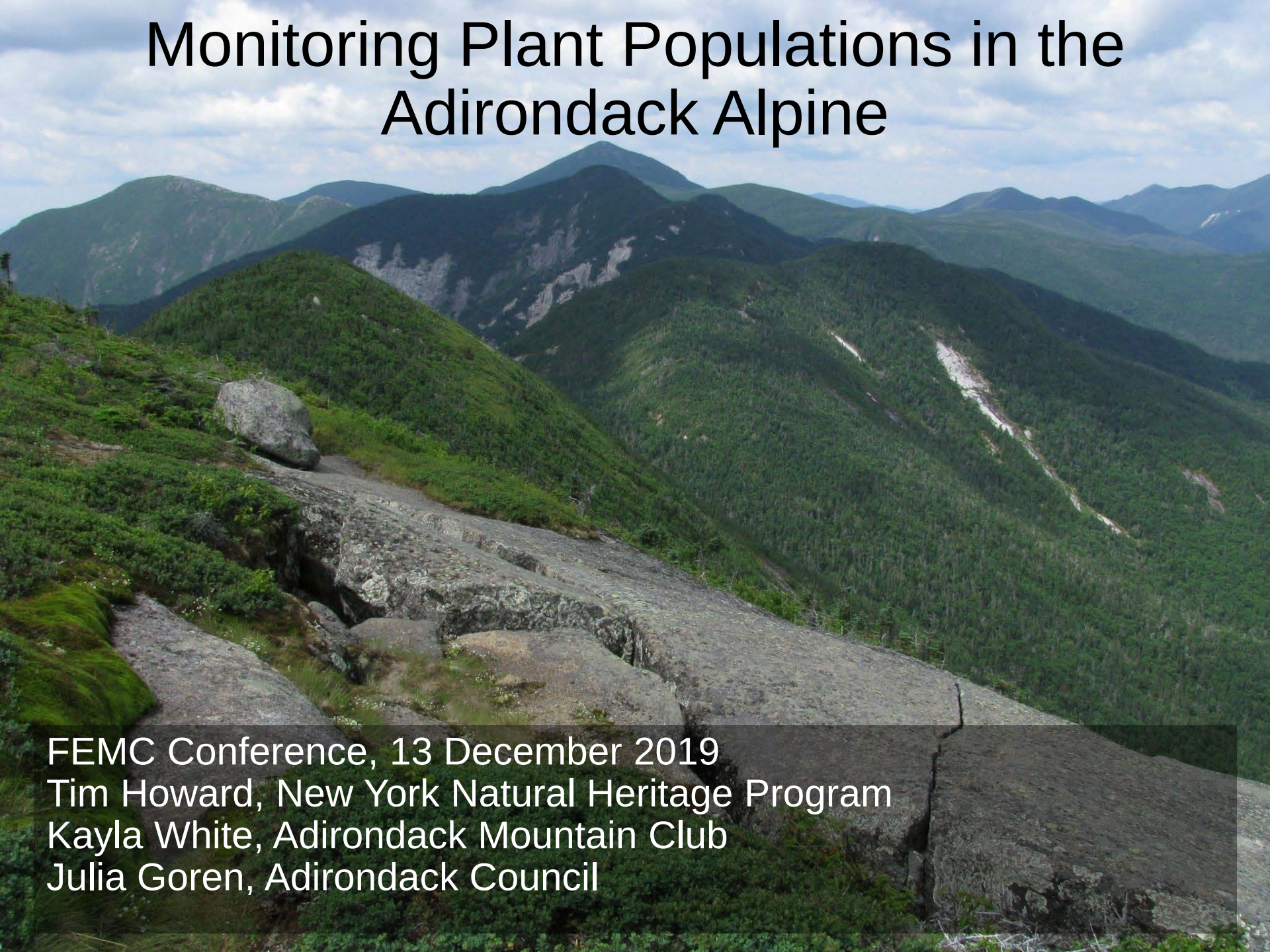
Monitoring Plant Populations in the Adirondack Alpine



FEMC Conference, 13 December 2019
Tim Howard, New York Natural Heritage Program
Kayla White, Adirondack Mountain Club
Julia Goren, Adirondack Council

Adirondack Alpine Zone

- 173 acres of alpine habitat spread over 21 summits
- 27 rare, threatened, or endangered alpine species

Boot's Rattlesnake root (*Nabalus bootii*, Ben Brosseau)

Climate Change and Adaptation: New England and Northern New York Forests

Changing Climate

average, while the red line shows the trend across the entire time period (an increase of 0.22 degrees per decade).

Longer Growing Seasons

Increased temperatures will also increase the length of the growing season, which is the period between the last freeze in in the spring and the first freeze in the fall. The growing season in this region today starts about 10 days earlier than it did 50 years ago, resulting in earlier spring flowers and longer periods of green leaves for many plants. By the end of this century, the growing season could be another 20 days longer in some parts of this region, and more than 50 days longer in others.

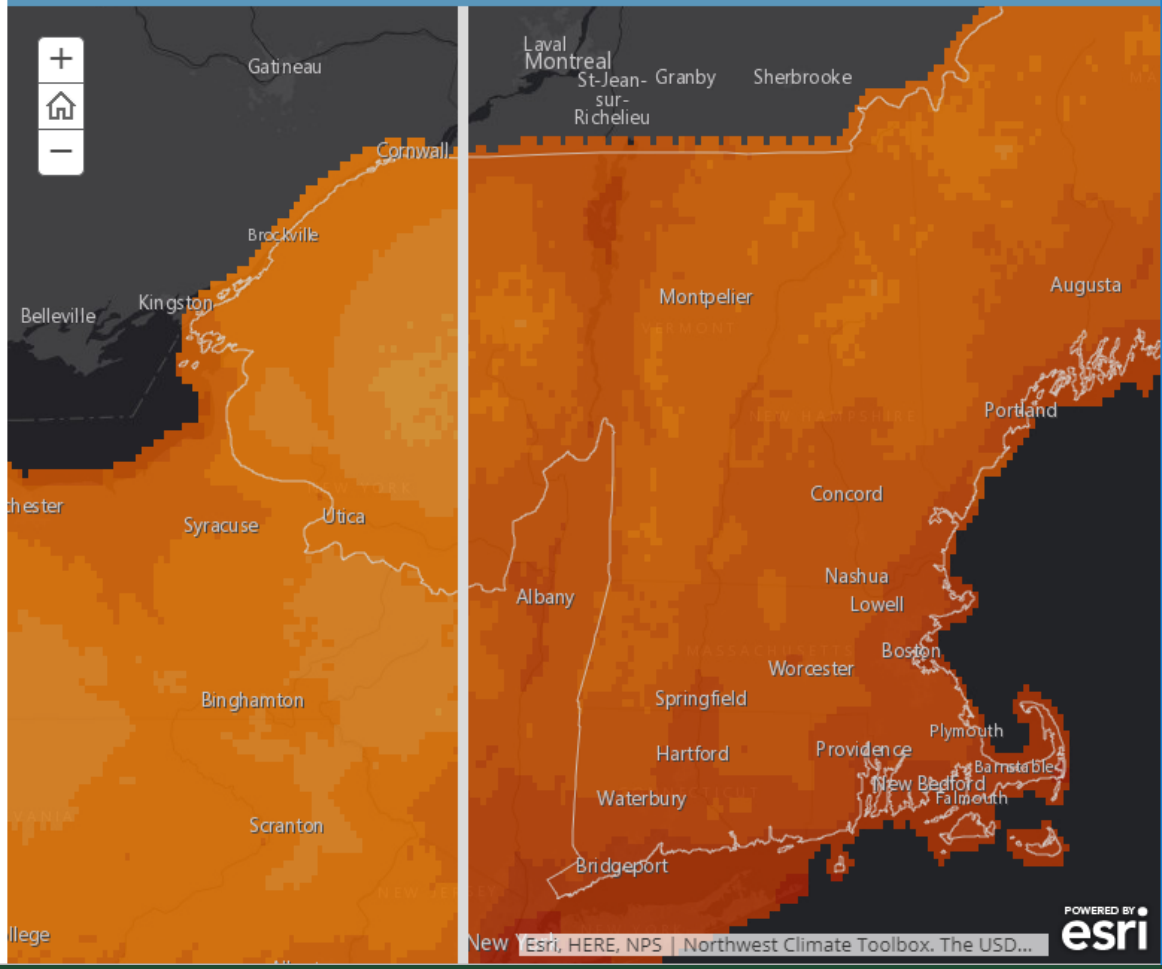
Length of Growing Season (Days)

