Back to the Future: drivers of long-term vegetation change in major habitats across Europe

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Introduction

Human activities impinge on vegetation through different mechanisms, or drivers of change, and different habitats vary in their sensitivity to these drivers. Increasing concern about environmental change has created a requirement for long-term vegetation change data that can quantify and characterise the change in a meaningful way. Botanical re-survey data can be an important resource for quantifying vegetation change and exploring links between environmental drivers and the observed changes. In this report, we compile the results from a survey of ALTERNet member organisations (and their contacts) carried out in 2014, where we requested and collected information on 29 re-survey studies carried out in 17 countries across Europe from five major habitat types: alpine habitats, forest, grassland, heathland and wetland. The methodology and types of analyses varied between studies, but a broad-scale meta-analysis has been possible here through quantifying and comparing the studies reporting different directions of vegetation change, and summarising which drivers have been identified as causing such change. The results show, on a European scale (from the studies provided), which are the most important documented trends in vegetation change and the drivers causing them across the five habitat types represented in this sample of re-survey studies.

Results

A table showing the results from all respondents of the original questionnaire is given in Appendix 1. Re-survey studies from forest habitat types are the most numerous out of those reported (10), followed by grasslands (9) and alpine habitats (5) (Table 1). There may be an insufficient number of studies reported from heathland (3) and wetland (2) to make valid conclusions, although these habitat types have the longest inter-survey periods, which is a strength.

The direction of change in species richness does not show a consistent pattern across habitat types, and there is no significant difference between the number of studies showing an increase or decrease in the pooled data (P=0.84) (Figure 1). Alpine habitats show the most

consistent trend, where four out of five studies report an increase in species richness and only one reports a decline. Conversely, significantly more studies report a decline than an increase in diversity in the pooled data (P=0.02), and this pattern is also reflected in the results for all the individual habitat types except alpine habitats.

The two most notable trends in vegetation change reported across all habitat types were the increase in the cover of graminoids (grass, sedge and rush species) and homogenization, both observed in 10 out of the 29 studies (Table 2). Homogenization was particularly apparent in alpine habitats and in forests, whereas increased graminoid cover was most commonly recorded in alpine habitats, grasslands and wetlands (Figure 3). Other commonly reported trends were decreased lichen cover, increase in the cover of thermophilic and mesophilic species, and decreased herb cover (5, 4 and 4 studies respectively). Again, the former two trends were recorded in 60% of studies in alpine habitats. Climate change was the most commonly reported driver of vegetation change, observed in 13 studies, closely followed by land use intensification occurring in 12 studies and 10 showing eutrophication (Figure 3). The remaining four drivers were reported in far fewer studies: invasive plant species (4 studies), acidification (3), grazing (2) and decreased herbivory (1). Climate change was particularly apparent in studies on alpine habitats, where 100% of them reported this effect, whereas land use intensification was found to be more important in forest, grassland and heathland (Table 3). Eutrophication was a key factor in forest habitat types, reported in 78% of those studies.

Habitat type	Number of studies	Mean (and range) length of inter-survey period in years	Countries where studies took place
Alpine habitats	5	23 (7-61)	Austria, France, Georgia, Greece, Italy, Norway, Romania, Russia, Scotland, Slovakia, Spain, Sweden, Switzerland
Forest	10 (9 completed)	46 (5-154)	Austria, Czech Republic, England, Germany, Norway, Poland, Scotland, Slovakia
Grasslands	9 (6 completed)	40 (4-154)	Austria, Czech Republic, England, France, Scotland, Slovakia, Sweden
Heathlands	3	76 (19-154)	Austria, England, Scotland
Wetlands	2	76.5 (21-154)	Austria, Scotland
All habitat types	29	47 (4-154)	Austria, Czech Republic, England, France, Germany, Georgia, Greece, Italy, Norway, Poland, Romania, Russia, Scotland, Slovakia, Spain, Sweden, Switzerland

Table 1: Characteristics of the re-survey studies included in the analysis.

