

What is Biocomplexity?

Biocomplexity: themes

1. Connecting components of the earth system that haven't been previously connected.

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1. Connecting components of the earth system that haven't been previously connected.
2. Understanding the self-assembling feedback loops between the biotic and physical systems of the earth.

***How does Biocomplexity
relate to Arctic System
Science?***

Biocomplexity can occur and be studied at the micro scale

Example: Scanning electron micrograph from P.A. Holden, UCSB:

Microbial colony embedded in extracellular polysaccharides bridging two sand grains. You can also see individual, naked bacteria on the sand surface

Image deleted for copyright

Arctic system science really begins with thinking at this scale: watershed processes



Image: Toolik Lake LTER website



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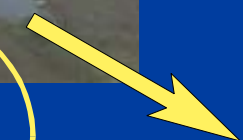
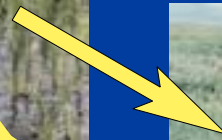
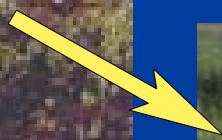
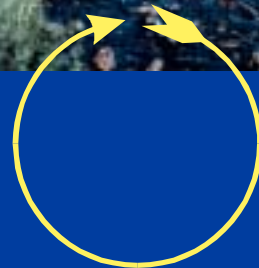
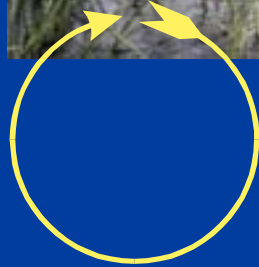
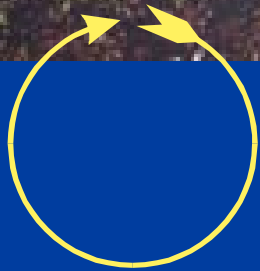
Image: Toolik Lake LTER website