0 75 150 225 365

The growing season length was modeled for two time periods, 1971-2000 and 2070-2099. The future projection uses a high greenhouse gas emission scenario (RCP8.5; no climate policy and high population). Growing season length is measured by the number of days per year with temperature remaining above

Length of Growing Season: 1971-2000 vs. 2070-2099

Left Side (historical period) ↔ Right Side (high climate change scenario at the end of the century)



Vulnerability Assessment from the Climate Change Response Framework
Story map at https://arcg.is/0eCuOv

How are alpine plants responding?

- Are lower elevation competitors moving in and causing reduced growth?
- Is mismatched climate negatively affecting alpine plants? Or positively?
- Other stressors on plant populations … trampling

Diapensia (*Diapensia lapponica*; T. Howard)

Best way to monitor populations?

- Need people who are up on the summits
- Need people trained to tread lightly in the alpine zone
- Need people trained in alpine plant identification

.....Botany Summit Stewards!

Deer's hair sedge (*Trichophorum cespitosum*; Julia Goren)

Summit Stewardship Program

The Nature Conservancy Adirondacks

Adirondack ADK Mountain Club

NEW YORK STATE Department of Environmental Conservation


HIGH PEAKS
SUMMIT
STEWARD
GORE-TEX

Estimating population size

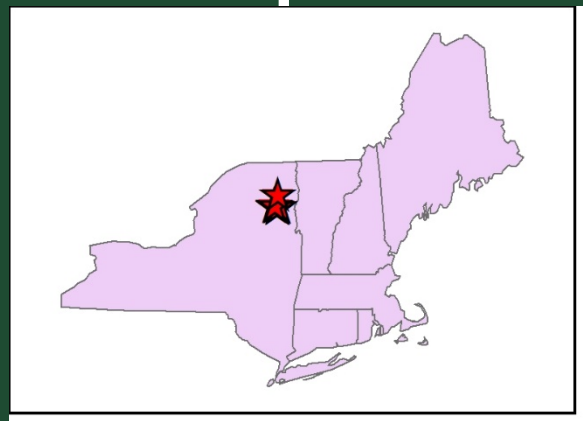
Problem:

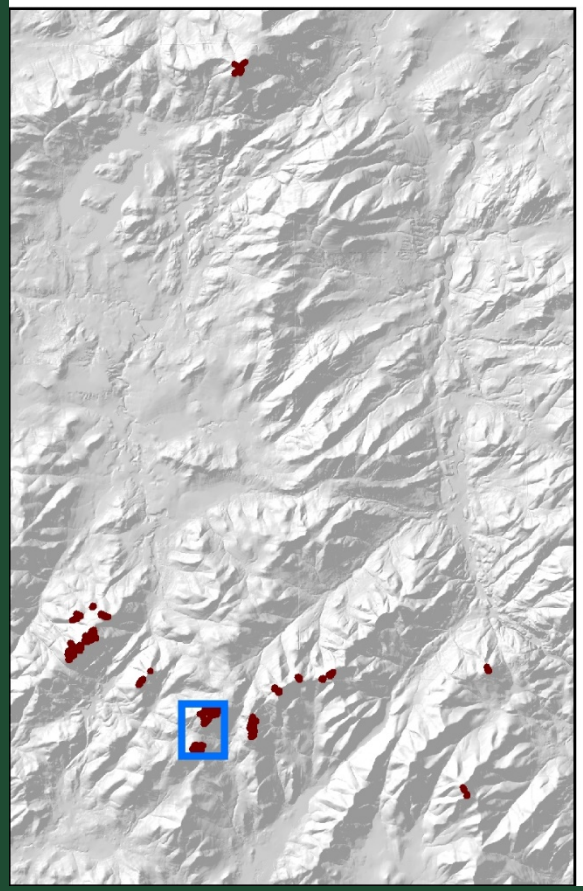
- Plants are scattered and difficult to count.
- How do we estimate population size?

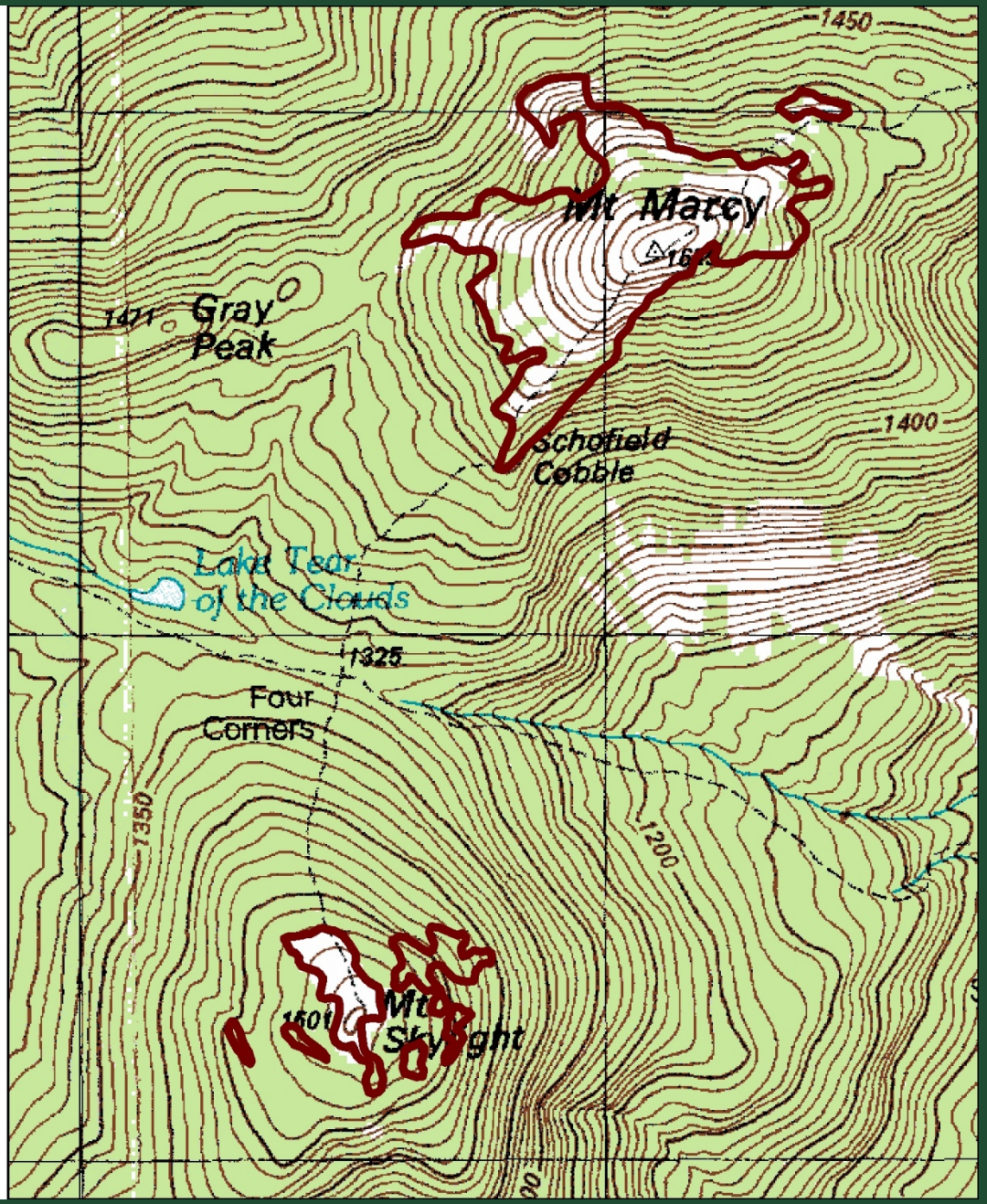
Solution:

- Count a subset of individuals on each summit.
- This sampling scheme needs to be:
  - quantitative
  - repeatable
  - with high precision

Sample where?





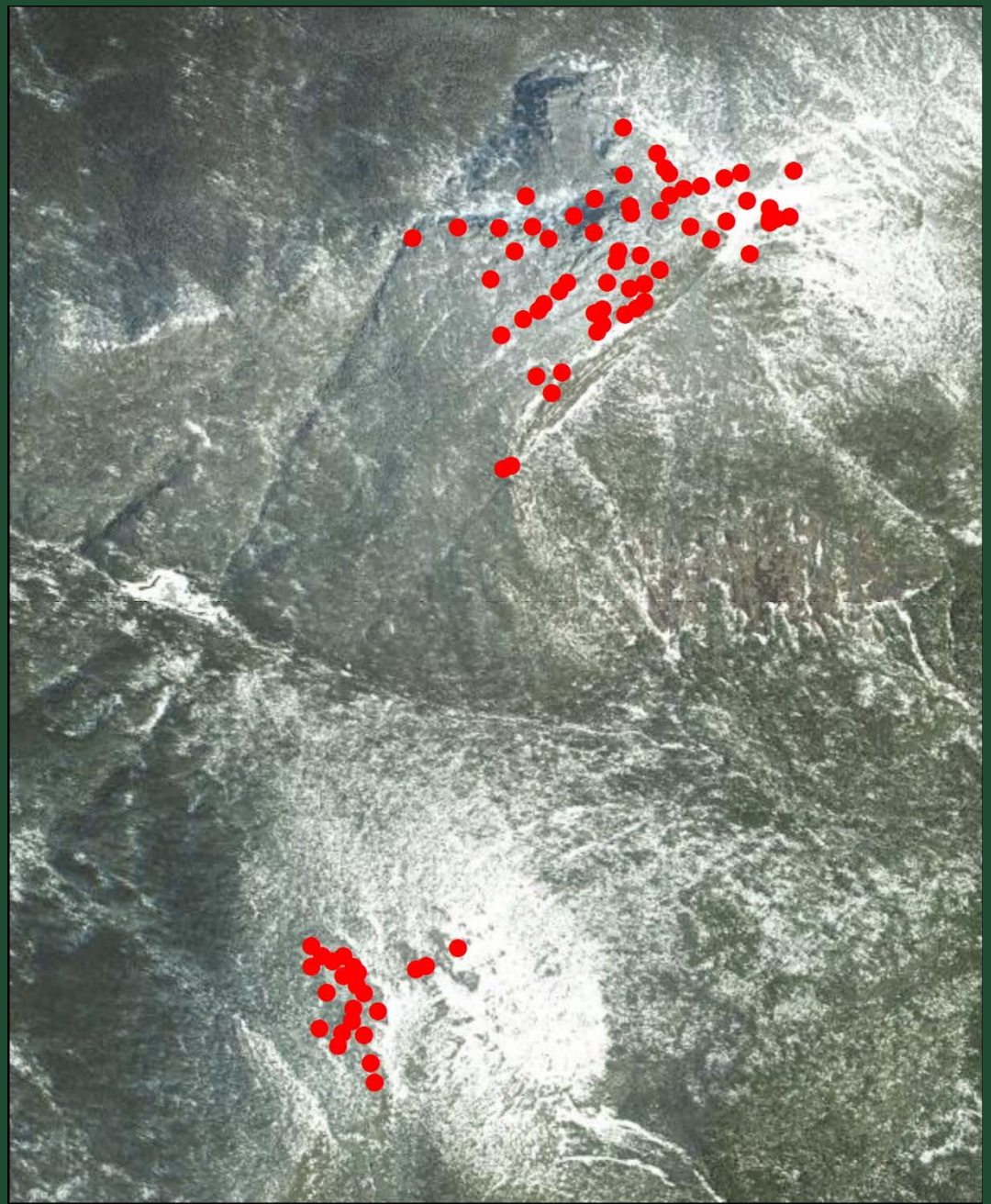


Random sample design

2006-2007

Total plots in 2006-2007:

