Modeling dynamics of tundra plant communities on the Yamal Peninsula

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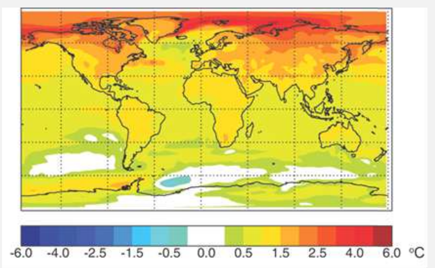
Introduction

The Yamal Peninsula is an area occupied by Nenets normadic reindeer herders and is also an area of lots of gas/oil products and affected by climate change. Research questions include: 1) how does climate change and herbivory affect tundra vegetation dynamics? 2) Do these effects differ along the latitudinal tundra gradient?



IPCC 2007

Photo: D.A. Walker

Fig.1. Amplified climate warming in the Arctic and overgrazing issue in the Yamal Peninsula, Russia

Methods and data

ArcVeg – Arctic tundra vegetation dynamics model

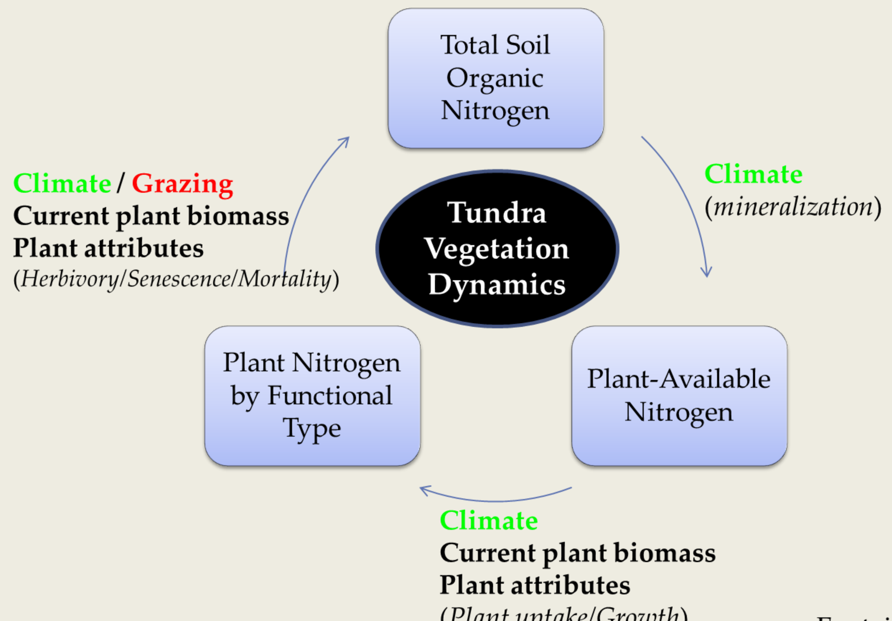


Fig.2. ArcVeg model diagram.