Landscape Processes

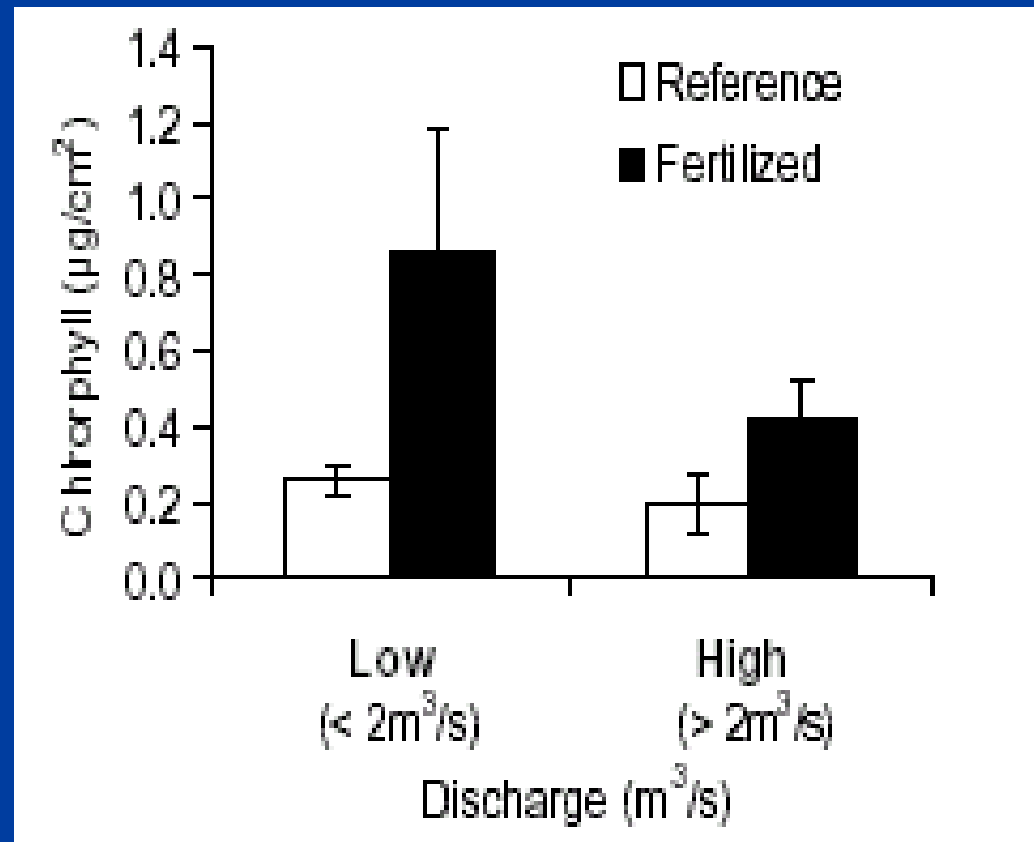


Nutrients move among system components

Nutrients cycle within systems

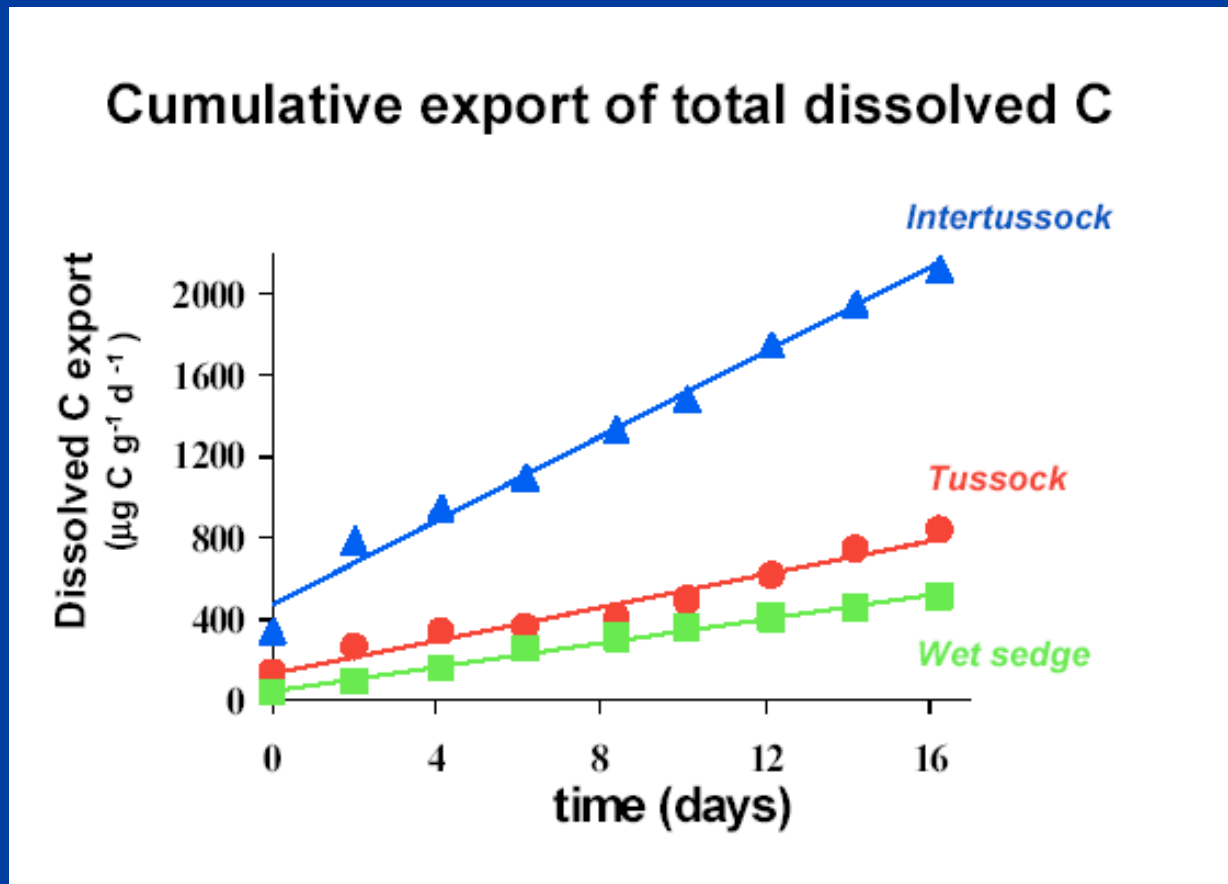


Algal productivity in the Kuparuk River responds strongly to P fertilization



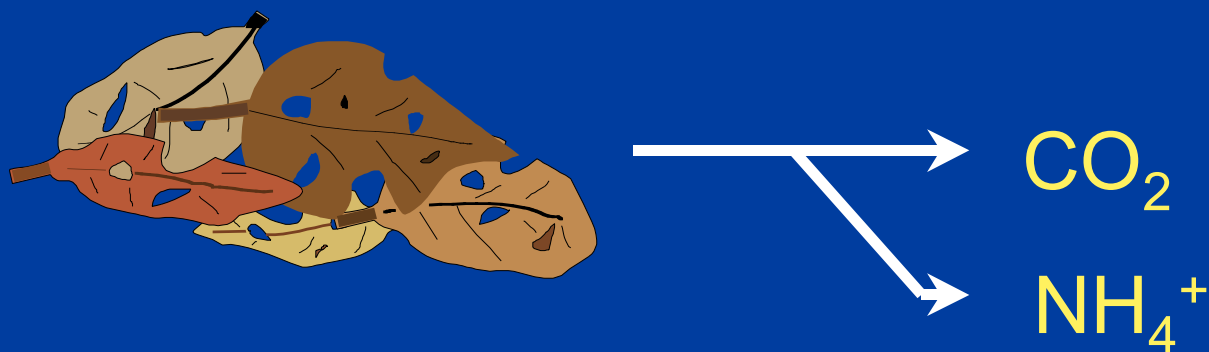
Graph from Toolik LTER web site

C export varies among tundra communities: substantial amounts as DOC



Graph from Toolik LTER web site

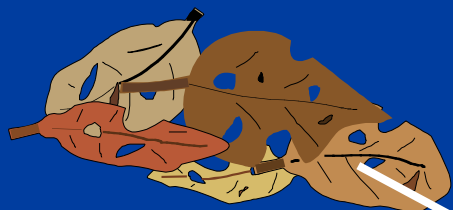
Current models of litter decay and soil organic matter turnover:



$$dC/dt = -kC$$

Models don't generate DOC!