376



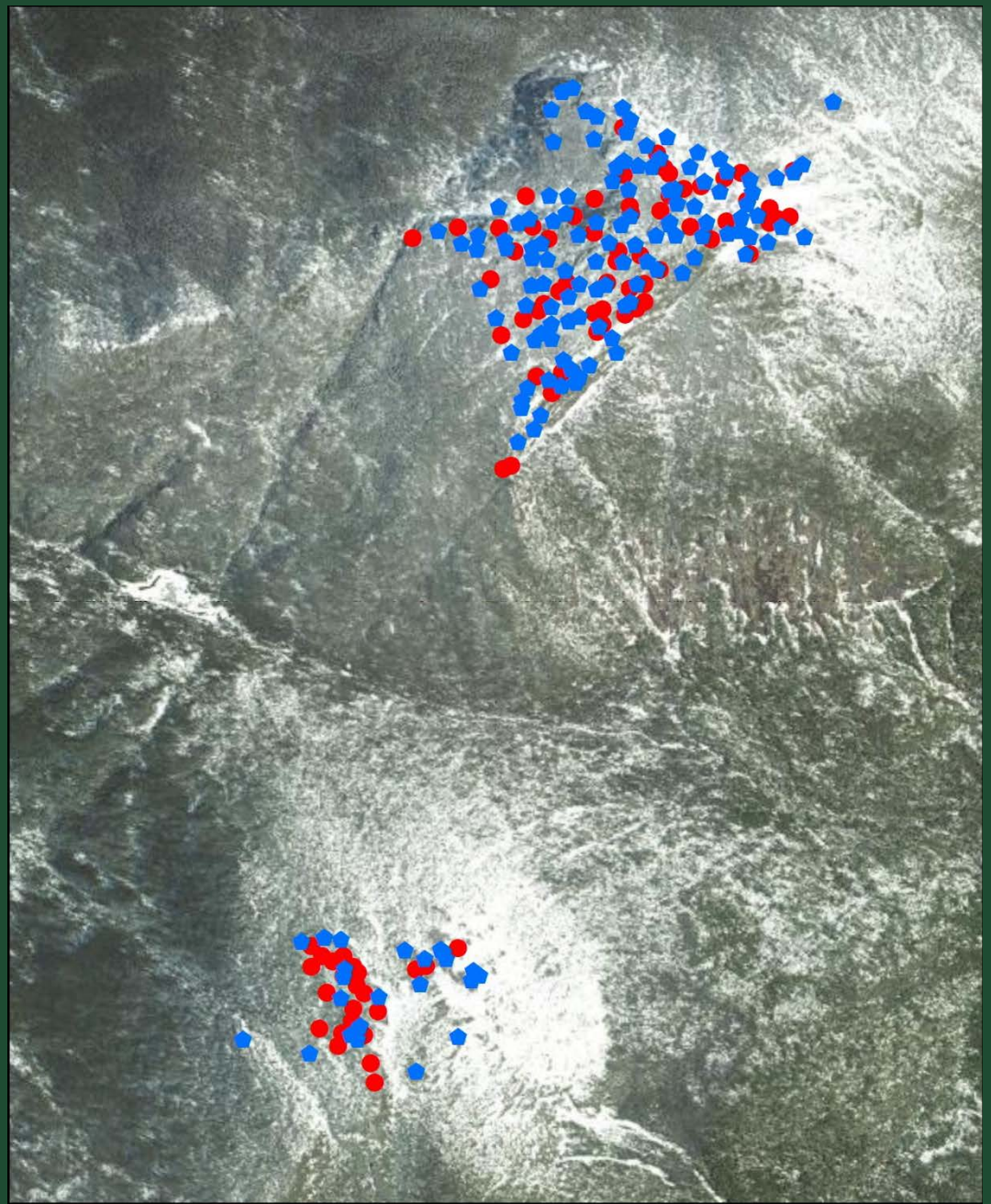
Marcy and Skylight

New sample of population each year

2013

Total plots in 2013:

371



Marcy and Skylight

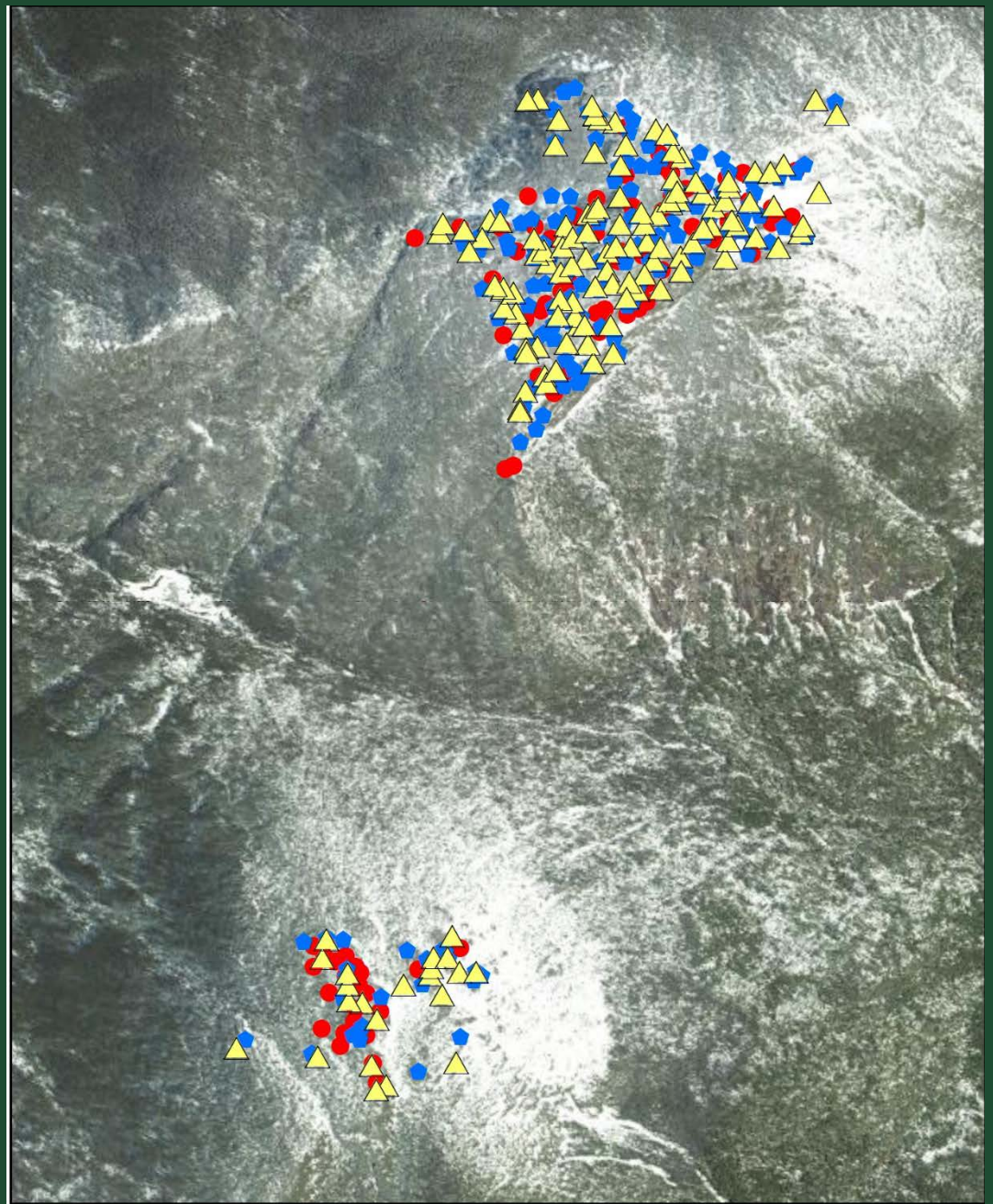
GRTS spatially-balanced

2018-2019

Total plots in 2018-2019:

379

Sampled the 17 summits with alpine vegetation each year



Marcy and Skylight

Sample what?

Target species:

- Diapensia (*Diapensia lapponica*)
- Black crowberry (*Empetrum nigrum*)
- Northern lowbush blueberry (*Vaccinium boreale*)
- Deer's hair sedge (*Trichophorum cespitosum*)
- Bigelow's sedge (*Carex bigelowii*)
- Mountain firmoss (*Huperzia appressa*)
- Northern bent (*Agrostis mertensii*)
- Alpine sweet grass (*Anthoxanthum monticola*)
- Bearberry willow (*Salix uva-ursi*)
- Cutler's alpine goldenrod (*Solidago leiocarpa*)
- Purple Crowberry (*Empetrum atropurpureum*)
- Lapland rosebay (*Rhododendron lapponicum*)
- Alpine birch (*Betula glandulosa*)
- Single-spike sedge (*Carex scirpoidea*)
- Boot's rattlesnake root (*Nabalus bootii*)
- False toad flax (*Geocaulon lividum*)
- Alpine azalea (*Kalmia procumbens*)
- Dwarf bilberry (*Vaccinium cespitosum*)
- Highland rush (*Oreojuncus trifidus*)

Mountain firmoss (*Huperzia appressa*, T. Howard)

