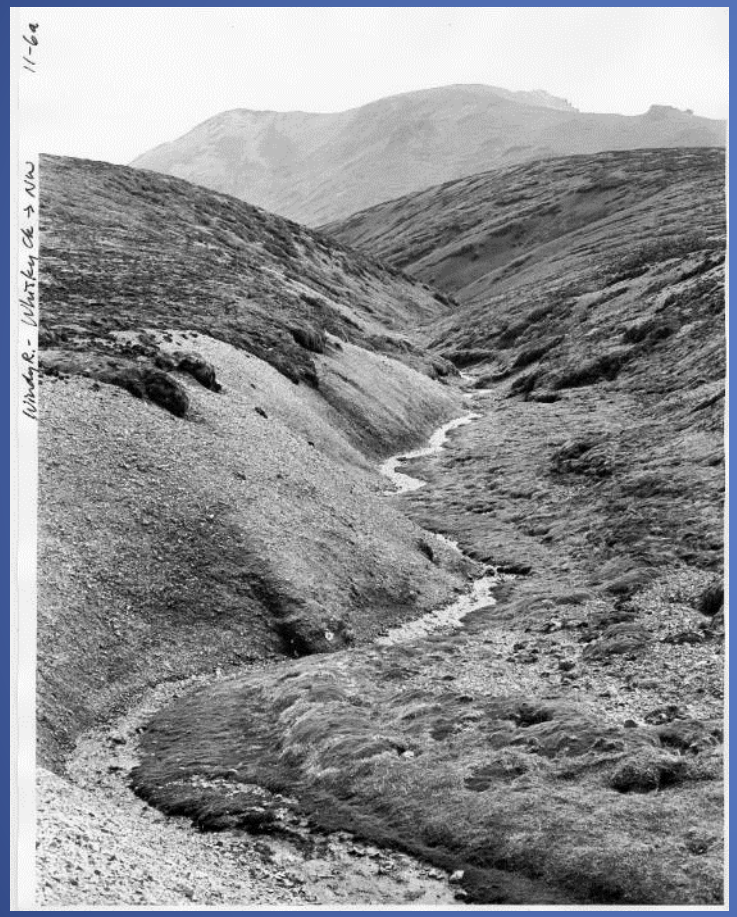
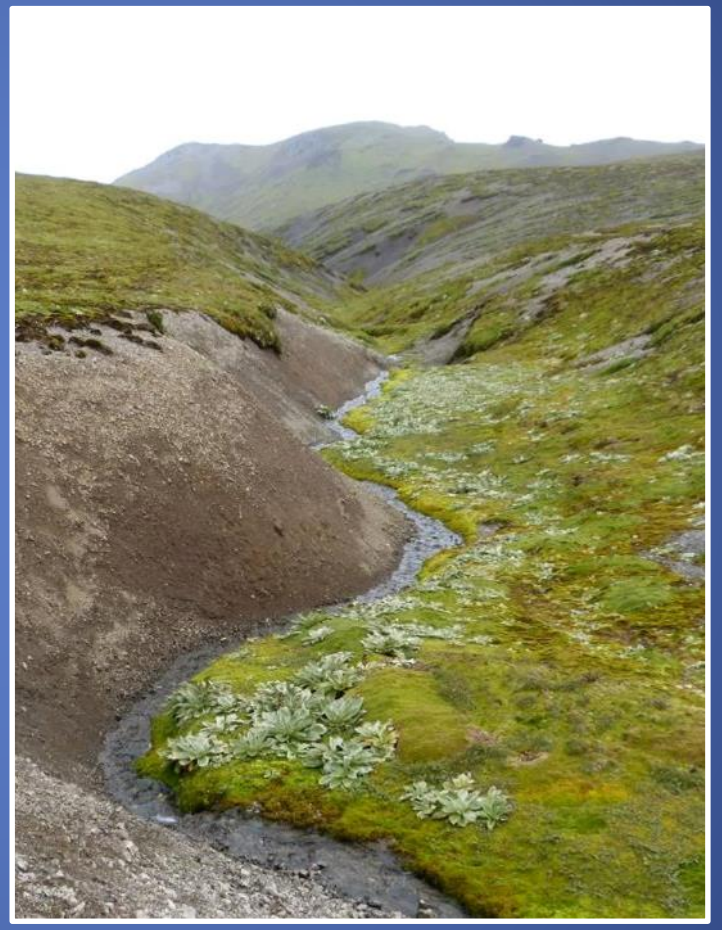
Stability and change in subantarctic tundra vegetation on Macquarie Island observed from repeat photography





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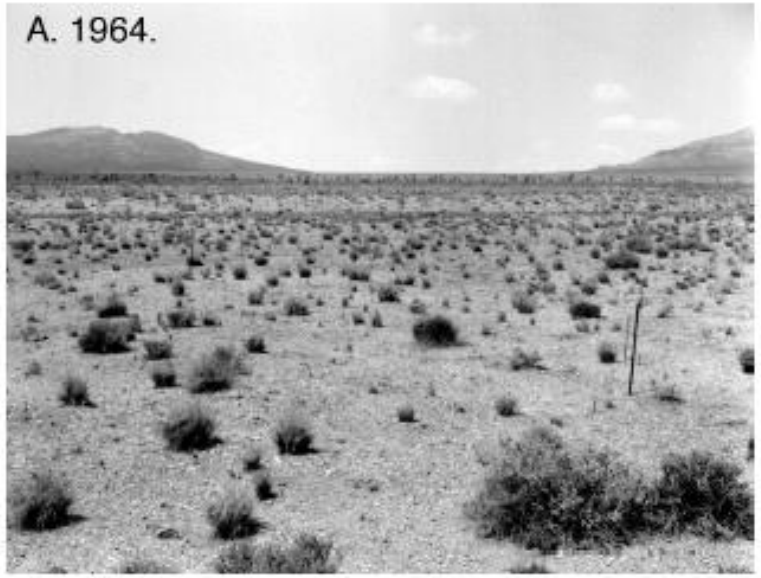
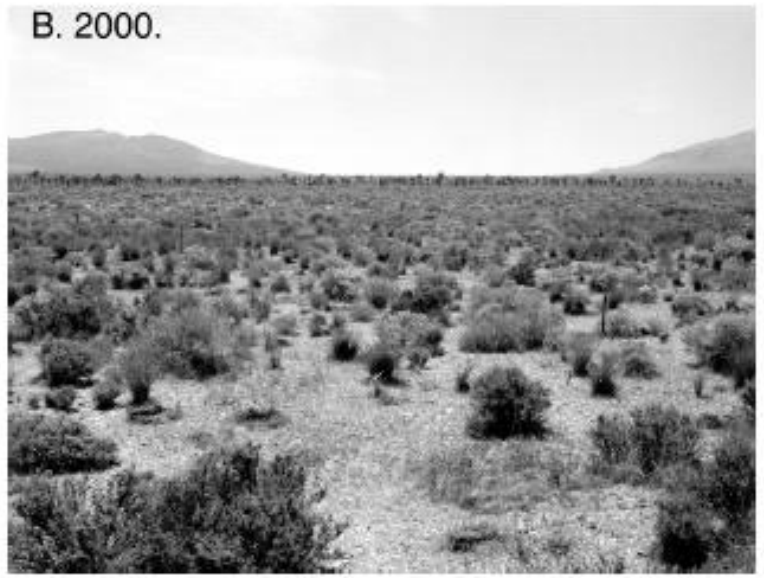
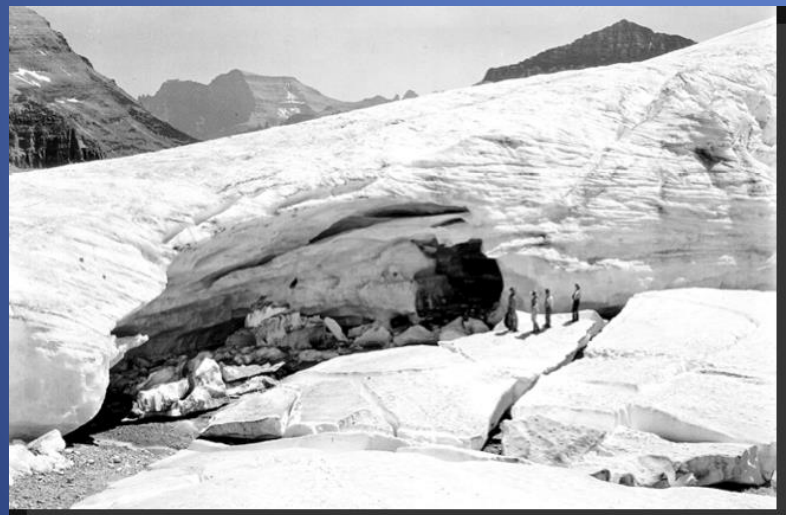
Research Questions

- Can decadal spatial change in vegetation be detected from repeat photography?
- Is there a spatial pattern to trends in vegetation and landscape change?
- How does the post-rabbit era compare with the period of high rabbit grazing pressure?
- Is remote sensing useful for monitoring subantarctic vegetation change?