Microbial-hydrology linkages in the tundra landscape



Extracellular
enzymes:
cellulase,
protease,
ligninases

DOC & N

sugars,
amino acids,
phenolics

**CO₂ &
NH₄⁺**

Microbial
metabolism

Hydraulic
flushing



Goal: linkage of soil ecology with watershed hydrology

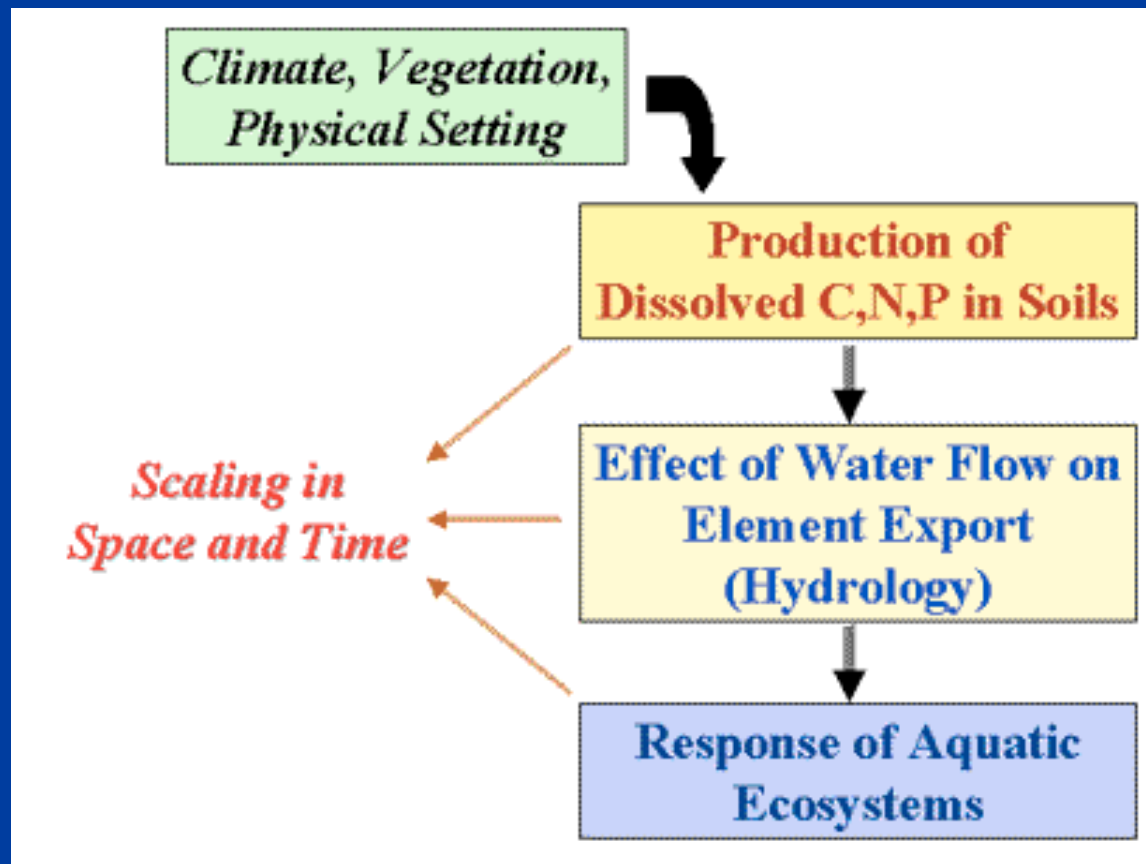


Image: Toolik Lake LTER website

Shrubs are increasing in the Alaskan Arctic

This is shown by analysis of old air
photos by Sturm et al. 2001. Nature
411: 546-547

e.g. image of the Ayiyak River

Image deleted for copyright

Effects of shrubs on snow distribution

Shrubs:

- a) Reduce redistribution
- b) Reduce sublimation

Net effect:

Shrubs greatly increase soil insulation

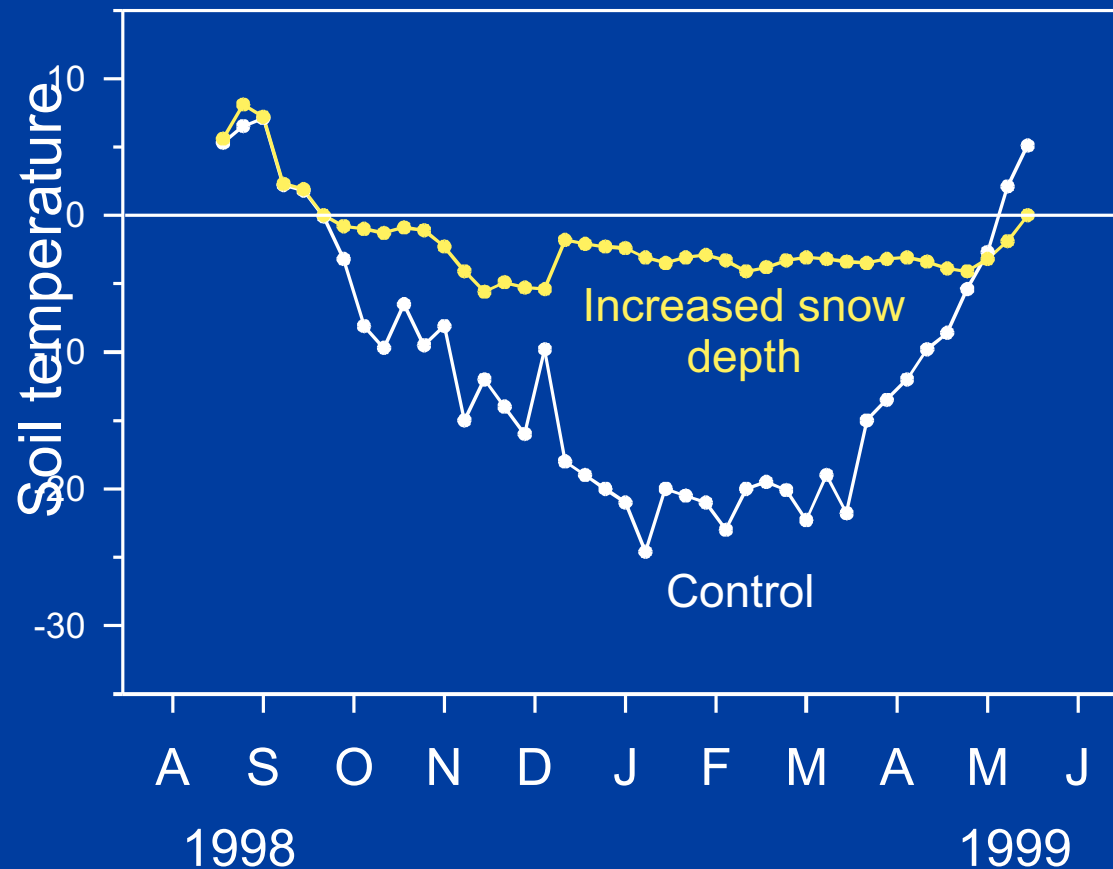
Example: Figure 9 from Liston et al.

