Shrub cover rather than climate is a direct driver of plant diversity in alpine tundra

F. Boscutti*[1], V. Casolo[1], M. D'Ambrogio[1], F. Salzillo[1], C. Rixen[2]

[1] *Department of Agricultural, Food, Environmental and Animal Sciences, University of Udine, via delle Scienze 91, 33100 - Udine, Italy;*

[2] *WSL Institute for Forest, Snow and Landscape Research SLF, Unit Ecosystem Boundaries, Alpine Ecosystems, Flüelastr. 11, CH-7260 Davos, Switzerland*

*francesco.boscutti@uniud.it

INTRODUCTION

Enhanced shrub growth and shrub expansion due to climate warming have been observed in many arctic and alpine ecosystems. Warmer temperatures and shrub expansion could cause major changes in plant community structure, affecting both species composition and diversity.

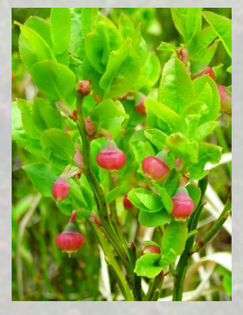
Studying interrelations between climate, shrub growth, shrub cover and plant diversity may improve our understanding of the ongoing changes in plant communities of the alpine tundra.

To get new insight on such processes, we studied growth of bilberry (*Vaccinium myrtillus* L.) and its plant communities along an elevation gradient in the eastern Alps.

METHODS

Sampling design

Sampling was conducted with a nested design in two valleys (i.e. blocks) of the Carnic Alps. In each valley, sampling areas (i.e. plots) of 25 m^2 were randomly selected within dwarf-shrubs communities along an elevation gradient (from c.a. 1600 to 2200 m asl), each 30 m . In total, 37 plots were surveyed (20 1st block +17 2nd block).



Data collection

***Vaccinium myrtillus* traits:**

Ten ramets of *V. myrtillus* were gathered in every plot and analyzed by overall 370 cross sections counting their xylem rings and measuring ring widths. In field, the length of the top shoot of the same ramets was also recorded.

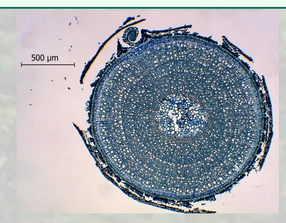
Vegetation survey:

In each plot, the cover of all occurring vascular plants was estimated in percentage. Dwarf shrubs cover was also recorded.

All the surveys were conducted in summer 2014.

