

12.15.2022

# Patterns and drivers of montane flower phenology and canopy closure

2022 FEMC Conference

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# Team effort

*Doug Weihrauch*

*Nancy Ritger*

*Kyler Phillips and many AMC Backcountry Educators*

*Adirondack Mountain Club*

*Baxter State Park*

*Green Mountain Club*

*Alpine Stewards*

*Many Hut Naturalists*

*Val Neuhausser, Patrick Lynch, Annie Evankow, and  
many Research Interns*

*Volunteers*

*National Phenology Network*

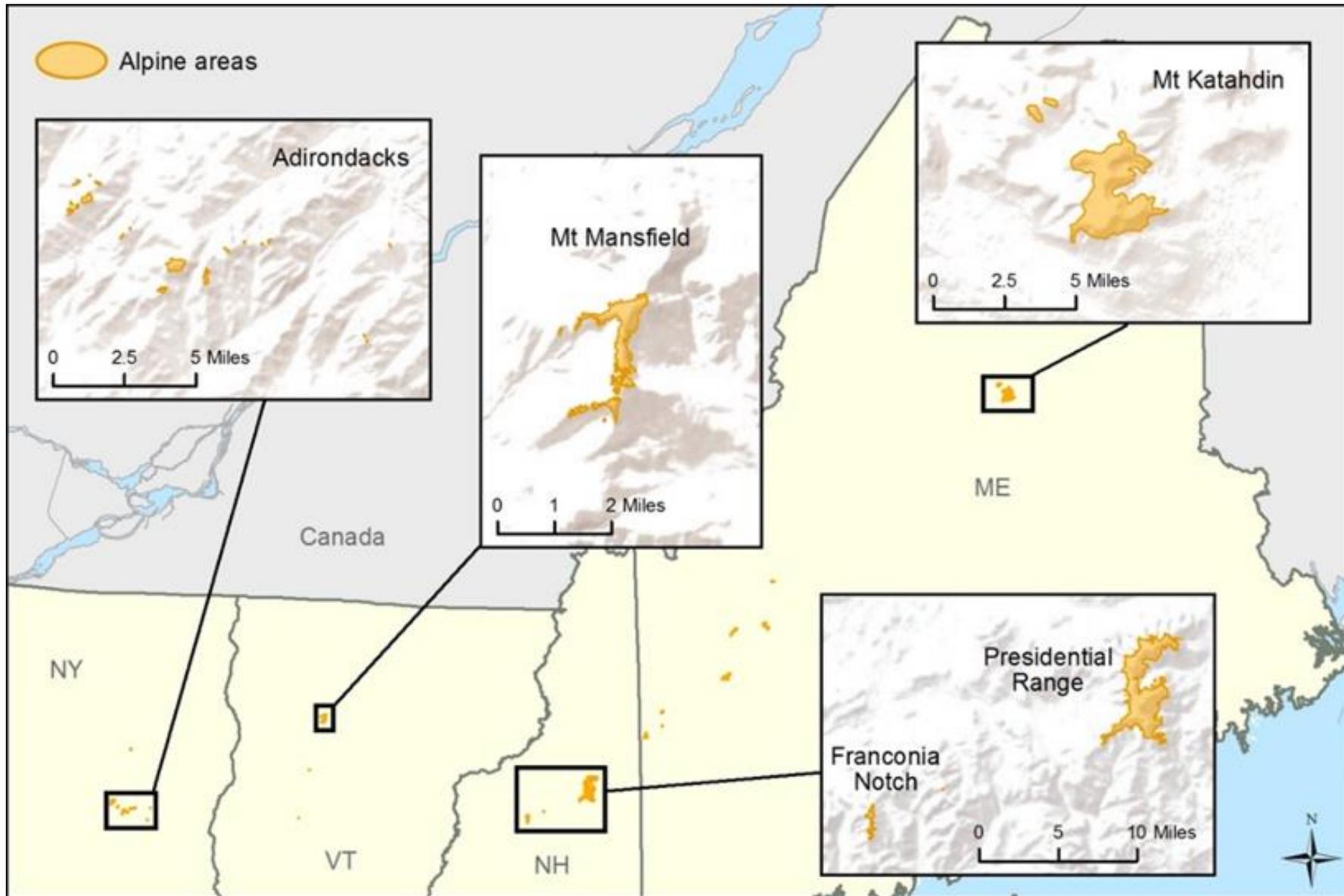
*iNaturalist*

*White Mountain National Forest*

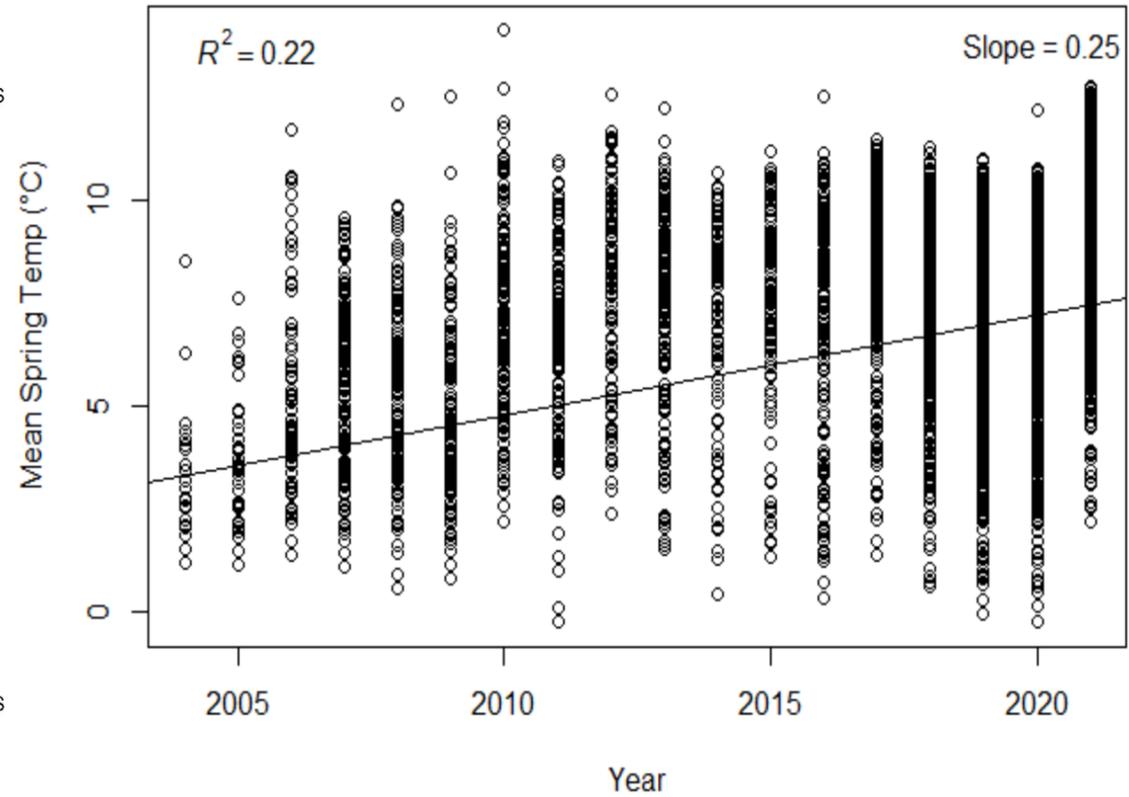
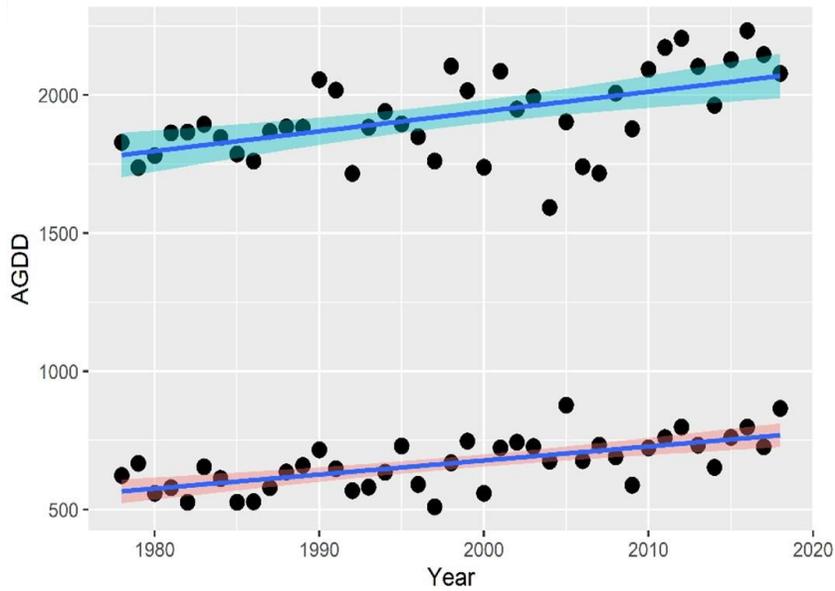
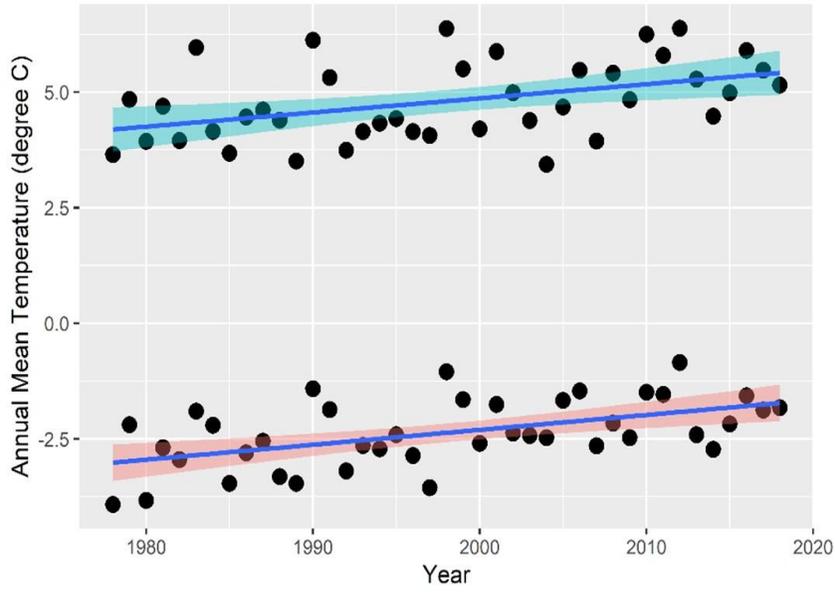
*AMC Research Staff*



# Northeast alpine areas



# Warming trends



# Evolution of plant phenology monitoring

## Mountain Watch

Alpine plots established 2004/5 with partner groups

Opportunistic sampling by hikers in Whites

Woodland plots established in Whites 2007

## National Phenology Network

Switch plots to NPN beginning in 2014

Some protocol adjustments

## iNaturalist

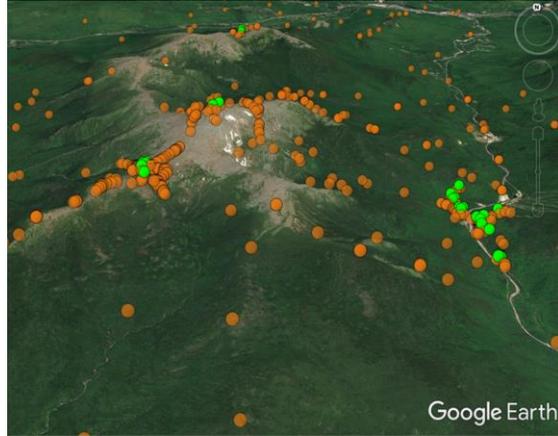