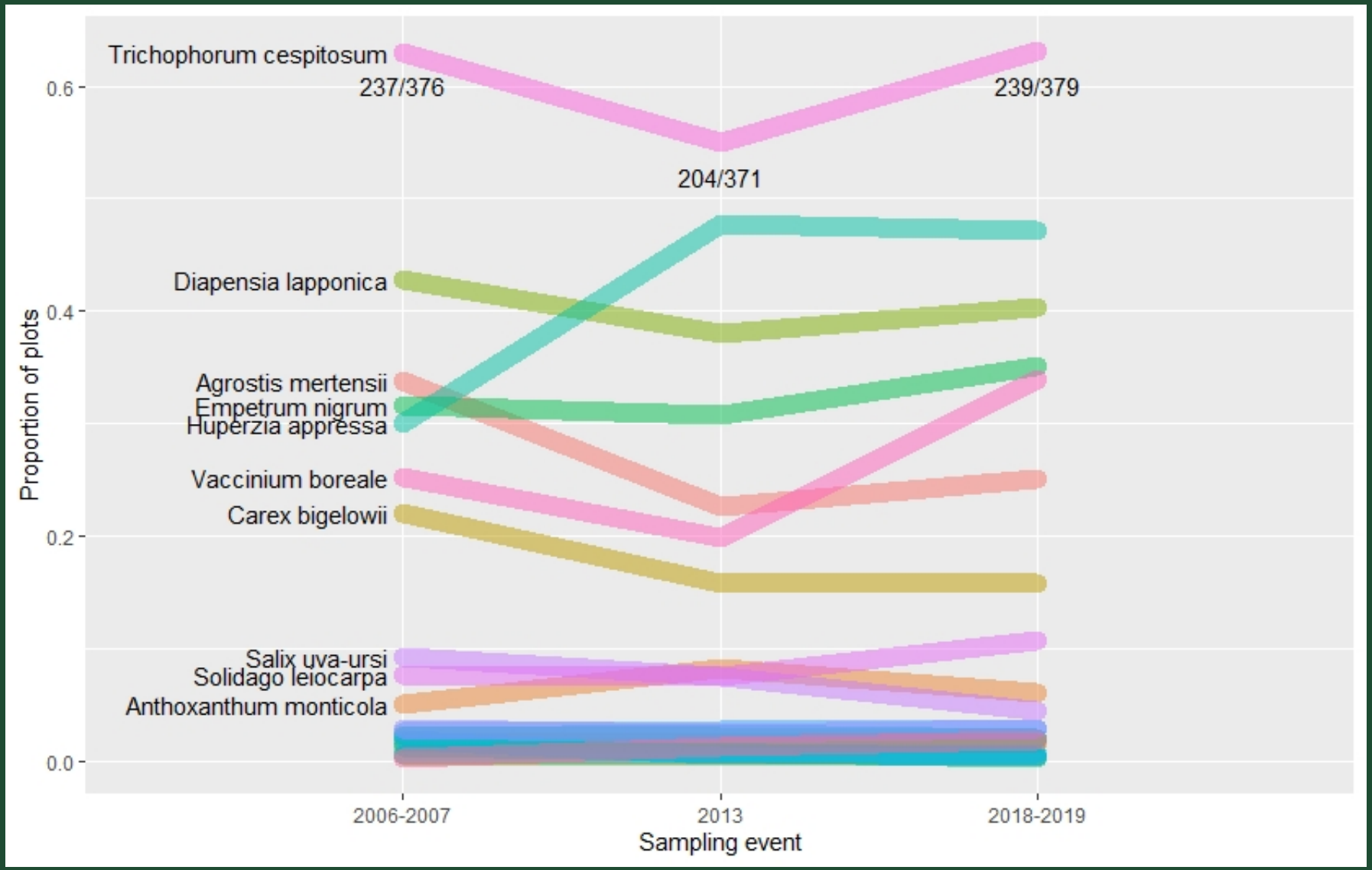
Sample how?

5 x 5 meter plots:

- Directed to location with GPS
- 2019: electronic data collection
- Count all clumps or estimate area covered

Sampling interval about 6 years: 2006/2007; 2013; 2018/2019

Results: prevalence



In how many plots was each species detected during each sampling bout?

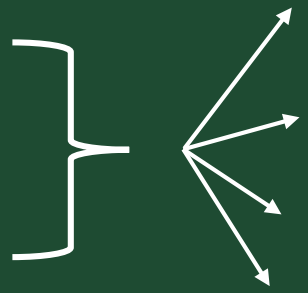
Number of Diapensia clumps by summit by year (!!)

... requires a pretty complex analytic setup ....

Analysis

Generalized linear mixed model:

- Testing for effect of sample event as ordered factor
- Use zero-inflated negative binomial (count data)
- Include random effects of summit
- Test for effect of spatial variation in:
  - Elevation
  - Solar radiation (on July 27)
  - Surface flow length
  - Surface curvature
  - Exposure to the west

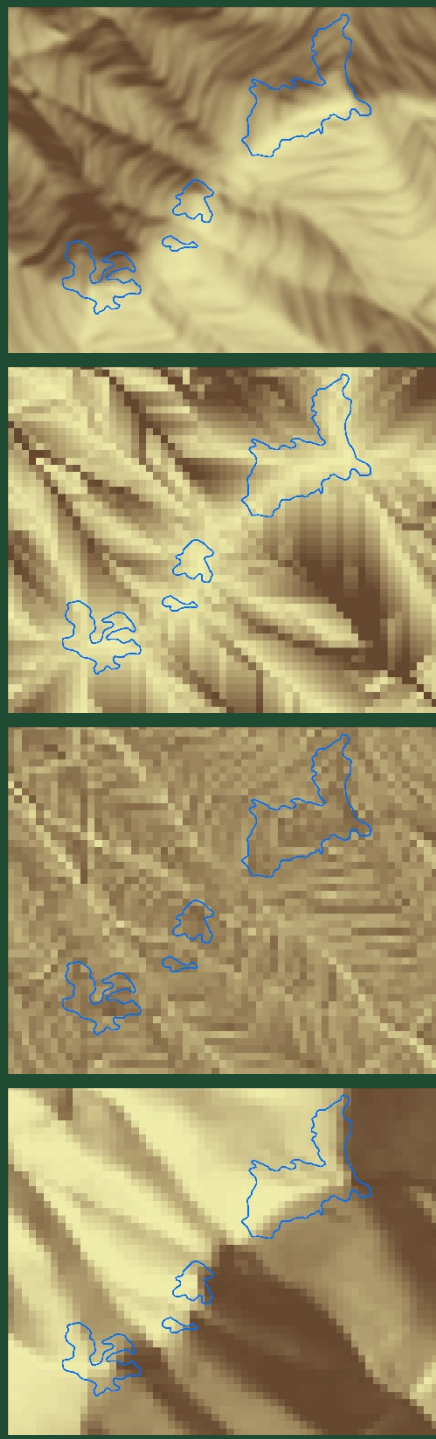


Thus, example formula:

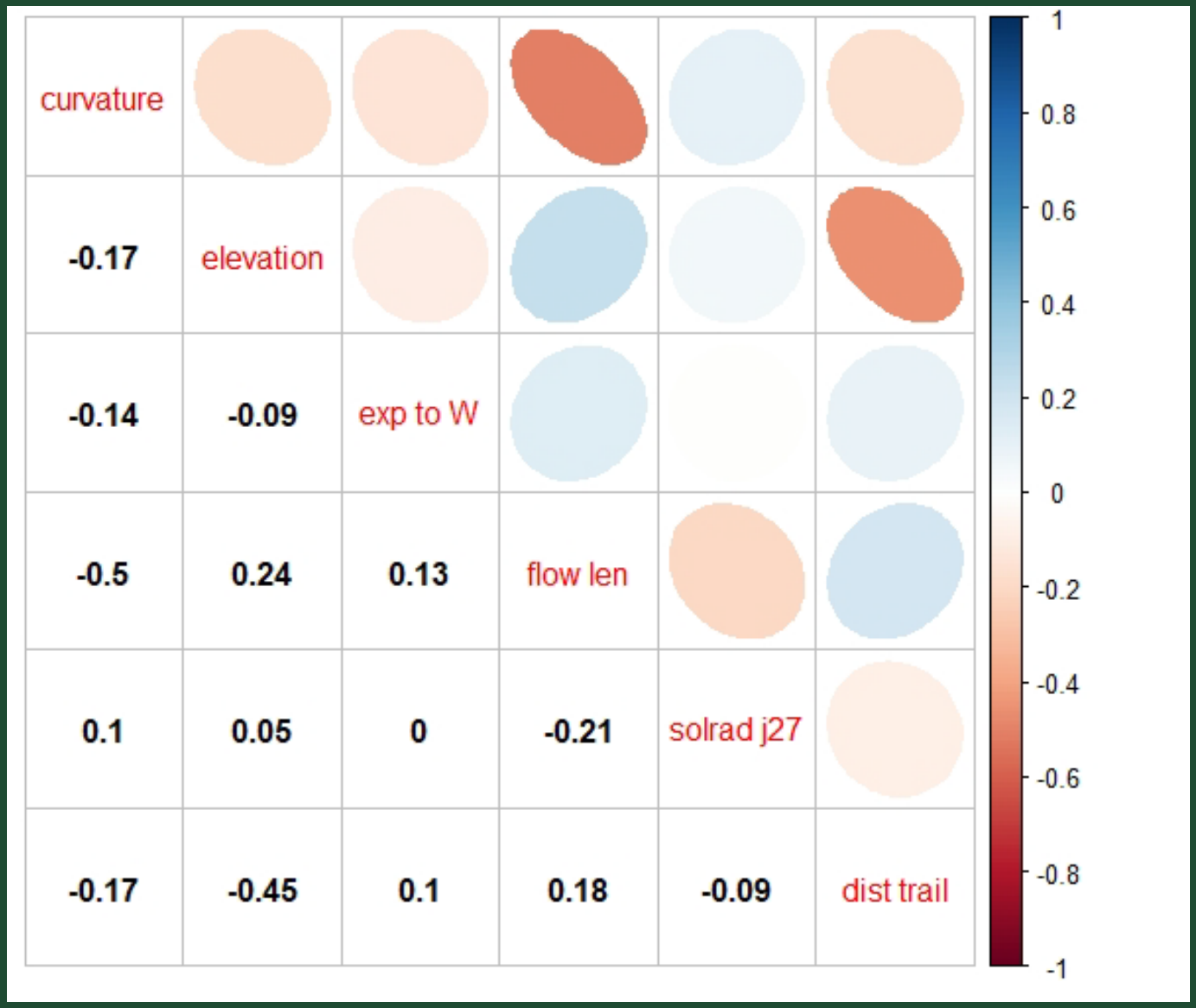
```
glmmTMB(clumps ~ yrgp + (1|summit) + elev +
          solrj27 + flolen + curv + expw,
        data = dat,
        family=nbinom2,
        ziformula = ~summit)
```

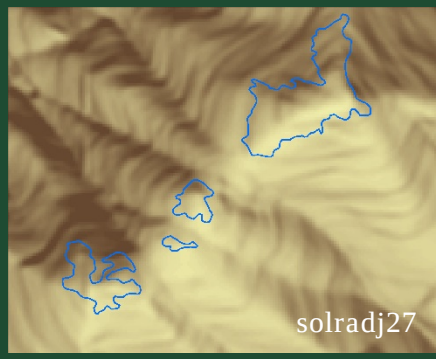
Analysis in R, using glmmTMB package

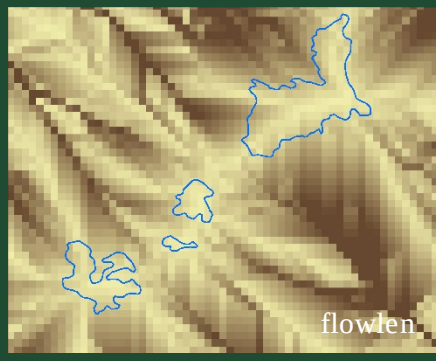
Test many models, model with the lowest AIC accepted

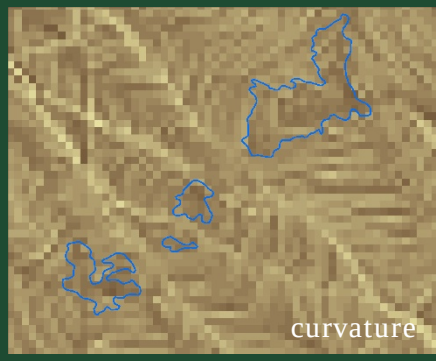


Environmental variables









Analysis output (Diapensia)

Random effects

Groups	Name	Variance	Std.Dev.
Summit	(Intercept)	0.00179	0.0423

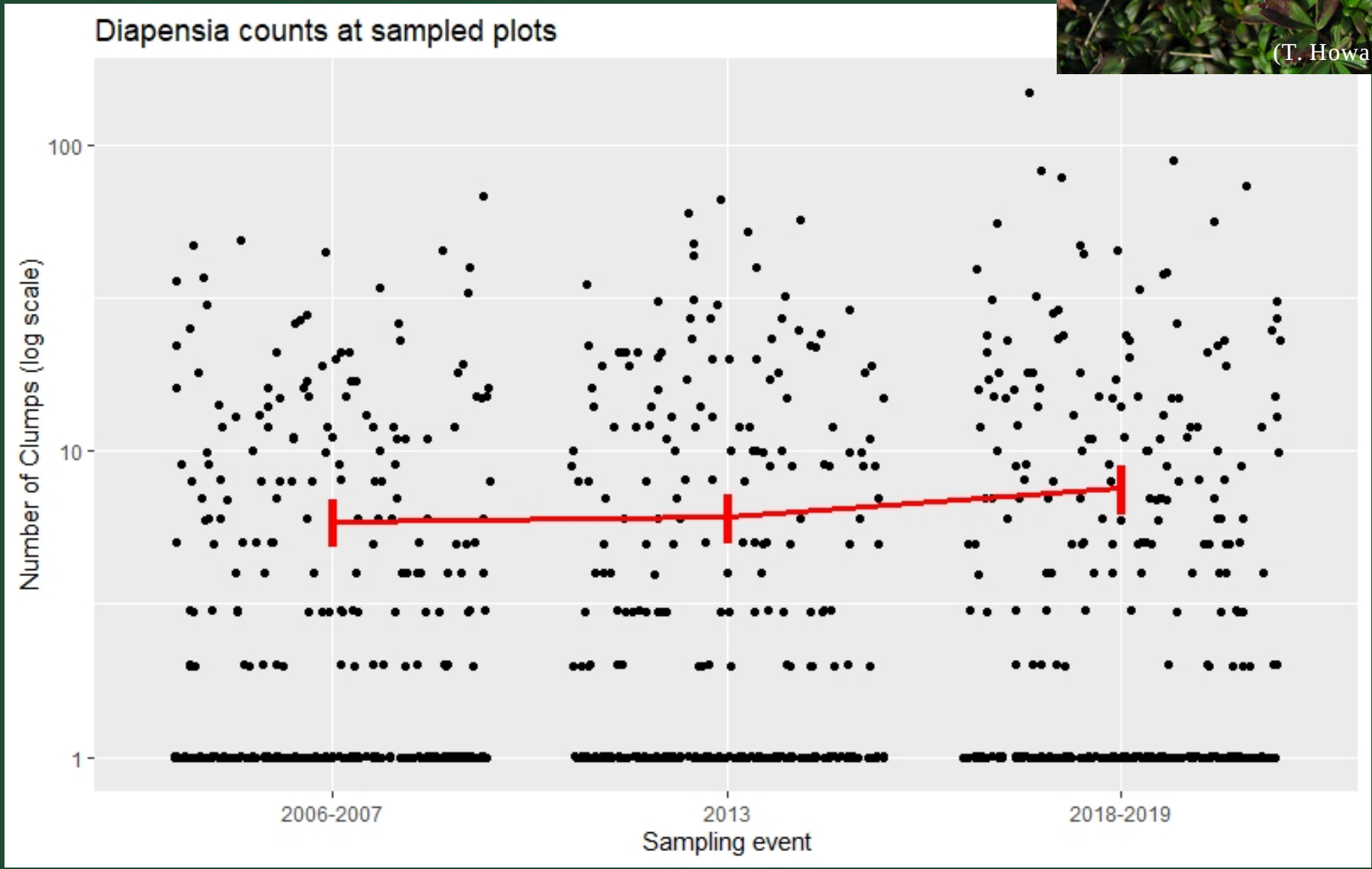
Main effects

	Estimate	Std. Error	z value	Pr(>|z|)	
(Intercept)	2.08502	1.63860	1.272	0.203216	
year.L	0.23846	0.09357	2.548	0.010820	*
year.Q	0.10747	0.09475	1.134	0.256670	
solrj27	-7.71502	0.82673	-9.332	<2e-16	***
elev	6.63152	1.73740	3.817	0.000135	***
expw	0.70850	0.20360	3.480	0.000502	**
flolen	0.55049	0.36017	1.528	0.126410	