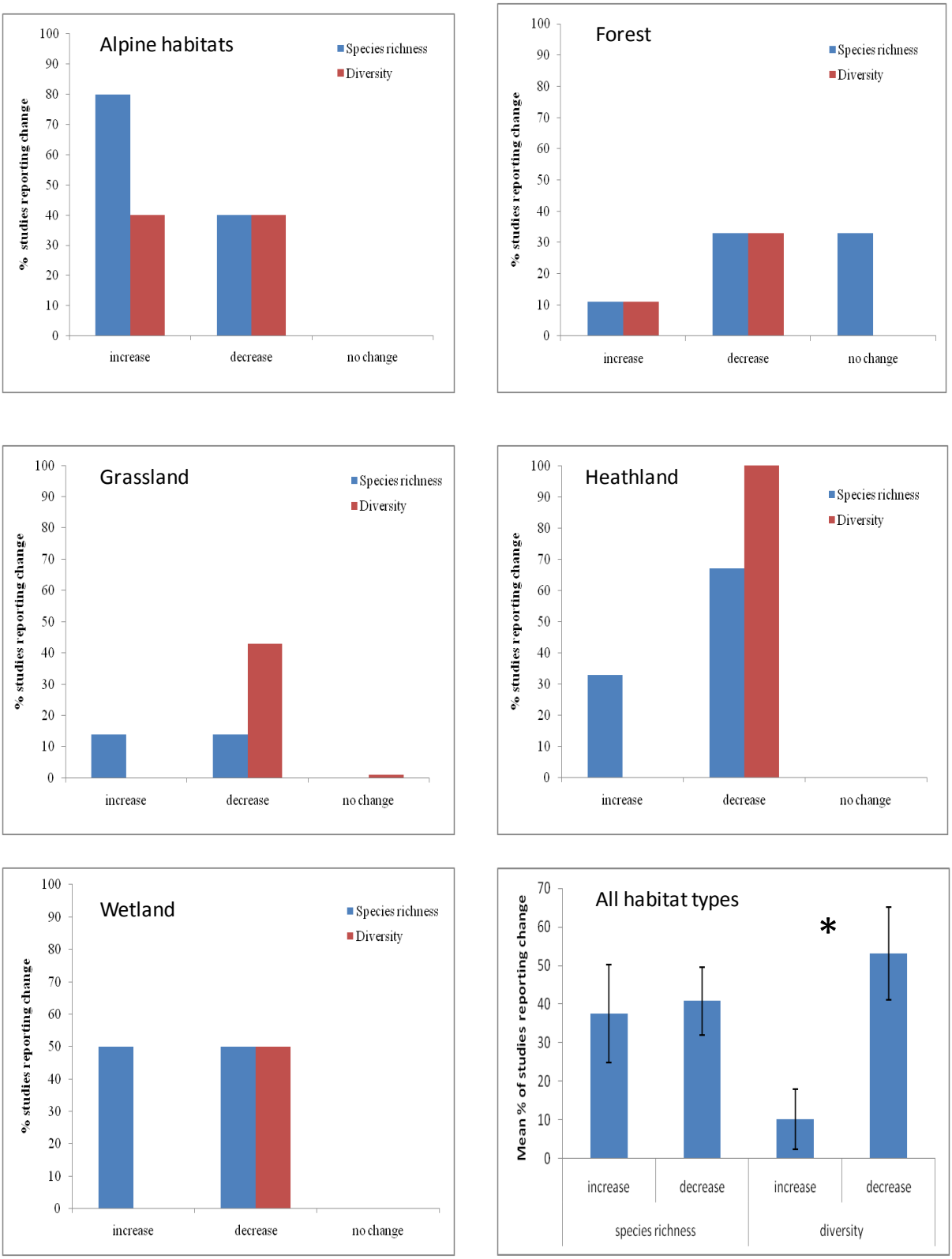

Figure 1: The percentage of studies showing the direction of change in species richness and diversity in each of the habitat types and in all habitat types combined.

	Alpine habitats		Forest		Grasslands		Heathlands		Wetlands	
	#	**%**	**#**	**%**	**#**	**%**	**#**	**%**	**#**	**%**
Decline in open habitats	0	0	1	11	0	0	0	0	0	0
Decrease in competitive species	1	20	0	0	0	0	0	0	0	0
Decrease in species preferring low soil nutrient levels	0	0	1	11	0	0	0	0	0	0
Decrease in stress-tolerant species	0	0	1	11	1	17	0	0	0	0
Decreased cover of competitive species	1	20	0	0	0	0	0	0	0	0
Decreased dwarf-shrub cover	1	20	1	11	0	0	0	0	0	0
Decreased herb cover	1	20	1	11	1	17	0	0	1	50
Decreased insolation	0	0	1	11	0	0	0	0	0	0
Decreased lichen cover	3	60	0	0	1	17	1	33	0	0
Decreased liverwort cover	0	0	1	11	0	0	0	0	0	0
Depressed development of shrub species	0	0	1	11	0	0	0	0	0	0
Homogenization	3	60	4	44	2	34	1	33	0	0
Increase in cover of thermophilic/ mesophilic species	3	60	0	0	1	17	0	0	0	0
Increase in drought and stress-tolerant species	1	20	0	0	0	0	0	0	0	0
Increase in light-demanding species	0	0	1	11	0	0	0	0	0	0
Increased bryophyte richness	0	0	0	0	0	0	1	33	0	0
Increased cover of *Festuca valesiaca*	0	0	0	0	1	17	0	0	0	0
increased dwarf-shrub cover	0	0	0	0	0	0	1	33	0	0
Increased graminoid cover	3	60	2	22	3	50	1	33	1	50
Increased graminoid richness	0	0	0	0	0	0	1	33	0	0
Increased herb cover	0	0	0	0	1	17	0	0	0	0
Increased herb richness	0	0	0	0	0	0	1	33	0	0
Increased nutrient indicator value	0	0	0	0	1	17	0	0	0	0
Increased shrub richness	0	0	0	0	0	0	1	33	0	0

Table 2: Reported trends in vegetation change in each habitat type. # = number of studies, % = percentage of studies.

