Arctic LTER Project

Arctic Tundra in a Changing Climate

The Terrestrial Research Group
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Towson University

Arctic LTER Mid-Term Review
24 June 2019

Arctic LTER Terrestrial PIs

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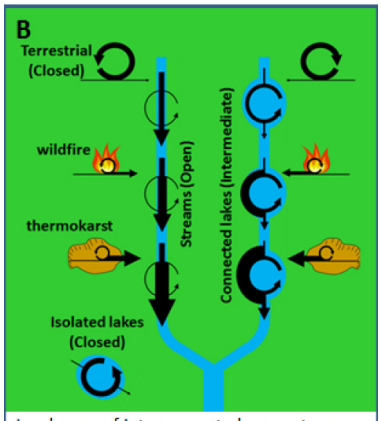
Plus grad students and postdocs!

Central Question for the Current Arctic LTER

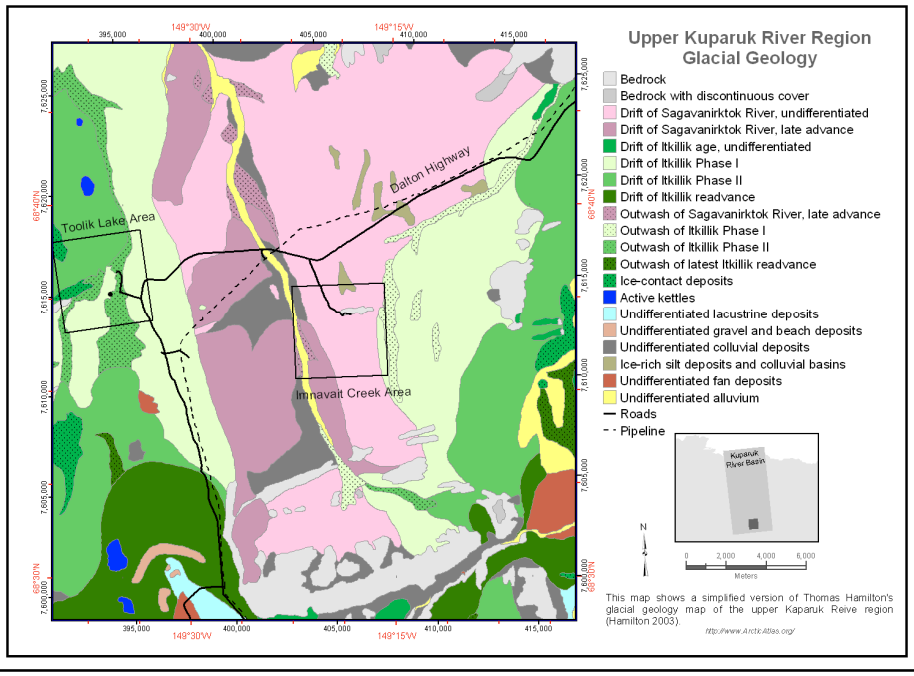
How do biogeochemical and community openness and connectivity shape responses to climate change and disturbance?