1932

T. J. Hileman photo
courtesy of GNP archives

1988

Jerry DeSanto photo
K. Ross Toole Archives
Mansfield Library, UM

Macquarie Island

Subantarctic 54.5°S 159°E

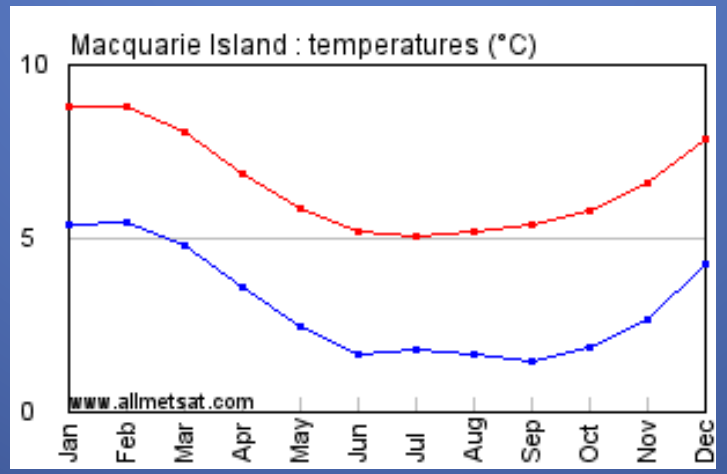
Igneous seafloor origins < 1 Mya

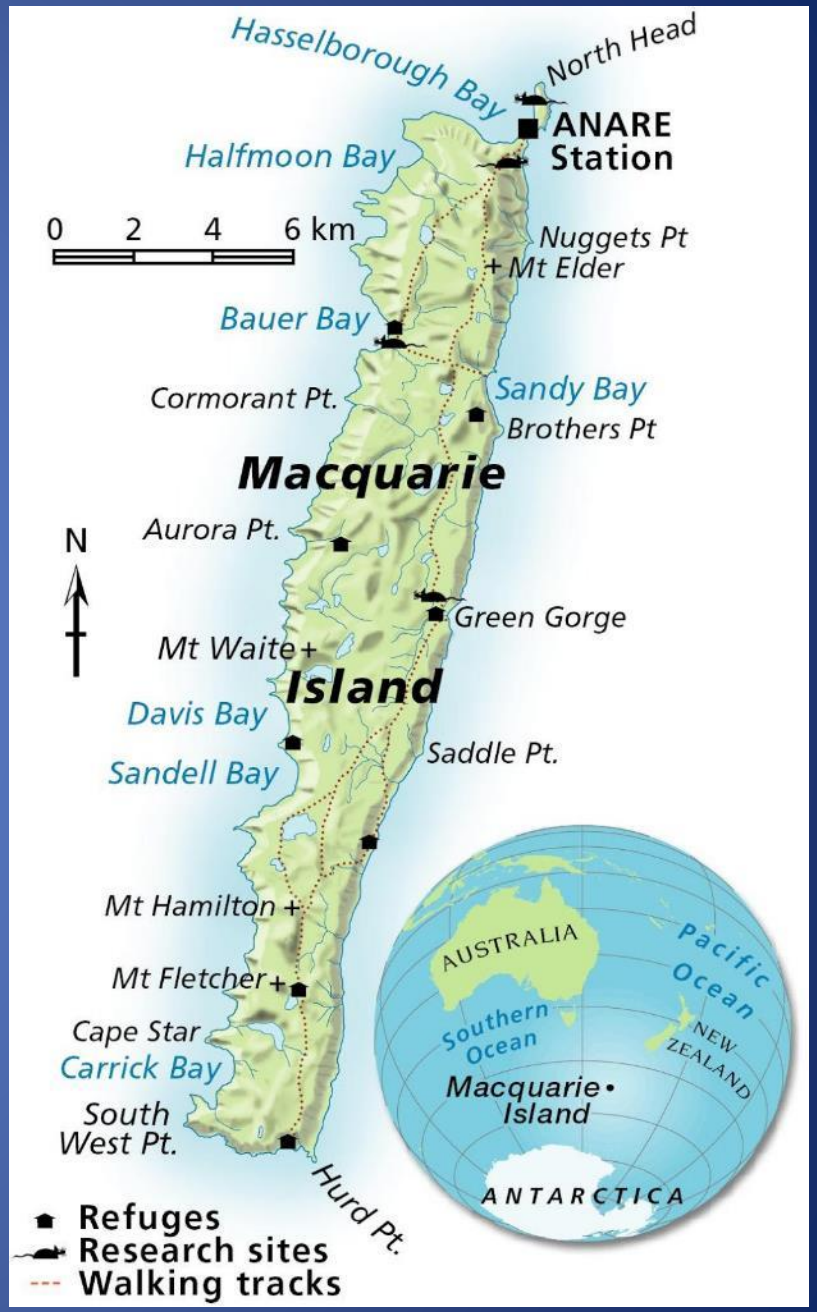
128 km^2

Elevation 0–410 m.a.s.l.

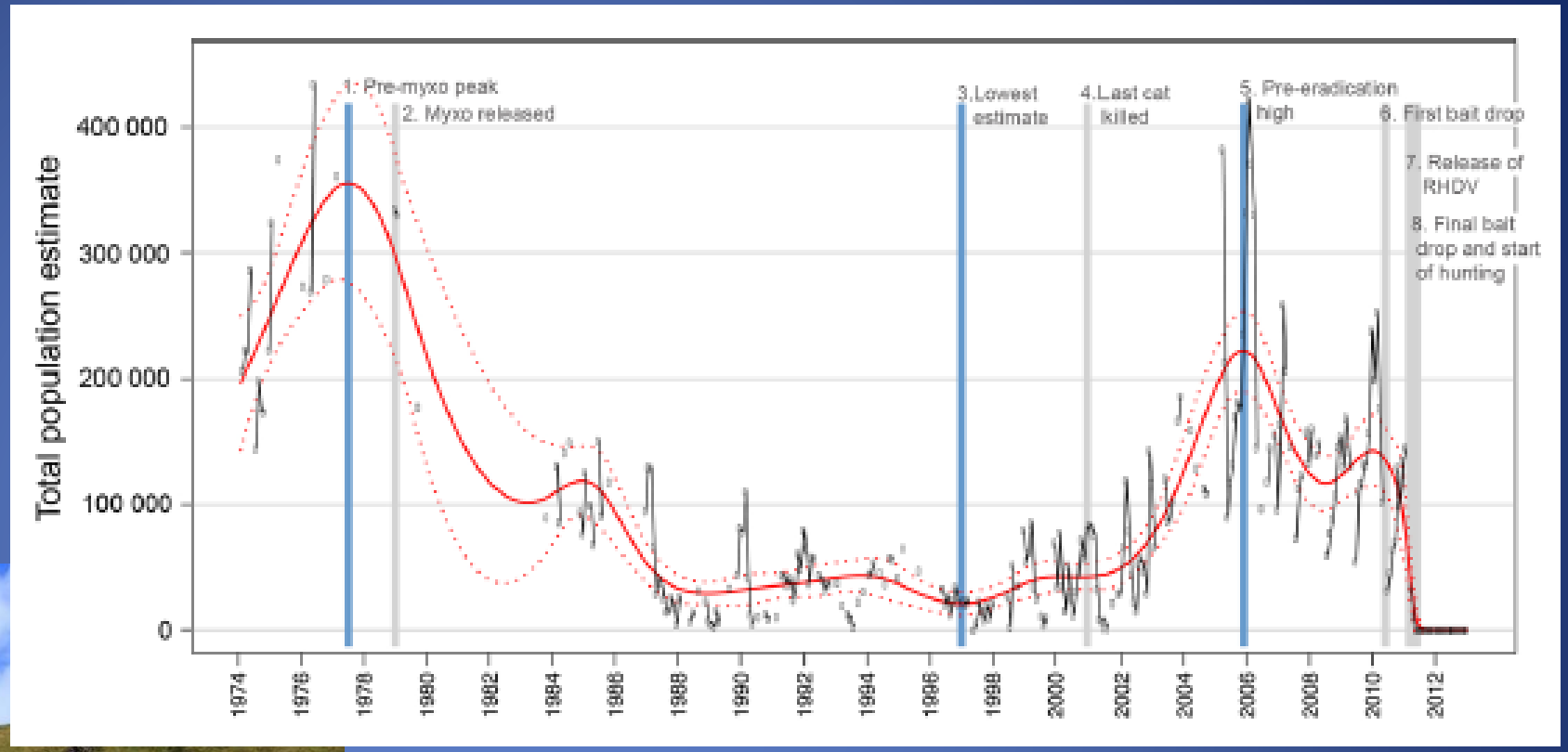
Hyper oceanic climate

- January means: 5.3–8.8°C
- July means: 1.6–4.9°C
- Annual precip^n 1033 mm (317 days)
- Mean annual windspeed 35 km/hr

