Climate Change and Goose Grazing on Svalbard's Tundra

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Introduction

Change in Arctic climate has direct effects on the growth and productivity of tundra vegetation and indirect effects through climate induced changes in herbivore intensity. Herbivores have huge potential to modify both species composition and biomass through selective grazing, intensity of grazing and trampling, and nutrient turnover through feces deposition. When considering future scenarios of climate impacts on Arctic tundra it is therefore important to include the knock-on effects of changes in grazing, caused by changes in climate and/or socio-economic/ political decisions. Land use changes in temperate biomes can affect Arctic systems via changes in the grazing pressure caused by migratory herbivores such as geese. Migratory geese breed in Svalbard in summer and return to Western Europe for the winter, feeding on wetlands and agricultural fields. Recent changes in climate, land use and the implementation of protective measures have dramatically improved the birds' ability to survive the winter. This has resulted in a 30-fold increase in the barnacle goose and a 4-fold increase in the pink-footed goose populations in Svalbard over the past 40 years. Increased temperatures in the Arctic as predicted by climate change models may result in earlier snow melt allowing birds to breed earlier and produce more offspring. Warmer temperatures during summer may also affect plant productivity and vegetation composition. Selective removal of plant tissue by geese may change the vegetation composition, amount and quality of plant litter produced and carbon balance of the system. Goose droppings and nitrogen fixation function as a nitrogen source thus increasing plant productivity. Arctic ecosystems are vulnerable to overgrazing, as shown by recent experience in N.E. Canada, where high numbers of snow geese caused large-scale degradation of pristine low arctic salt marshes, leading to desertification of these ecosystems. This project aims to assess the vulnerability of Svalbard tundra ecosystems to further increases in breeding goose populations caused by changes in European land use and bird protection measures, in a context of future climatic change. This paper presents the methodology used for the field experiment and results from the first field season.

Methods

The experiment was carried out in Adventdalen, 15 km east of Longyearbyen, Svalbard (78°N) in two habitats representative of those used by geese in summer; a mesic tundra vegetation with shrubs, flowering plants and grasses and a wet moss-dominated vegetation with grasses. Open top chambers (OTCs) were used as small greenhouses to increase the temperature of the air and ground. Captive wild barnacle geese were put on the 2 x 2 m experimental plots for one or five hours, to simulate 'natural' and 'high' grazing pressure. The grazing pressure was calculated from the time spent foraging during the grazing trials based on observations of goose behaviour and compared to data from the literature of grazing pressure in a natural situation on Svalbard. The number and length of shoots of key species were recorded before and after grazing to determine the amount grazed. Moss depth was measured at eight locations in each plot after the first field season.

Results

2003 was an unusually warm summer on Svalbard; however the open top chambers increased temperatures above ground in both habitats and below ground in the mesic habitat (Table 1); temperature increases were highest in the mesic habitat. OTCs increased the size of plants of *Alopecurus borealis* but had no significant effect on *Dupontia* sp. (Figure 1).

The grazing pressure created with captive geese on experimental plots for one hour was similar to that observed in natural systems on Svalbard for both mesic and wet habitats (Table 2). The 5 hour treatment achieved a grazing pressure much higher than that observed experimentally in one hour or in natural systems on Svalbard. Foraging time was 2.6 and 3.4 times higher in the 5 hour compared to the one hour treatment for mesic and wet habitats (respectively). Geese are selective grazers- they prefer the wet habitats and start grazing *Equisetum* then *Dupontia* then switch to mosses. The proportion of shoots grazed or removed by grazing was higher in the 5 hour treatment than in the one hour treatment for *Bistorta vivipara* and *Alopecurus borealis* on the mesic habitat and *Equisetum arvense* and *Dupontia sp.* in the wet habitat (Figure 2). Trampling by the geese caused a reduction in the depth of moss in the wet habitat (Figure 3).

Conclusions

This unique field experiment has enabled a detailed study into climate-goose-vegetation interactions. In our presentation we show further tundra responses to the experimental treatments outlined here.

Acknowledgements

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Table 1. Mean July temperatures (°C) of ambient and warmed plots in Adventdalen, Svalbard, 2003.

		Ambient	Open Top Chamber	Temperature difference
Above ground				
	Mesic	10.1	11.3	+1.2
	Wet	9.2	9.7	+0.5
Below ground				
	Mesic	4.9	6.5	+1.6
	Wet	5.5	5.3	-0.4

Table 2. Grazing pressure in experimental plots compared to observations made of natural goose populations on Svalbard.

Habitat	Type of grazing		Grazing pressure min/ m^2	Reference
Mesic	Experimental	1 hr	**9**	This study
	Experimental	5 hr	**22**	This study
	Natural		4	Drent et al. 1998
Wet	Experimental	1 hr	**14**	This study
	Experimental	5 hr	**46**	This study
	Natural		9	Drent et al. 1998
	Natural		6	Prop et al. 1984
	Natural		22	Loonen et al. 1998, Stahl and Loonen 1998.

Figure 1. Length of live leaves (mm per plant) at the end of July 2003. n = 25.

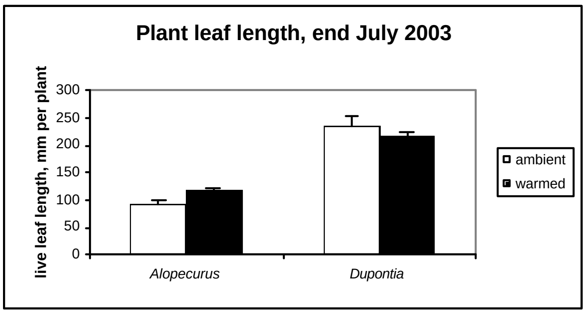

Figure 2. Percentage of shoots present which were grazed.n = 5.

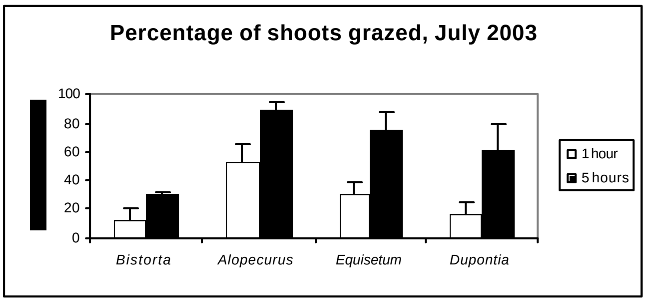

Figure 3. Moss depth after one season of treatments. n = 5.