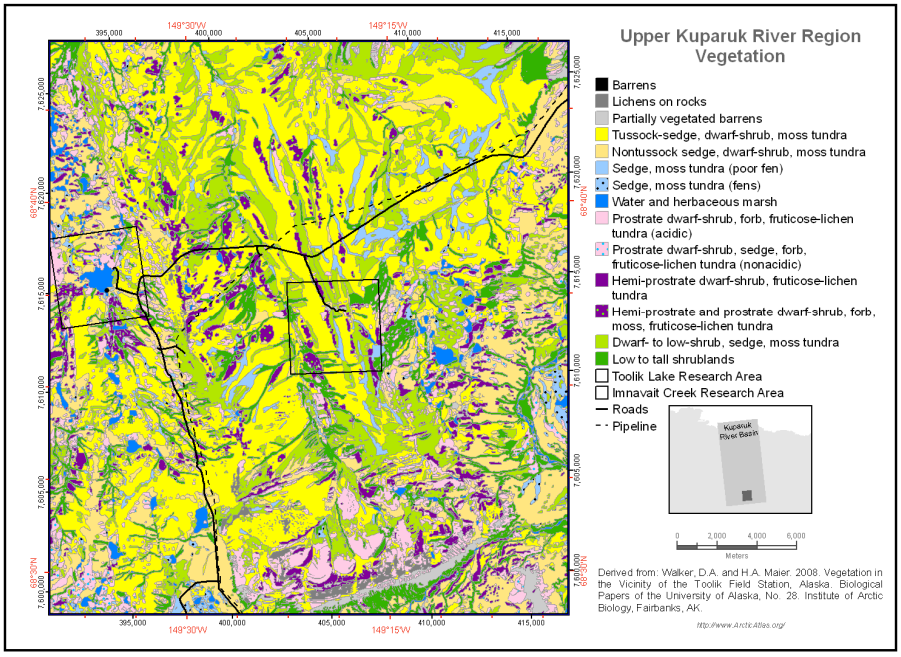
Terrestrial Tundra

- *Relatively closed biogoechemically*
- *Plant community closed*



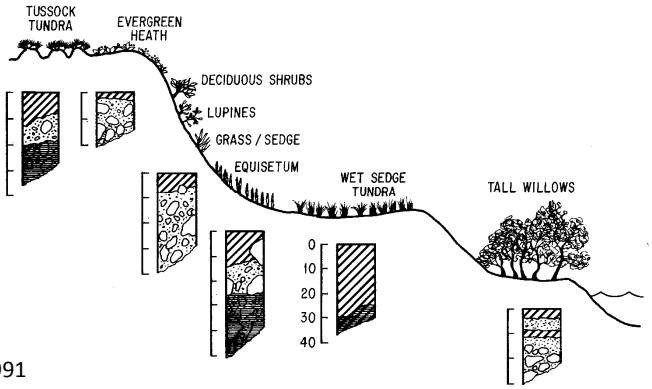
Landscape of interconnected ecosystems with various degrees of openness to C, nutrients, organisms, and species.





Characteristics of Arctic Tundra

- soils frozen, snow-covered most of the year
- clonal, long-lived perennial plants dominate
- species diversity, NPP low



Giblin et al. 1991

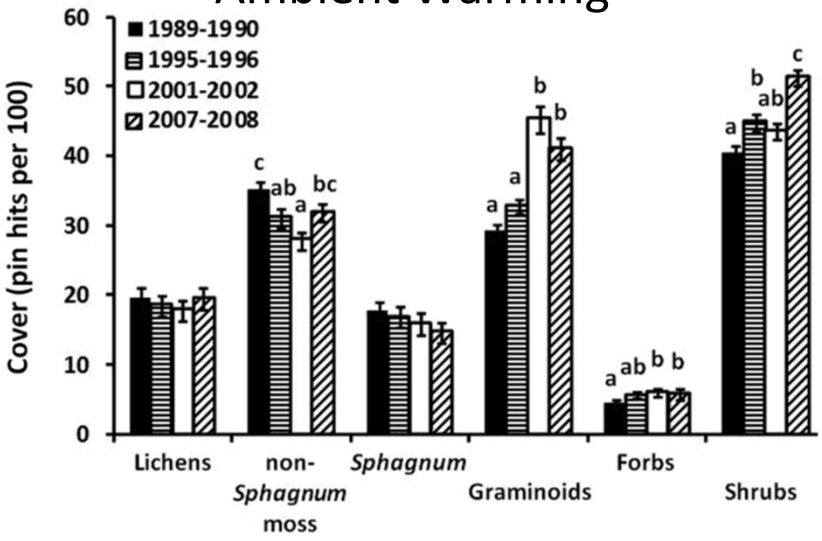
Central Question for the Current Arctic LTER *Terrestrial Research*

How do biogeochemical and community openness and connectivity shape responses to climate change and disturbance?