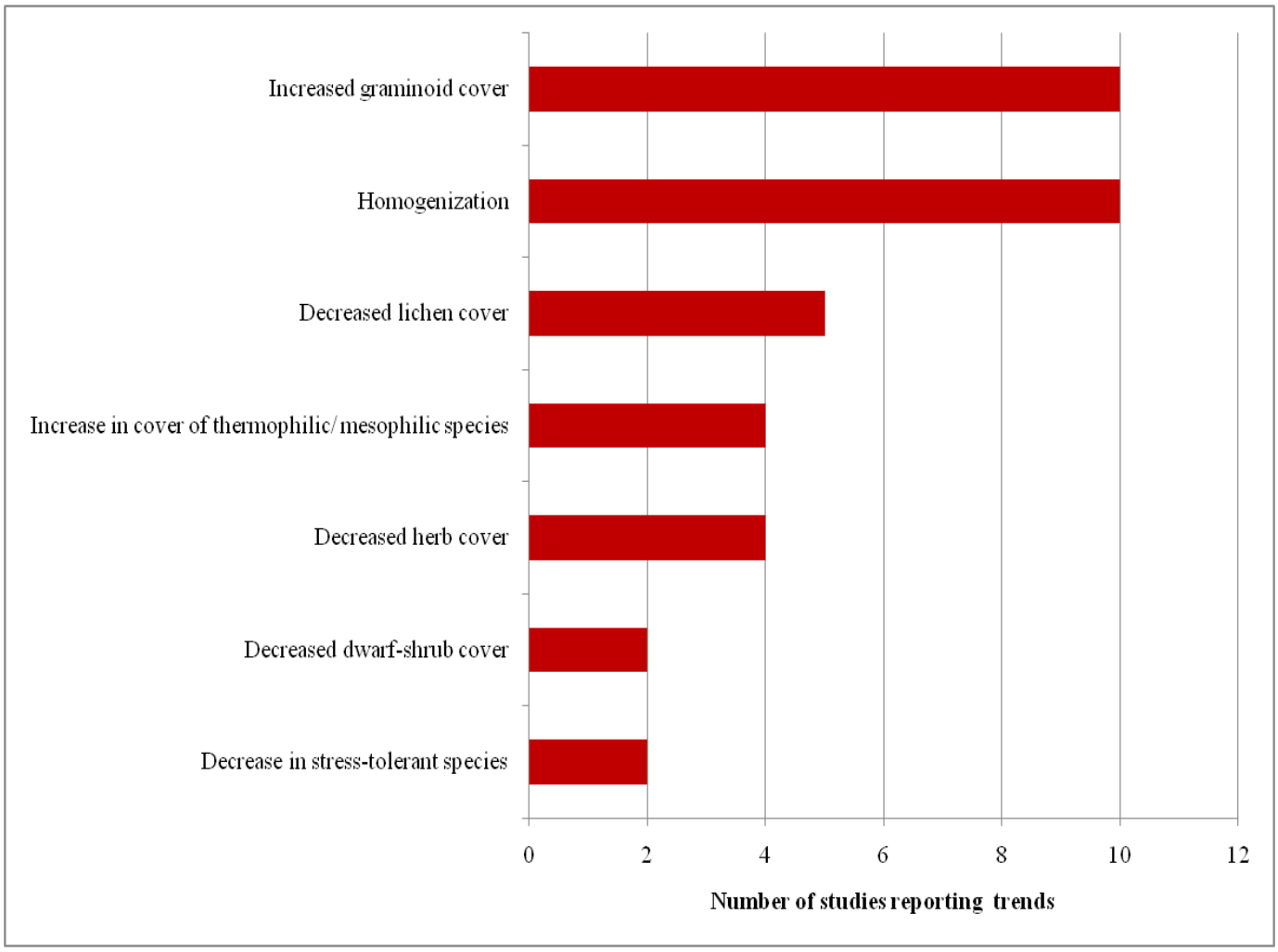

Figure 2: Trends in vegetation change reported in more than one study across all habitat types.

