Detection and Attribution of Long-Term Changes in Vegetation Phenology and Growth in Northern Alaska

-Rob Slider and Bob Hollister-
Changes in Vegetation Phenology and Growth due to Long-term Warming in Northern Alaska

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The Arctic is warming and is predicted to continue warming.

Rapid & dramatic warming
(4 - 8ºC)
predicted over next century
(IPCC 2007)
Arctic soils are warming and snow is melting earlier.

AK permafrost warmed ~2°C in past 30 years (ACIA 2004)
Warmer soils impact C budget

Cooler

Warmer

Microbial Decomposition

Carbon Release

Carbon Release
Earlier snowmelt alters energy balance
Changing plant cover alters energy balance
Arctic vegetation is changing

Sturm et al 2001
Changing vegetation alters trophic interactions

Migratory Residents

Residents

Predators

Migratory Breeders
Importance of Arctic plants

- **Carbon Budget**
  - Cooler
  - Warmer
  - Microbial Decomposition
  - Carbon Release

- **Energy Balance**
  - Earlier snowmelt alters energy balance

- **Trophic Interactions**
  - Migratory Residents
  - Migratory Breeders
  - Predators
  - Residents
How will warming impact Arctic plants?
Warming on Arctic plants
Findings of previous studies

**Growth**

- Earlier Greenup
- Longer leaves

**Reproduction**

- Earlier flowering
- More flowers
- Longer Inflorescences

(Arft et al 1999) (Hollister et al 2005)
Study Sites

Barrow
71°18’N
156°40’W

Atqasuk
70°29’N
157°25’W
Warming 1-3°C using open-top chambers
Traits Measured

**Flower Burst** (*P. kanei*)

**Leaf Burst** (*L. arctica*)

**Flower** (*S. rotundifolia*)

**Leaf Length** (*A. latifolia*)

**Inflorescence**

**Length** (*D. micropetala*)

**Traits Measured**
Meta-analysis: Calculating effect sizes

Barrow Dry site 1994

Effect size of warming on flower burst date

\[ d = \frac{(\bar{X}_E - \bar{X}_C)}{S} \]

All species
Example: Earlier flowering at Barrow Dry site
Warming effect by trait and site (Effect sizes and 95% CI’s)

- Taller inflorescences
- Longer leaves
- Earlier flowering (Barrow)
- Fewer flowers (Atqasuk Dry site)
- More flowers (Barrow Dry site)
- Earlier leaf burst (Barrow Dry site)
Growth Forms

- **Evergreen Shrub** (*C. tetragona*)
- **Deciduous Shrub** (*S. pulchra*)
- **Graminoid** (*C. stans*)
- **Forb** (*S. hieracifolia*)
Warming effect by trait and growth form (Effect sizes and 95% CI’s)

- **Warming effect size**
  - 2
  - 1
  - 0
  - -1
  - -2
  - -3
  - -4
  - -5
  - -6

- **Inflorescence length**
- **Leaf length**
- **Flower number**
- **Leaf burst date**
- **Flower burst date**

- **Evergreen shrub**
- **Forb**
- **Deciduous shrub**
- **Graminoid**

- Taller inflorescences (all but E. Shrubs)
- Longer leaves (Forbs & Graminoids)
- Fewer Flowers (D. Shrubs)
- Earlier leaf burst (D. Shrubs)
- Earlier flowering
Most Common Warming Effects

• Taller inflorescences

• Longer leaves

• Earlier Flowering
Future Questions

• How have traits changed over time?

• How do changes relate to other factors?
  – Snowmelt
  – PAR
  – Soil moisture
  – Temperature in previous seasons
  – Snow depth
  – Thaw depth
  – Extreme temperatures
  – Community change
Sources


Questions?
Warming soils will impact C budget

Frozen Ground

Thawed Ground

$\text{CO}_2$

$\text{CH}_4$
The Arctic Tundra

Vegetation Layer
(Mosses, grasses, and other plants)

Active Layer
(Seasonally thawed soil)

Permafrost
(Permanently frozen soil)