- *Ambient and experimental warming*
- *Experimentally increased soil nutrients*
- *Fire*

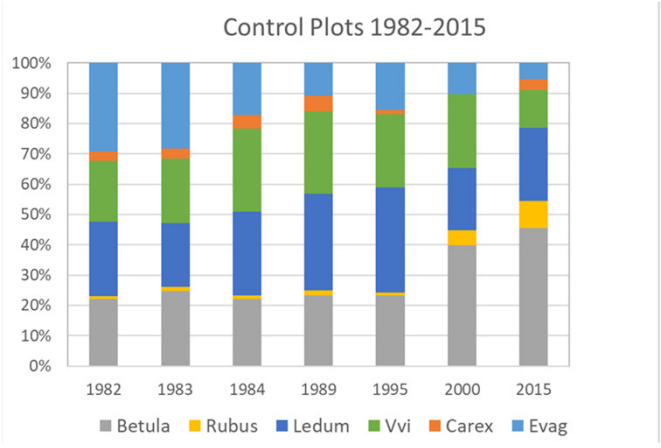
Does Warming Open Tundra Communities and Ecosystems?

Shrubs and Graminoids Benefit from Ambient Warming

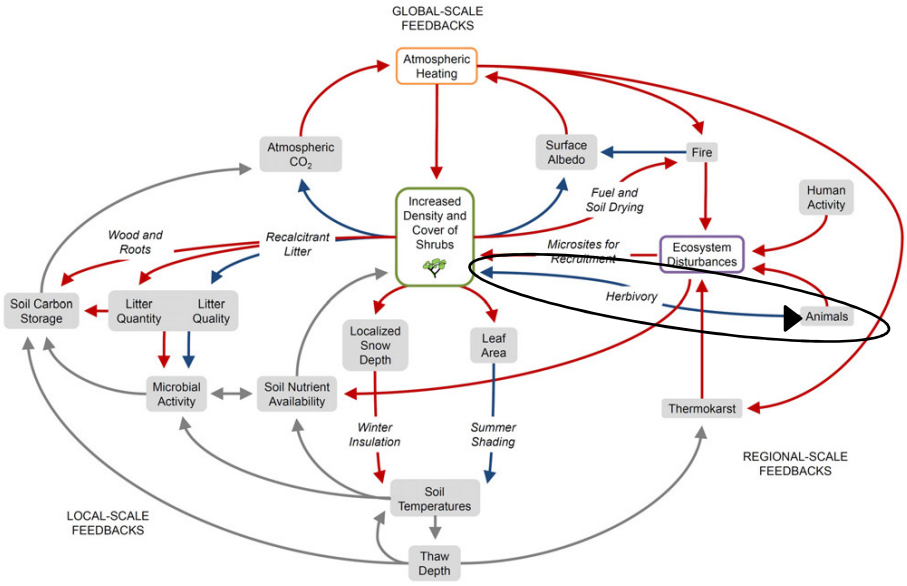


Gould and Mercado-Diaz in Shaver et al. 2014

Relative Abundance of Aboveground Biomass Shifting Towards Shrubs

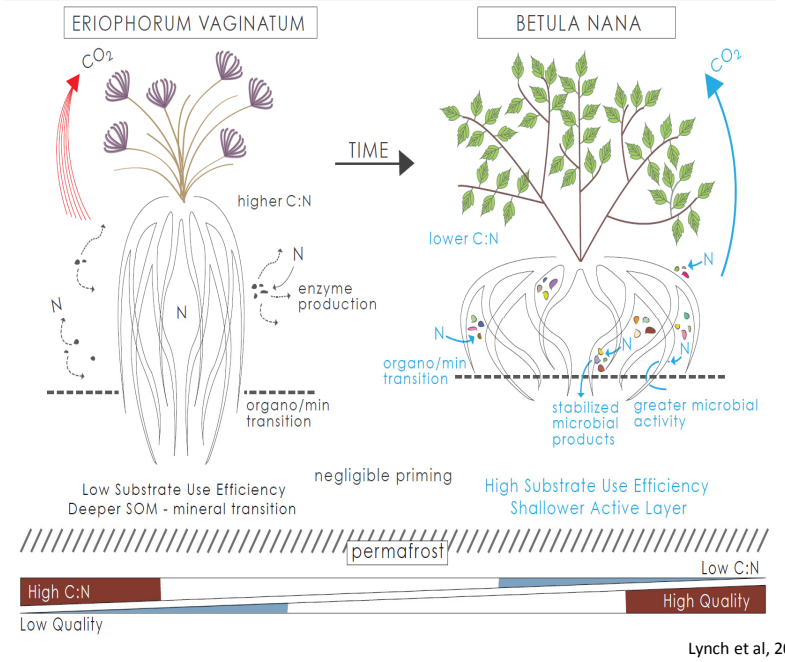


Shaver et al. unpublished



Shrub Hub

Myers-Smith et al. 2011



Lynch et al, 2018 SBB

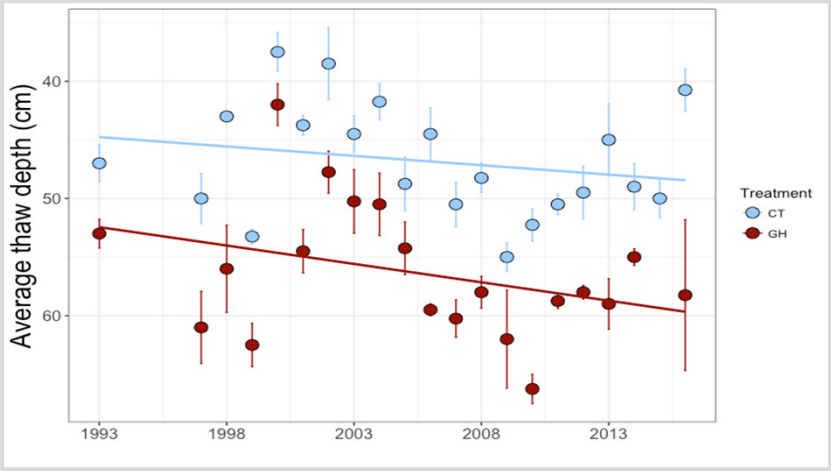
Long-Term Greenhouse Warming Favors Deciduous Shrubs

Plant biomass (2002; g dry weight m^{-2})	**Control**	**Greenhouse**
Vascular aboveground	**369.5 ± 26.0**	**720.7 ± 85.9 *** **