Epstein et al. 2000

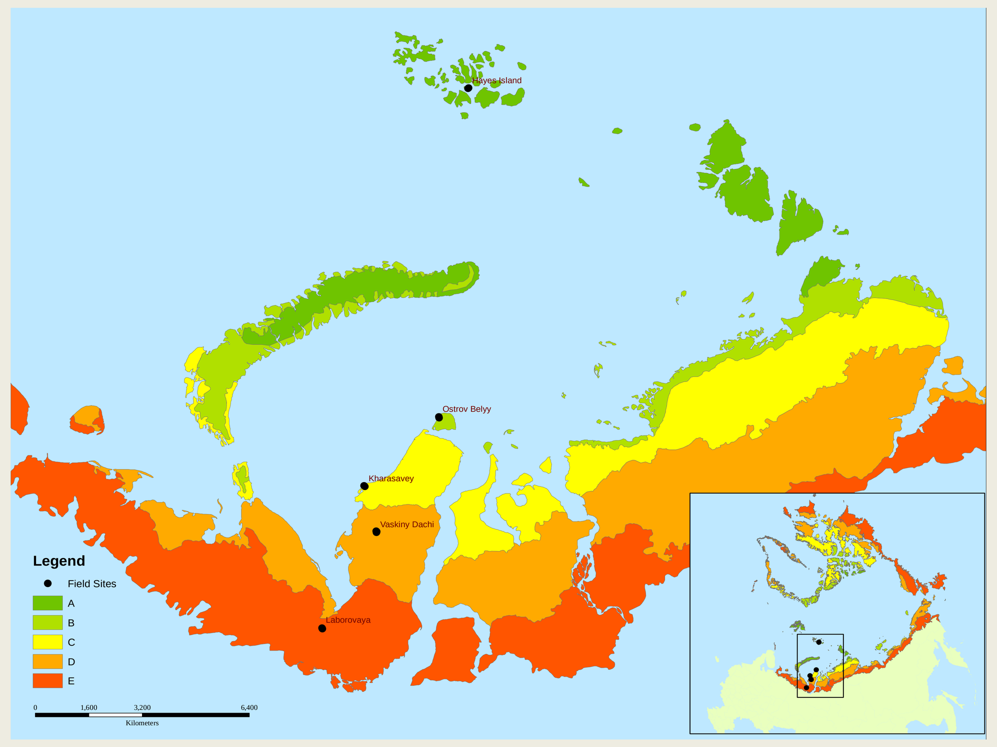


Fig.3. Study region.

Model setting

ArcVeg simulations were conducted with field collected parameters:

- **Bioclimate subzones**
- **Soil nutrients – soil organic nitrogen**
- **Grazing**: (0.1, 25%), (0.1, 50%), (0.5, 25%), (0.5, 50%)
- **Climate warming**: 2°c transient warming and equilibrium warming

Subzone	sites	N%	%Sand	Active Layer Depth(cm)	SON (g/m^2)
A	KR-1	0.11	60.08	33.60	449
A	KR-2	0.10	81.40	32.80	277
B	BO-1	0.03	36.50	49.98	227
B	BO-2	0.01	83.76	77.60	145
C	KH-1	0.06	24.47	56.33	844
C	KH-2	0.07	65.60	75.50	599
D	VD-1	0.03	28.90	71.75	271
D	VD-2	0.04	38.28	68.60	202
D	VD-3	0.05	92.80	113.80	135
E	LV-1	0.06	18.00	81.20	570
E	LV-2	0.01	93.60	114.60	148

Table 1. Field collected data for model input

Results – NMS ordination

- Simulated results suggest that: grazing can be as important as the latitudinal climate gradient (~12°C) for tundra plant communities

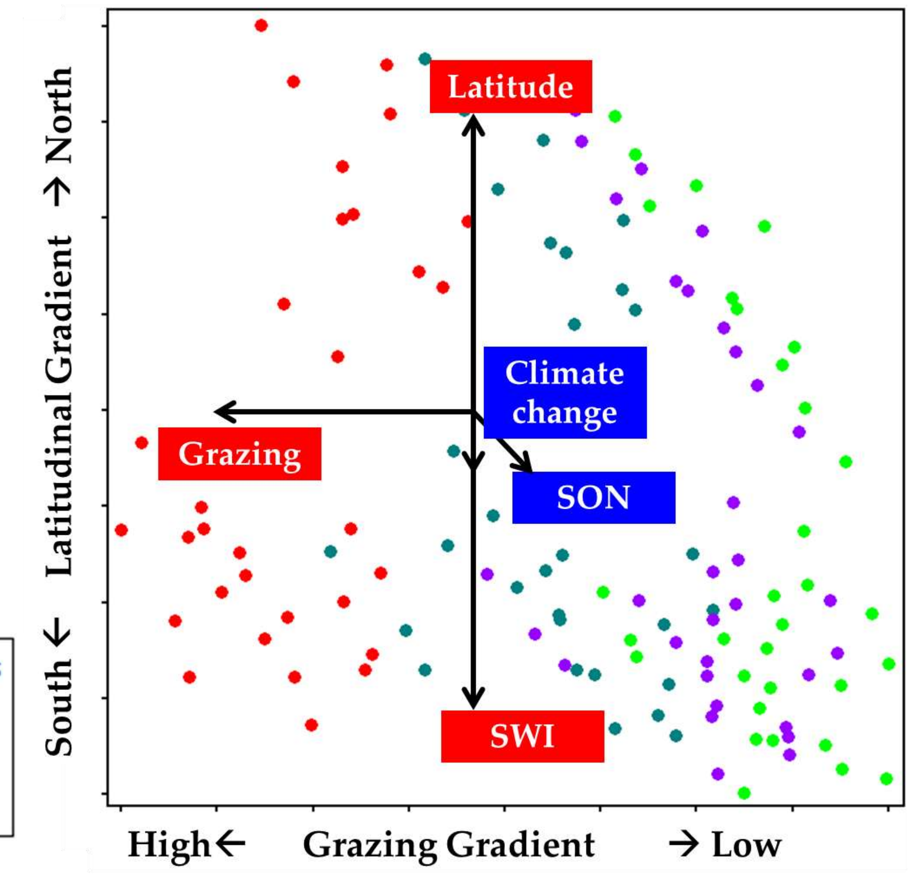


Fig. 4. Nonmetric Multidimentional Scaling is used for structure analysis.