Driver	Alpine habitats		Forest		Grasslands		Heathlands		Wetlands	
	#	%	#	%	#	%	#	%	#	%
Climate change	5	100	4	44	1	17	2	67	1	50
Acidification	1	20	0	0	0	0	1	33	1	50
Land use intensification	0	0	6	67	3	50	2	67	1	50
Invasive plant species	0	0	1	11	1	17	1	33	1	50
Decreased herbivory	0	0	0	0	1	17	0	0	0	0
Eutrophication	0	0	7	78	2	35	1	33	0	0
Grazing	0	0	2	22	0	0	0	0	0	0

Table 3: Drivers of vegetation change reported from each habitat types. # = number of studies, % = percentage of studies.

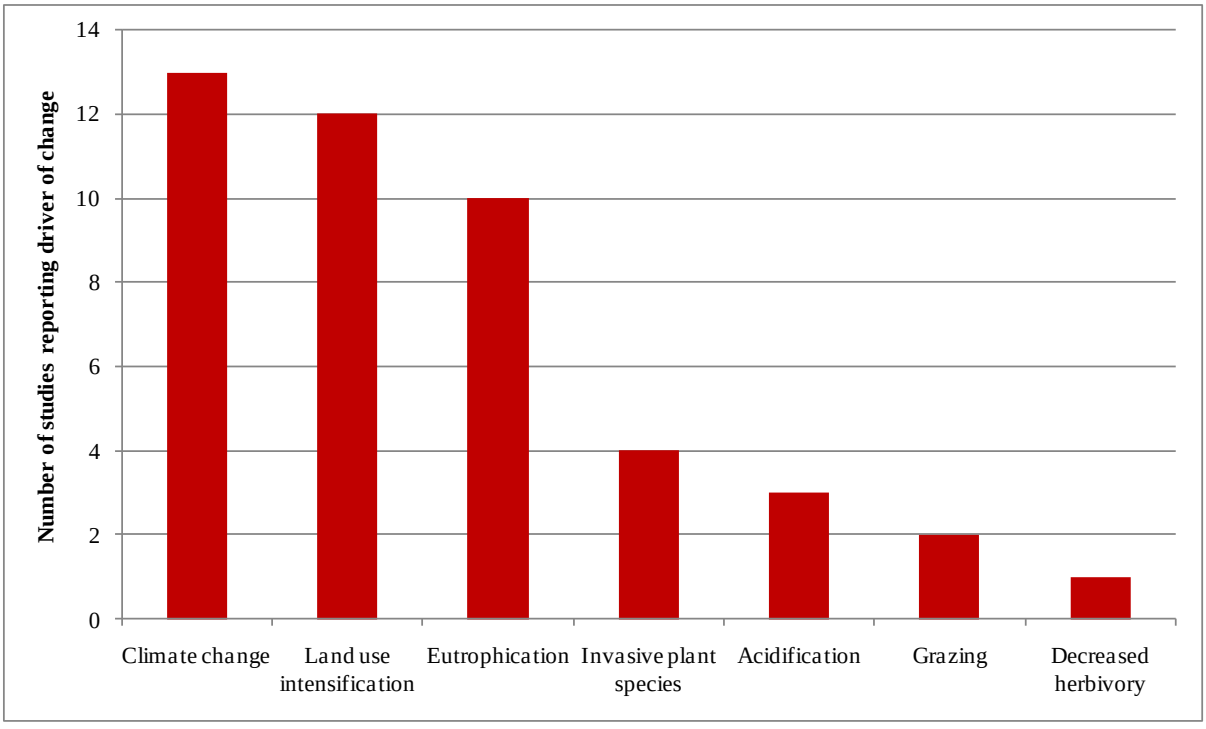

Figure 3: The number of studies reporting drivers of vegetation change across all habitat types.

Further work

There is potential for future collaboration amongst ALTER-Net partners using these results, with the aim of producing a publication in a peer-reviewed journal. A weakness of this report that needs to be addressed is the lack of standardisation in the responses of the contributors, and the gaps in the information provided. A new questionnaire could be issued whereby contributors would respond to pre-determined options and choose from lists of possible trends concerning the nature and direction of the observed vegetation change and related drivers, based on the responses generated by this pilot study. Other approaches to analysis may also be undertaken, such as comparing change in different regions of Europe.

This type of broad-scale meta-analysis with pre-determined options would provide a more comprehensive overview of vegetation and environmental change across Europe that can be interpreted with confidence, without the need for pooling and re-analysing multiple and possibly incompatible datasets. As there are rather few studies reported on heathland and wetland, it may be sensible to exclude these from further analysis (or search more widely for other studies), as any conclusions drawn would be rather tenuous. New re-survey studies at various stages of development may also come to light in the interim, which could also be included, and for which the ALTER-Net partners in each country could act as data gatherers and advisors to those planning re-survey studies.

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