Predictive modelling of tundra changes in mountain treeline ecotone over the last 60 years with remote sensing time series data (case study of Western Brooks Range, Alaska, USA)

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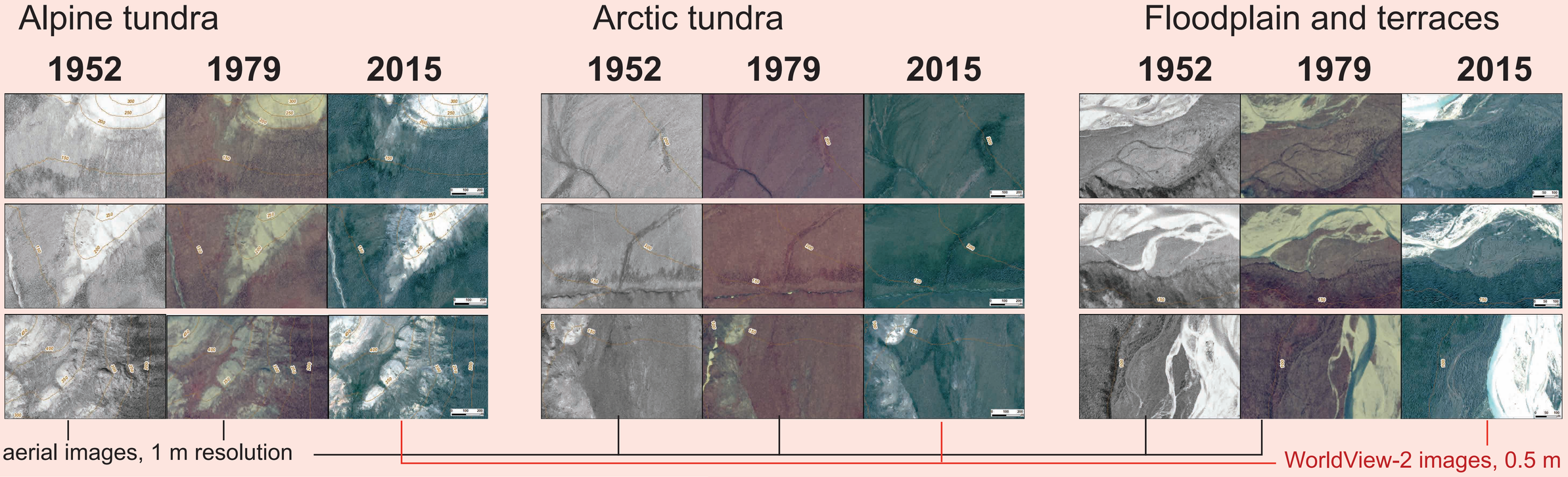
Overall aim

Mountain tundra responses to climate change by mainly increasing of forest cover and altitudinal position of uppermost trees. Using very high-resolution satellite imagery of 1952, 1979 and 2015 we compared the position and abundance of five main vegetation types of the Agashashok river valley Alaska, USA: closed forest, open woodland, shrubs, tundra and unvegetated areas for these dates and then used the generalized linear models to predict tree abundance in tundra depending on morphometric variables and temperature changes.

