Effects of long term warming on vegetation in northern Alaska

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Climate Change and the Arctic

Climate change affects entire globe
Most pronounced at high latitudes
Warming in the arctic
Documented since the 1800’s
More rapidly since the mid 20th century

(IPCC 2007)
Effects of Warming on Tundra Plants

Even small variations in the environment effect community function
Reproductive effort, growth rates, and nutrient cycling

(Chapin and Shaver, 1985)

Responses to warming are often within one growing season
Graminoids and Shrubs often show the most increased growth

(Arft et al, 1999; Hobie and Chapin, 1998)

Increased growth of these taller plants shift competitive advantage

Bryophytes and lichens become light deficient and decline in abundance

(Epstein et al, 2004; Wahren et al 2004)
This Study

Investigated how 4 plant communities in Northern Alaska respond to experimental warming and between year variations.
Hypotheses

Increase in overall cover

Increase in tall plants (Graminoids and Shrubs)

Decrease in short plants (Forbs, Bryophytes, and Lichens)

Diversity should decrease

All trends should be consistent across time and in response to warming
Site Locations

Barrow

Atqasuk

DRY

WET

Site Locations

Barrow

Atqasuk

DRY

WET
Site Setup and Warming

24 Warmed and 24 Control plots

All plots are 1m²

Open-Top Chambers (OTC)

Light enters and traps heat in

Warmed air temp 1-3°C

Established between 1994-96

International Tundra Experiment (ITEX)
Point Frame Method

3 Samplings

Summers of 1995-96, 2000, and 2007-08

Same 2 weeks each year

Point Frame Grid
- 75cm by 75cm
- 100 points

Measurements
- At each point

Top and Bottom contact

Species

Live/Dead Status

Height

(Hollister et al, 2005)
Analysis

Only live contacts were used for taxa and diversity analyses

Ran a mixed model repeated measures ANOVA
Initial changes were often not the same as secondary changes.

Directional changes were site specific.
Between year variation had more influence than warming overall.

Only Barrow Dry Site had a year/warming interaction.

Shrubs and Graminoids responded positively overall.

Short plants had mixed responses.
Amplifying Effects of Taxa on Growth Form

Atqasuk Wet Site

<table>
<thead>
<tr>
<th></th>
<th>Sampling1</th>
<th></th>
<th>Sampling2</th>
<th></th>
<th>Sampling3</th>
<th></th>
<th>Diff</th>
<th>W</th>
<th>Y</th>
<th>Int</th>
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<tr>
<td></td>
<td>Ctl</td>
<td>OTC</td>
<td>Diff</td>
<td>Ctl</td>
<td>OTC</td>
<td>Diff</td>
<td>Ctl</td>
<td>OTC</td>
<td>Diff</td>
<td>W</td>
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<tr>
<td><strong>Graminoids</strong></td>
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<tr>
<td><strong>Single Graminoids</strong></td>
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<tr>
<td>Carex australis complex</td>
<td>22.0</td>
<td>21.1</td>
<td>-0.9</td>
<td>13.5</td>
<td>16.7</td>
<td>3.2</td>
<td>31.4</td>
<td>37.7</td>
<td>6.3</td>
<td>*</td>
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<tr>
<td>Dupontia fisheri/psilosantha</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.1</td>
<td>0.1</td>
<td>0.2</td>
<td>0.1</td>
<td>-0.1</td>
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<tr>
<td>Eriophorum angustifolium</td>
<td>3.2</td>
<td>2.8</td>
<td>-0.4</td>
<td>3.1</td>
<td>3.4</td>
<td>0.3</td>
<td>6.8</td>
<td>7.9</td>
<td>1.1</td>
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<tr>
<td>Eriophorum russeulum complex</td>
<td>2.1</td>
<td>1.9</td>
<td>-0.2</td>
<td>1.7</td>
<td>2.1</td>
<td>0.4</td>
<td>3.4</td>
<td>5.2</td>
<td>1.8</td>
<td></td>
</tr>
</tbody>
</table>

Best example is in second sampling

All taxa within the Graminoids respond positively and add to the change in the Growth Form

This example most difference driven by *Carex australis* complex
**Taxon Changes Cancelling Each Other Out**

