Consequences of arctic ground squirrels on soil carbon loss from Siberian tundra

[1]Nigel Golden, [2]Susan M. Natali, [3]Nikita Zimov,

[1]University of Wisconsin-Stevens Point, [2]Woods Hole Research Center, Woods Hole, Massachusetts, [3]Northeast Science Station, Cherskiy, Russia.

THE POLARIS PROJECT

INTRODUCTION

- A large pool of organic carbon has been accumulating in the Arctic for thousands of years frozen in permafrost and unavailable for microbial decomposition. As the climate warms and permafrost thaws, the fate of this large C pool will be driven not only by climatic conditions, but also by ecosystem changes brought about by arctic animal populations.
- The Arctic ground squirrel (Spermophilus parryii), which is distributed across much of the Arctic, digs colonial burrows that cause important shifts in soil structure and composition
- Ground squirrel burrowing can impact soil carbon cycling as a result of nutrient addition and bioturbation which can alter the plant community, soil moisture, and soil aeration[1-3] (Figure 1).
- We examined the effects of artic ground squirrel activity activity on soil C mineralization in dry heath tundra underlain by continuous permafrost in the Kolyma River watershed in northeast Siberia, Russia

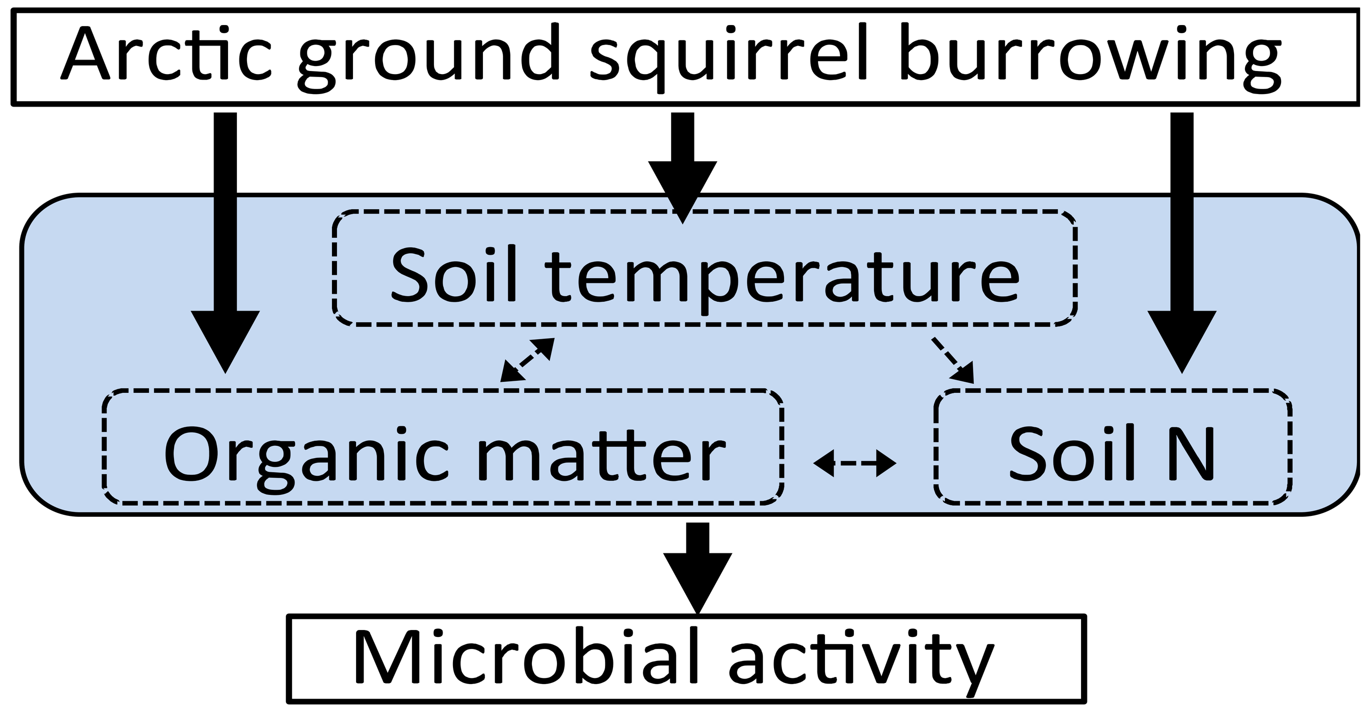


Figure 1. Conceptual model illustrating the hypothesized effects of arctic ground squirrels burrowing in the arctic which creates improved conditions for microbes that consume C.