Changes in different tundra types as observed from remote sensing data



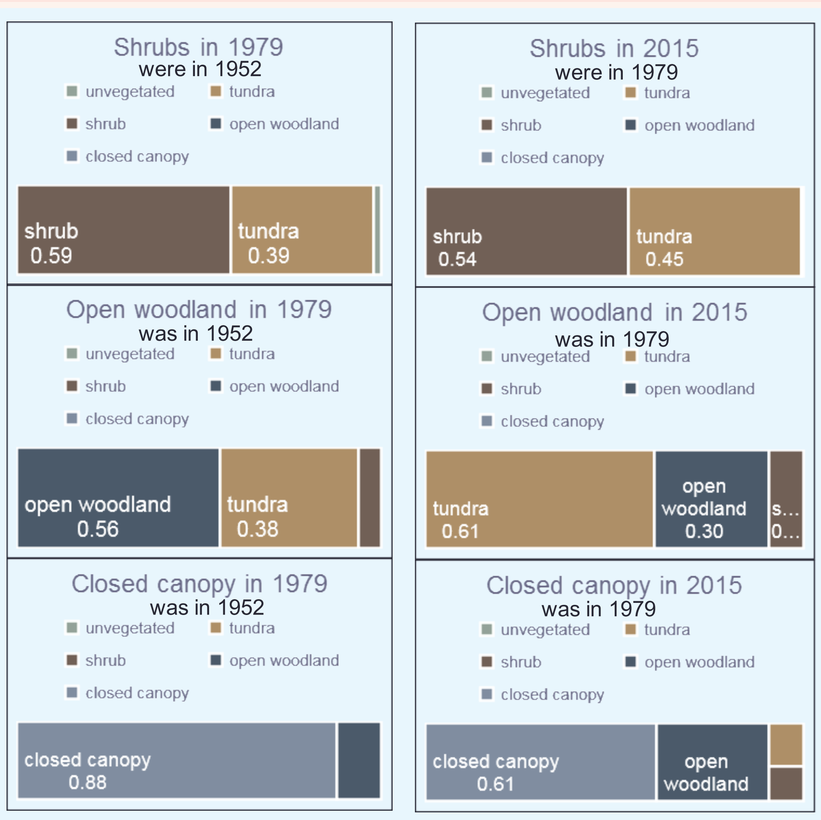
Landscape changes over the last 63 years

Changes over 1952-1979 (27 years), %

		1979					
		unvegetated	tundra	shrub	open woodland	closed canopy	TOTAL POINTS (1952)
1952	unvegetated	86.87	12.12	1.01	0.00	0.00	100
	tundra	0.18	56.55	6.55	0.07	0.00	100
	shrub	0.00	0.02	88.52	9.84	0.00	100
	open woodland	0.00	0.00	0.00	77.14	22.86	100
	closed canopy	0.00	0.00	0.00	0.00	100.00	100
	Rate of change, %/decade	**-5.00**	**-3.46**	**+15.22**	**+12.08**	**+4.79**	

Changes over 1979-2015 (36 years), %

		2015					
		unvegetated	tundra	shrub	open woodland	closed canopy	TOTAL POINTS (1979)
1979	unvegetated	91.91	7.51	0.58	0.00	0.00	100
	tundra	0.40	72.26	11.98	13.17	2.20	100
	shrub	0.00	2.17	77.17	10.87	9.78	100
	open woodland	0.00	0.00	0.00	34.02	65.98	100
	closed canopy	0.00	0.00	0.00	0.00	100.00	100
	Rate of change, %/decade	**-2.00**	**-7.90**	**+10.03**	**+3.24**	**+13.68**	



We created 995 random points over the valley (area about 72 sq. km), classified them manually into 5 main vegetation classes, 2 types of geomorphology and calculated morphometric variables from Arctic DEM. Then we estimated the rates of changes of each class and analyzed the initial states of each class for both periods .

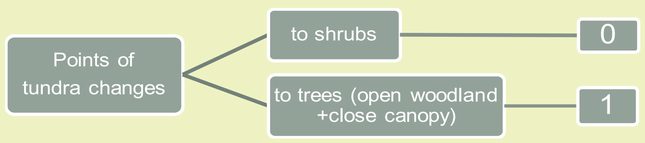
Results:

Over the 63 years more than 30% of landscape has changed;