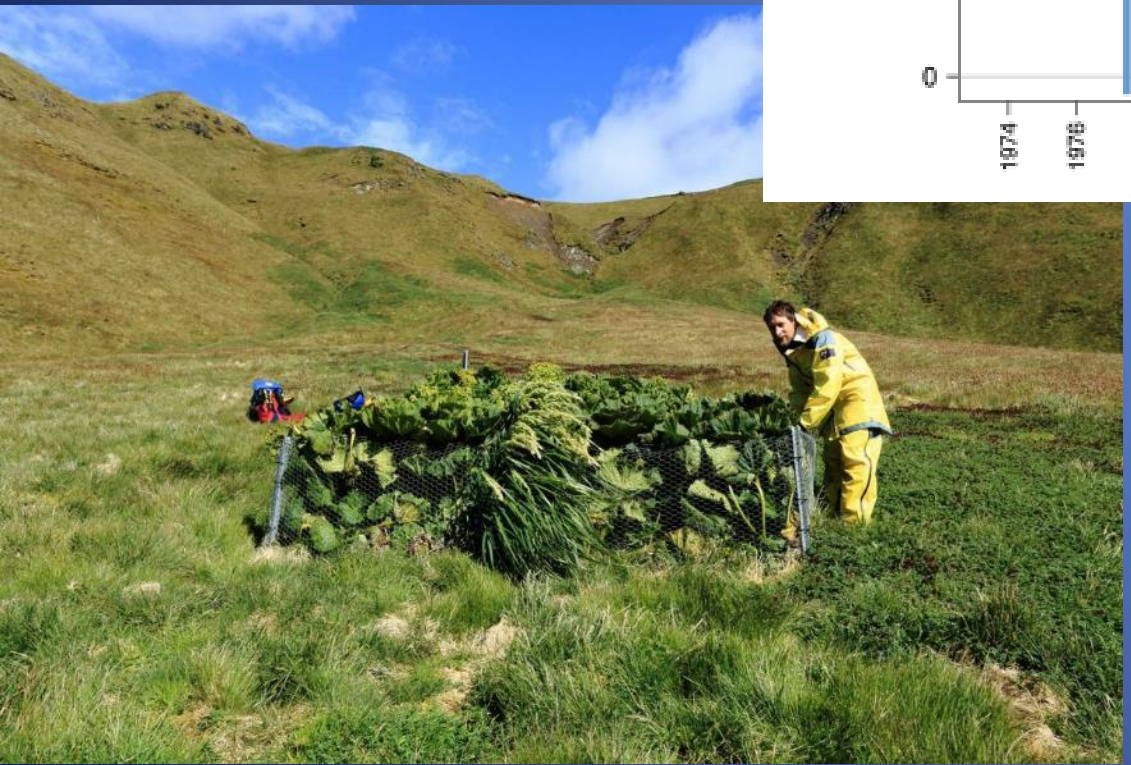




Vegetation and rabbits



Terauds *et al.* 2014



- Vegetation recovery 1980-2000
- Severe vegetation damage early 2000s
- MIPEP baiting 2010-11, last rabbits killed late 2011

Methods

Rephotography: 1980, 2009, 2014
Vegetation monitoring plots: 1981–2015
Remote sensing: 2009-10 Summer, 2012-3 Summer