Vascular belowground	**438.3 ± 88.7**	**712.4 ± 70.6 ***
Deciduous Shrub	**218.7 ± 51.8**	**551.2 ± 119.1 ***
Graminoid	227.0 ± 57.5	179.0 ± 92.9
Litter and standing dead	**569.3 ± 134**	**758.4 ± 171.4***
Moss	**75.5 ± 10.8**	**16.3 ± 4.4 ****
Lichen	**29.9 ± 6.4**	**11.8 ± 6.7 ***

all values reported as means ± one se

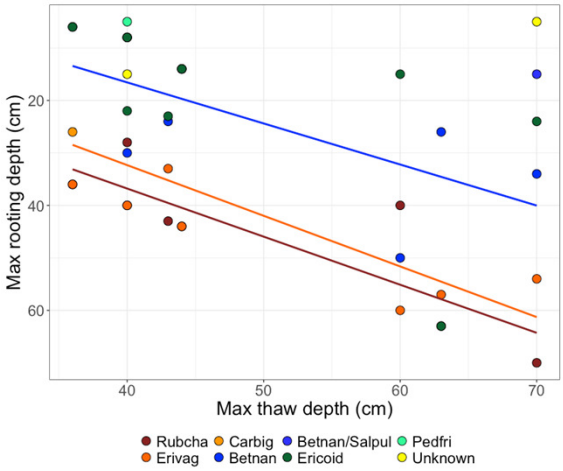
Sistla et al. 2013 Nature

Greenhouses Substantially Increase Thaw Depth



ARC LTER long-term data

Eriophorum, *Rubus*, and *Betula* Root Deeper when Soils Thaw More



R^2=0.43, p<0.05

R^2=0.50, p<0.01

R^2=0.67, p<0.001

Hewitt, Mack, et al. unpublished

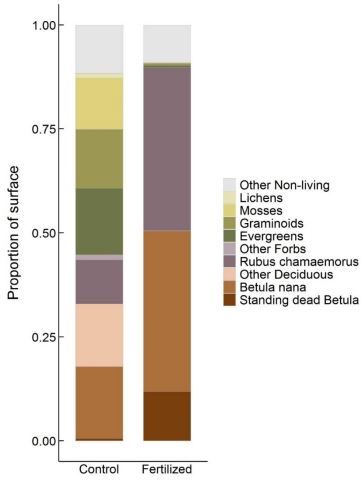
Plant Community Remains Closed

- Species richness unchanged in 2015
- Abundance of several species decreased in greenhouses