Launched 2019

Mirrors NPN phenophases

Opportunistic sampling only



# Protocol considerations



Datasheet_ID	Vol_ID	Datasheet_Type	No_on_Hike	DS_Code_ID	Date_of_Col
3732	2520	Detailed	1	16	7/22/2014
3731	2520	Detailed	1	16	7/15/2014
3730	2520	Detailed	1	16	6/24/2014
3729	2520	Detailed	1	16	7/1/2014
3728	2521	Detailed	1	16	6/28/2014
3727	2518	Detailed	2	16	6/21/2014
3726	2519	Detailed	1	16	6/15/2014
3725	2255	Detailed	1	16	6/14/2014
3724	1308	Detailed	1	6	5/16/2013
3723	2401	Detailed	1	9	6/13/2013
3722	2401	Detailed	1	9	6/7/2013
3721	2388	Detailed	1	13	7/12/2013
3720	2388	Detailed	1	13	6/30/2013
3719	2388	Detailed	1	13	6/27/2013
3718	2329	Detailed	1	13	6/15/2013
3717	2388	Detailed	1	13	6/15/2013
3716	2388	Detailed	1	13	6/1/2013
3715	2388	Detailed	1	13	6/5/2013
3714	2466	Detailed	1	11	9/20/2013
3713	2466	Detailed	1	11	9/13/2013
3712	2466	Detailed	1	11	9/10/2013

## Phenophases

- Flowering focus
- Expanded to vegetative phases

## Plots & Opportunistic

- Plots est. in 2004/2007
- Tried opp. sites with casual observers; location errors
- Revisiting opp. with geolocated photos: iNaturalist