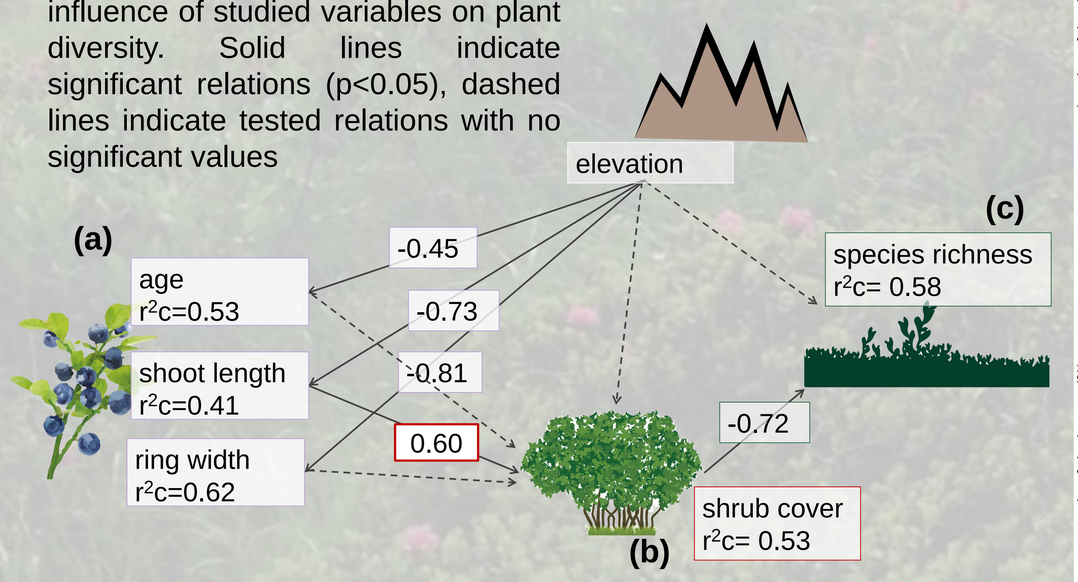
Data analysis

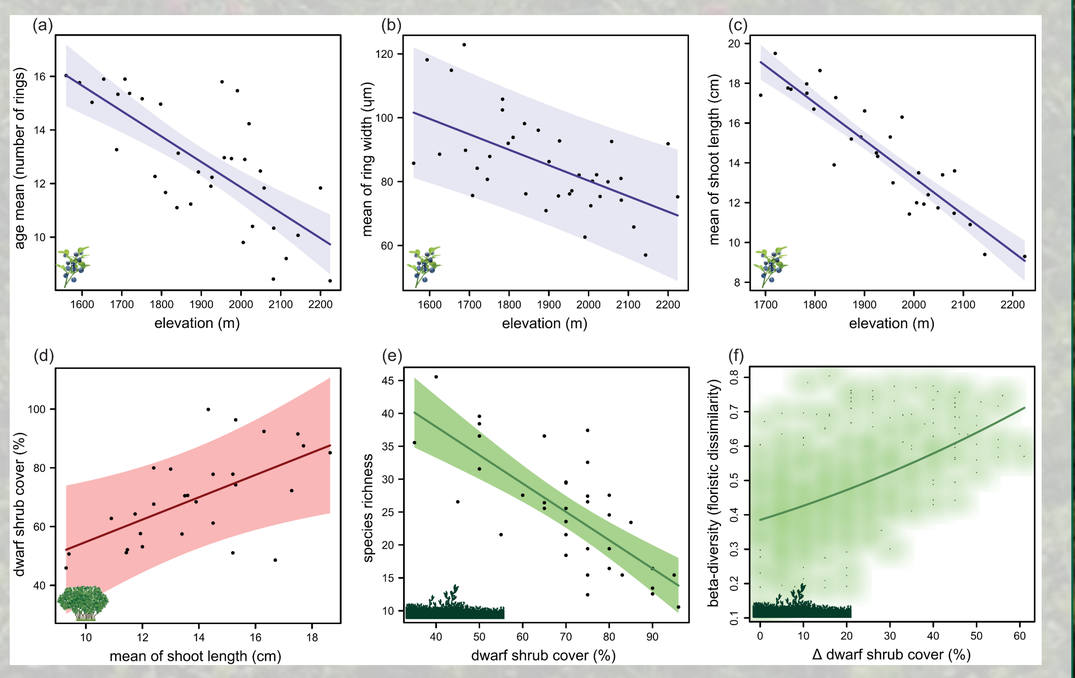
Linear mixed models were applied using piecewise structural equation modelling (Lefcheck, 2016) to examine the complex relationships between ecological drivers and vegetation responses. We thus structured a cause-and-effect map to explain variable effects on plant diversity. Effects on beta-diversity were assessed by regression on distance matrices (MRM) (Lichstein, 2007). All analyses were performed in R Statistical Software 3.1.1 (R Core Team, 2015)



RESULTS

Figure 1 Path diagram showing influence of studied variables on plant diversity. Solid lines indicate significant relations (p<0.05), dashed lines indicate tested relations with no significant values





At higher elevation, ramets of *V. myrtillus* were younger, with shorter shoots and smaller year rings, whereas elevation and shrub cover were unrelated (Fig. 1a, Fig. 2a-b-c).

In turn, shrub cover was positively related with shoot length of *V. myrtillus* (Fig. 1b, Fig. 2d).

Enhanced shrub cover had a negative effect on species (alpha-, Fig. 1c, Fig. 2e) and community (beta-, Tab. 1, Fig. 2f) diversities, which were, on the other hand, not explained by elevation.

variable	type of model	Interc	Coef	Pval	R2
Δ elevation					
	Linear	0.43	0.0001	0.05	0.019
	Quadratic I	0.46	0.43	0.07	0.021
	II		-0.11		
Δ dwarf shrub cover					
	Linear	0.37	0.005	0.0001	0.279
	Quadratic I	0.46	1.66	0.0001	0.280
	II		0.11		

Figure 2 Effect of elevation on *V. myrtillus* traits (a, b, c), *V. myrtillus* shoot length on shrub cover (d), and of shrub cover on alpha- (e) and beta-diversity (f)

Table 1 MRM outcomes showing effects of elevation and shrub cover on beta-diversity

DISCUSSION

Our results demonstrate the importance to study a range of variables from traits of key species to community structure to interpret changes in ecosystems. Shoot growth of *V. myrtillus* enhanced shrub cover, which subsequently decreased plant diversity. Elevation, as a proxy for temperature, influenced growth parameters of *V. myrtillus* but had no direct effect on shrub cover or plant diversity. Hence, our findings suggest that enhanced shrub growth might be a direct driver of plant diversity whereas temperature could be only an indirect one.

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