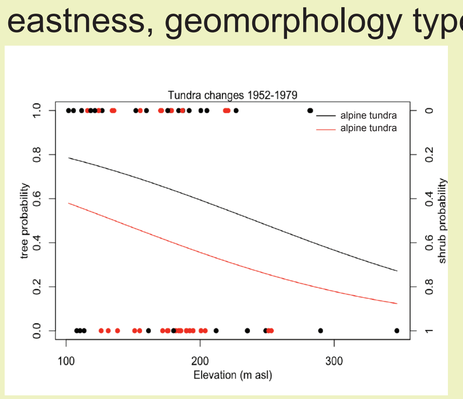
The acceleration of tree and shrub occurrence after 1979

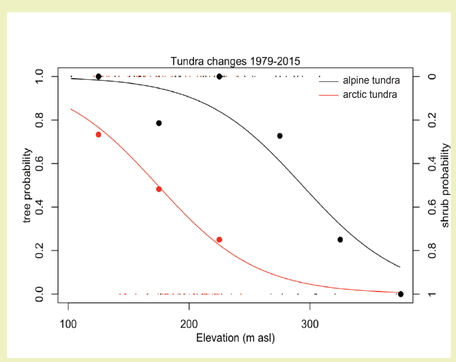
Modelling of tree presence in tundra

- Generalized Linear Model (glm)



- Full backwards stepping regression with all environmental variables (elevation, slope, northness, eastness, geomorphology type and their interactions



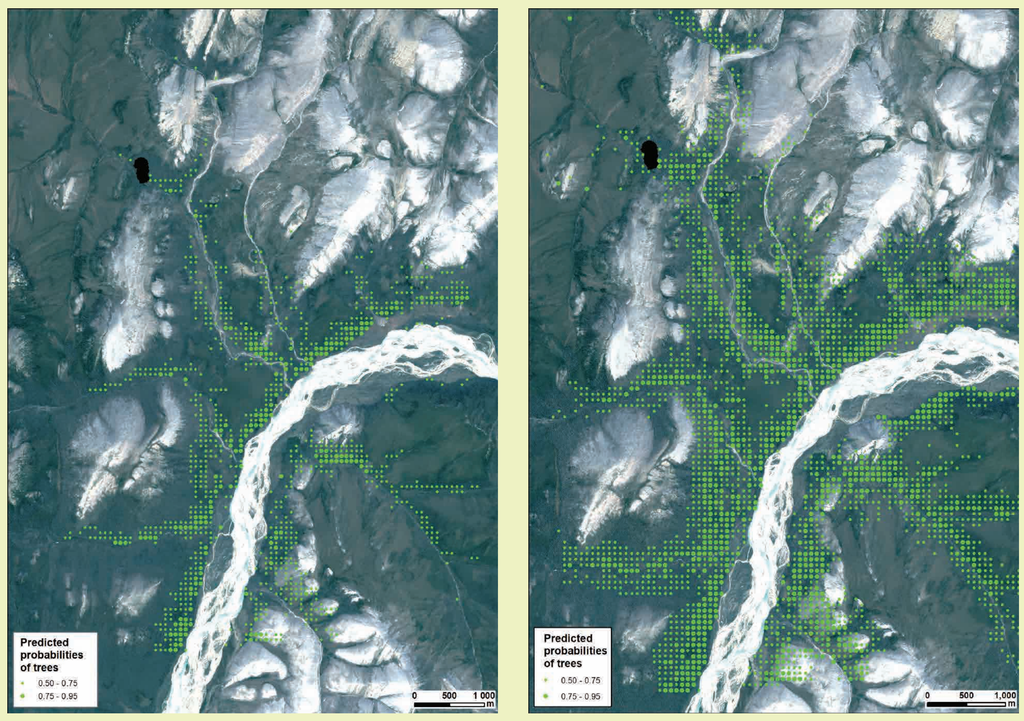


Results:

Morphometric variables are significant and have potential to explain the tree vs shrub occurrence in former tundra after 1979

Change from tundra	To tree	To shrub
Increasing Elevation	Less likely	More likely
More Easterly	More likely	Less likely
More Northerly	Less likely	More likely
Steeper	More likely	Less likely

Tree presence in 1952 Tree presence in 2015



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