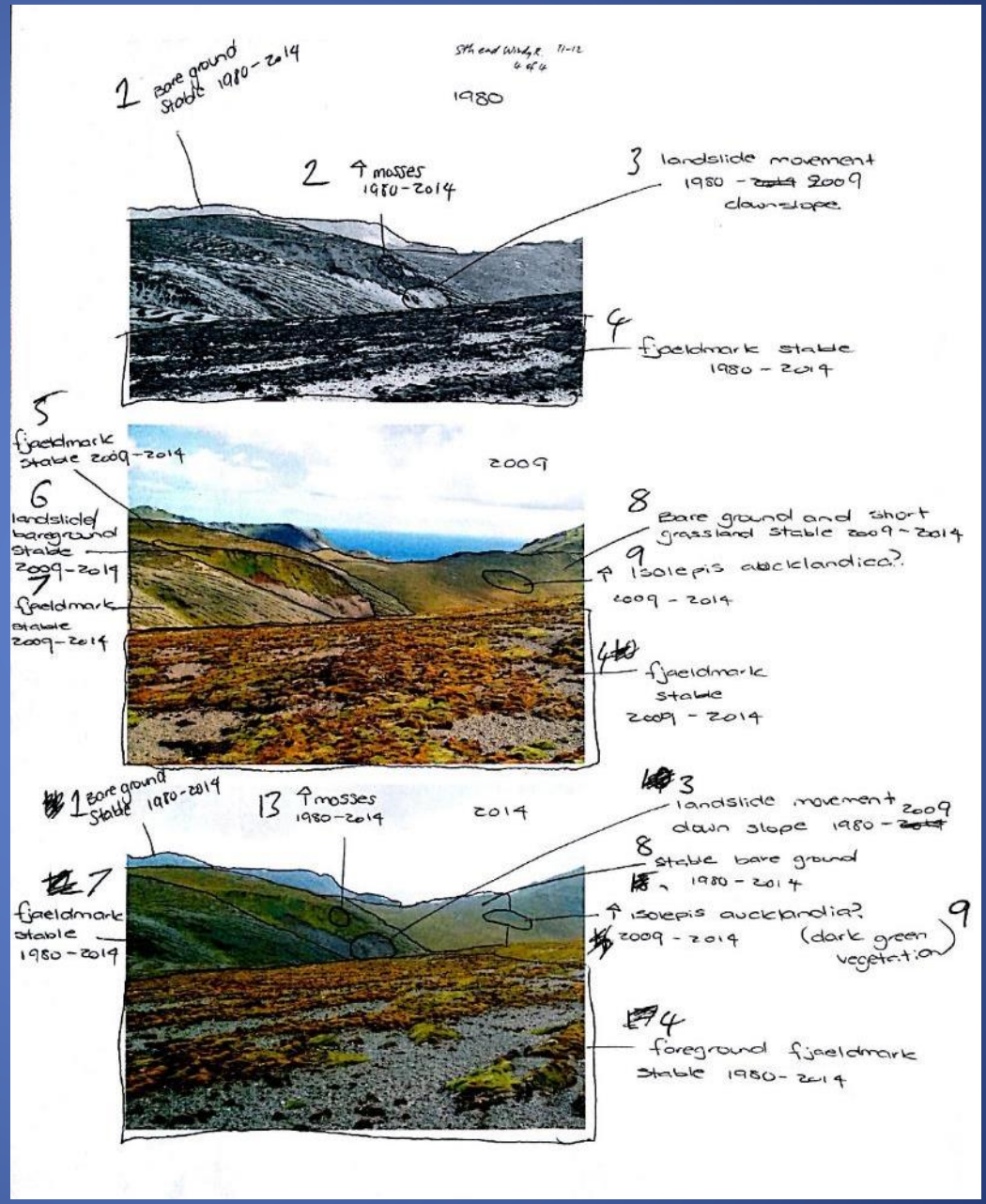
Rephotography sites

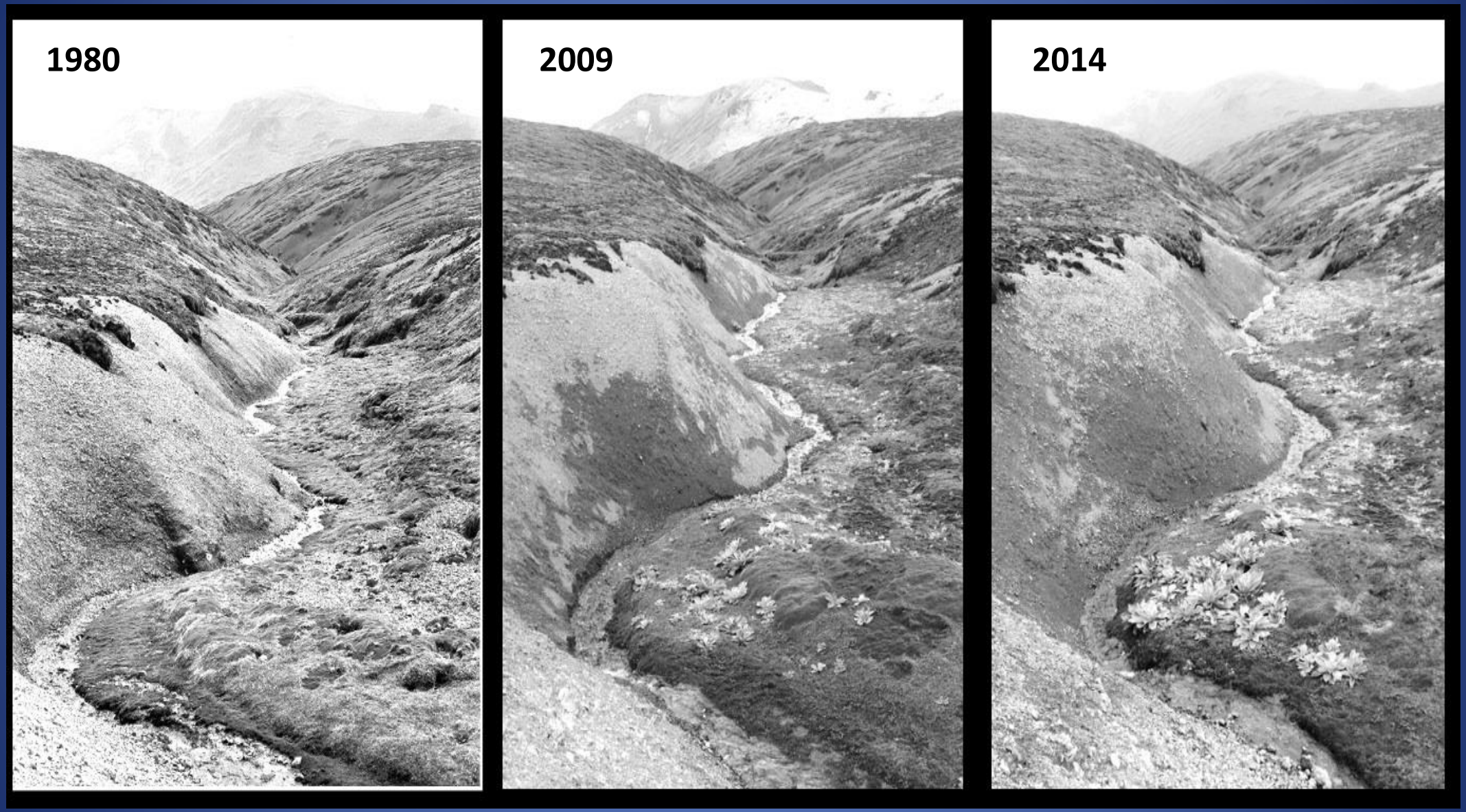
75 photo locations

- Panoramas of 1-7 photos
- > 200 individual photos
- 1980, 2009, 2014

Photo Interpretation

- Vegetation type
- Moss +/-
- Cushion plants +/-
- Bare ground +/-
- *Pleurophyllum* +
- Sedges +
- Tussock grass +/-
- *Acaena* spp. +



