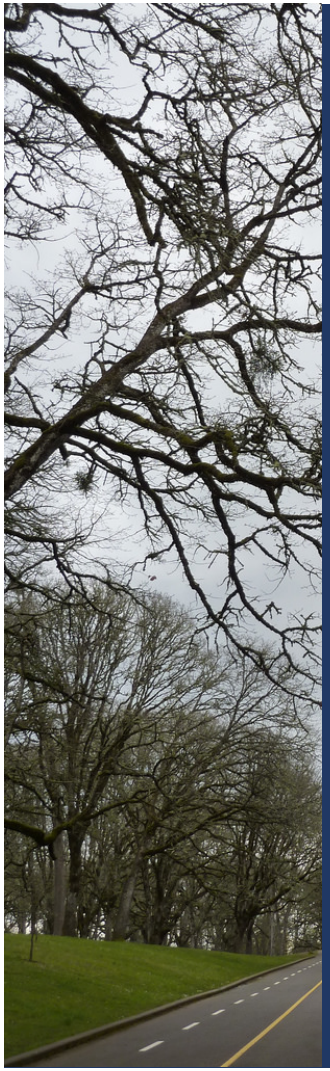

Response of urban plant phenology to anthropogenic climate change and natural climate oscillation

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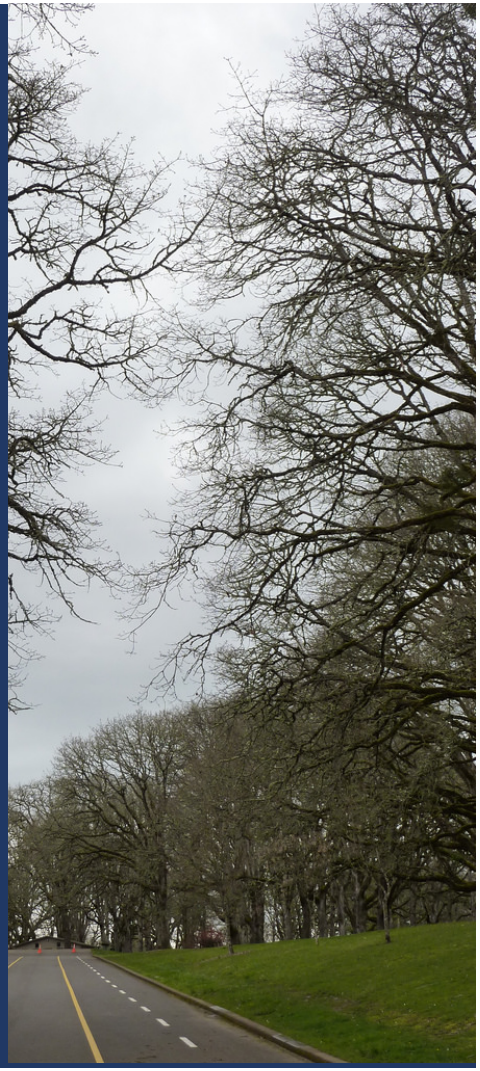
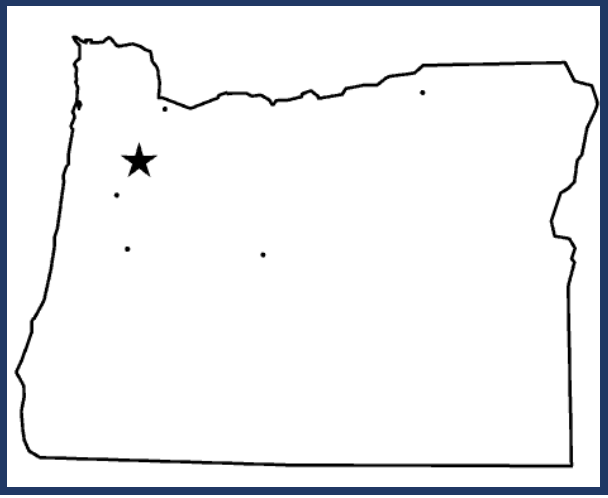
Kees McGahan
University of Utah

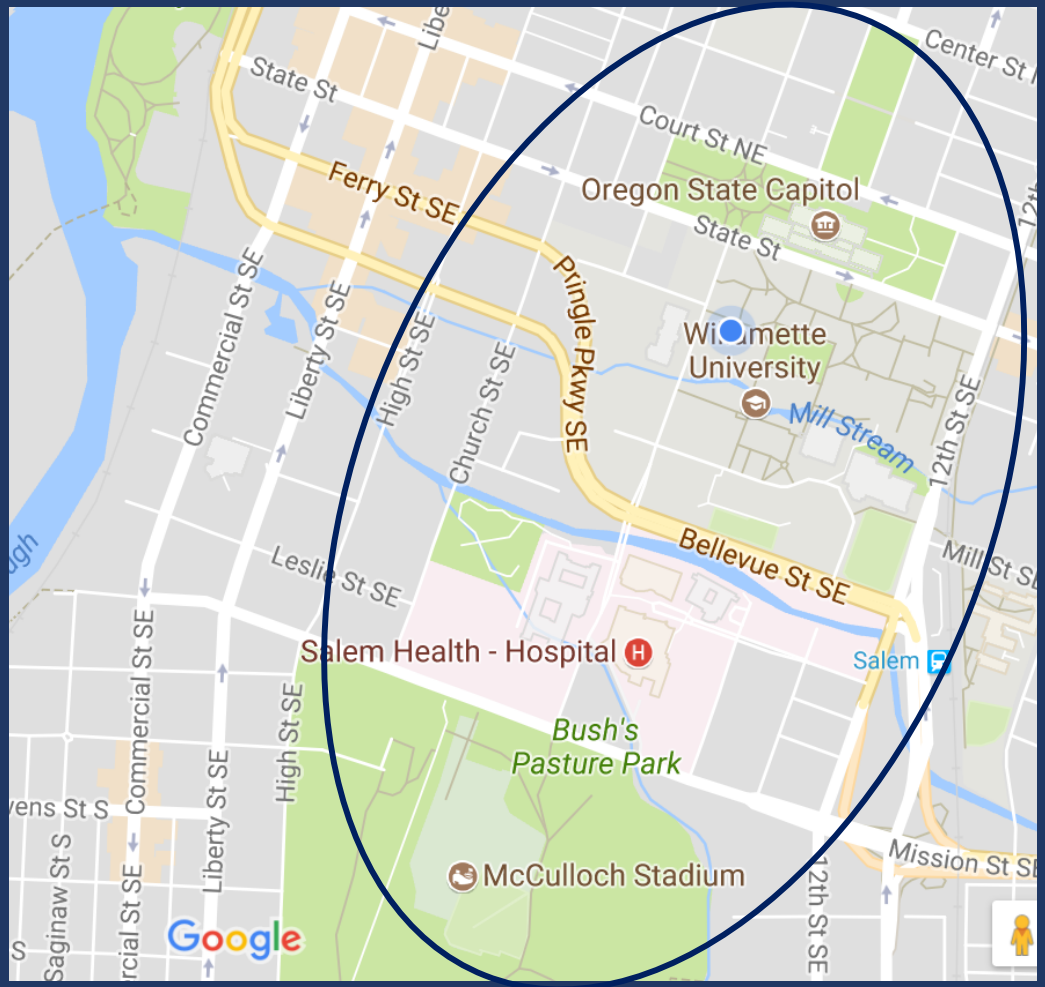
Wilbur Bluhm
Salem, OR



Study site: Salem, Oregon

Bush's Pasture Park
Willamette University
Oregon State Capitol





- Bush's Pasture Park
- 90 acres
- Remnant oak savanna and riparian forest
- Proximity of natural area to urban center and University makes citizen science possible.