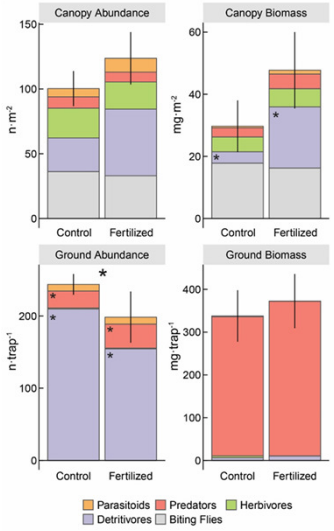
New Warming Experiment Established 2018

Are terrestrial consumer communities open under changes in arctic climate?

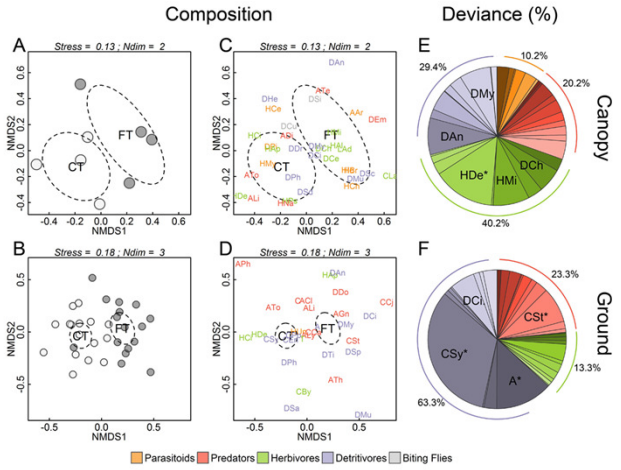
Arthropod Biomass and Abundance Similar to Controls After 24 Years of Nutrient Addition