Results - Warming Effects at both community and PFT level

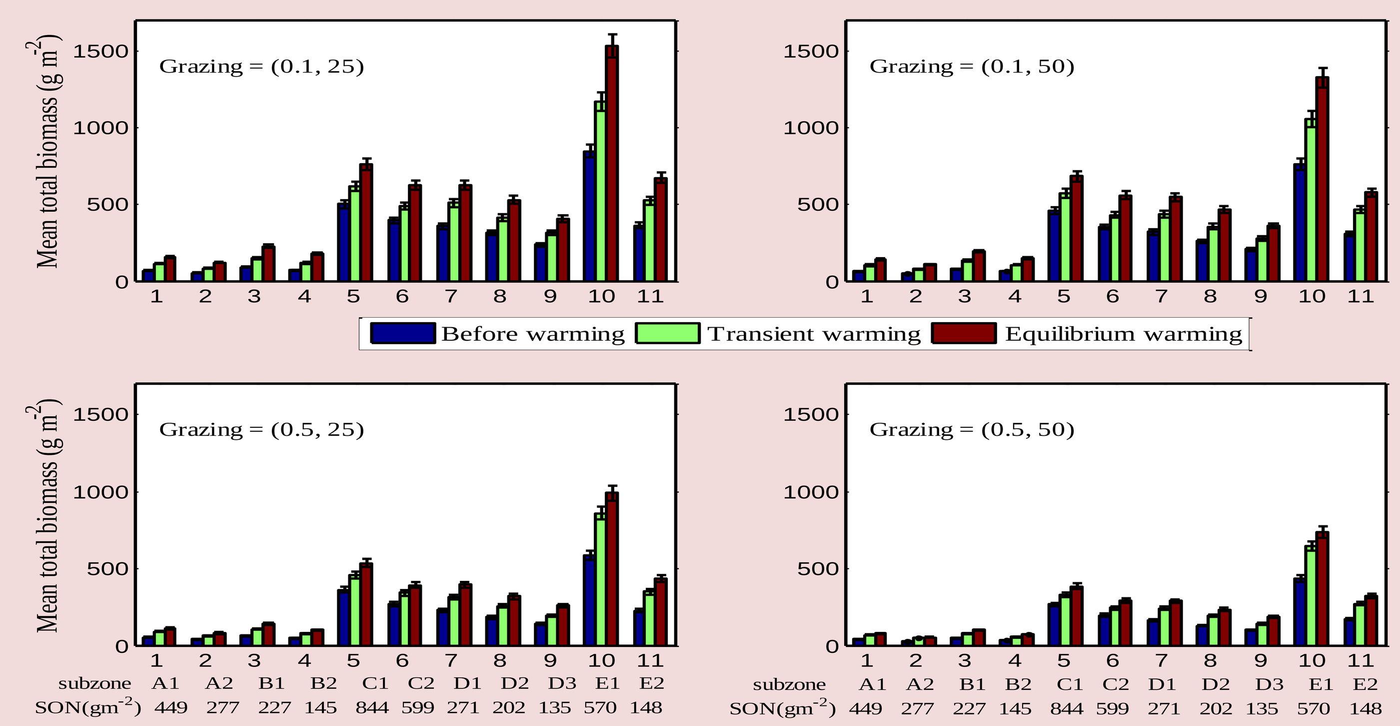


Fig.5. Warming effects on tundra plant community.

- Climate warming increases tundra plant community biomass and NPP in general due to increased nitrogen mineralization rate.