Methods

- Legacy phenology dataset collected in urban parks by trained horticulturist Wilbur Bluhm.
- 1959-2016

Acer campestre starting fall color

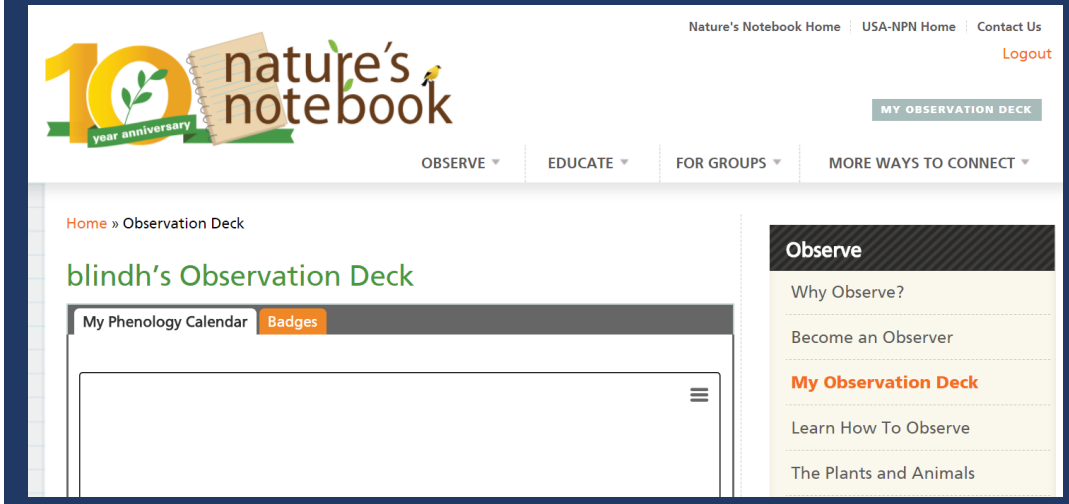
Wilbur Bluhm walked same route twice a week and estimated phenological events to the day.

Epilobium canum started flower a week ago

Ribes sanguineum started fall color two days ago

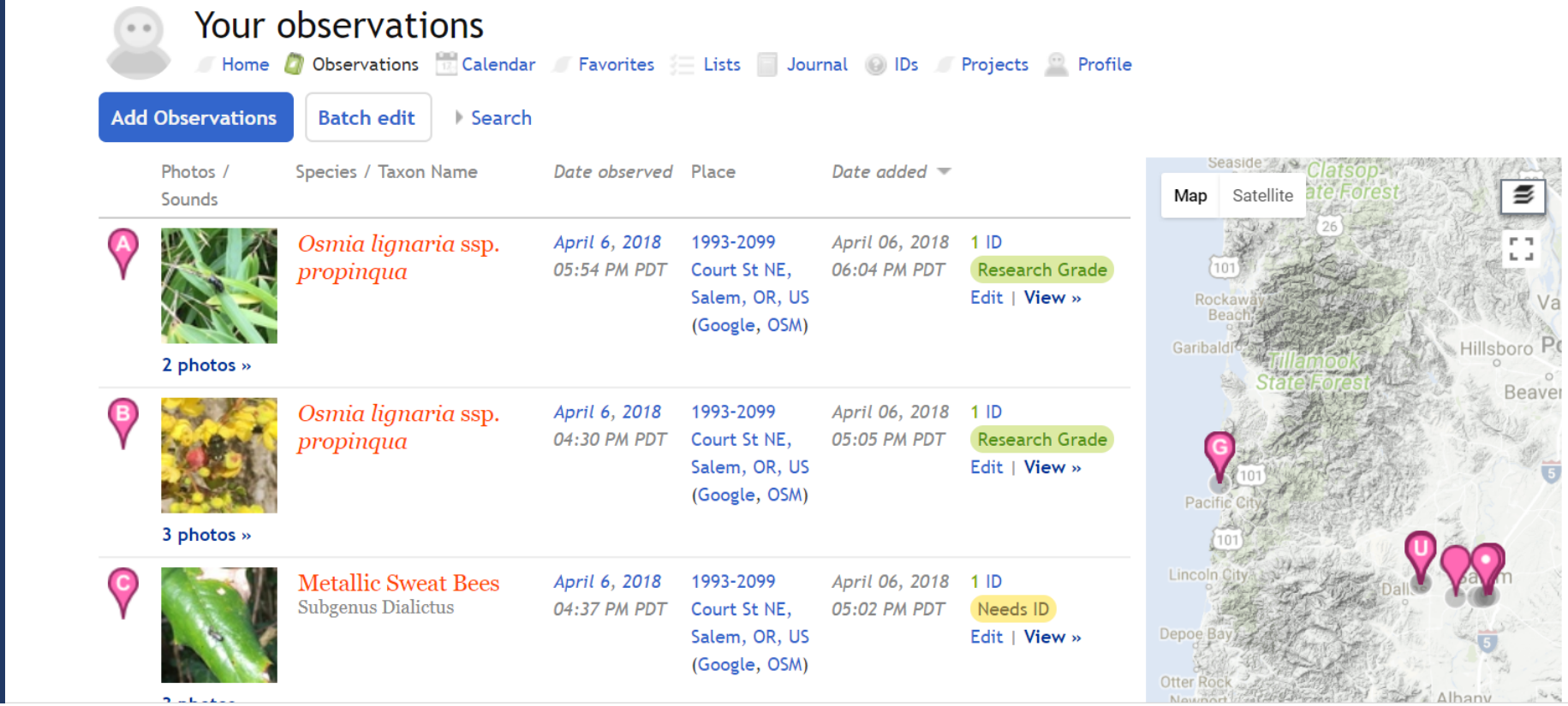
	1959-2016 58 year dataset	1996-2016 21 year dataset
Number of species	115	607
	Number of species per event	
Start leaf	71	367
Start flower	46	773
Maximum flower	37	57
Flower end		451
Start fall color		369
Defoliation		280
Total species-events	154	2298

Continued data collection National Phenology Network Weekly



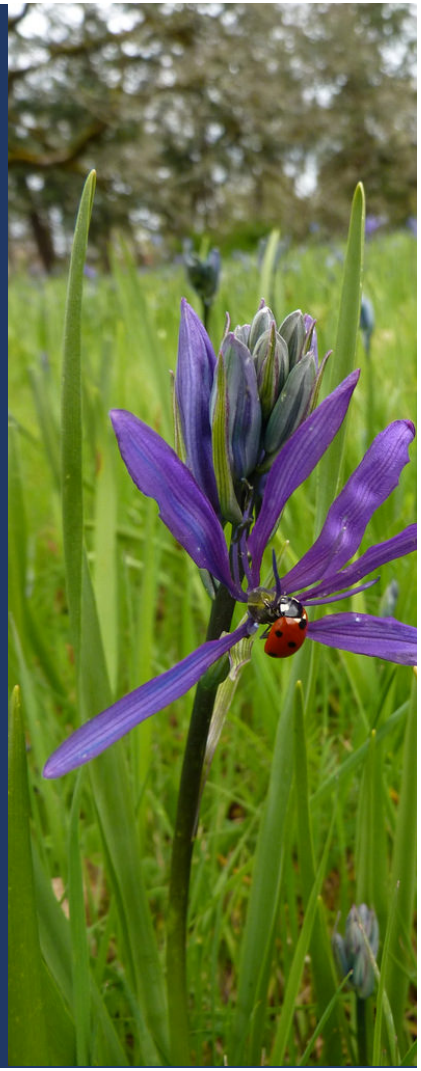
	02/06/2018	Circle all no Delete
Do you see **breaking leaf buds?**	Y (N) ?	What value?
Do you see **leaves?**	Y (N) ?	What value?
Do you see **increasing leaf size?**	Y (N) ?	What value?
Do you see **colored leaves?**	Y (N) ?	What value?
Do you see **falling leaves?**	Y (N) ?	
Do you see **flowers or flower buds?**	Y (N) ?	What value?
Do you see **open flowers?**	Y (N) ?	What value?
Do you see **pollen release?**	Y (N) ?	What value?
Do you see **fruits?**	Y (N) ?	What value?
Do you see **ripe fruits?**	Y (N) ?	What value?
Do you see **recent fruit or seed drop?**	Y (N) ?	What value?

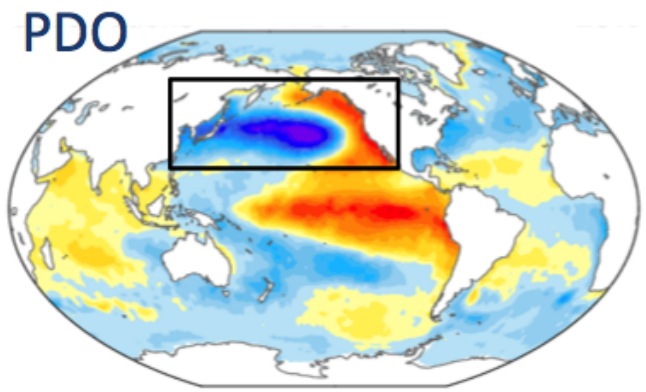
iNaturalist for insect floral visitors and herbivores