HYPOTHESES

We hypothesize that disturbance of tundra soils by the burrowing activities (disturbed) of ground squirrels is likely to break up the soil structure and increase the amount of organic matter available for microbes to decompose. We also hypothesize that ground squirrels will increase nitrogen availability in tundra soils, which should relieve nitrogen limitation and stimulate microbial activity.

METHODS

- Soil samples collected from 5 burrows and 5 adjacent undisturbed locations.
- Collected top 10 cm soil from each site.
- Incubated 10 g of soil for 10 days. For undisturbed soils we incubated 5 g of organic soil and 5 g of mineral.
- Soils incubated with 2 levels of N addition high (20 grams; half nitrate and half ammonium) and low (5 grams total nitrogen and 5 grams half nitrate and half ammonium) along with a control with no N added.
- Respiration was measured 5 times and averaged.

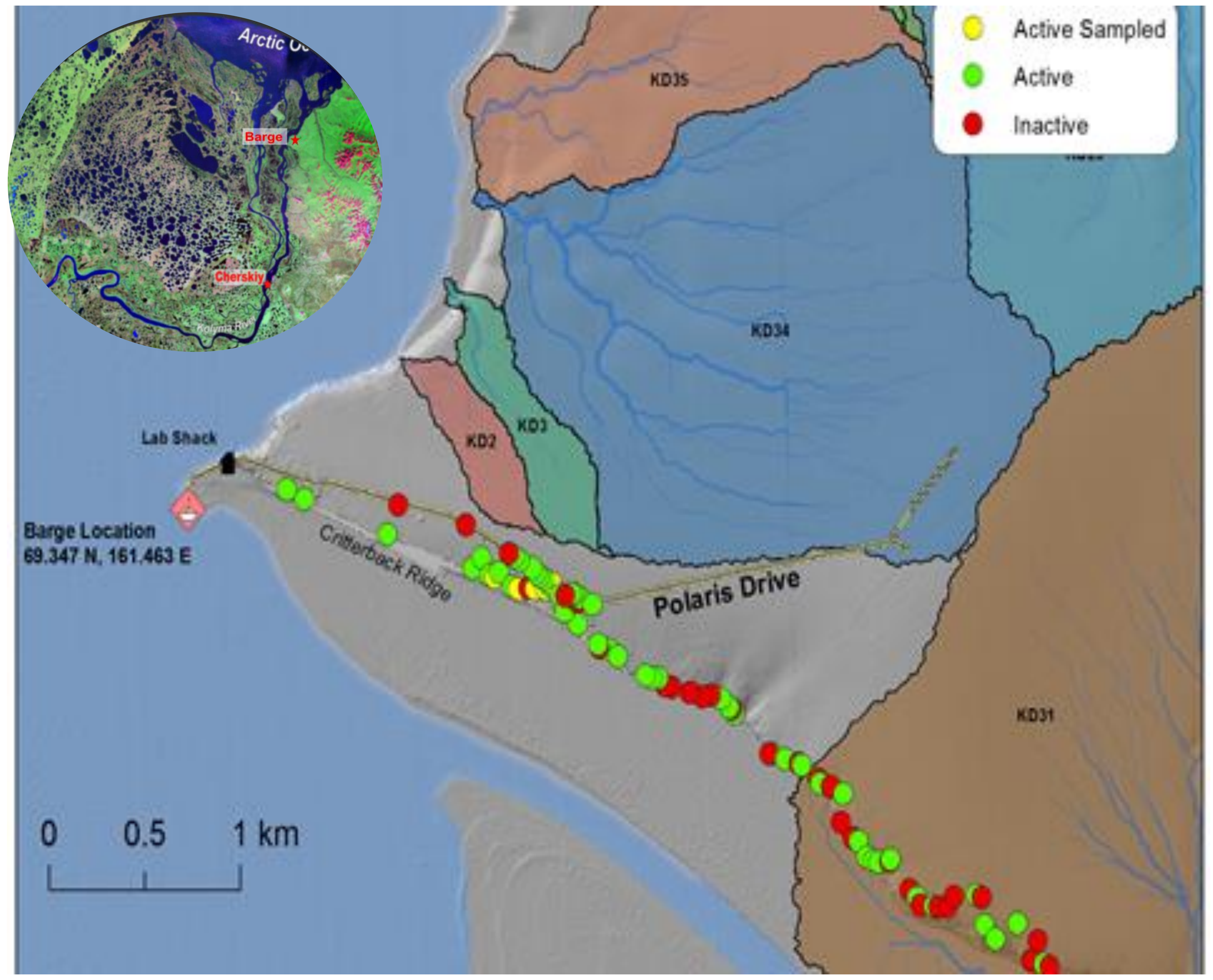
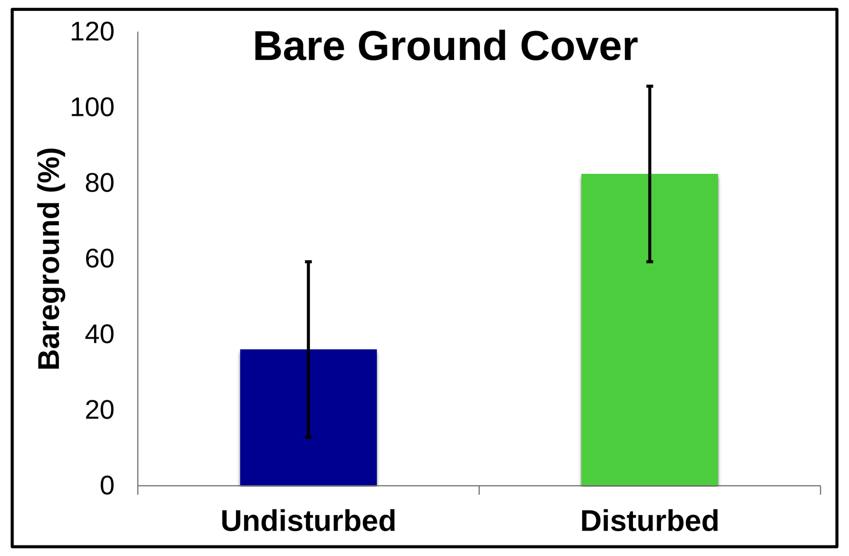
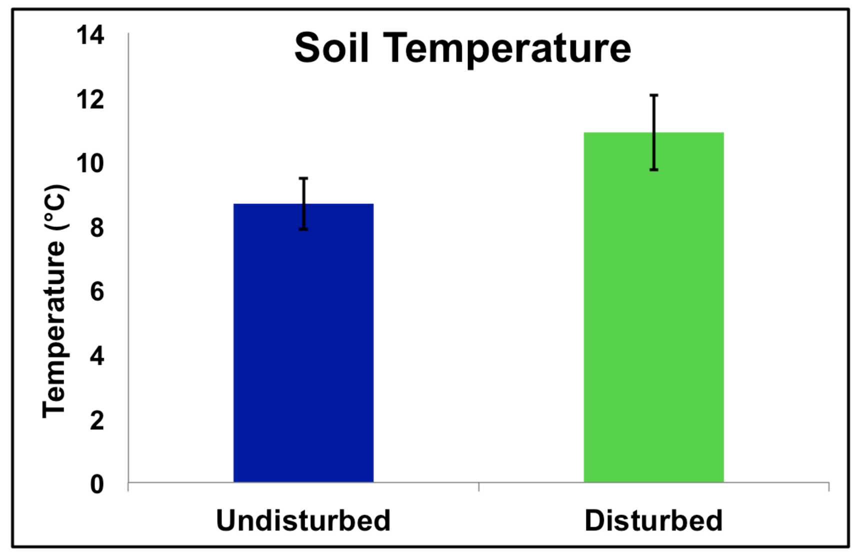
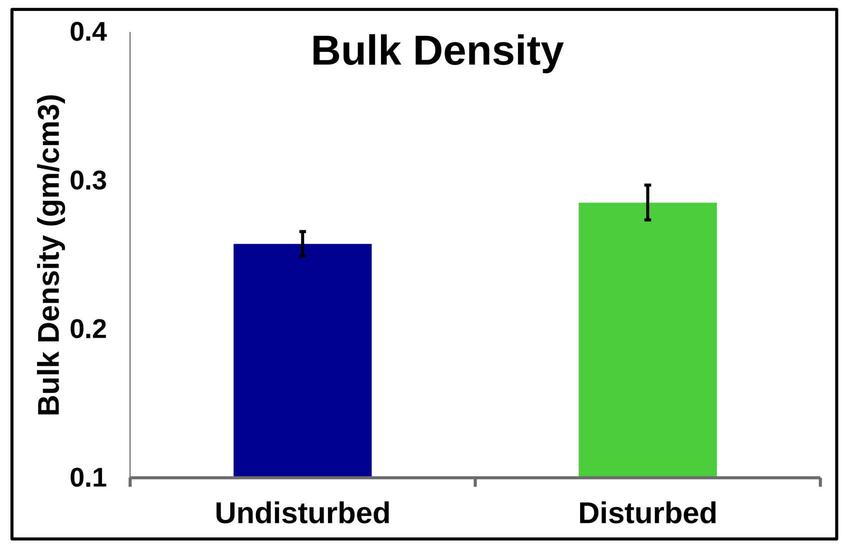
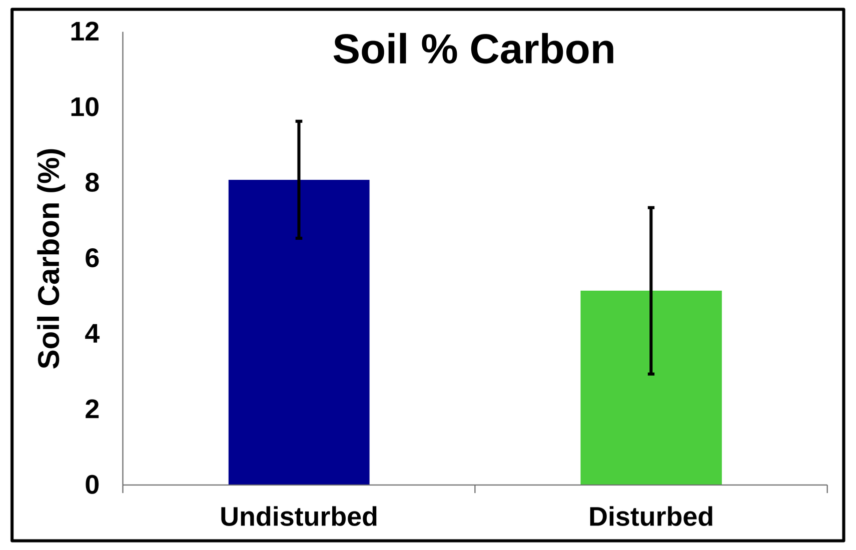