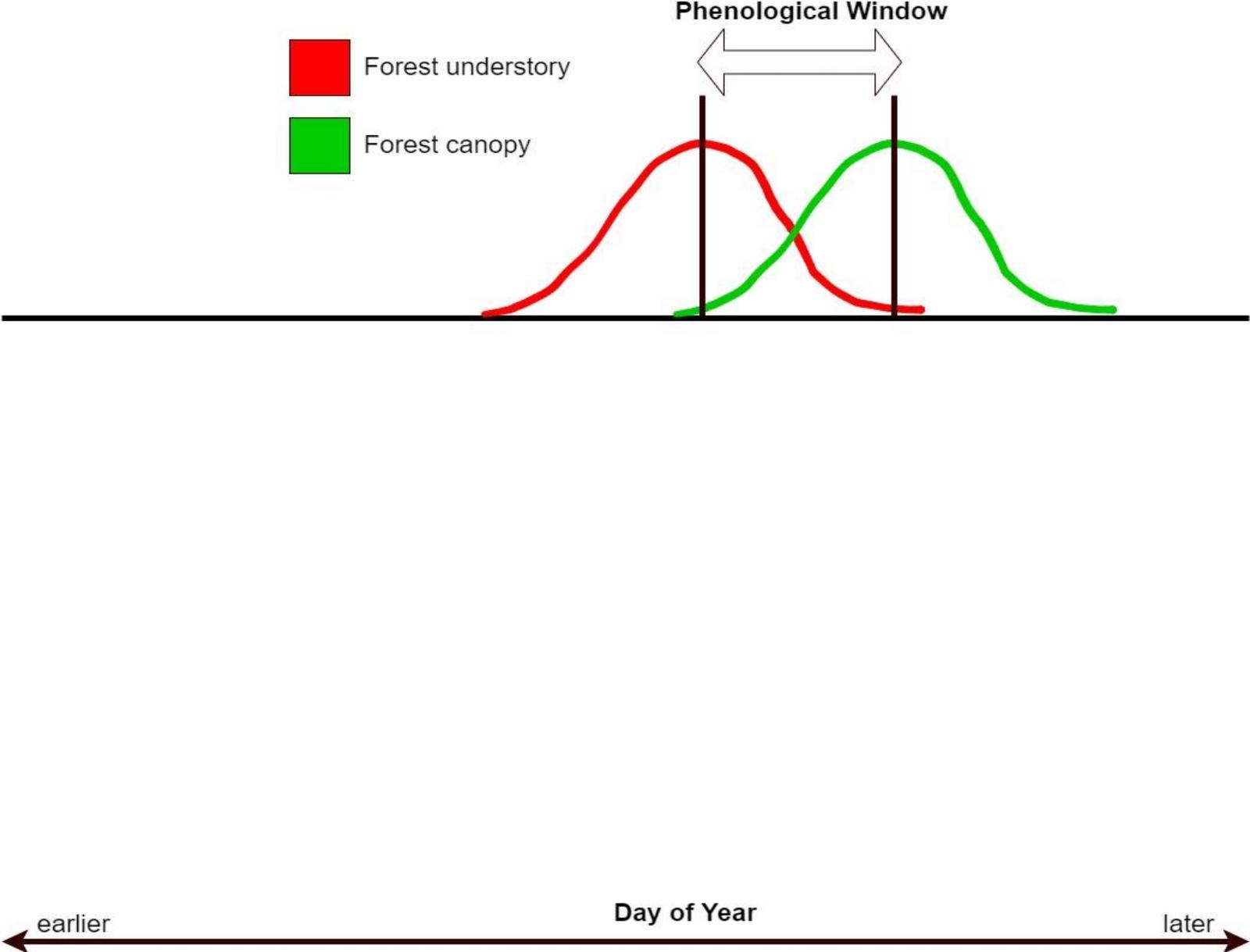
## Staff & Volunteers

- Partner groups
- Seasonal staff
- Trained volunteers
- Casual volunteers

## Databases

- AMC Access database
- National Phenology Network
- iNaturalist

# Shifting spring phenology



# Main research questions

- What are the patterns (spatial and temporal) of understory spring phenology (flowering)?
- What are the relationships between understory phenology and climate?
- How does understory phenology compare to canopy closure (leaf out) or to alpine phenology?
- Is there evidence for phenological advance of understory plants as a result of warming?