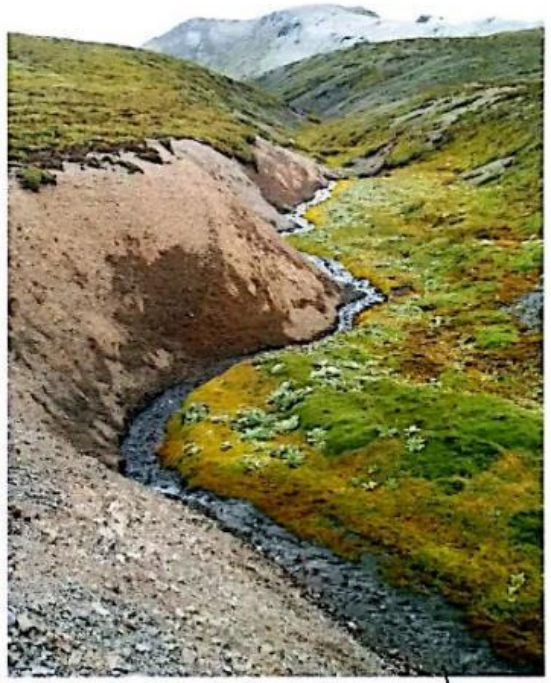

1980
2009
2014

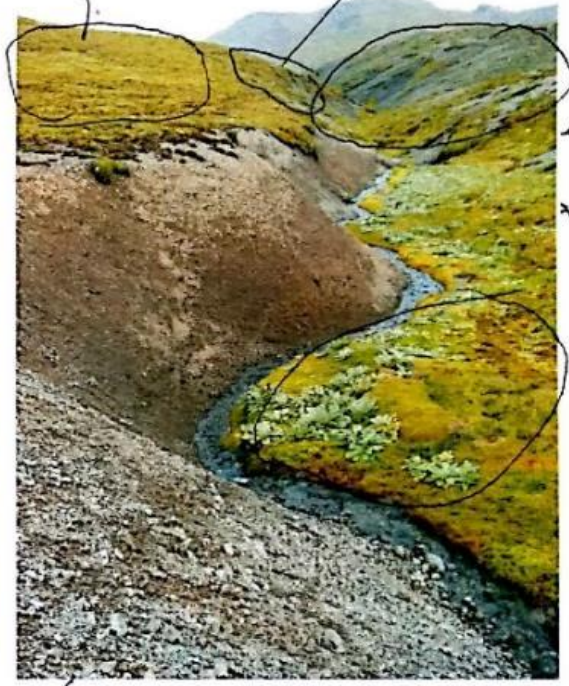
1169

1980

2009

2014





2

1980-2014

↑ moss

↑ cushion

↓ bare

1980 - 2014 cf. 2009 - 2014

① ↑ Pleurophyllum

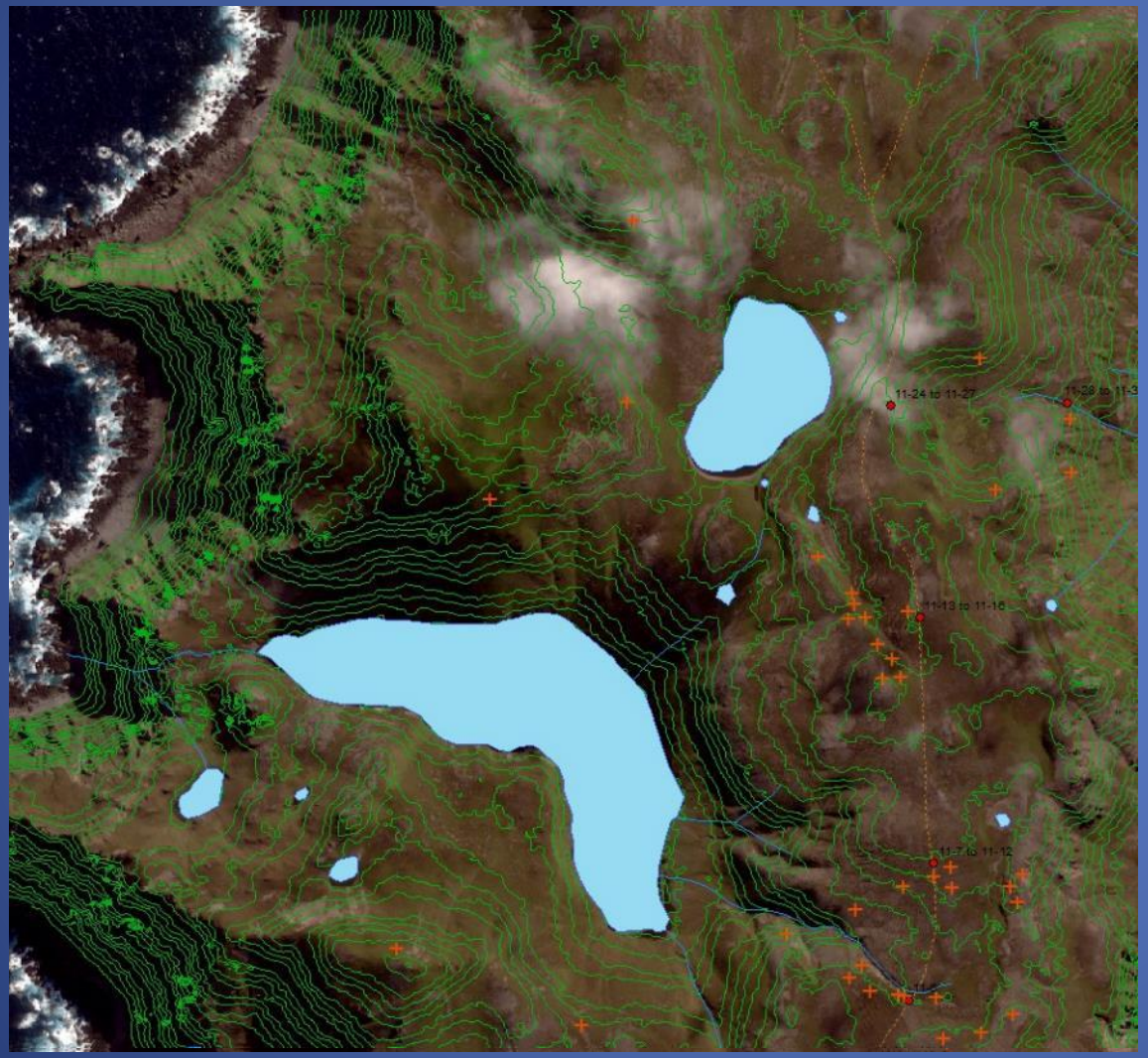
↑ moss

↑ cushion

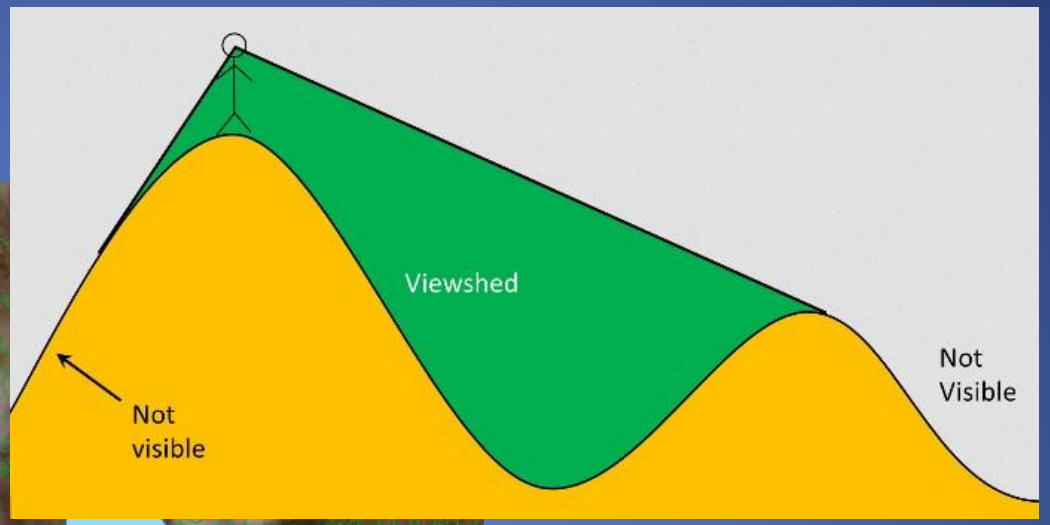
↓ bare

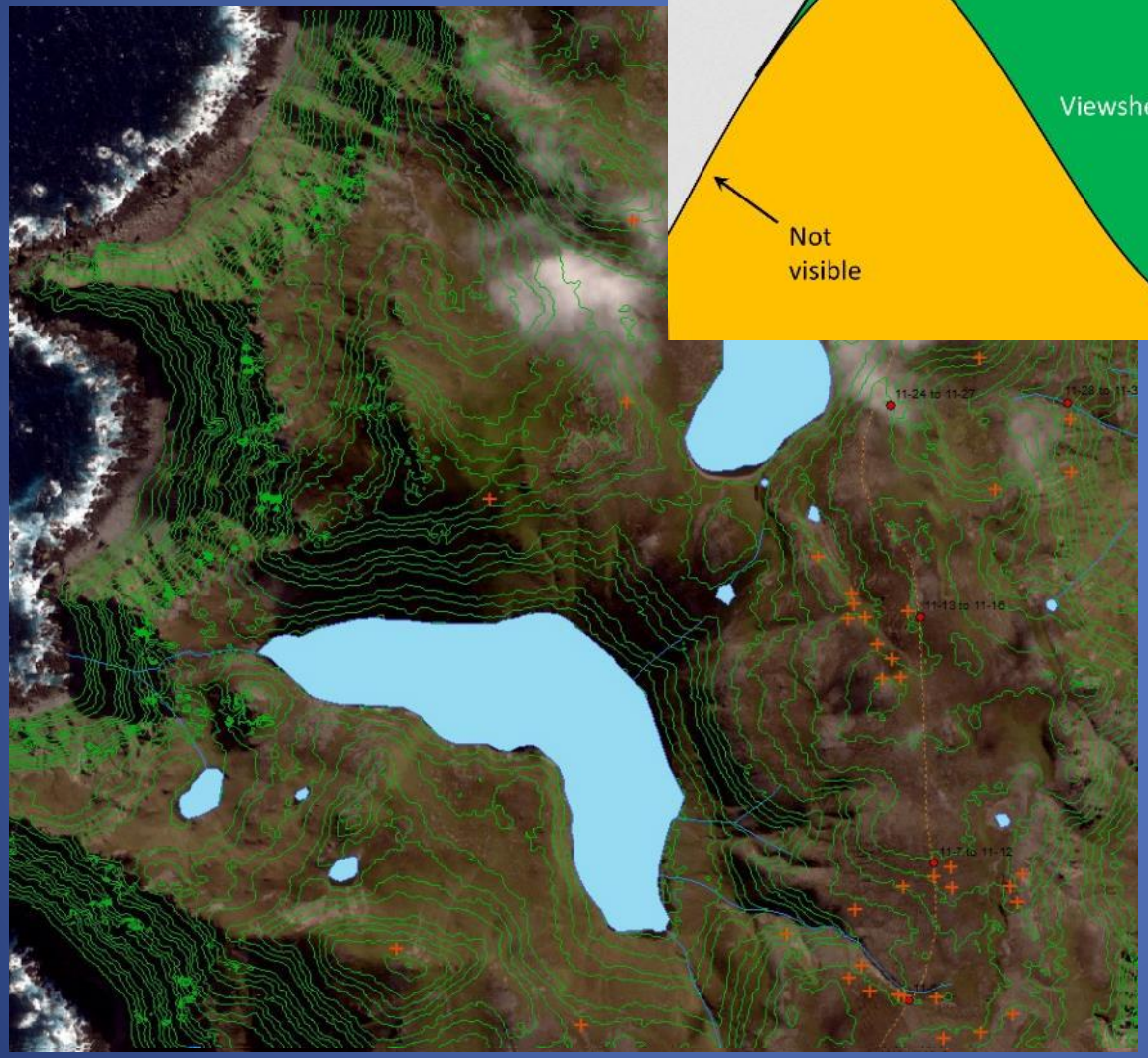
① ↑ Pleurophyllum ↓ moss ↓ cushion

Geolocation



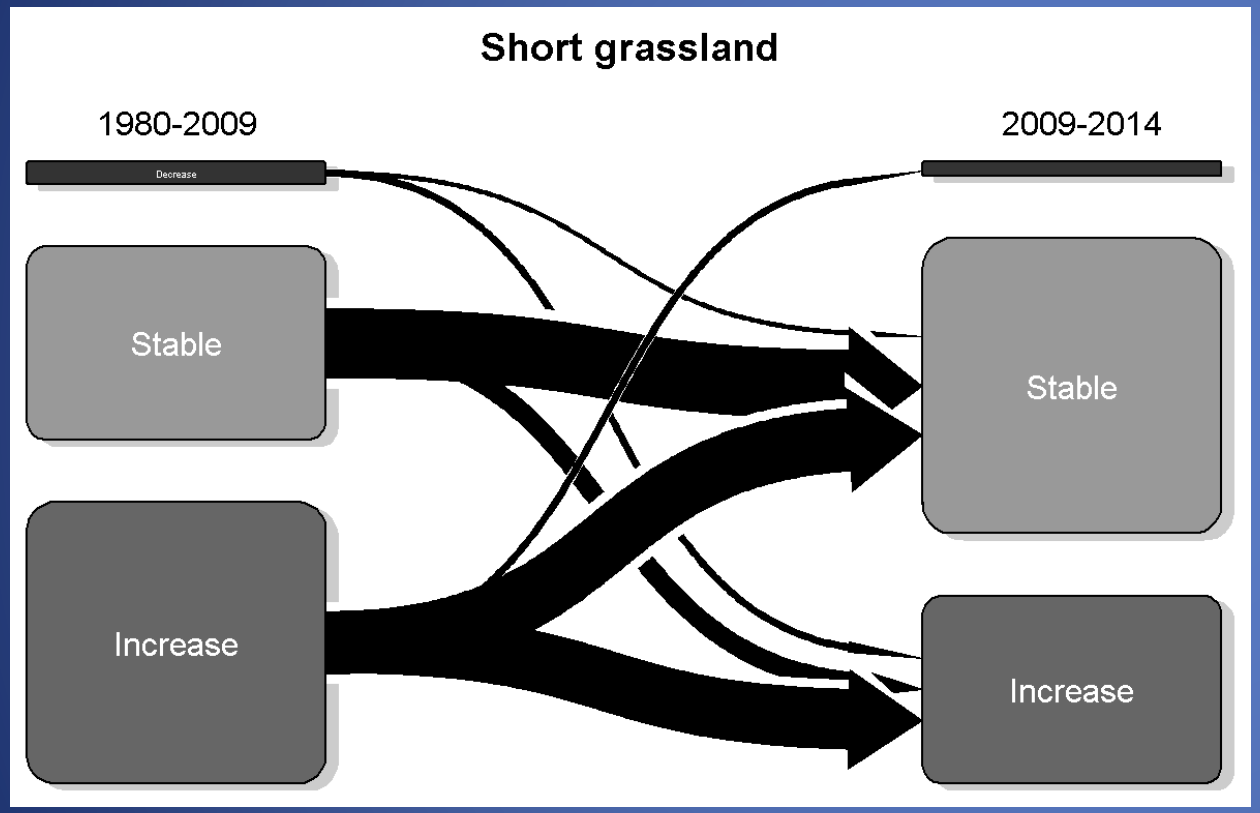
Geolocation



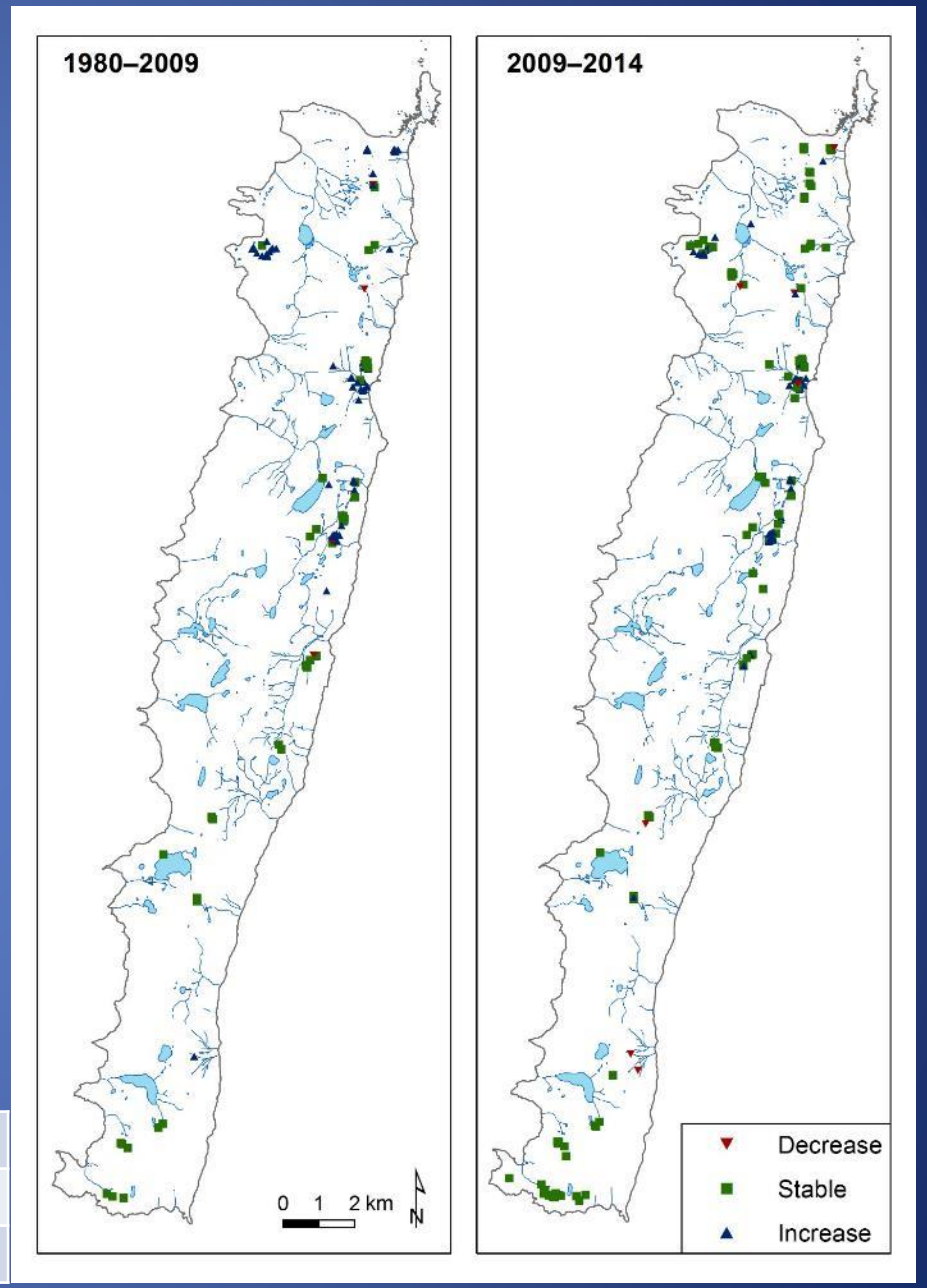


Geolocation

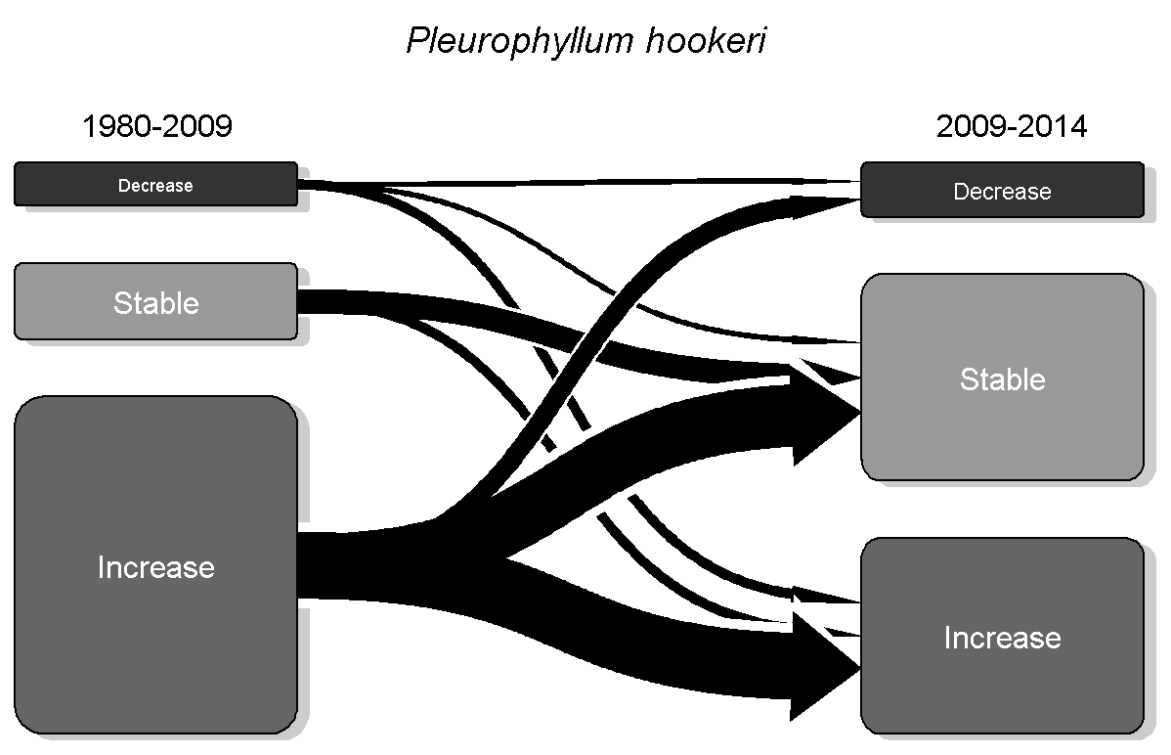
Rephotography Results

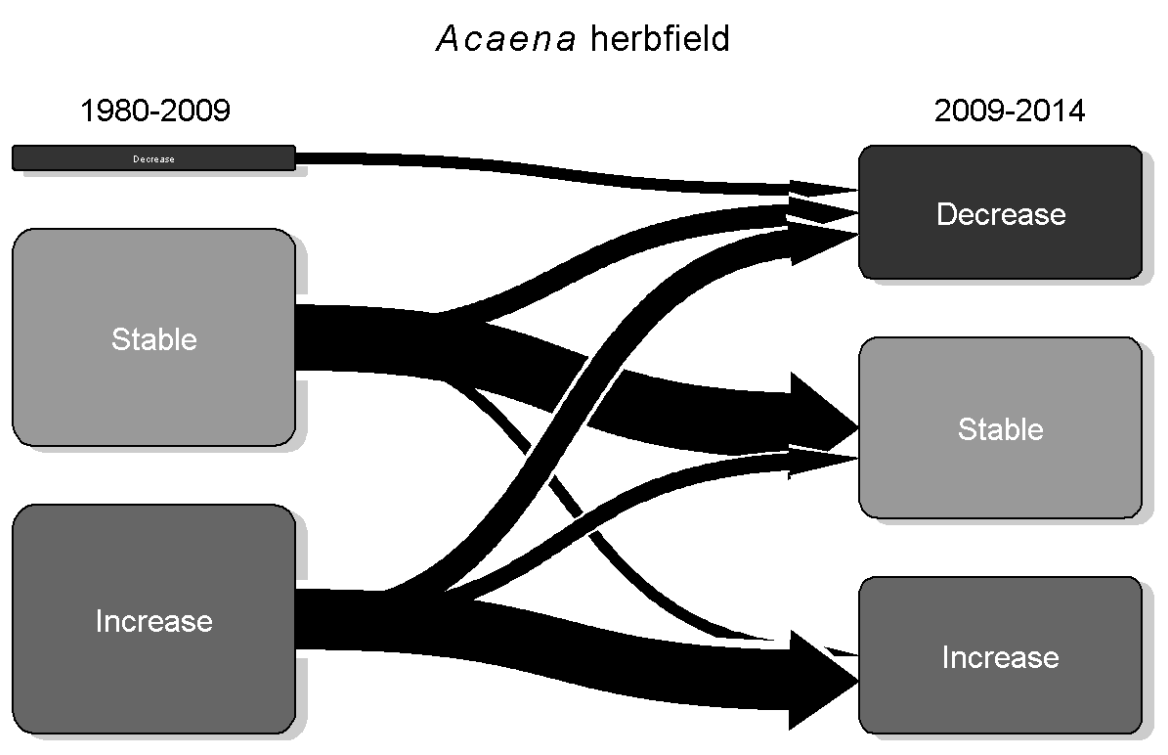