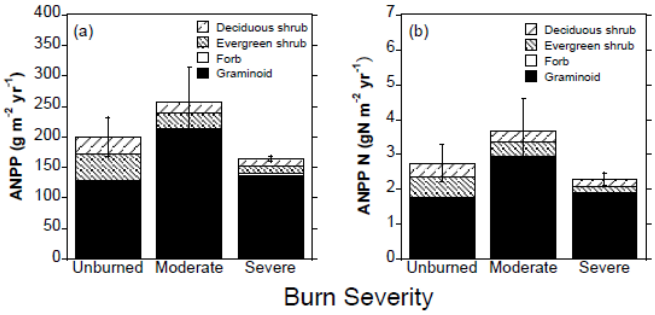
Asmus et al. 2018 *Oikos*



Fertilization Affects Arthropod Community Composition

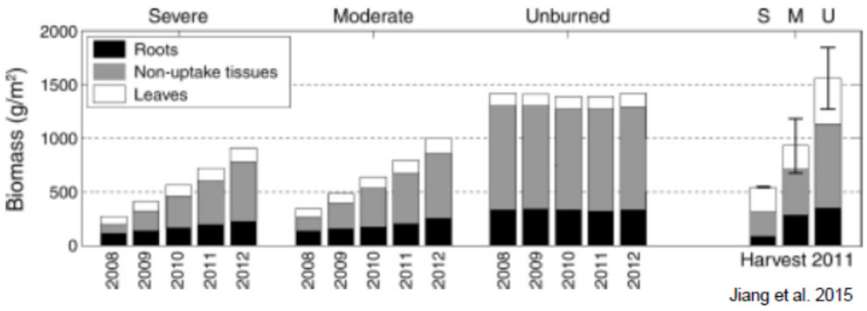


Asmus et al. 2018

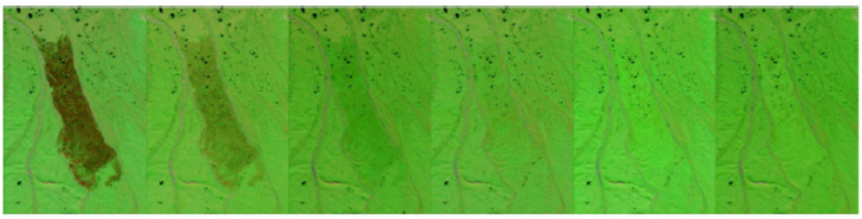


Bret-Harte et al. Proc. Royal Academy London B

Quick recovery of plant growth and net CO_2 exchange after fire

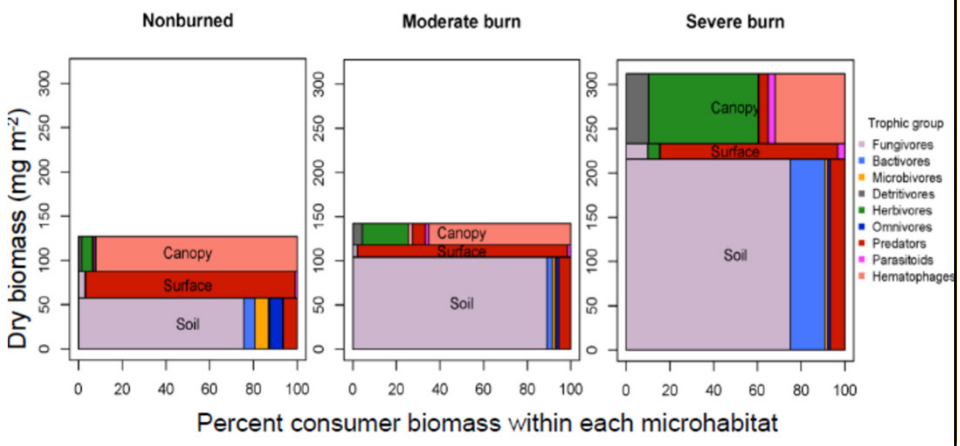


Jiang et al. 2015



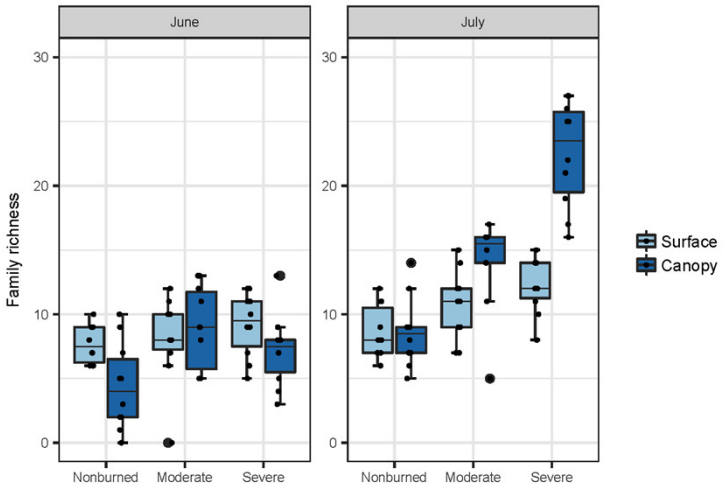
Jiang et al. 2016

Consumer biomass recovers beyond nonburned (control) site



Koltz et al. in prep

Arthropod Richness Greater in Severely Burned Tundra



Koltz et al. in prep

Small Mammal Communities Increase Abundance After Fire, No Change in Richness

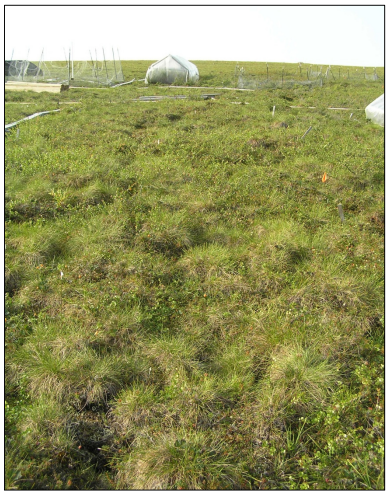
		Microtus		*Myodes*		*Dicrostonyx*		*Sorex*	
Year	**Total**	**control**	**burned**	**control**	**burned**	**control**	**burned**	**control**	**burned**
2014	42	4	35	0	0	0	0	0	3
2017	20	0	4	0	0	1	0	2	13
2018	22	1	13	1	0	0	1	2	4
Total	84	5	52	1	0	1	1	4	20