# Target species

Woodland Forbs



Canopy Trees



Alpine Plants

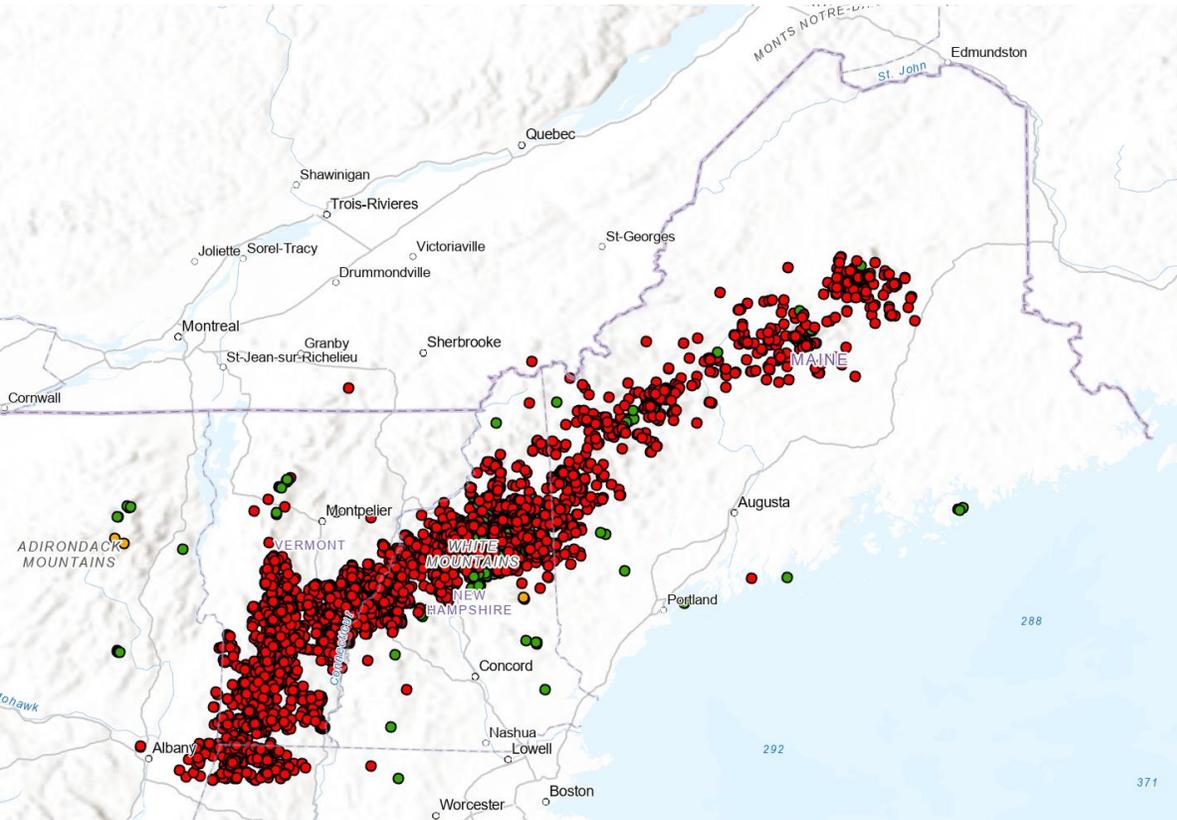


# Methods

Mountain Watch

National Phenology Network

iNaturalist



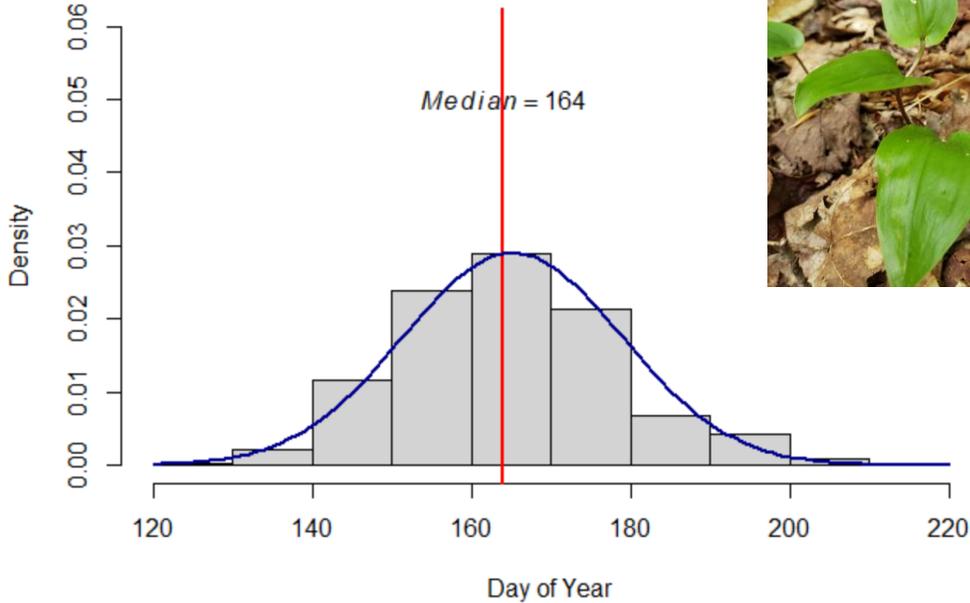
- Synthesized and collated ~800,000 observations since 2004
- Exploratory analysis: Correlation between DOY (flowering time for woodland and alpine plants, leaf out time for trees) and climate variables – linear regression
- Calculated median flowering time
- Multiple linear regression and model selection
- Bayesian regression to compare shifts between flowering and canopy leaf out (closure)