**Atqasuk Dry Site**

<table>
<thead>
<tr>
<th></th>
<th>Sampling1</th>
<th></th>
<th></th>
<th>Sampling2</th>
<th></th>
<th></th>
<th>Sampling3</th>
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<th></th>
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<tbody>
<tr>
<td></td>
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<td>OTC</td>
<td>Diff</td>
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<td>Diff</td>
<td>Ctl</td>
<td>OTC</td>
<td>Diff</td>
<td>W</td>
<td>Y</td>
<td>Int</td>
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<tr>
<td><strong>Evergreen Shrubs</strong></td>
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</tr>
<tr>
<td><em>Cassiope tetragona</em></td>
<td>26.7</td>
<td>28.0</td>
<td>1.3</td>
<td>20.6</td>
<td>23.3</td>
<td>2.7</td>
<td>33.8</td>
<td>35.2</td>
<td>-3.6</td>
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<tr>
<td><em>Diapensia lapponica</em></td>
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<td>8.9</td>
<td>2.4</td>
<td>4.7</td>
<td>7.8</td>
<td>3.1</td>
<td>12.6</td>
<td>13.2</td>
<td>0.6</td>
<td>*</td>
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<tr>
<td><em>Ledum palustre</em></td>
<td>3.4</td>
<td>3.2</td>
<td>-0.2</td>
<td>2.5</td>
<td>2.0</td>
<td>-0.5</td>
<td>6.3</td>
<td>4.6</td>
<td>-1.7</td>
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<tr>
<td><em>Vaccinium vitis-idaea</em></td>
<td>10.1</td>
<td>9.7</td>
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<td>8.1</td>
<td>8.3</td>
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<td>10.7</td>
<td>9.5</td>
<td>-1.2</td>
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</tbody>
</table>

Most pronounced in the first sampling

*C. tetragona* responds positively to warming

Other evergreen shrubs respond negatively

Overall they mute the change for in Growth Form
### Diversity

<table>
<thead>
<tr>
<th>Sampling 1</th>
<th>Sampling 2</th>
<th>Sampling 3</th>
<th>Effects</th>
</tr>
</thead>
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<tr>
<td></td>
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<tr>
<td>CTL</td>
<td>OTC</td>
<td>Diff</td>
<td>CTL</td>
</tr>
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<td>Atqasuk Dry Site</td>
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<tr>
<td>Richness</td>
<td>17.58</td>
<td>17.42</td>
<td>-0.17</td>
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<tr>
<td>Simpson</td>
<td>0.88</td>
<td>0.87</td>
<td>-0.01</td>
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<tr>
<td>Atqasuk Wet Site</td>
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</tr>
<tr>
<td>Richness</td>
<td>13.75</td>
<td>13.13</td>
<td>-0.63</td>
</tr>
<tr>
<td>Simpson</td>
<td>0.80</td>
<td>0.80</td>
<td>0.00</td>
</tr>
<tr>
<td>Barrow Dry Site</td>
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<td></td>
</tr>
<tr>
<td>Richness</td>
<td>19.33</td>
<td>18.71</td>
<td>-0.63</td>
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<tr>
<td>Simpson</td>
<td>0.87</td>
<td>0.84</td>
<td>-0.03</td>
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<tr>
<td>Barrow Wet Site</td>
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<tr>
<td>Richness</td>
<td>18.67</td>
<td>17.96</td>
<td>-0.71</td>
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<tr>
<td>Simpson</td>
<td>0.86</td>
<td>0.85</td>
<td>-0.01</td>
</tr>
</tbody>
</table>

- **Year effects had more influence than warming did overall**
- **Richness decreased in all sites across all samplings**
- **Simpson’s Diversity decreased in all sites across all samplings**
- **Differences were most pronounced in Barrow sites**
So why does Year effect make so much of a difference?

Yearly Differences In:

- Winter snow cover and depth
- Summer precipitation amounts
- Temperatures increasing

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**Atqasuk**

- S1
- S2
- S3

**Barrow**

- S1
- S2
- S3

Years of study:

- 1995
- 1997
- 1999
- 2001
- 2003
- 2005
- 2007
Conclusions

There was a larger difference between years than between treatments

Tall plants (Shrubs and Graminoids) increased in cover over time but had mixed responses to treatments by site

Short plants (Forbs, Lichens, and Bryophytes) were often site specific in responses and were resistant to change over time

Some taxa within groups respond differently and mute overall Growth Form change

Richness and Simpson Diversity decrease over time (except the Barrow Dry Site) and in response to warming
Acknowledgements

Rob Slider, Jennifer Liebig, Amanda Snyder, Jean Galang, and Mike Lothshultz
References

Barbour, Michael; Jack Burk; Wanna Pitts; Frank Gilliam; and Mark Schwartz. 1999. Terrestrial Plant Ecology. 210-239.


Questions?