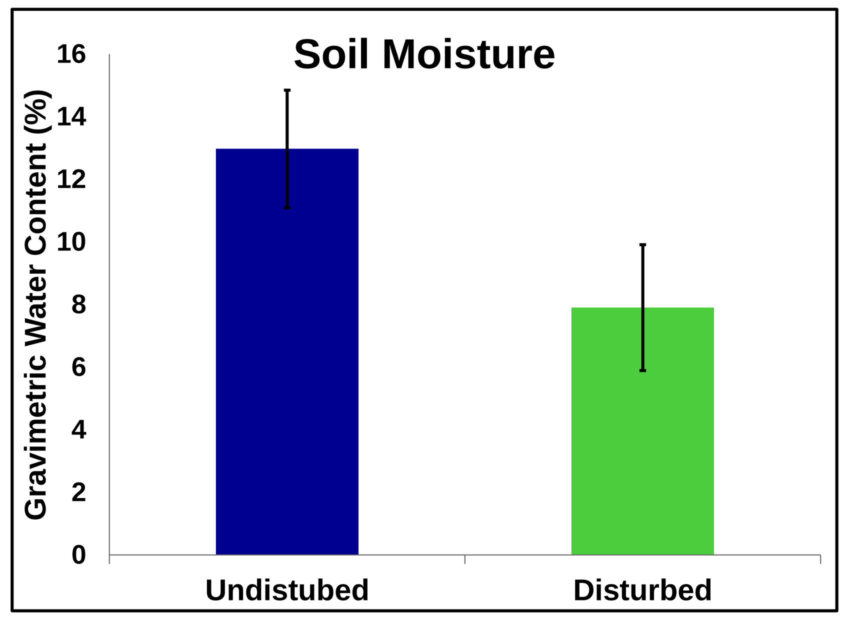
Figure 2. Sampling occurred near the mouth of the Kolyma river watershed in Siberia