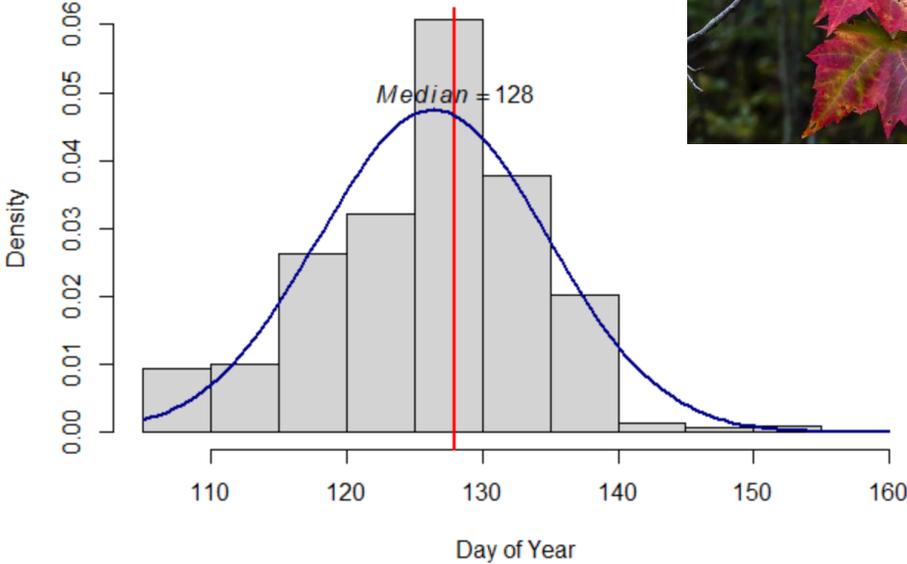
# Summary of spring phenology



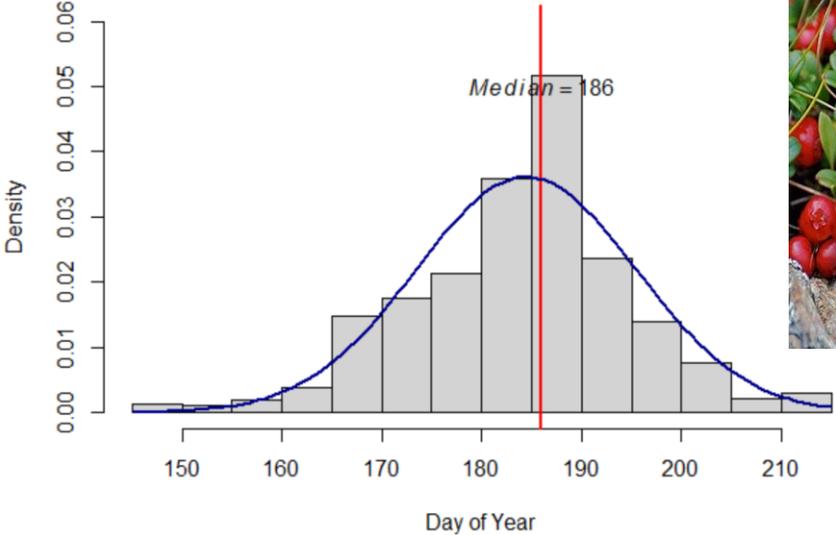
**Maianthemum canadense**



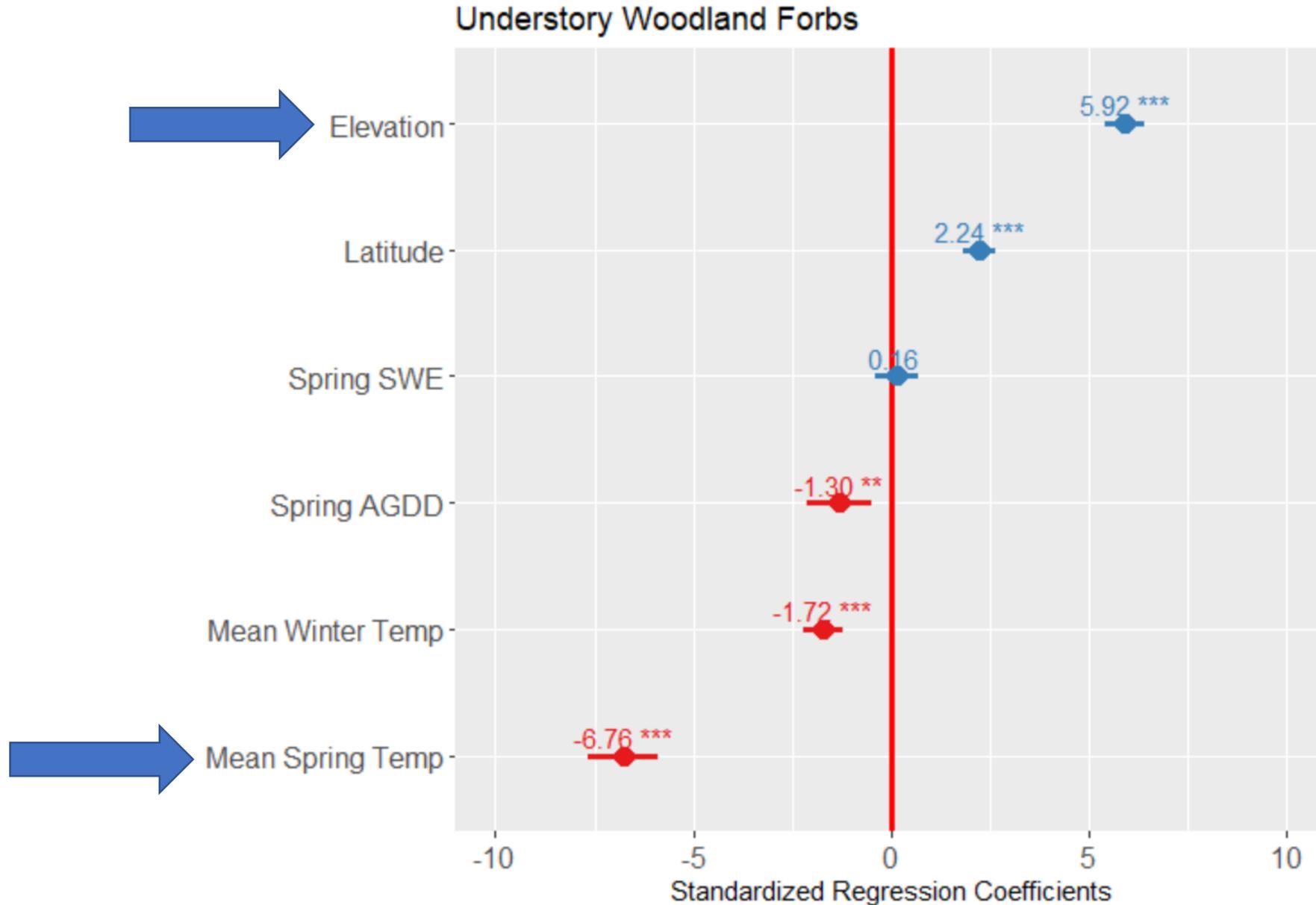
**Acer rubrum**



**Vaccinium vitis-idaea**



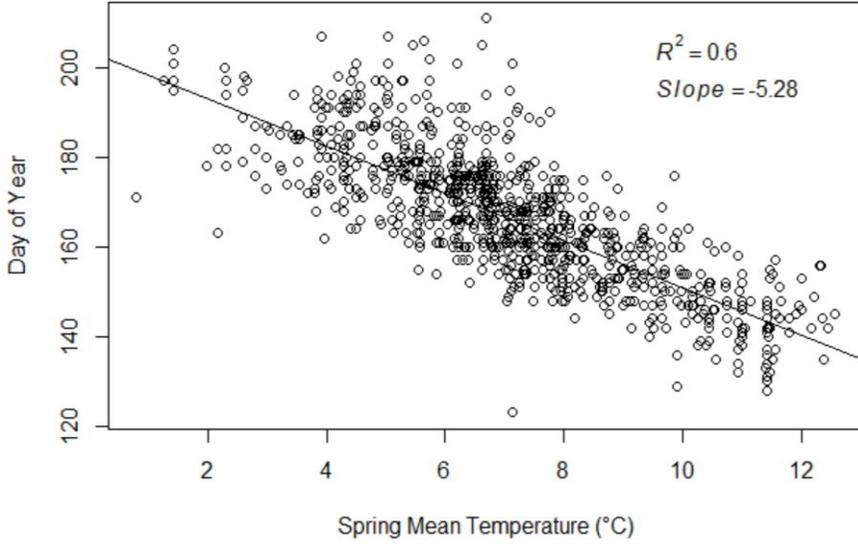
# Climate predictors of woodland flowering time