Vegetation class	Period	Decrease	Stable	Increase	χ^2	*p* value
Short grassland	P1	9	46	79	54.9	**<0.001**
	P2	9	105	66	77.7	**<0.001**



Rephotography Results





Vegetation class	Period	Decrease	Stable	Increase	χ^2	*p* value
Pleurophyllum	P1	2	5	27	32.9	<0.001
hookeri	P2	4	20	31	20.1	<0.001
***Acaena* spp.**	P1	0	13	15	-	-
	P2	13	18	15	0.83	0.687

Togopographic Variables

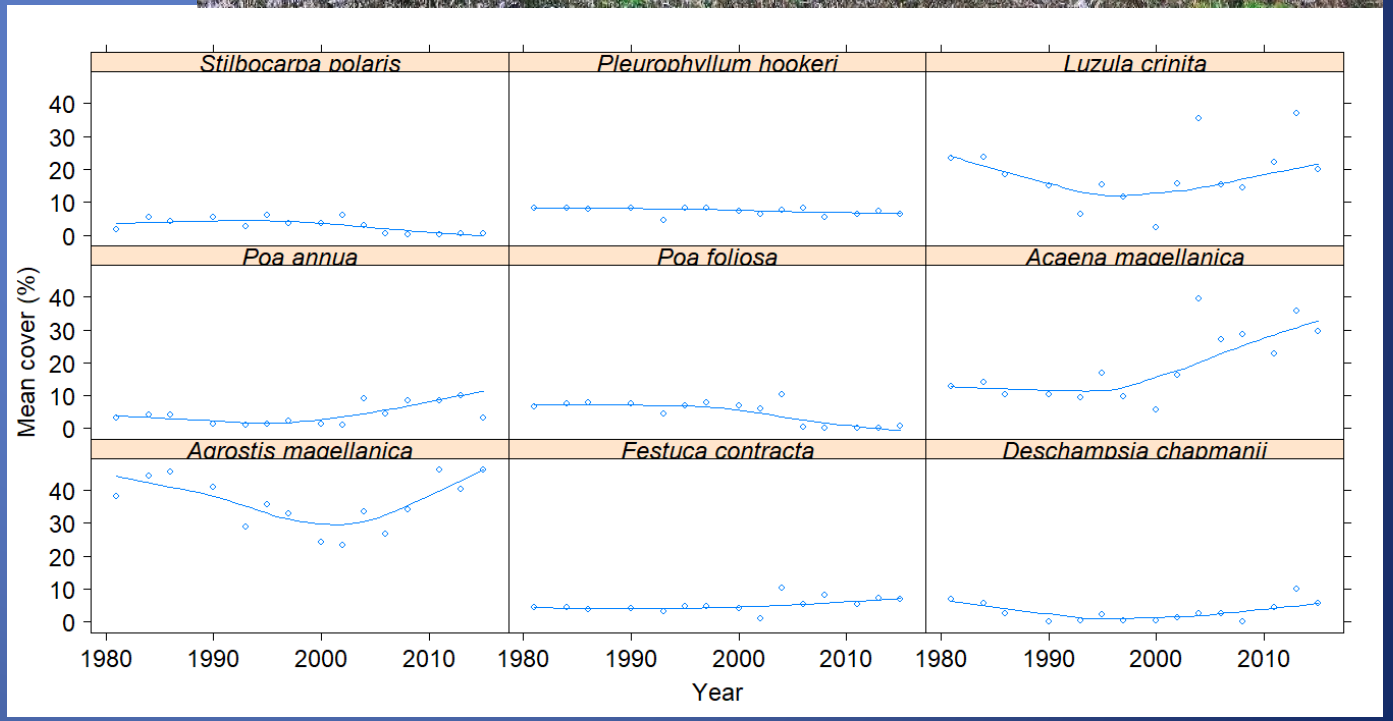
Vegetation change trajectories frequently vary with elevation

- Short grassland – less change at higher elevations (P2)
- *P. hookeri* – stable below 100 m.a.s.l., increase at higher elevations
- *Acaena* spp. – increase below 100 m.a.s.l., stable at higher elevations
- Bare ground – incr. below 100 m, decr. higher (P1), decr. below 100, stable above (P2)

Vegetation class	Period	Elevation		Aspect		Slope	
		χ^2	p value	χ^2	p value	χ^2	p value
Short grass	P1	12.39	0.060	4.75	0.610	12.00	0.061
	P2	23.64	**0.002**	8.30	0.219	2.70	0.866
Pleurophyllum	P1	20.05	**0.002**	15.07	**0.012**	4.44	0.658
hookeri	P2	11.90	0.062	7.23	0.301	7.49	0.274
***Acaena* spp.**	P1	6.34	**0.031**	8.07	**0.036**	1.03	0.846
	P2	13.11	**0.023**	7.79	0.283	10.09	0.134
Azorella	P1	1.94	1.000	8.476	0.180	7.54	0.076
	P2	4.21	0.389	10.68	0.099	3.177	0.530
Bare ground	P1	21.98	**0.002**	6.39	0.388	16.37	**0.012**
	P2	50.53	**<0.001**	12.53	**0.030**	7.42	0.270