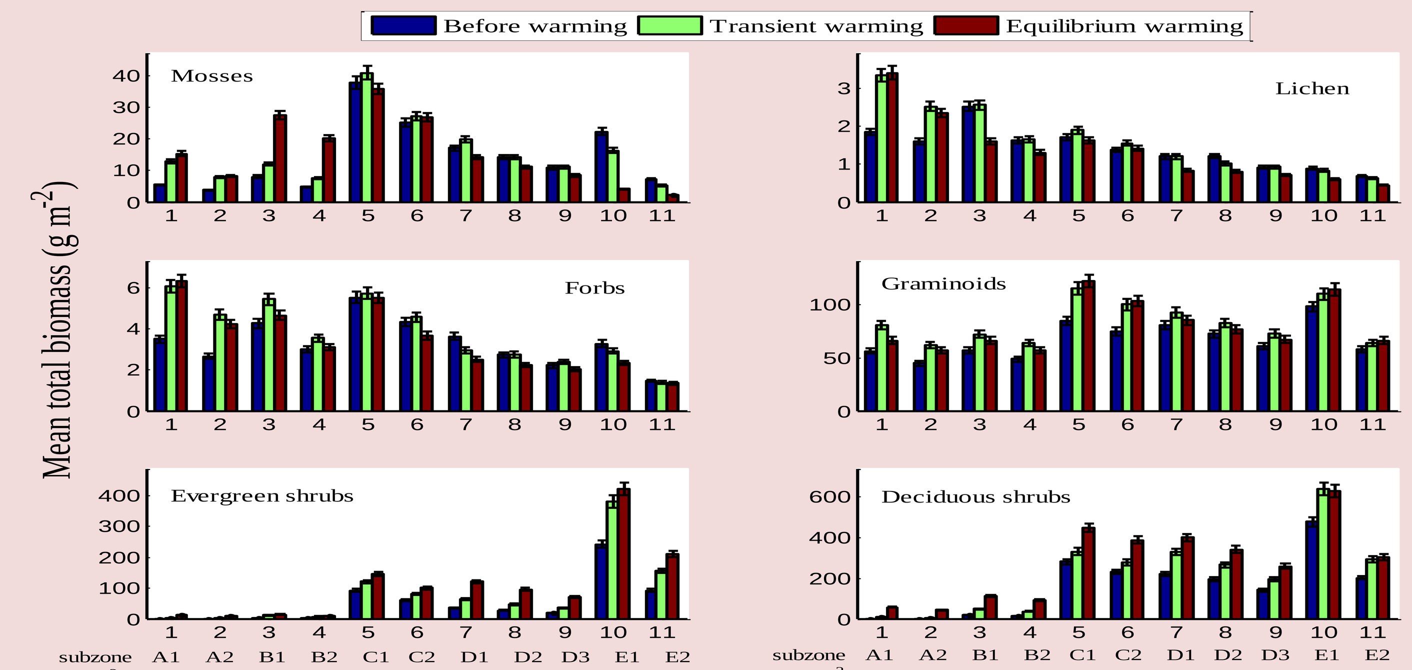


Fig.6. warming effects on each PFT.

- Shrub increase in the low arctic is suggested by many field and remote sensing studies (e.g. Sturm et al, 2001; Jia et al 2004)
- Modeled increase in graminoid and decline in non-vascular plant is consistent with field studies (Gould et al 2010)

Acknowledgements

- NASA/NEESPI Land Cover Land Use Change Initiative, Grant No. NNG6GE00A
- NSF Grant No. ARC-0531180, part of the Synthesis of Arctic System Science initiative (Greening of the Arctic)
- NSF Grant No. ARC-0902152, part of the Changing Seasonality of Arctic Systems initiative
- Department of Environmental Sciences, Univ. of Virginia

