Arctic Tundra in a Changing Climate

The Terrestrial Research Group
Laura Gough, Coordinator
Towson University

Arctic LTER Mid-Term Review
24 June 2019

Arctic LTER Terrestrial PIs

- Natalie Boelman, Columbia
- Donie Bret-Harte, UAF
- Eugenie Euskirchen, UAF
- Ned Fetcher, Wilkes
- Kevin Griffin, Columbia
- Erik Hobbie, New Hampshire
- Michelle Mack, N. Arizona
- Jennie McLaren, UT El Paso
- John Moore, Colorado State
- Sue Natali, WH Res Center
- Ed Rastetter, MBL
- Adrian Rocha, Notre Dame
- Becca Rowe, New Hampshire
- Josh Schimel, UCSB
- Gus Shaver, MBL
- Jim Tang, MBL
- Matt Wallenstein, Colorado State
- Mike Weintraub, U. Toledo

Senior RA: Jim Laundre, MBL

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 biogeochemically
• Plant community closed
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 unpublished
Long-Term Greenhouse Warming Favors Deciduous Shrubs

<table>
<thead>
<tr>
<th>Plant biomass (2002; g dry weight m⁻²)</th>
<th>Control</th>
<th>Greenhouse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vascular aboveground</td>
<td>369.5 ± 26.0</td>
<td>720.7 ± 85.9 ***</td>
</tr>
<tr>
<td>Vascular belowground</td>
<td>438.3 ± 88.7</td>
<td>712.4 ± 70.6  *</td>
</tr>
<tr>
<td>Deciduous Shrub</td>
<td>218.7 ± 51.8</td>
<td>551.2 ± 119.1  *</td>
</tr>
<tr>
<td>Graminoid</td>
<td>227.0 ± 57.5</td>
<td>179.0 ± 92.9</td>
</tr>
<tr>
<td>Litter and standing dead</td>
<td>569.3 ± 134</td>
<td>758.4 ± 171.4*</td>
</tr>
<tr>
<td>Moss</td>
<td>75.5 ± 10.8</td>
<td>16.3 ± 4.4   **</td>
</tr>
<tr>
<td>Lichen</td>
<td>29.9 ± 6.4</td>
<td>11.8 ± 6.7   *</td>
</tr>
</tbody>
</table>

all values reported as means ± one se

Sistla et al. 2013 Nature
Greenhouses Substantially Increase Thaw Depth

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

Anaktuvuk River Fire 2007

1,000 km² burned
Quick recovery of plant growth and net CO₂ exchange after fire

Arthropod Richness Greater in Severely Burned Tundra
Small Mammal Communities Increase Abundance After Fire, No Change in Richness

<table>
<thead>
<tr>
<th>Year</th>
<th>Total control</th>
<th>Microtus</th>
<th>Myodes</th>
<th>Dicrostonyx</th>
<th>Sorex</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>control burned</td>
<td>control</td>
<td>control</td>
<td>control</td>
<td>control</td>
</tr>
<tr>
<td>2014</td>
<td>42</td>
<td>4</td>
<td>35</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2017</td>
<td>20</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2018</td>
<td>22</td>
<td>1</td>
<td>13</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>84</td>
<td>5</td>
<td>52</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

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

After 20 years of nutrient fertilization...

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?

Monitoring Recovery
How does vegetation affect connectivity to aquatic systems?

Runoff and Soil Characteristics Influence Nutrient Losses Downslope
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

Questions?