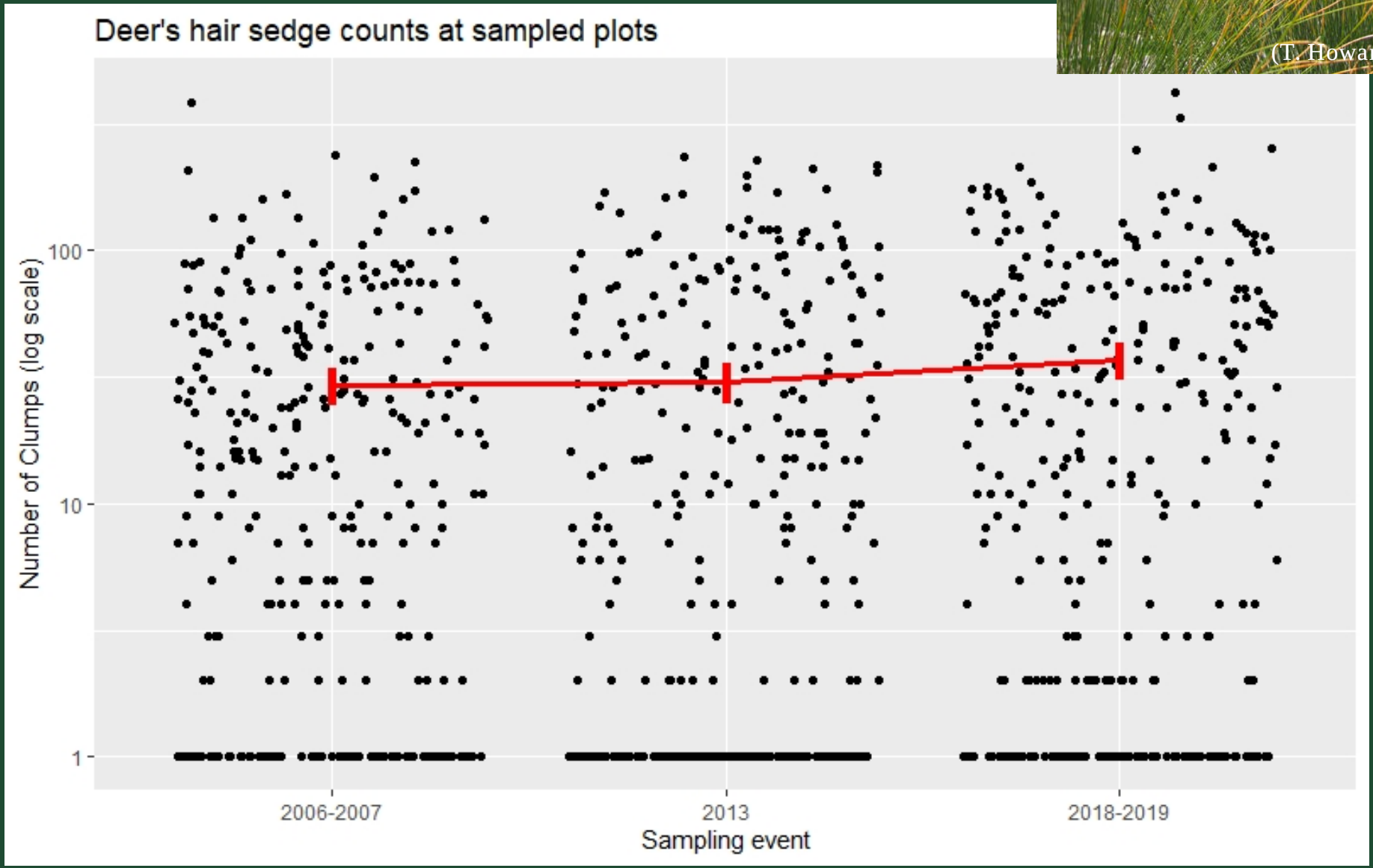
Model fit

AIC	BIC	logLik	deviance	df.resid
4191.0	4288.2	-2075.5	4151.0	932

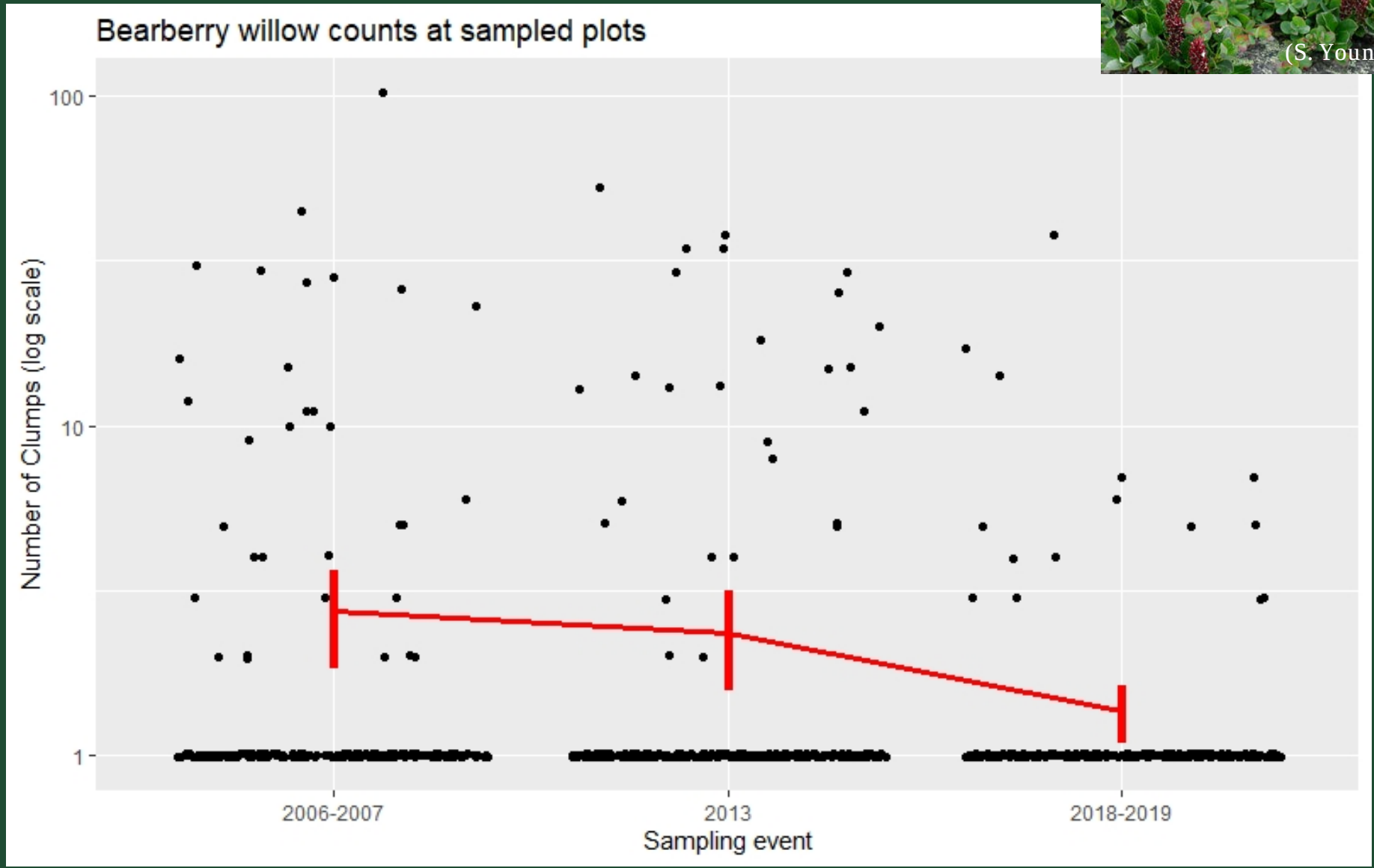
Diapensia by sample event



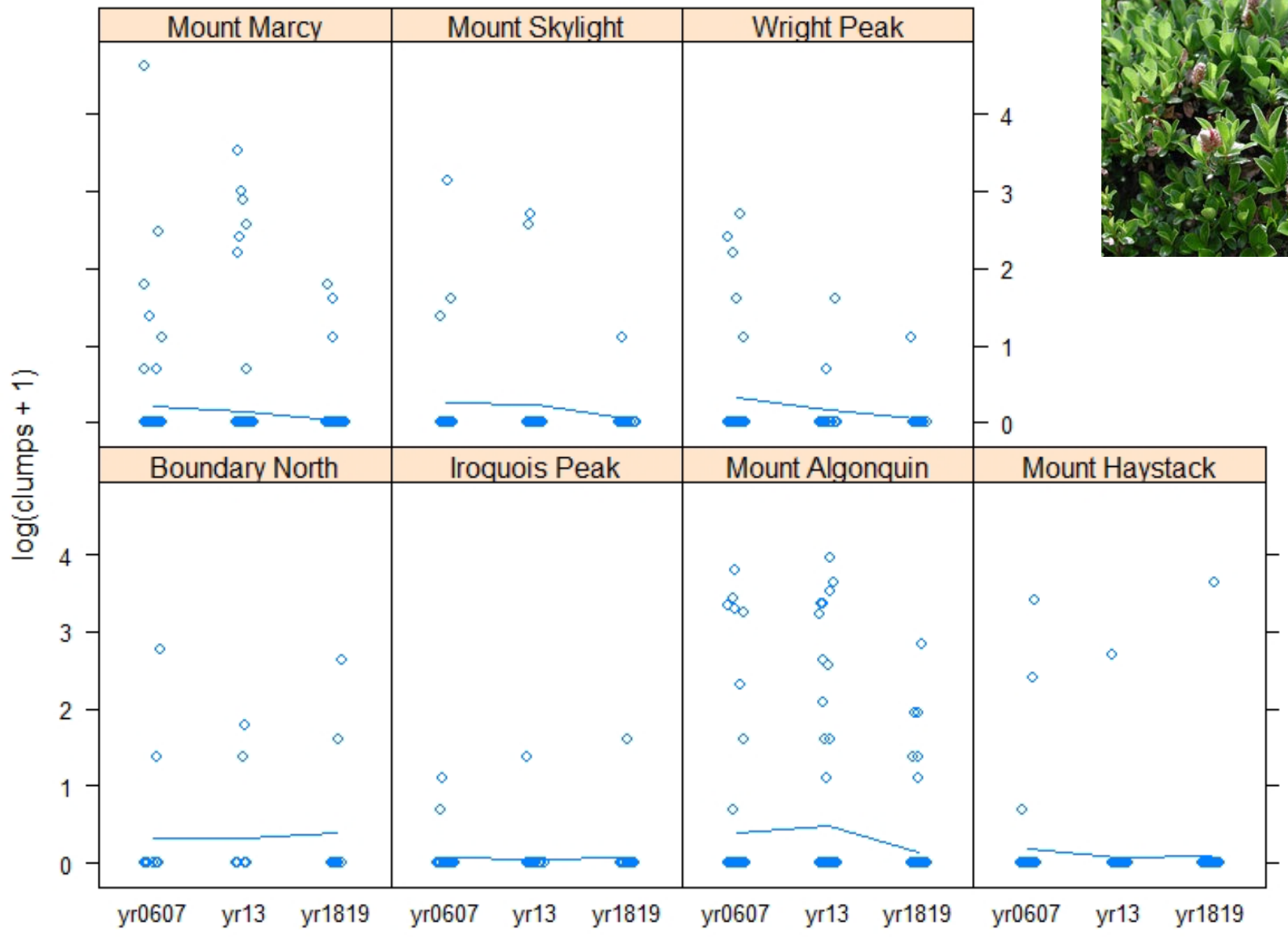
Deer’s hair sedge by sample event



Bearberry willow by sample event



Bearberry willow by summit, sample event



Variables in best models

Species	solRad	elev	expToW	flowLen	curv
Northern bent (*Agrostis mertensii*)		X			X
Alpine sweet grass (*Anthoxanthum monticola*)		X			
Bigelow's sedge (*Carex bigelowii*)		X			X
Diapensia (*Diapensia lapponica*)	X	X	X	X	
Black crowberry (*Empetrum nigrum*)	X	X	X	X	
Mountain firmoss (*Huperzia appressa*)	X	X	X	X	X
Bearberry willow (*Salix uva-ursi*)	X	X			
Cutler's alpine goldenrod (*Solidago leiocarpa*)			X	X	X
Deer's hair sedge (*Trichophorum cespitosum*)			X		X

Overall effect of year for nine species

Species	Linear estimate	*P*	
Northern bent (*Agrostis mertensii*)	0.088	0.586	
Alpine sweet grass (*Anthoxanthum monticola*)	**0.880**	0.028	*
Bigelow's sedge (*Carex bigelowii*)	0.033	0.843	
Diapensia (*Diapensia lapponica*)	**0.238**	0.011	*
Black crowberry (*Empetrum nigrum*)	-0.132	0.198	
Mountain firmoss (*Huperzia appressa*)	**0.521**	<0.001	***
Bearberry willow (*Salix uva-ursi*)	**-0.802**	0.009	**
Cutler's alpine goldenrod (*Solidago leiocarpa*)	**1.486**	<0.001	***
Deer's hair sedge (*Trichophorum cespitosum*)	**0.163**	0.040	*

(T. Howard)

Summary

Based on three sampling events over the last 13 years, the alpine plant populations seem to be holding their own.

For the nine most abundant monitored species:
- Five had significant positive linear response
- One had a significant negative linear response
- Three had non-significant linear response (stayed the same)

Possible mechanisms for positive response?
- Summit Steward Program!
- longer growing season?

Overall this is a very successful and fruitful collaboration between the Summit Steward program and the Natural Heritage Program.

Thank You!

Ben Brosseau

New York Natural Heritage Program

- Family of Dr. Norton Miller
- Will Cummer Gear Fund
- Yuuka McPherson
- Connor Moore
- Ryan Nerp
- Patrick Murphy

Northern New York Audubon

patagonia

Adirondack Garden Clubs

Adirondack ADK Mountain Club

New York State Department of Environmental Conservation

The Nature Conservancy Adirondacks