring phenology](image-url)

- Early-spring
- Fall

<table>
<thead>
<tr>
<th>Change in spring phenology (days per decade)</th>
<th>Sensitivity (Δ days per ℃)</th>
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</thead>
<tbody>
<tr>
<td>0</td>
<td>Early-spring</td>
</tr>
<tr>
<td>-15</td>
<td>Fall</td>
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</tbody>
</table>

adapted from Parmesan 2007

adapted from Wolkovich et al. 2012
Herbarium specimens

- Can be used to examine flowering phenology (via collection date of flowering specimens) over long periods of time and broad geographic gradients

- For broad geographic scales it is important to pair collection data with climate data
In this study we investigated if species found in the Pacific Northwest (PNW) have flowering phenologies that are sensitive to climate warming.
Hypotheses

- Day of collection (proxy for flowering phenology) of species across the Pacific Northwest is sensitive to spring temperatures
  - i.e. warmer springs → earlier collection dates
- Sensitivity will vary depending on flowering date and geographic range position (elevation, latitude and longitude)
Methods: Target species

• 1901-2015 collection dates and locations for herbs and shrubs were gathered from the Consortium of Pacific Northwest Herbaria

• Targeted species have conspicuous flowers

• At least 100 flowering specimens per species
Methods: Climate data

- Climate data from ClimateNA_MAP (Wang et al. 2016):
  - collection location
  - year of collection
  - 1960-1990 means for that location
Methods: Determining responses

- Sensitivity to temperature

  mean spring temp. at collection location
  − mean 1960-1990 spring temp.
  Temp. anomaly

- spring: three months preceding mean species collection date

- Use linear regression (day of year vs. anomaly) to determine species’ sensitivity to temperature
Results: Our dataset

- 8,540 specimens
- 39 species
- Mean collection dates
  - May 21 to August 12
Results: Regional temperatures (1901-2015)

- Study region temperatures increased 0.1°C/decade

p<0.001
R²=0.17
Results: Sensitivity to spring temperatures

- 28 out of 39 species are sensitive (p<0.05) to spring temperatures
- Day of collection changed between +0.3 and -9.3 days per 1°C increase in spring temperature
Early bloomers more sensitive to temperature

- Sensitivity to spring temperature decreases 1.4 days for every 30 day delay in mean flowering date

\[ p=0.005 \]
\[ R^2=0.19 \]
Coastal species more sensitive to temperature

- Sensitivity to spring temperature decreases 0.9 days per 1° longitude

\[ p < 0.001, \quad R^2 = 0.29 \]
• Earlier flowering species are more sensitive to warming (Wolkovich et al. 2012)

• Spring “starts” earlier in the western part of the PNW

• Species near the coast flower earlier and therefore are more sensitive to warming temperatures
Going forward

- Longitudinal gradients in coastal regions deserve more attention, especially concerning phenology and climate change.
- With digitization, we can go bigger with more!
Questions?