Results - Grazing Effects at both community and PFT level

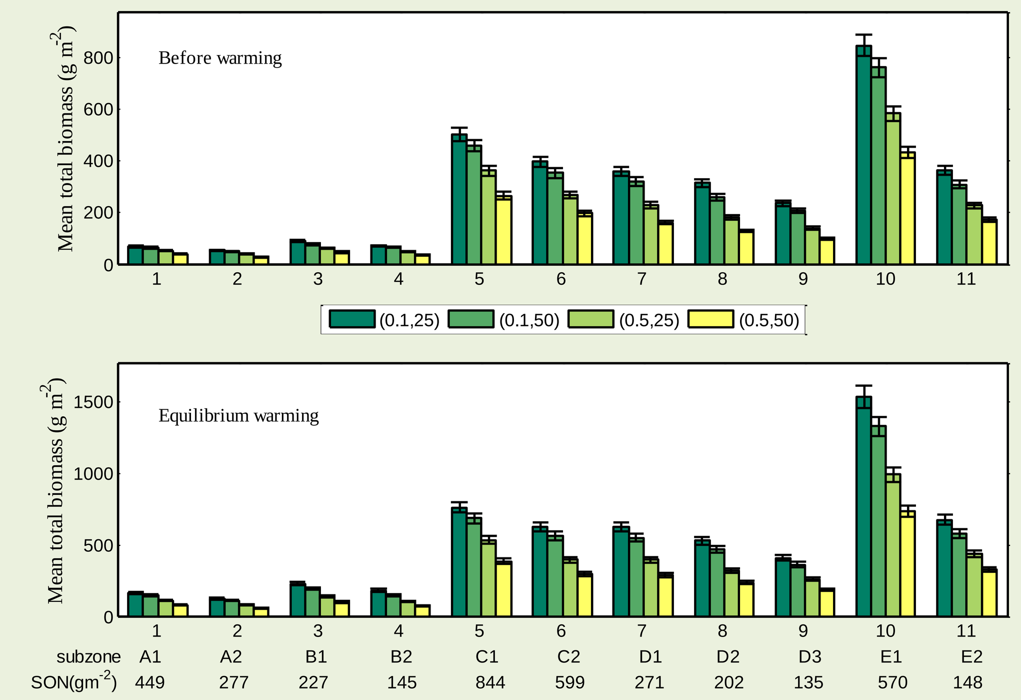


Fig.7. Grazing effects at community level

- Grazing generally causes decline in tundra plant community biomass.

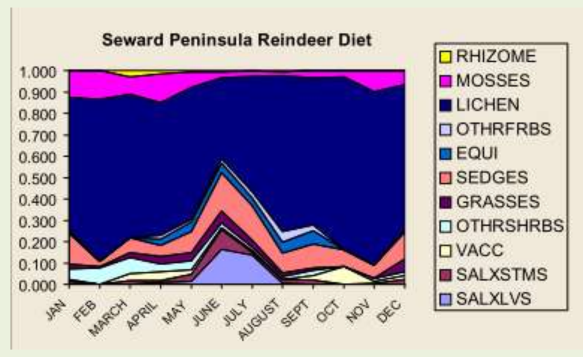


Fig.8 reindeer diet. (Meagan 2007.)