Vegetation quadrat data

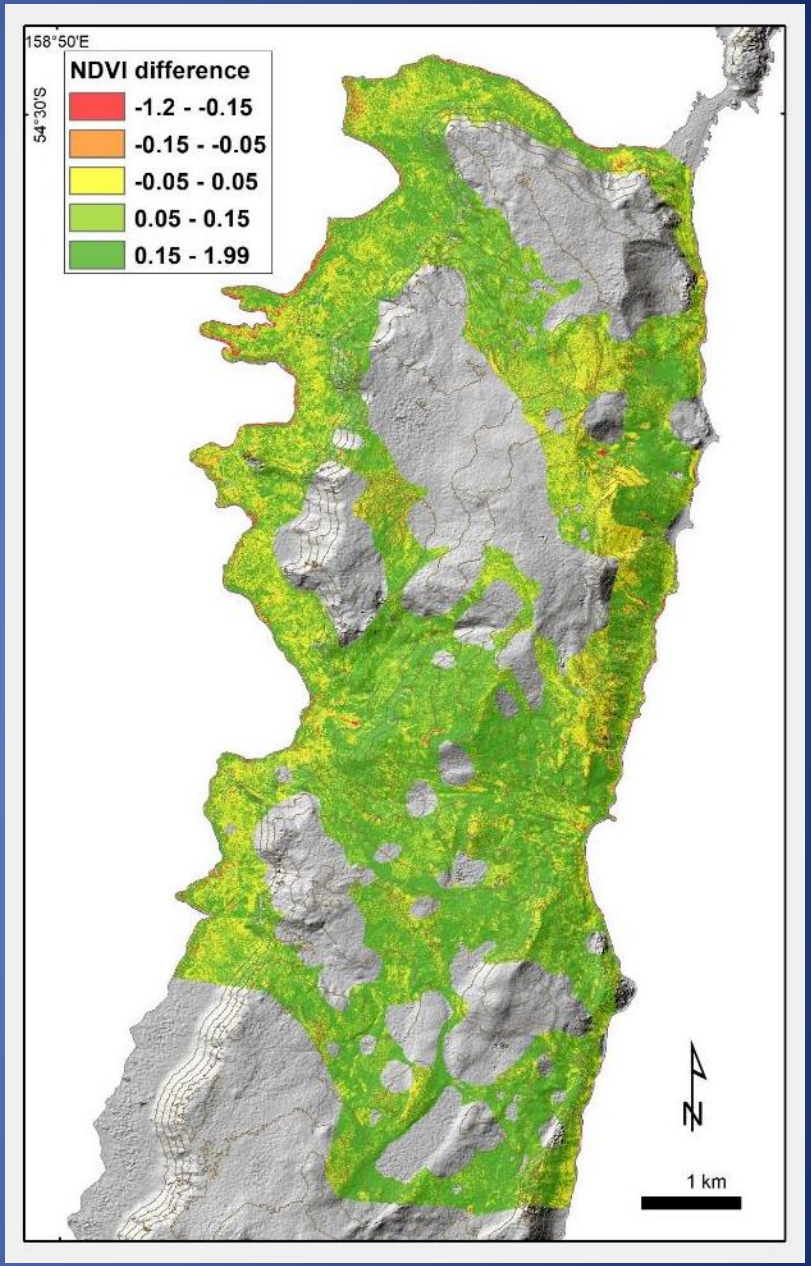
- Short grassland and herbfield vegetation
- Vascular plant species cover 1981–2015
- 30 quadrats (20 x 20 m)
- Most species decreased 1981–2008, increased 2011–2015
- Megaherbs (*Pleurophyllum hookeri, Stilbocarpa polaris*) at low levels throughout the 34 years



Satellite Image Analysis

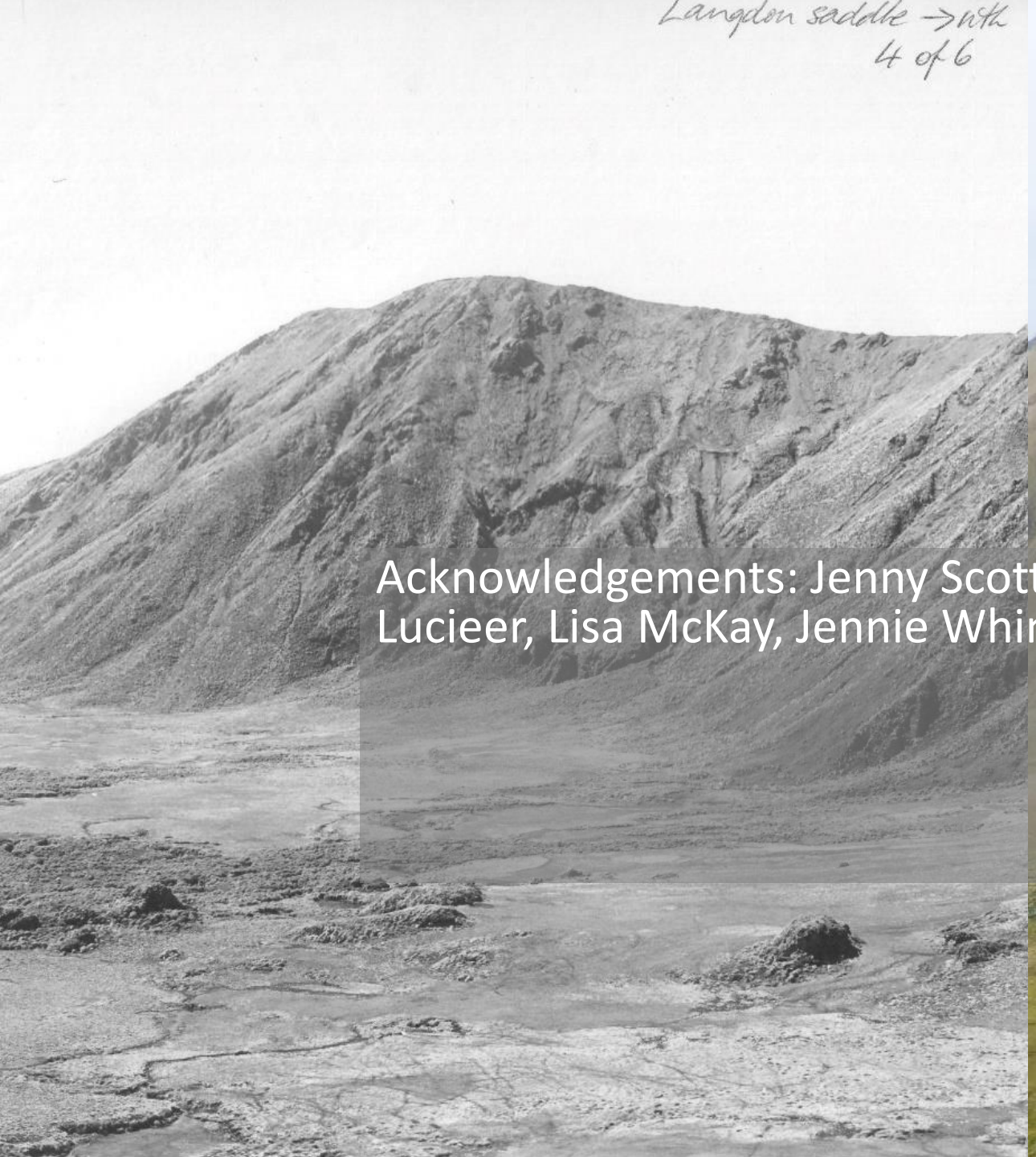
- Spectral Vegetation Indices calculated from high resolution (1.84 m) WorldView-2 satellite images
- December 2009 and January 2013
- Each SVI reclassified into 5 classes
- χ^2 test for relationship with topography

	Elevation		Aspect		Slope	
	χ^2	*p* value	χ^2	*P* value	χ^2	*p* value
NDVI	170.61	<0.0001	5.906	0.921	31.23	0.002
MTVI2	228.12	<0.0001	55.29	<0.0001	17.139	0.144
SGI	51.882	<0.0001	27.378	0.007	88.905	<0.0001



Conclusions

- Feldmark vegetation – little change detectable over 34 years
- Tussock grassland and megaherbs – transition to short grassland and herbfield prior to 2009, some increase 2009–2014
- Change trajectories frequently related to elevation, less so to slope and aspect
- Rephotography effective for detecting some types of change
- Remote sensing has limitations in this situation



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