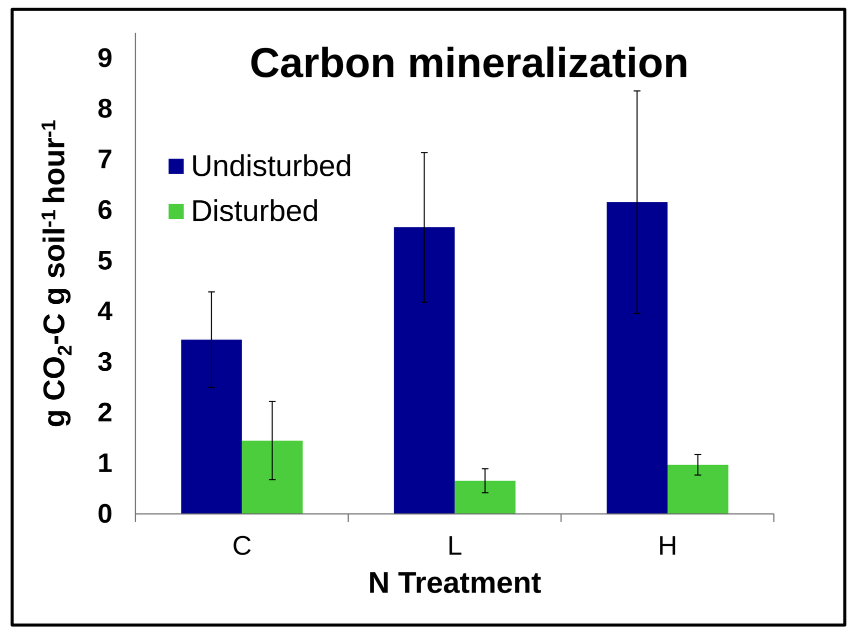


Figure 4a. Arctic ground squirrel

Figure 4b. Inactive burrow

Figure 4c. Active burrow

Figure 4d. Measuring carbon flux from incubation jars

RESULTS

- Ground squirrels are agents of community disturbance; their burrowing behavior causes key changes in ecosystem processes.
- Ground squirrel burrowing increased soil temperature, which may make permafrost more vulnerable to thaw.
- Lower %C in the disturbed areas suggests lower C inputs and/or higher losses from the ground squirrel burrows.
- Undisturbed soil was N limited, while disturbed burrow soil did not respond to N addition. This suggests that squirrel activity reduced N limitation through fertilization or that other factors became more limiting (e.g., soil moisture, soil C).
- Wildlife behavioral ecology (foraging demands, styles, population dynamics ,etc.) may be important in determining the date of vulnerable ecosystem C to climate warming.

Acknowledgements

We would like to thank the Polaris 2014 team, Les Werner, John Schade and Mike Loranty for project development, Chris Linder for photos, and for funding from NSF (# 1044610)

Literature Cited

1. Yensen, E.P. Sherman. 2003. Wild Mammals of North America: Biology, Management, and Conservation 2nd Edition: Spermophilus and Ammospermophilus species. The John Hoplins University Press.
2. Barker, O.A. and A. Derocher. 2010. Habitat selection by arctic ground squirrels (Spermophilus parryi). Journal of Mammology, 91: 1251-1260.
3. Väisänen, M., H. Ylänne, E. Kaarlejärvi, S. Sjögersten, J. Olofsson, N. Crout and S. Stark. 2014. Consequences of warming on tundra carbon balance determined by reindeer grazing history. Nature Climate Change, 4: 384-388.