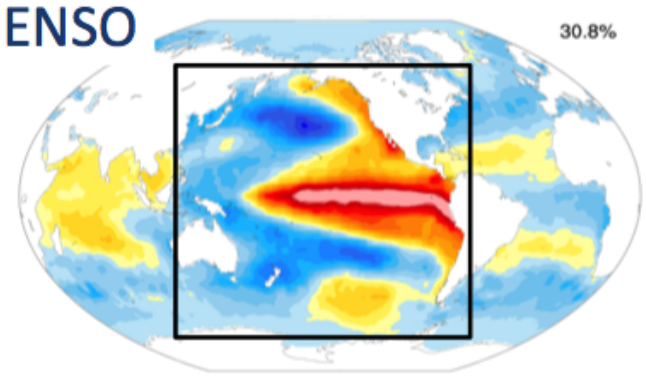


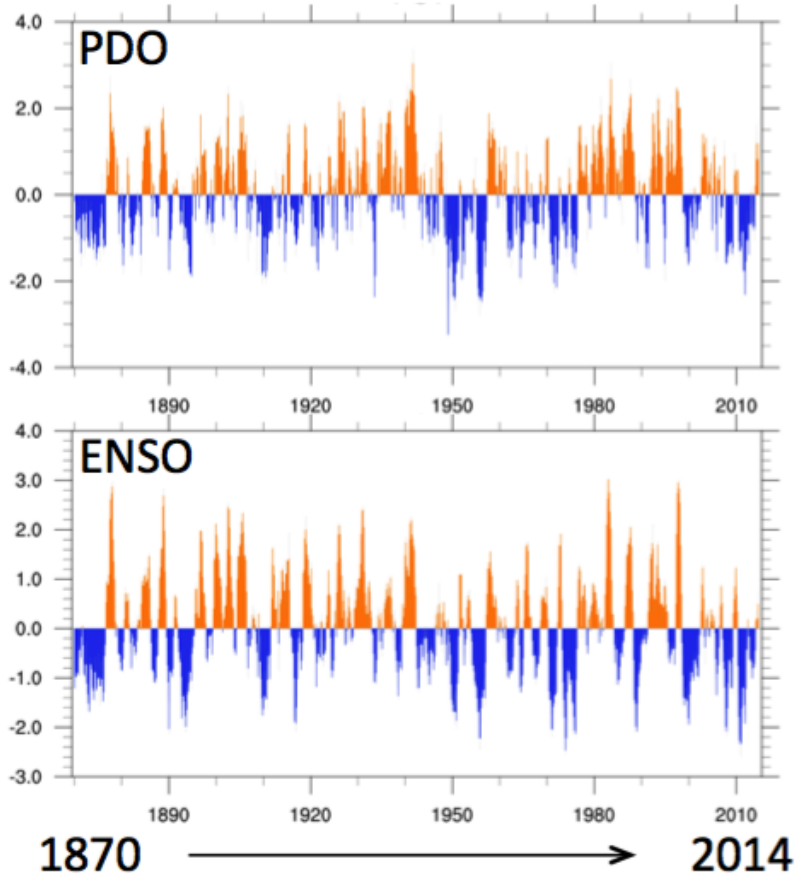
Background

- Long-term legacy phenology datasets show that first flowering dates are advancing by up to 5 days per decade in some locations.
- Previously no legacy datasets for Pacific Northwest.
- The Pacific Northwest of the US has warmed 0.7 ^{o}C in 100 years.
- Strong natural temperature variation correlated with the Pacific Decadal Oscillation (PDO).



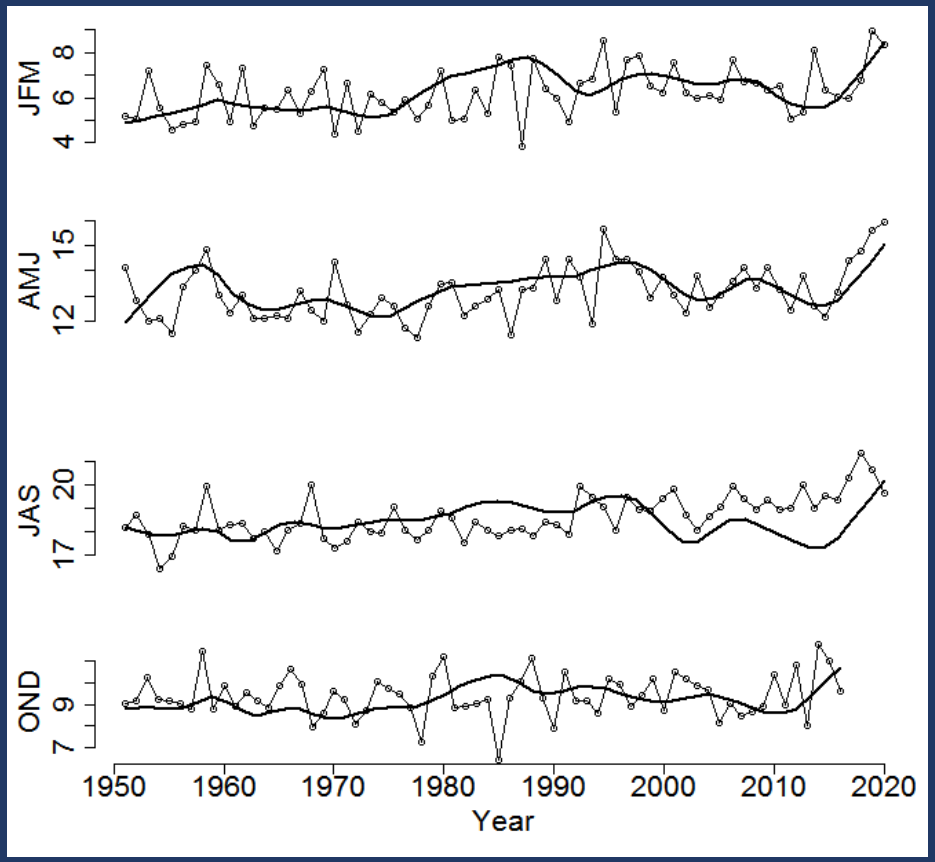






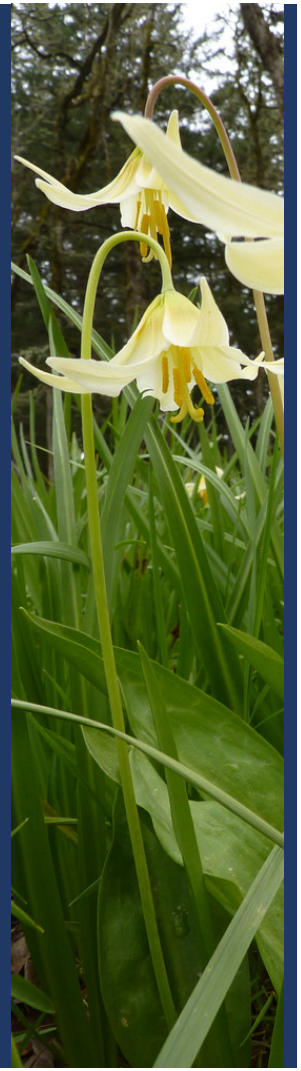
2010**	0.83
2011**	-0.92
2012**	-1.38
2013**	-0.13
2014**	0.3
2015**	2.45
2016**	1.53
2017**	0.77
2018**	0.7

Average seasonal temperature (points) and PDO index (smoothed curve)



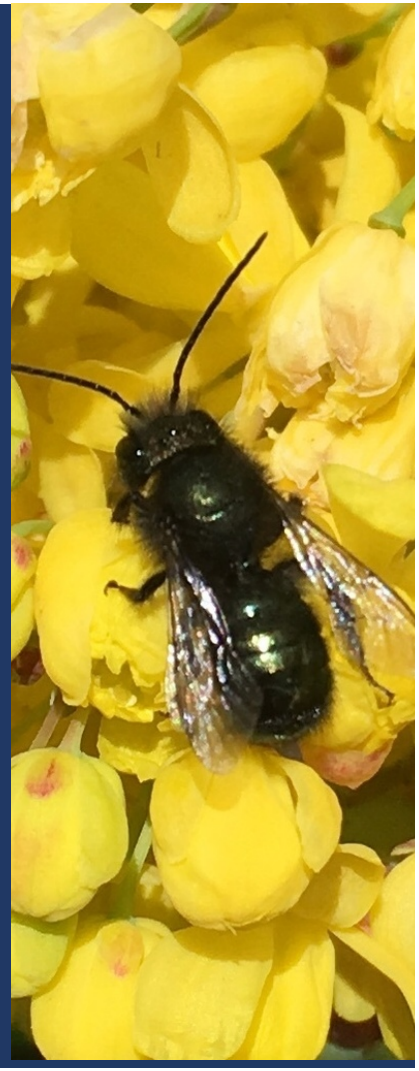
Winter, spring and summer temperature increased 0.2-0.3 °C per decade ($p<0.004$).