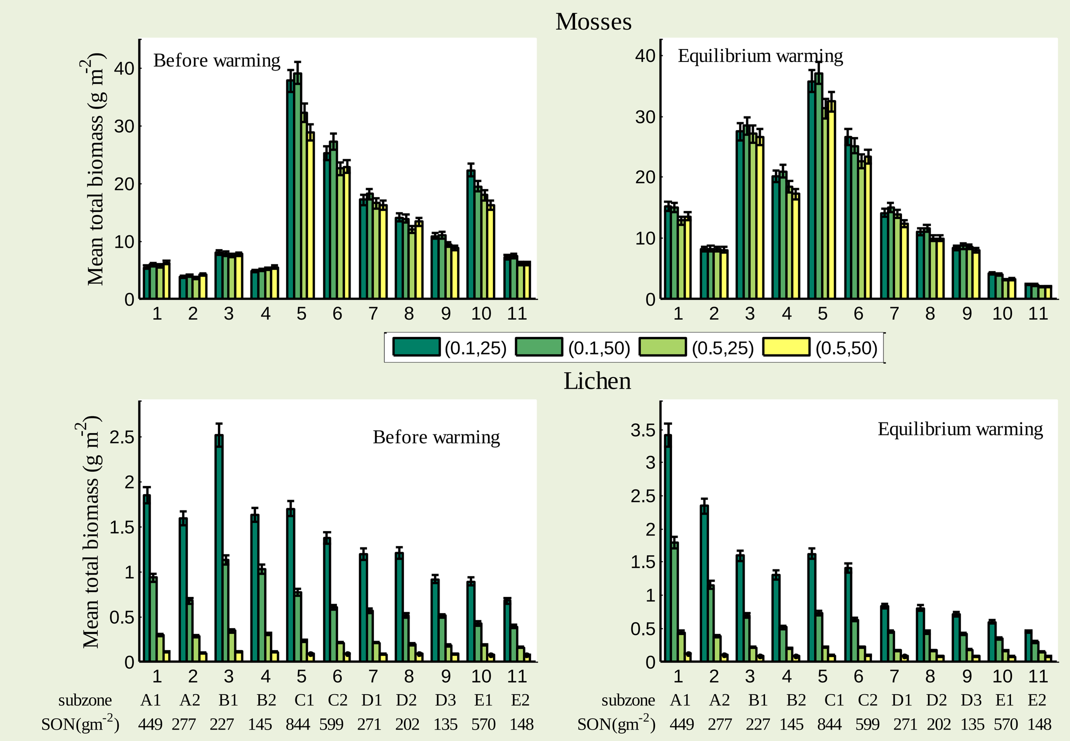


Fig. 9. Mosses and lichen responses to increased grazing effects under two climate scenarios.

- Mosses has a nonlinear response to increased grazing pressure, this is consistent with other studies (e.g. Van der Wal, 2006)
- Lichen biomass as reindeer preferred forage declined as grazing intensity increased.

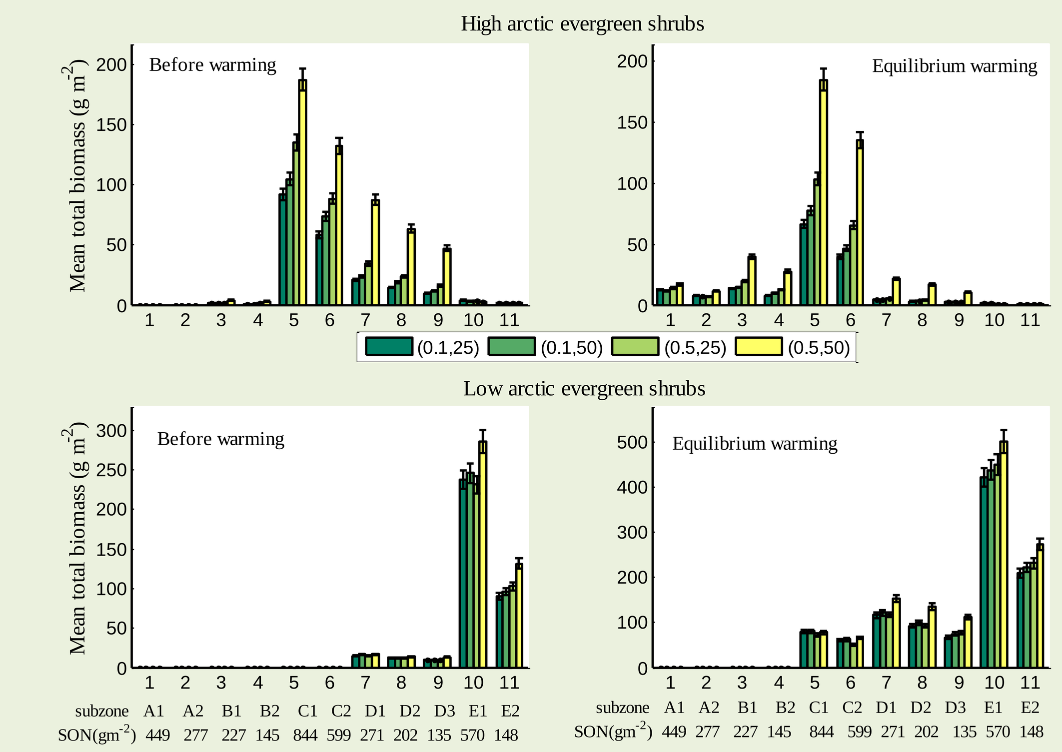


Fig. 10. Grazing effects under two climate scenarios on high arctic and low arctic evergreen shrubs.

- PFTs such as evergreen shrubs may benefit from increased grazing intensity

Conclusion

- Our results are consistent across a variety of soil nutrient levels; soil nutrients affect the magnitude but not the direction of change.
- Simulated results suggest that:

1. Grazing can be as important as the latitudinal climate gradient (~12°C) for tundra plant communities
2. PFTs such as evergreen shrubs may benefit from increased grazing intensity
3. Mosses has a nonlinear response to increased grazing pressure, this is consistent with other studies (e.g. Van der Wal, 2006)
4. Initial vegetation responses to climate change during transient warming are different from the long term equilibrium responses due to shifts in the controlling mechanisms (nutrient limitation and competition) on tundra plant communities