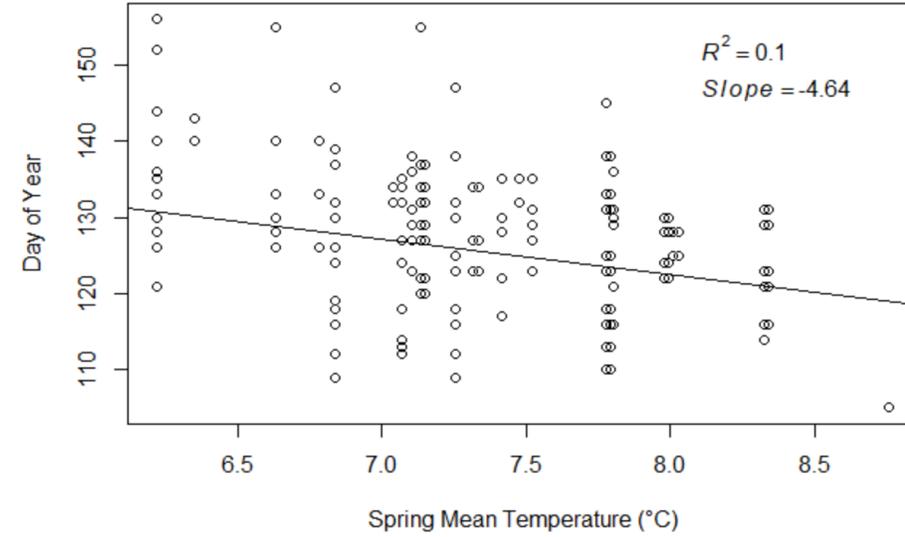
# Phenology – climate relationships



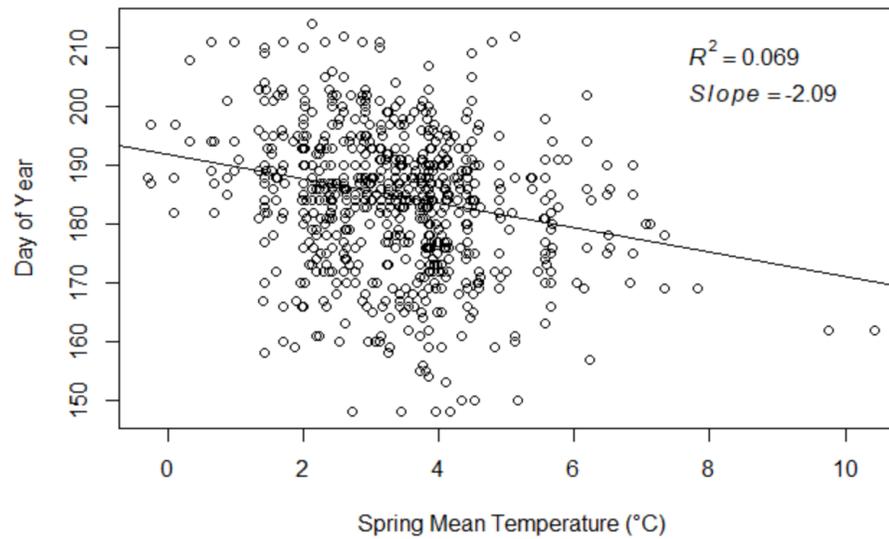
**Maianthemum canadense**



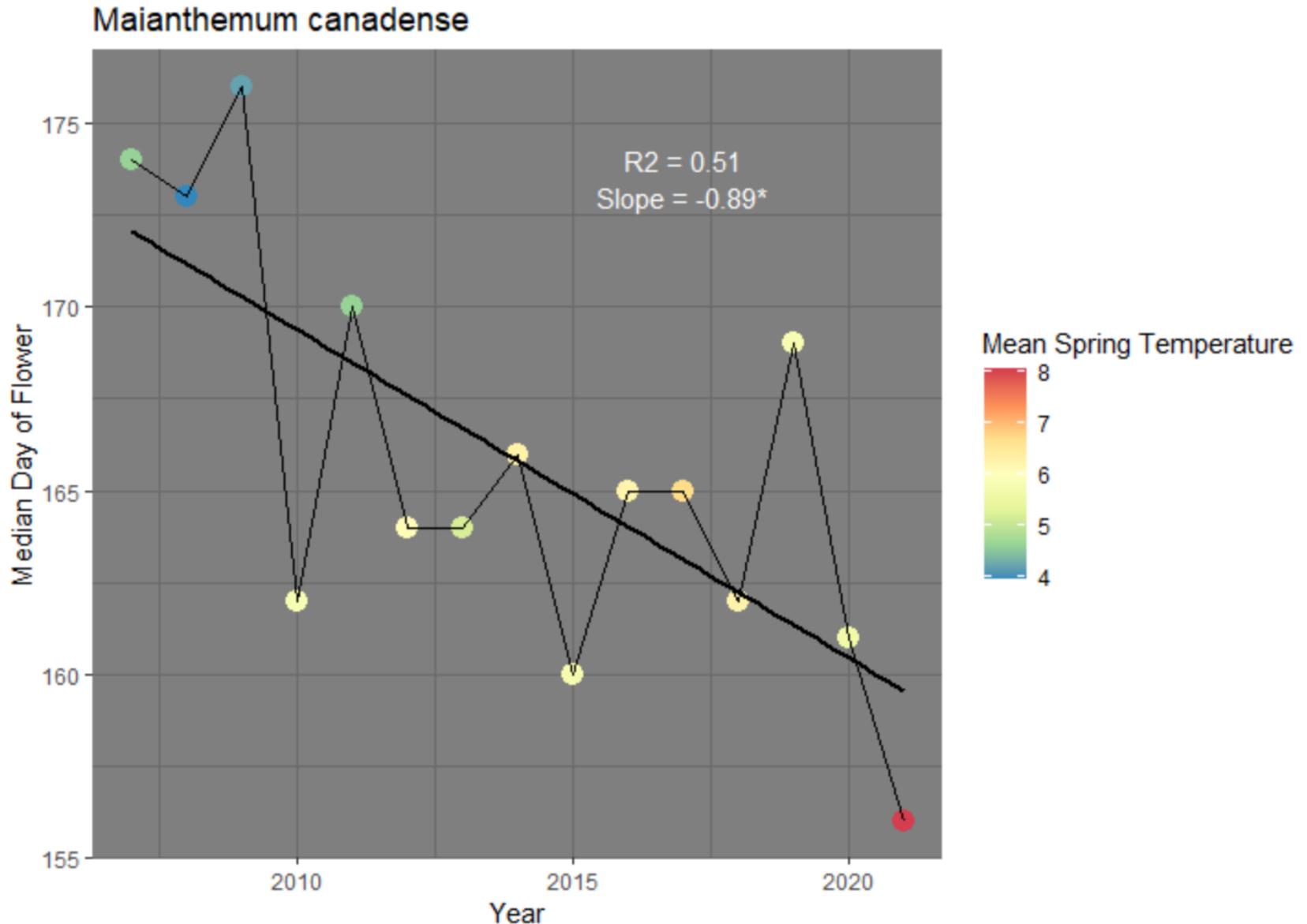
**Acer rubrum**



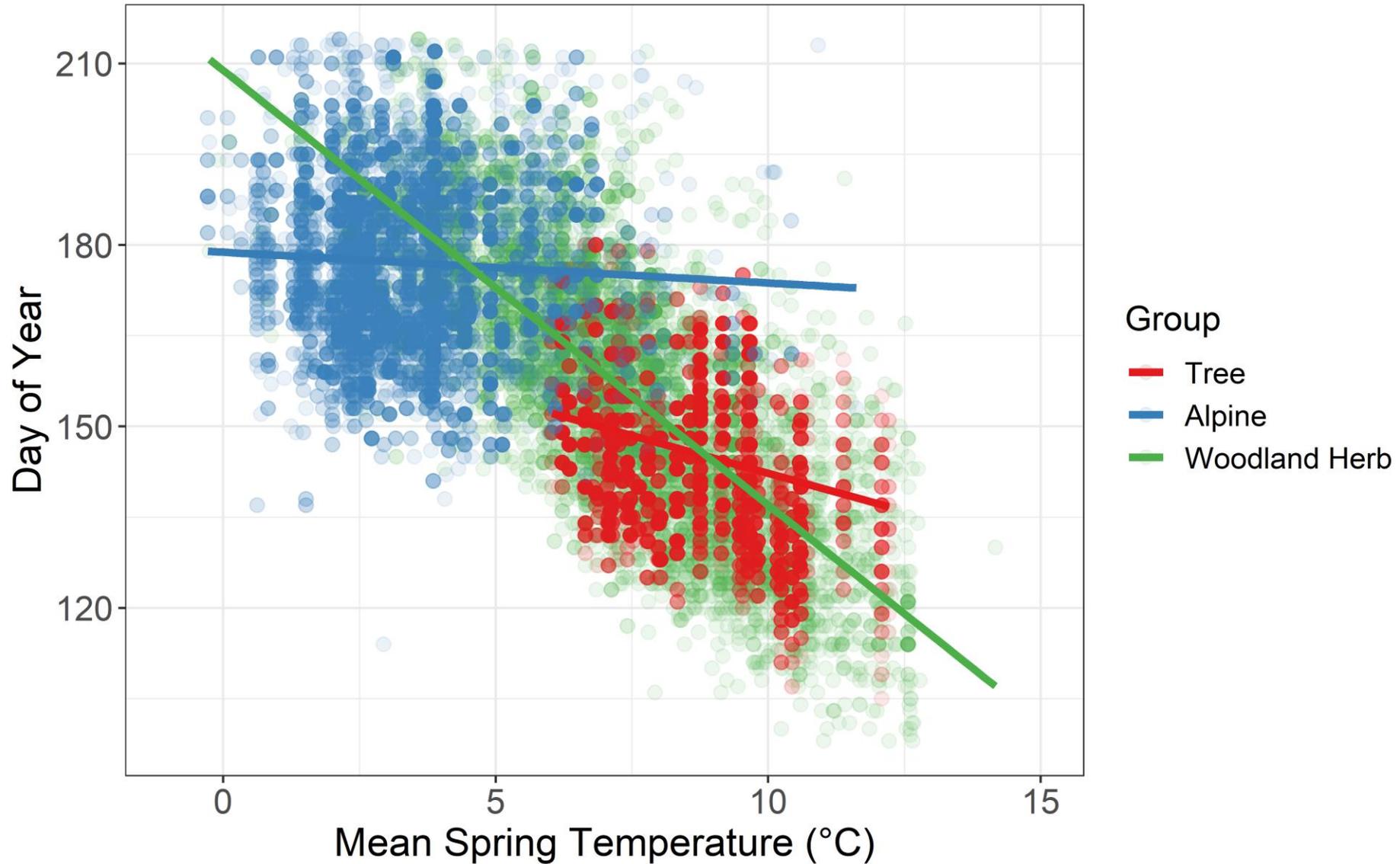
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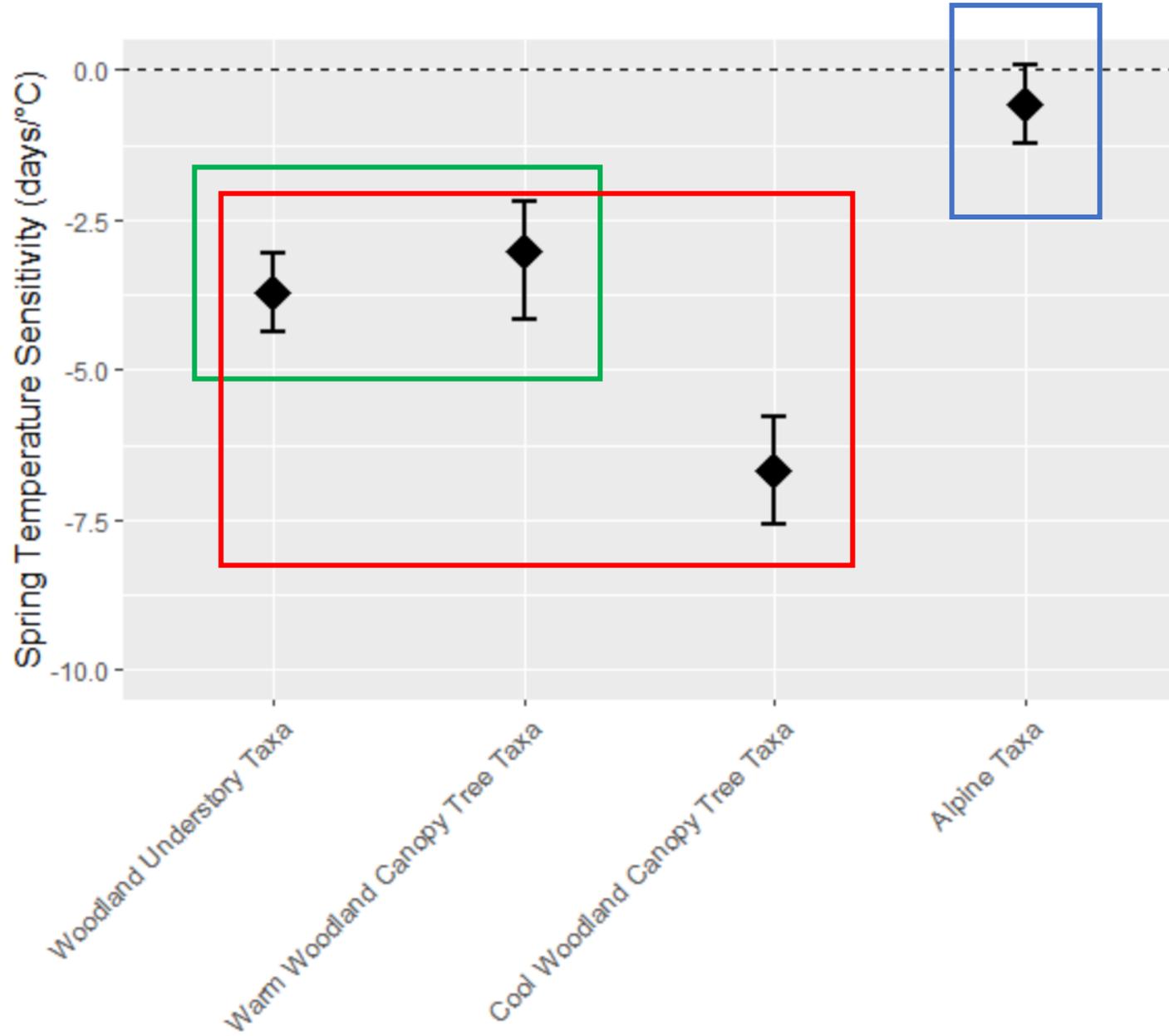
# Flowering during warm years



# Spring phenology variation by vegetation group



# Flowering – canopy closure mismatch



# Conclusions

- Multiple data streams allow for better spatial and temporal resolution
- We now have a foundational understanding of spring phenology for multiple understory species
  - Patterns across latitude and elevation are what we would expect
- Alpine species not as responsive to warming as woodland species
  - Why?
  - What species might be useful as indicators?
- Differences in spring phenology between various vegetation types may be important for forest regeneration
- There will likely be climate winners and losers – may depend on spatial context in addition to species traits