Fall no change $p=0.22$



Study goals

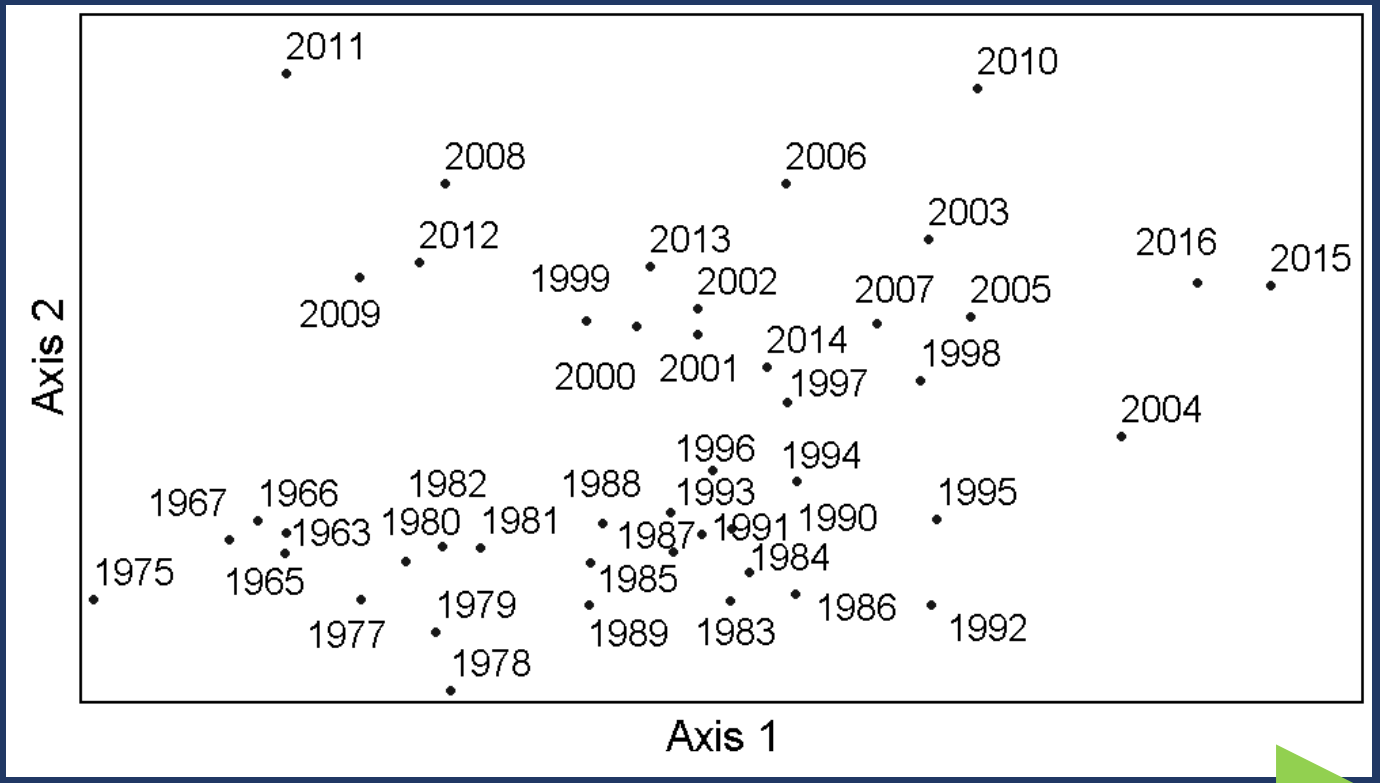
- Test whether the phenology of urban plant community in the Pacific Northwest has been exhibiting directional or just oscillating changes in phenology.
- Focus on how natives are responding.
- Involve students in monitoring phenology of plants and associated insects.