2002. *Global Change Biology* 8: 17-32 showing changes in snow distribution under different vegetation morphologies

Figure deleted for copyright

Increased winter snowpack increases soil temperature

snow fence experiment in tussock tundra

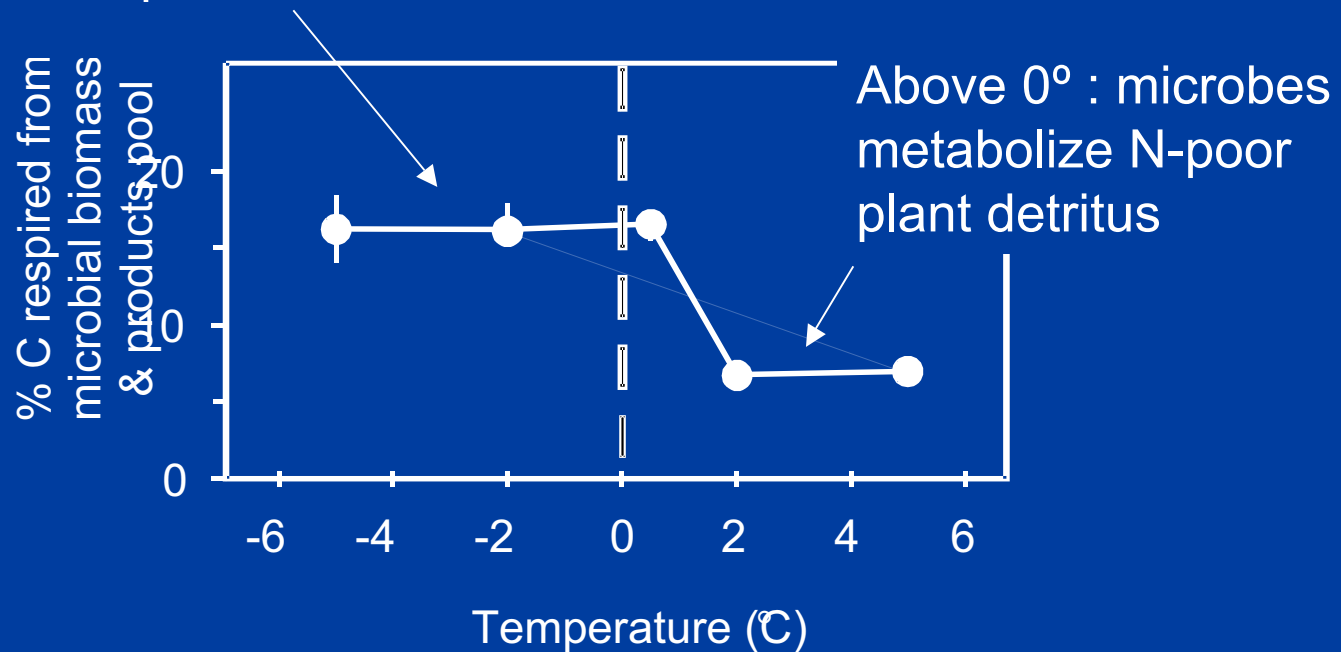


Data from Bilbrough et al. submitted

Changing microbial substrate use with temperature

^{14}C label microbes, measure enrichment of CO_2

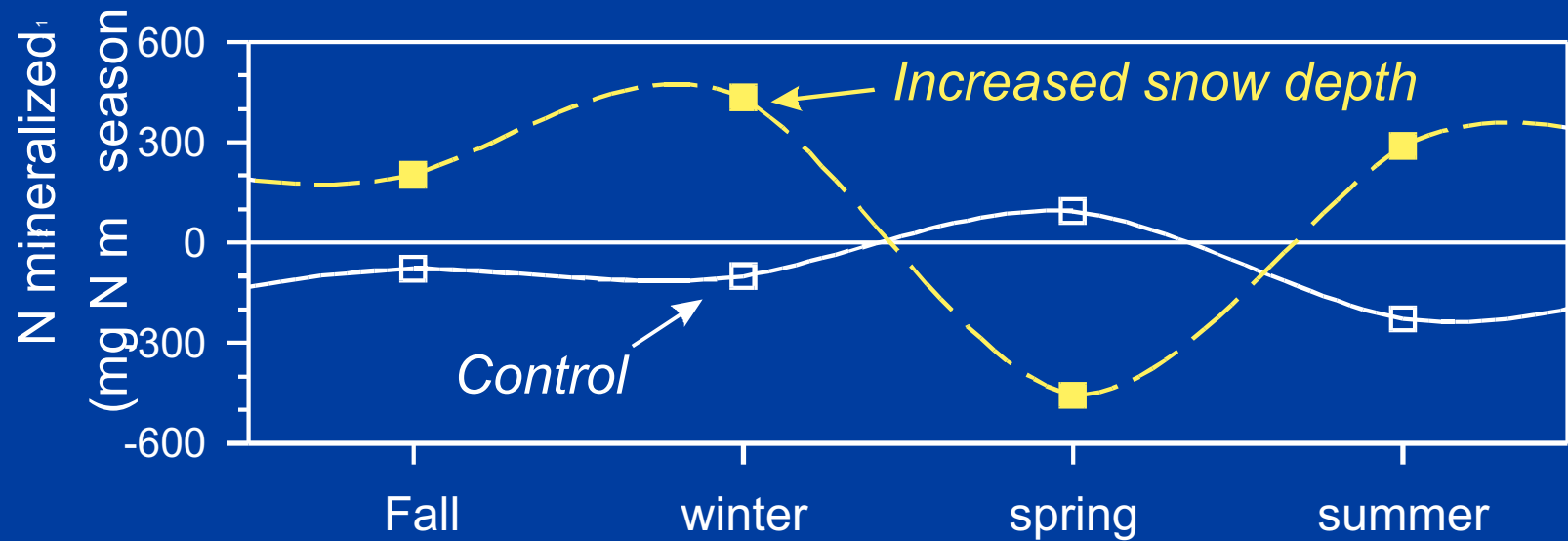
Below 0° : microbes
rely more on N rich
microbial products



Data from Mikan & Schimel, in prep.

Increased winter snowpack increases *in situ* N mineralization in tundra soils

Inter-tussock soil



Data from Bilbrough et al. submitted

Shrub-snow-soil feedback cycle

Climate warming

Shrub density

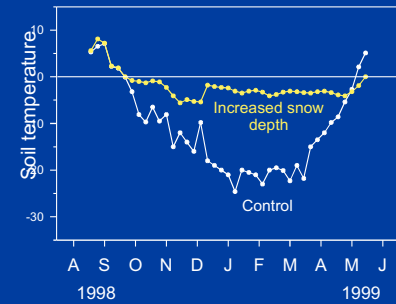
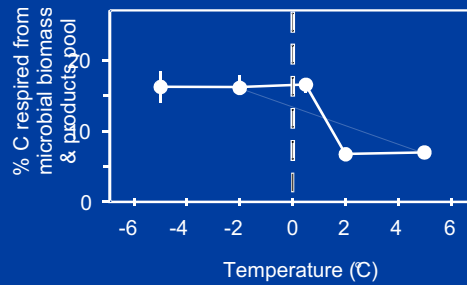
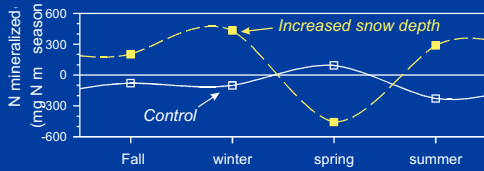
Shrubs are increasing

Nutrient availability

Snow depth

Microbial activity

Soil temperature



Traditional arctic scientific year