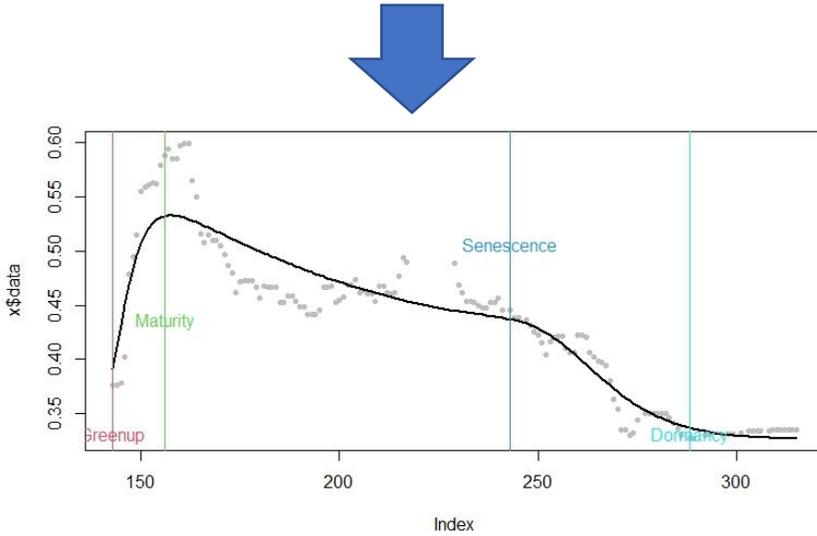
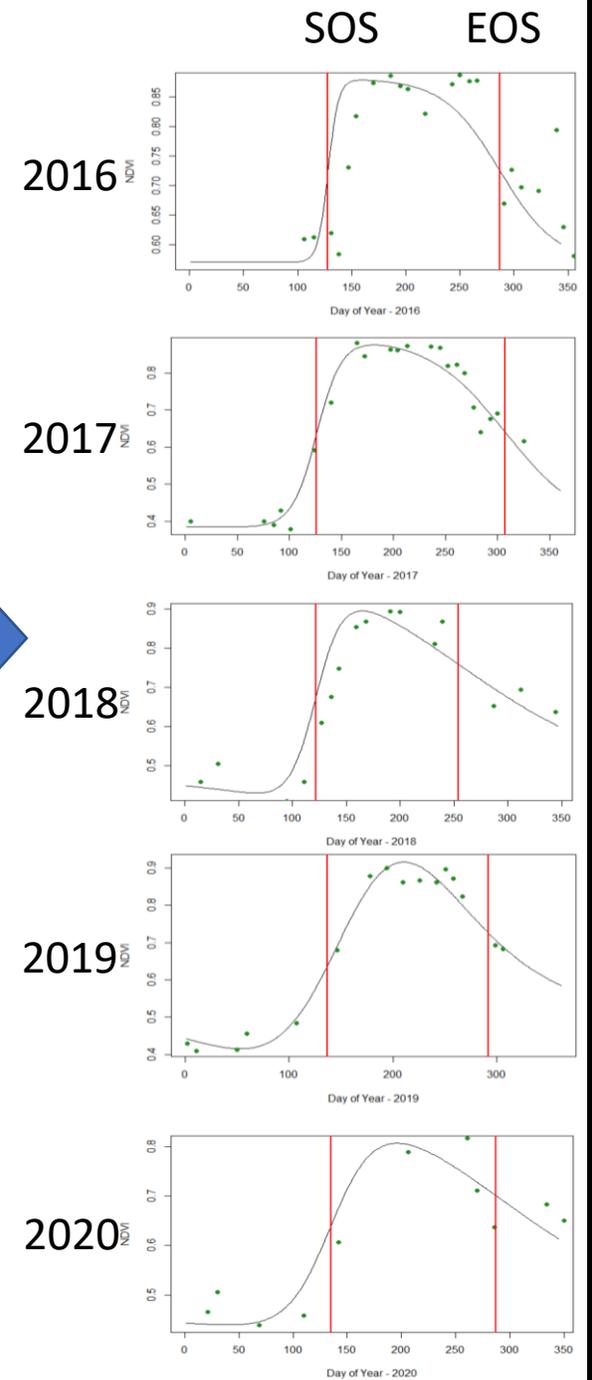


# Next steps – remote sensing of phenology

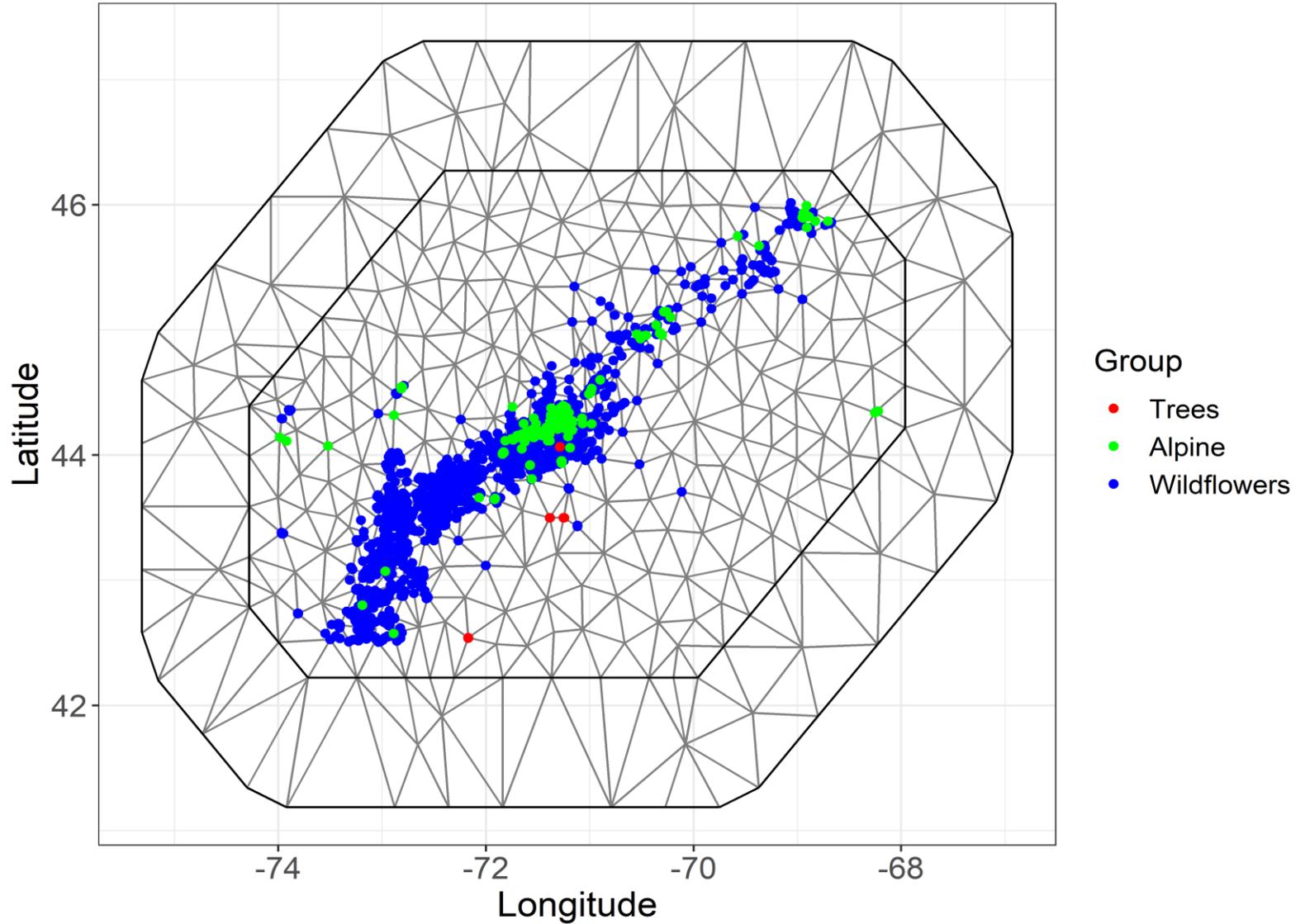
## Phenocams (GCC)



## Satellite (NDVI, EVI): Landsat + MODIS



# Next steps – trees + seedlings



# QUESTIONS?