Osmia lignaria

NMS ordination of years in terms of phenology

1959-2016,
154 species-events

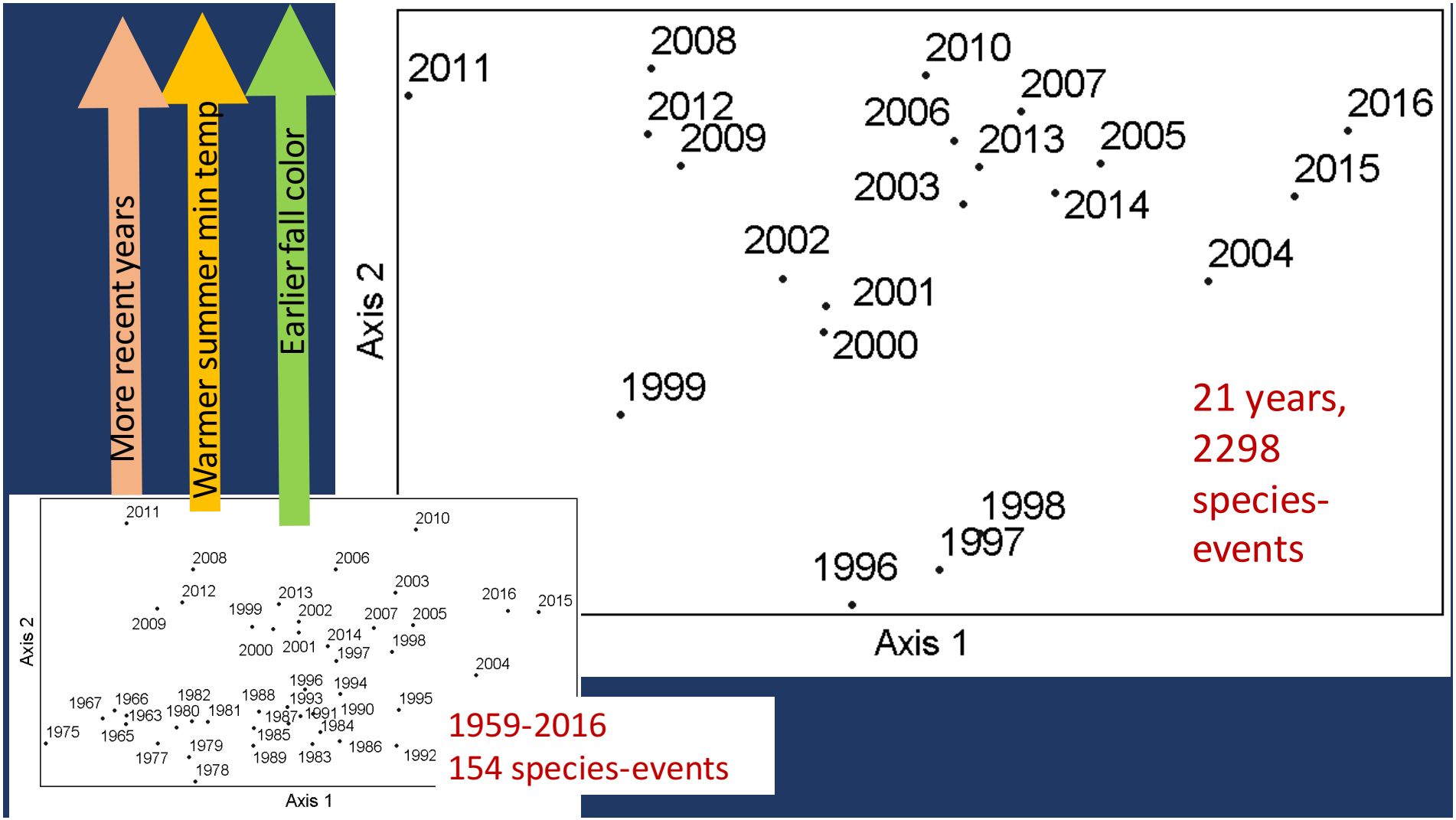


Earlier spring start leaf and flower

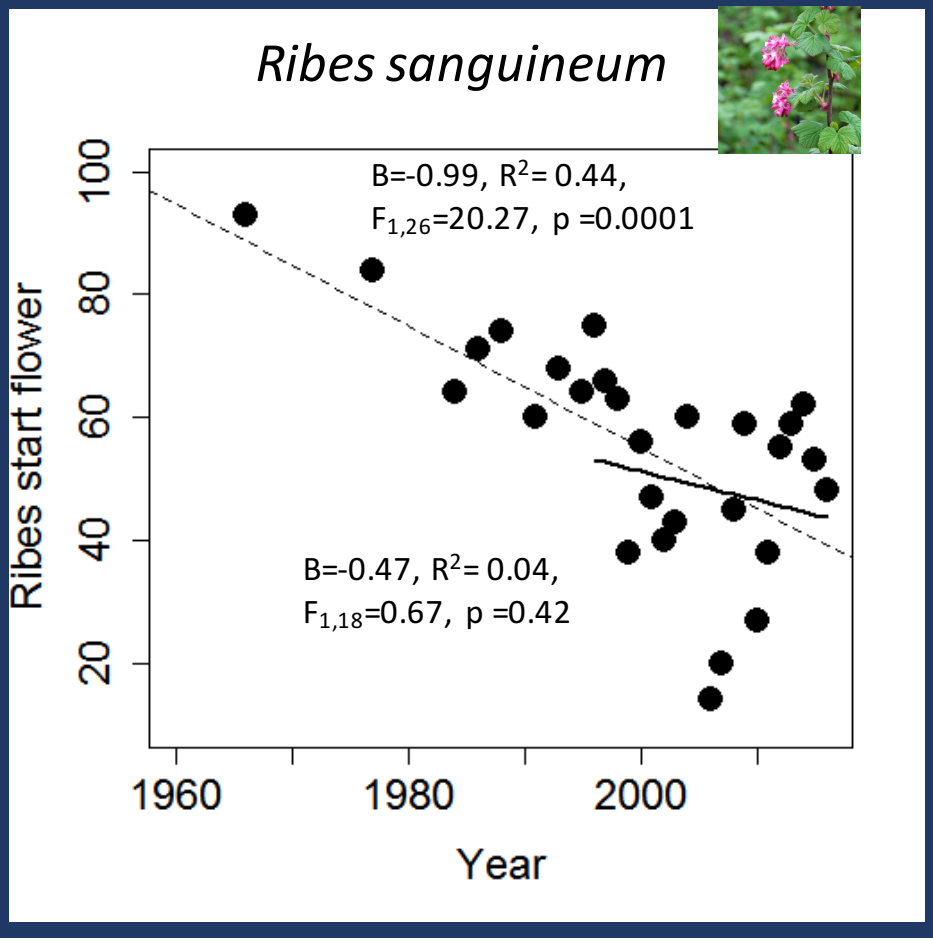
Warmer winter/spring average temperature

Higher PDO index

More recent years

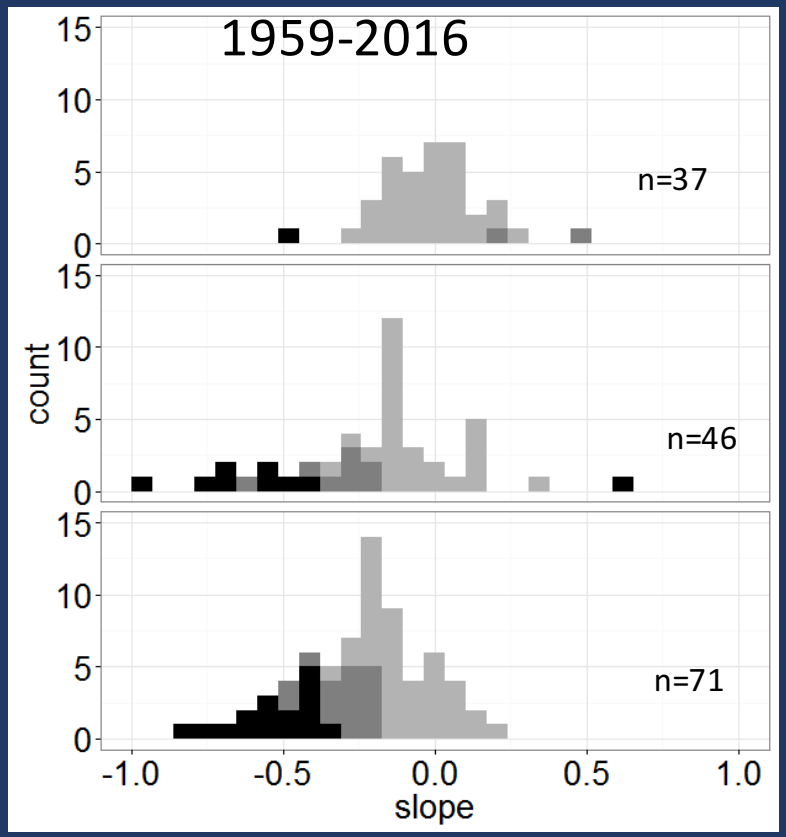

More recent years
Warmer summer min temp
Earlier fall color
Axis 2
Axis 1
2011
2008
2010
2012
2006
2007
2016
2009
2013
2005
2015
2003
2014
2002
2004
2001
2000
1999
1998
1997
1996
21 years,
2298
species-
events
1959-2016
154 species-events