Rowe et al. unpublished

Ongoing Consumer Measurements

- Small mammal trapping at AR burn sites and as part of Team Vole
- NEON arthropod data collection
- Additional arthropod monitoring in experimental plots

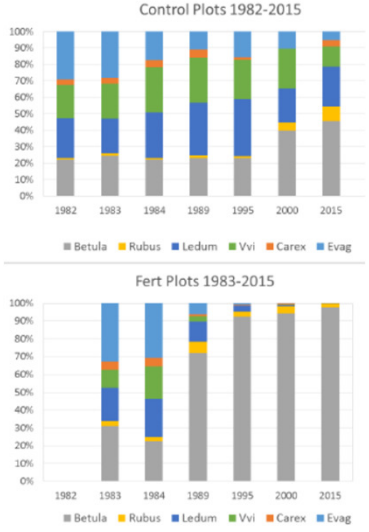
How Do Terrestrial Ecosystems Respond to Long-term N and P Addition?



Control

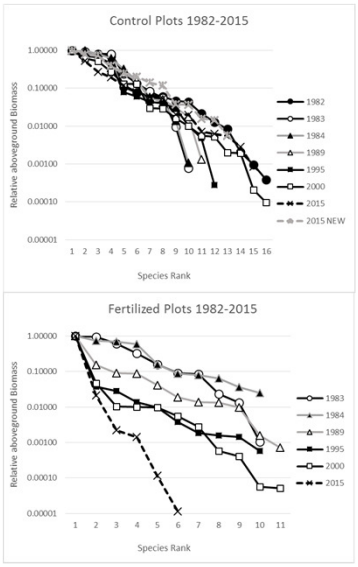
Annual N and P addition

Dramatic Shift Towards *Betula* Dominance



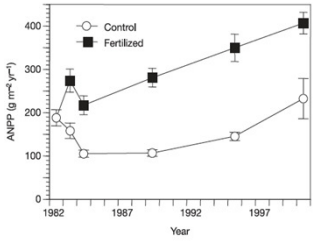
Shaver et al. unpublished

Species Lost and Gained

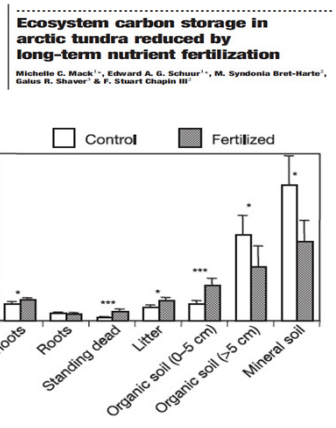


Shaver et al. unpublished

After 20 years of nutrient fertilization…



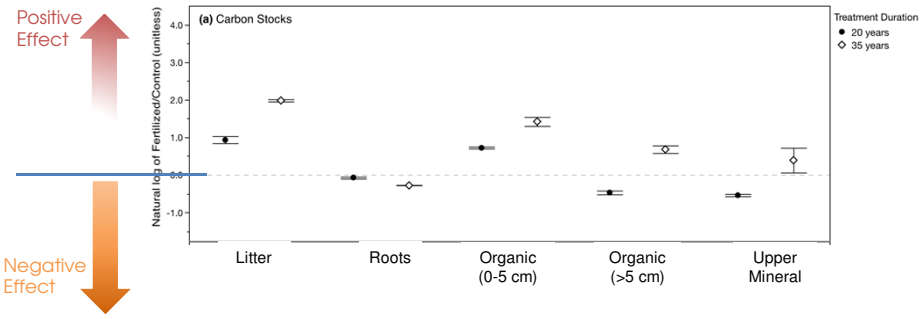
Nitrogen



Mack et al, 2004 Nature

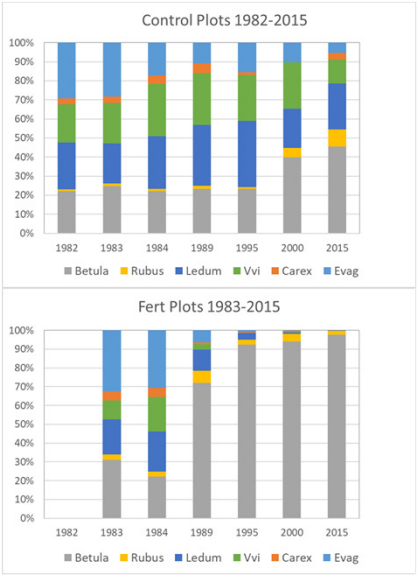
Net ecosystem loss of ~ 2,000 g C m^{-2} over 20 years

After 35 years, soil C stocks recovered and exceeded control levels: closing again?

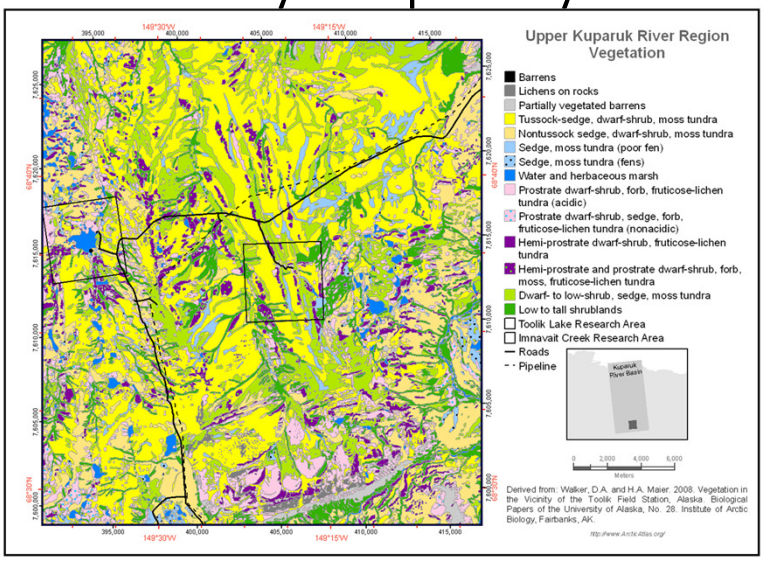