Snowmelt:
*hydrologists
year begins*



Flowering:
*ecologists
year begins*



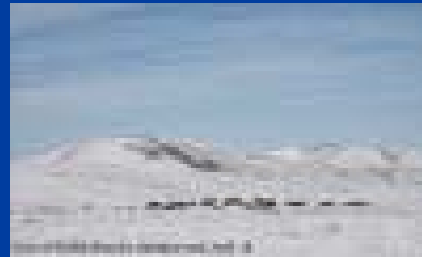
Mid season:
*prime
ecological
work time*



Fall:
*research
year ends*

*Images: UAF Water resource center,
Toolik LTER, and Toolik Field Station web sites*

New perspective on the Arctic year



Fall:
*snow timing
controls
winter soil
temperature*

Winter:
*under-snow
processing*

Summer:
*processes
regulated by
winter conditions*

Images: Toolik LTER, and Toolik Field Station web sites

Arctic Landscapes in Transition: complex interactions in space and time

Taken together, these different perspectives- understanding landscape interactions and potentially rapid transitions in the structure and function on Arctic ecosystems- gives us a much more dynamic perspective on the Arctic and a view that better integrates the feedbacks that exist among biotic and abiotic processes that occur in the Arctic.

*Image of the Kugurorum watershed from Sturm et al. 2001.
Nature 411: 546-547 deleted for copyright*