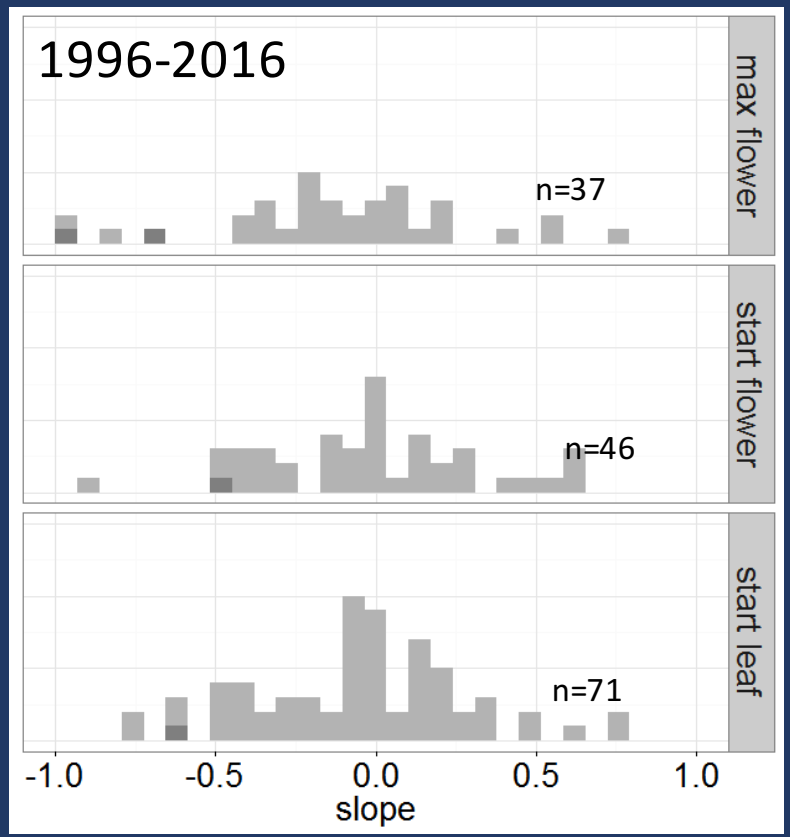
Change in phenology over time



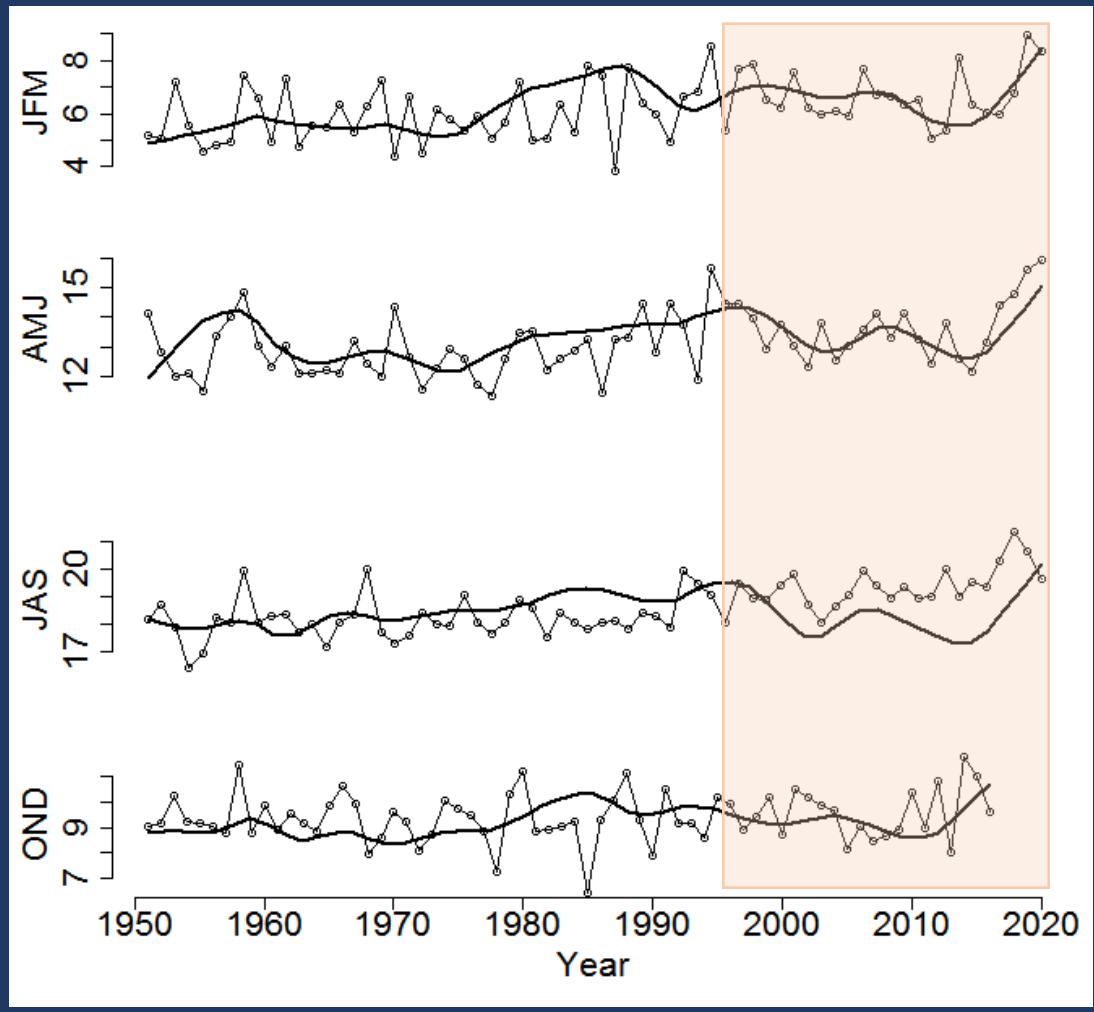
Bombus vosnesenskii

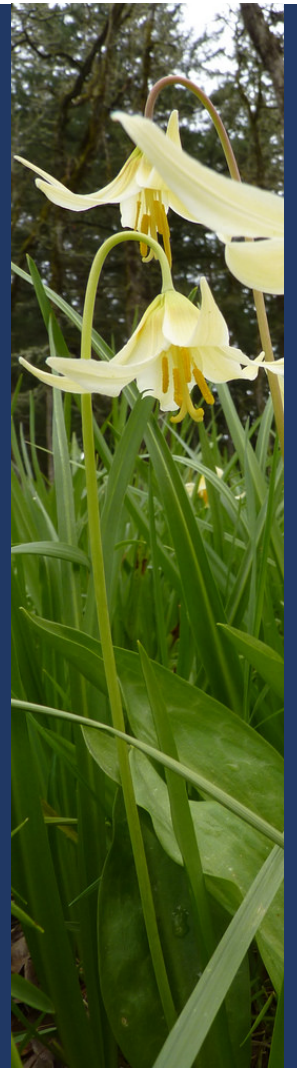
Distribution of slopes of phenological events over time



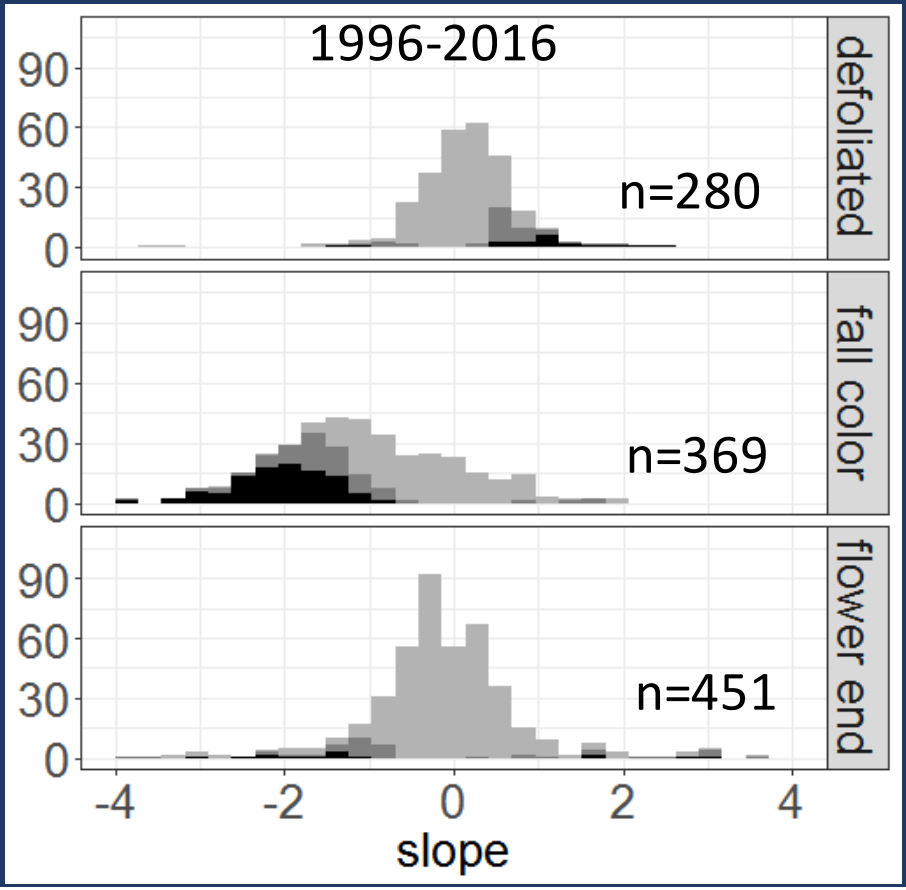


Average seasonal temperature (points) and PDO index (smoothed curve)