Machmuller et al, in prep

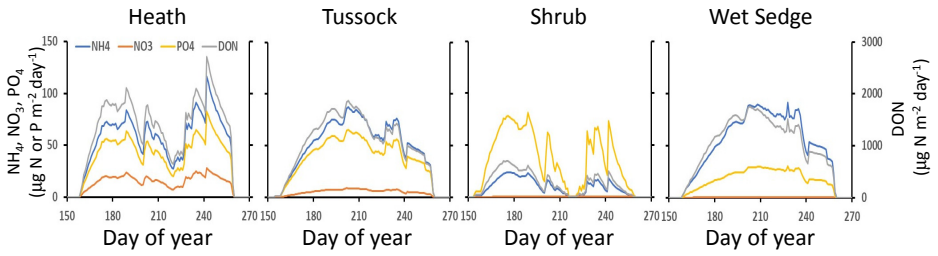
Monitoring Recovery



How does vegetation affect connectivity to aquatic systems?



Runoff and Soil Characteristics Influence Nutrient Losses Downslope



Rastetter unpublished

ArcLTER Terrestrial Research Take-Home Messages

ArcLTER Central Question

How do biogeochemical and community openness and connectivity shape responses to climate change and disturbance?

Key messages

- Compared with streams and lakes, tundra is closed biogeochemically and has closed plant communities
- Warming promotes plant access to soil nutrients but has not affected plant community
- Plant and arthropod communities may include "new" species following increases in nutrient availability, fire
- Short and long-term responses to increased nutrients differ
- Soil characteristics may overwhelm vegetation differences in controlling nutrient runoff to aquatic systems