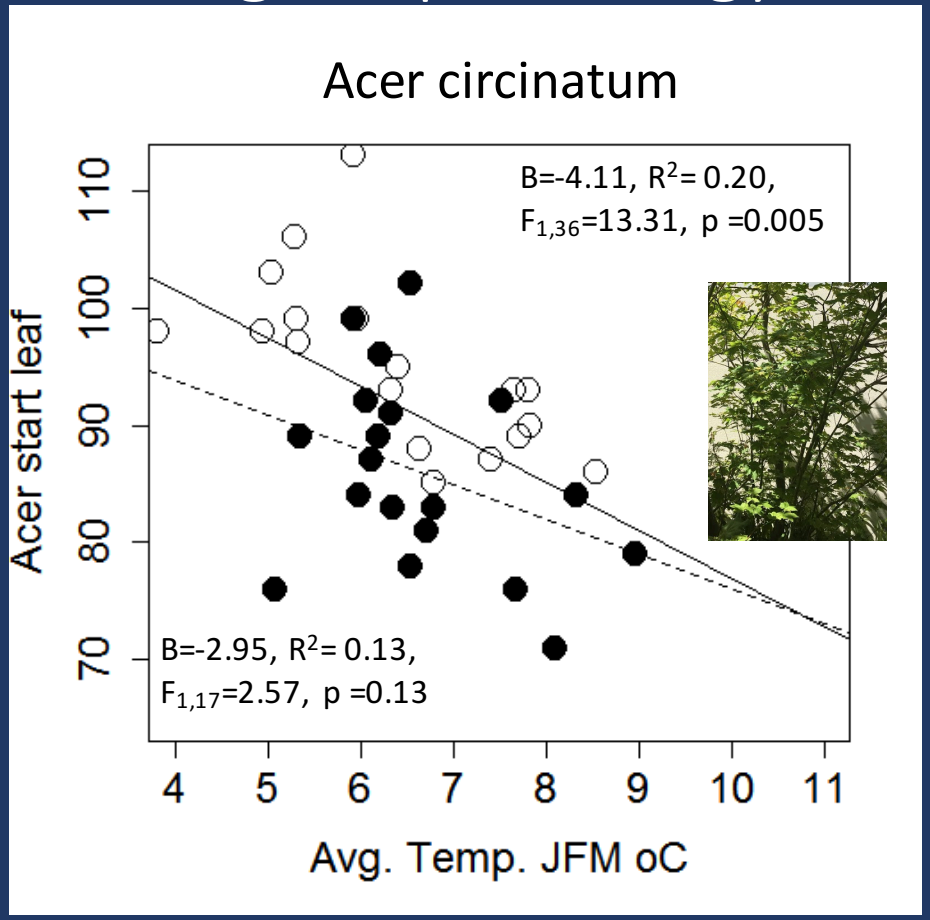


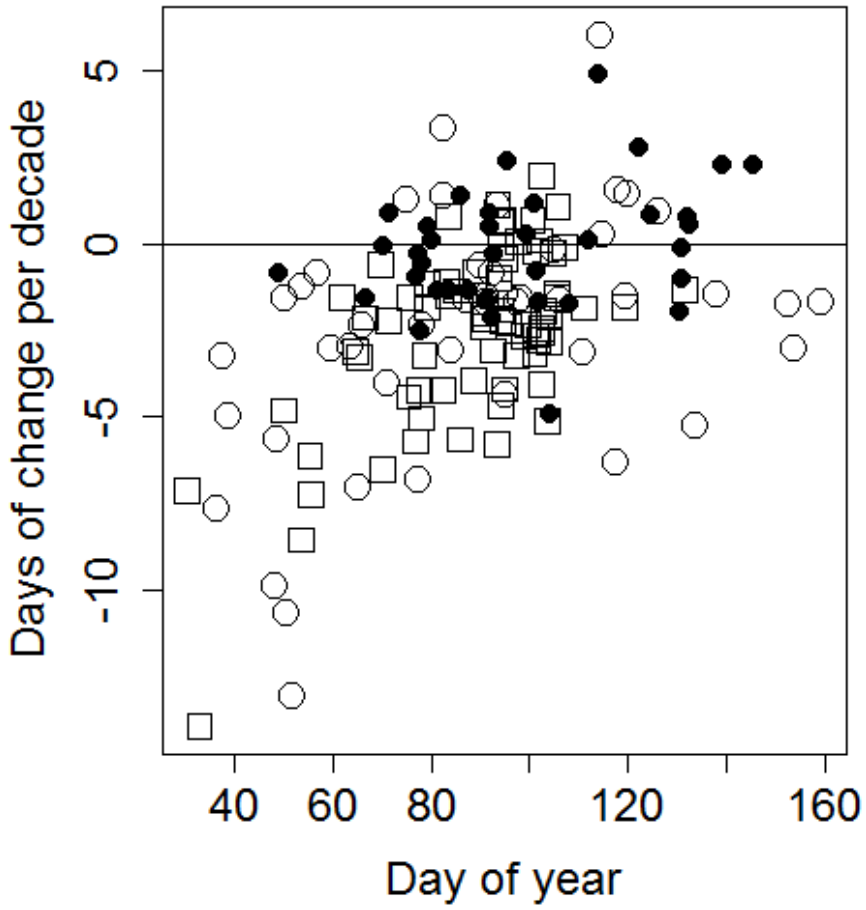


Slopes of phenological events versus time

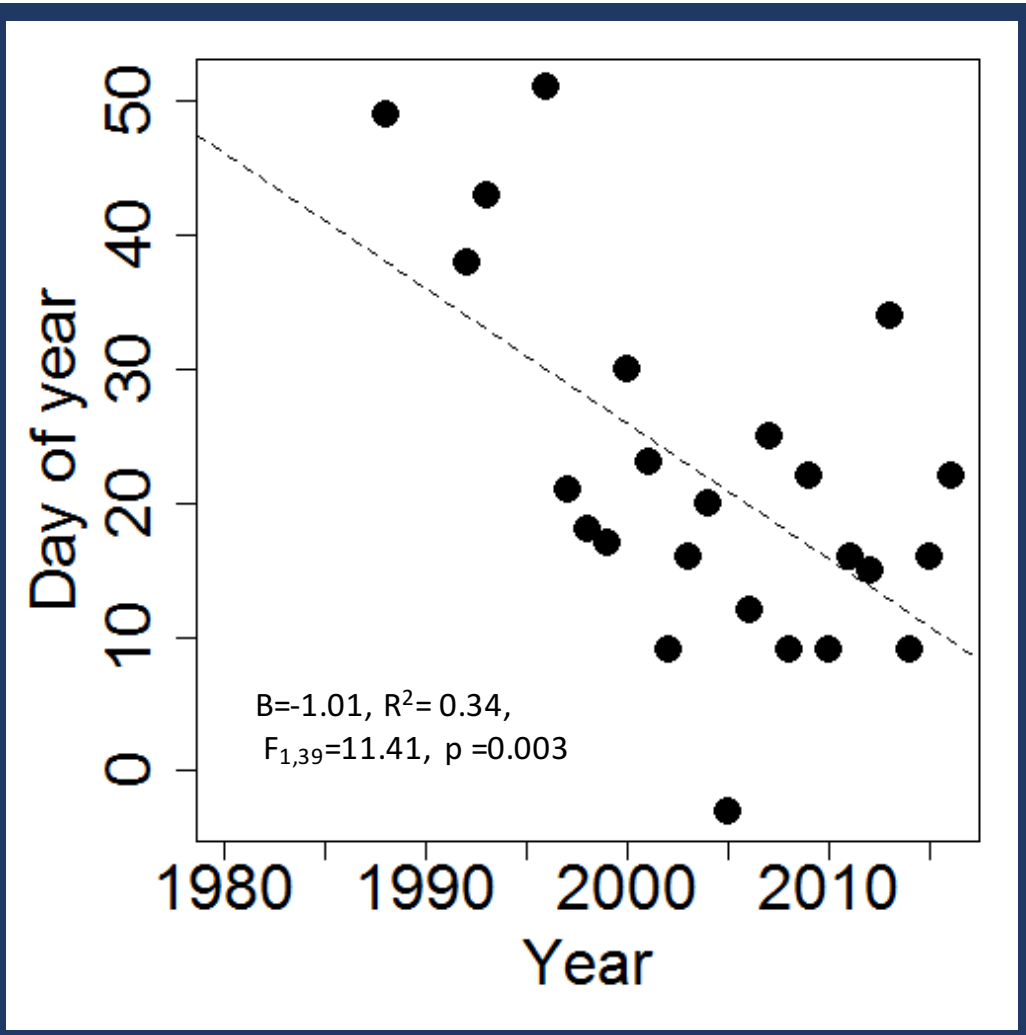


Change in phenology versus temperature





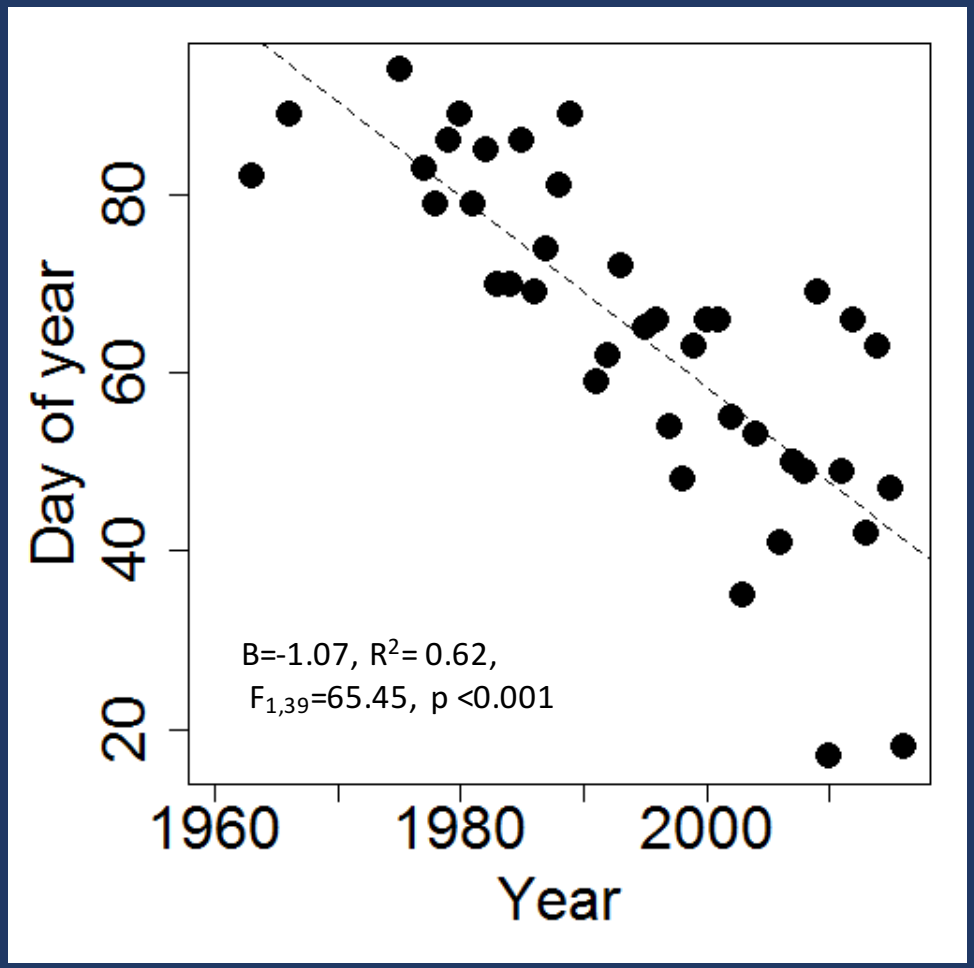
Change in phenology over time (days per decade) for 154 individual species-events versus average day of the year that the phenological event occurred. Empty squares = first leaf. Empty circles = first flower. Filled circles = maximum flower.



Oemleria cerasiformis

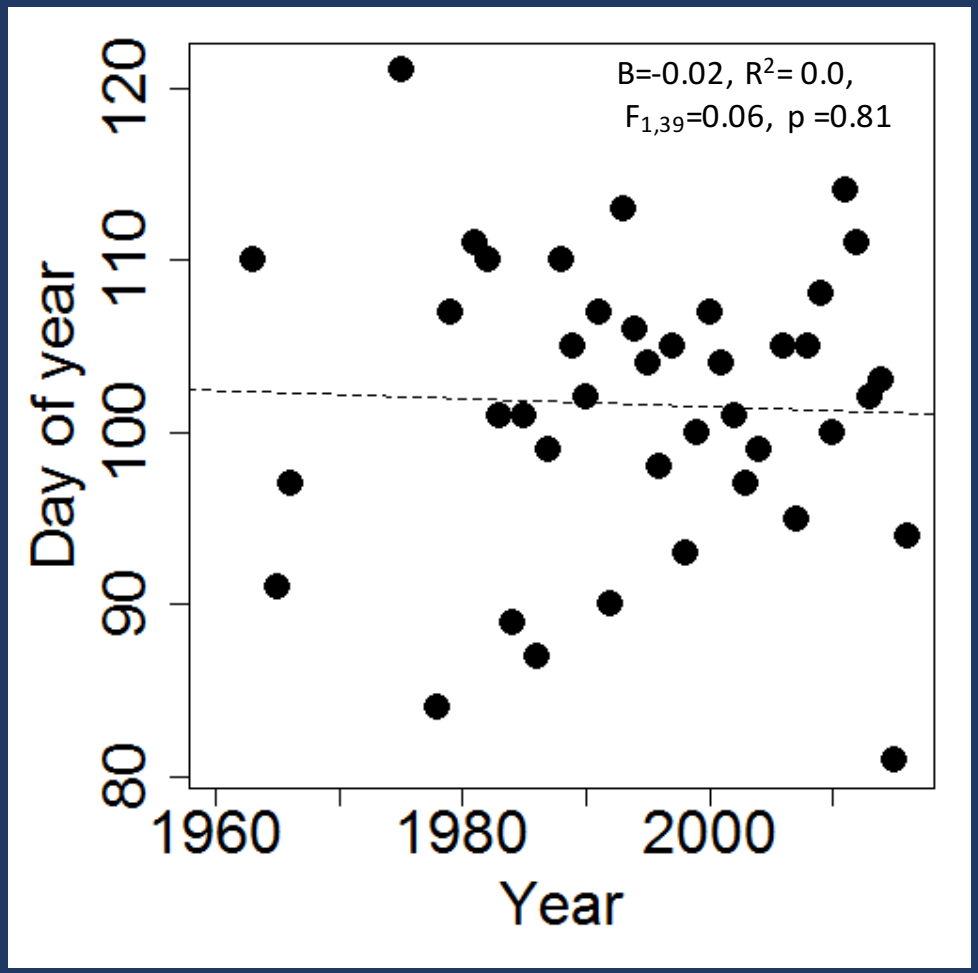
Osoberry

Start leaf

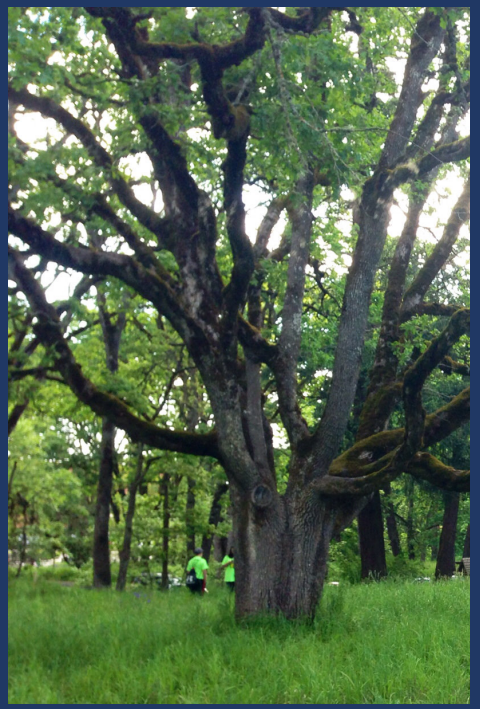


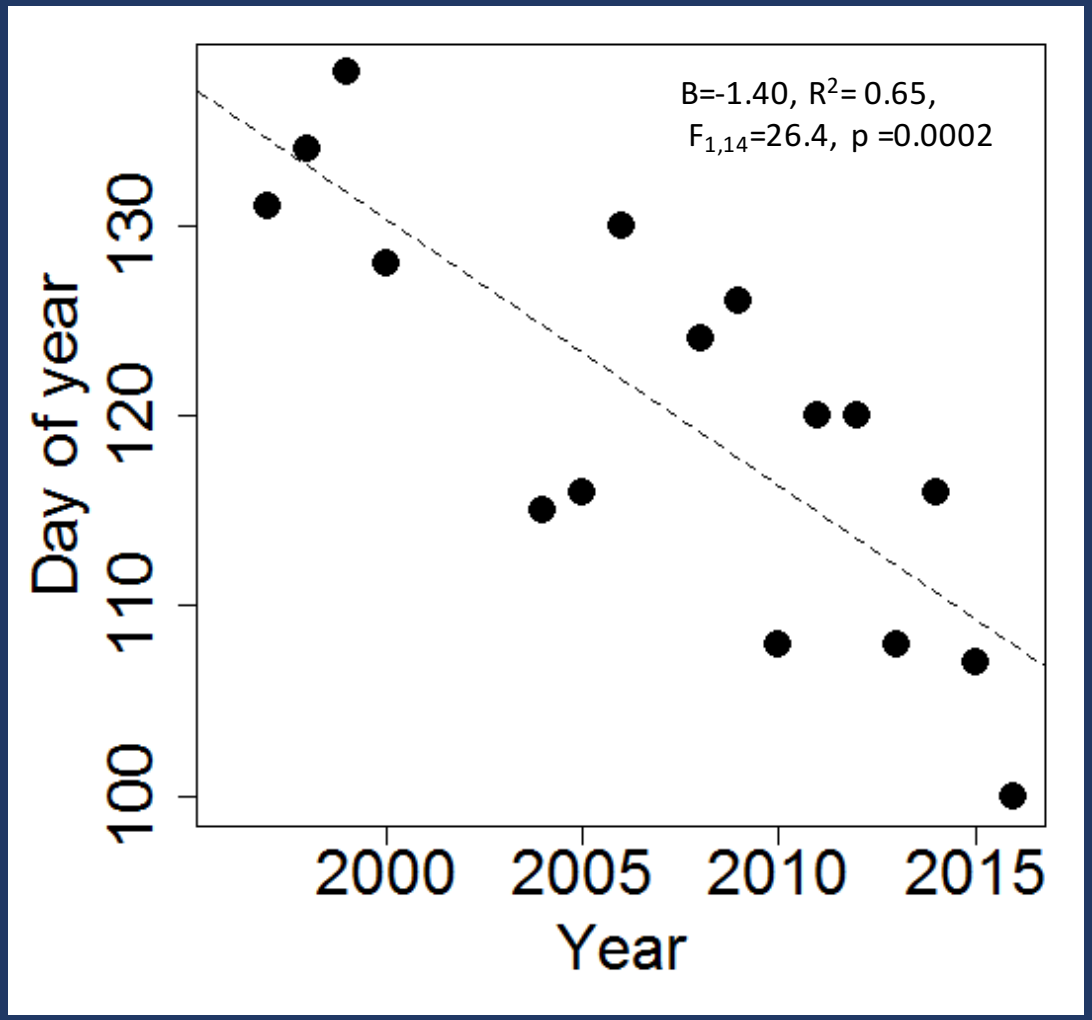
Mahonia aquifolium
Oregon grape
Start flower

Andrena



Quercus garryana
Oregon oak
Start leaf





Sidalcea campestris Start flower

Photo: Xera plants

Conclusions

- Spring phenology occurred on average 2.5 days earlier per decade in 1959-2016 dataset.
- Most events did not occur earlier over time in 21 year dataset because the PDO effect overwhelms the climate change signal.
- Short studies should focus on response to temperature (see Bolmgren et al. 2013).
- Earlier events are happening much earlier while later events are changing less.
- Need to study interactions of plant phenology and pollinator phenology.
- Urban oak remnants are important because they allow large number of citizen scientists to observe native species.

Acknowledgements

Preliminary analysis supported by Carson grant from Willamette University to Kees McGahan

Wilbur Bluhm dedicated observer who collected, cleaned and entered these data.

Dave Craig, Willamette Biology Department provided photos and data access.