

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

-Rob Slider and Bob Hollister-



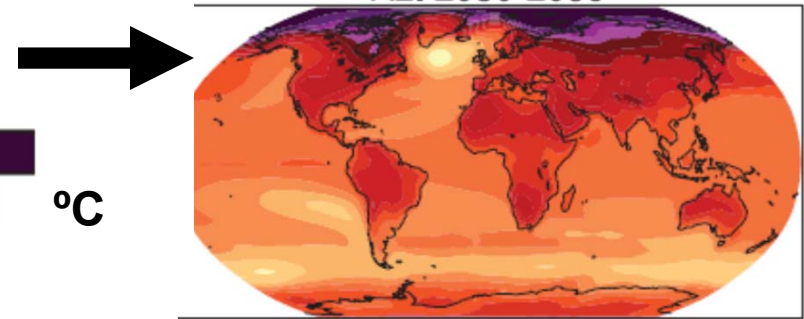
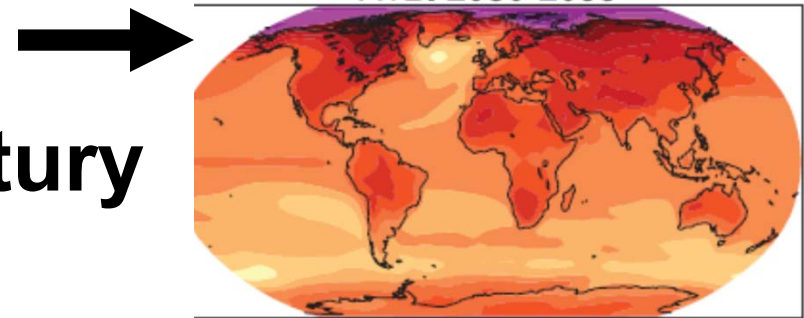
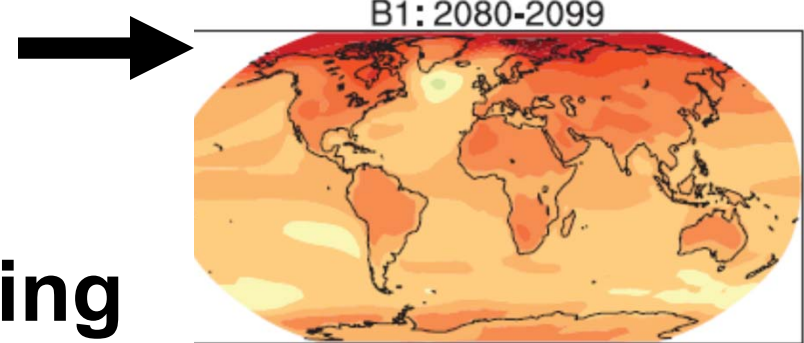
# Changes in Vegetation Phenology and Growth due to Long-term Warming in Northern Alaska

-Rob Slider and Bob Hollister-



# The Arctic is warming and is predicted to continue warming

**Rapid & dramatic warming**  
**(4 - 8°C)**  
**predicted over next century**  
(IPCC 2007)



# Arctic soils are warming and snow is melting earlier

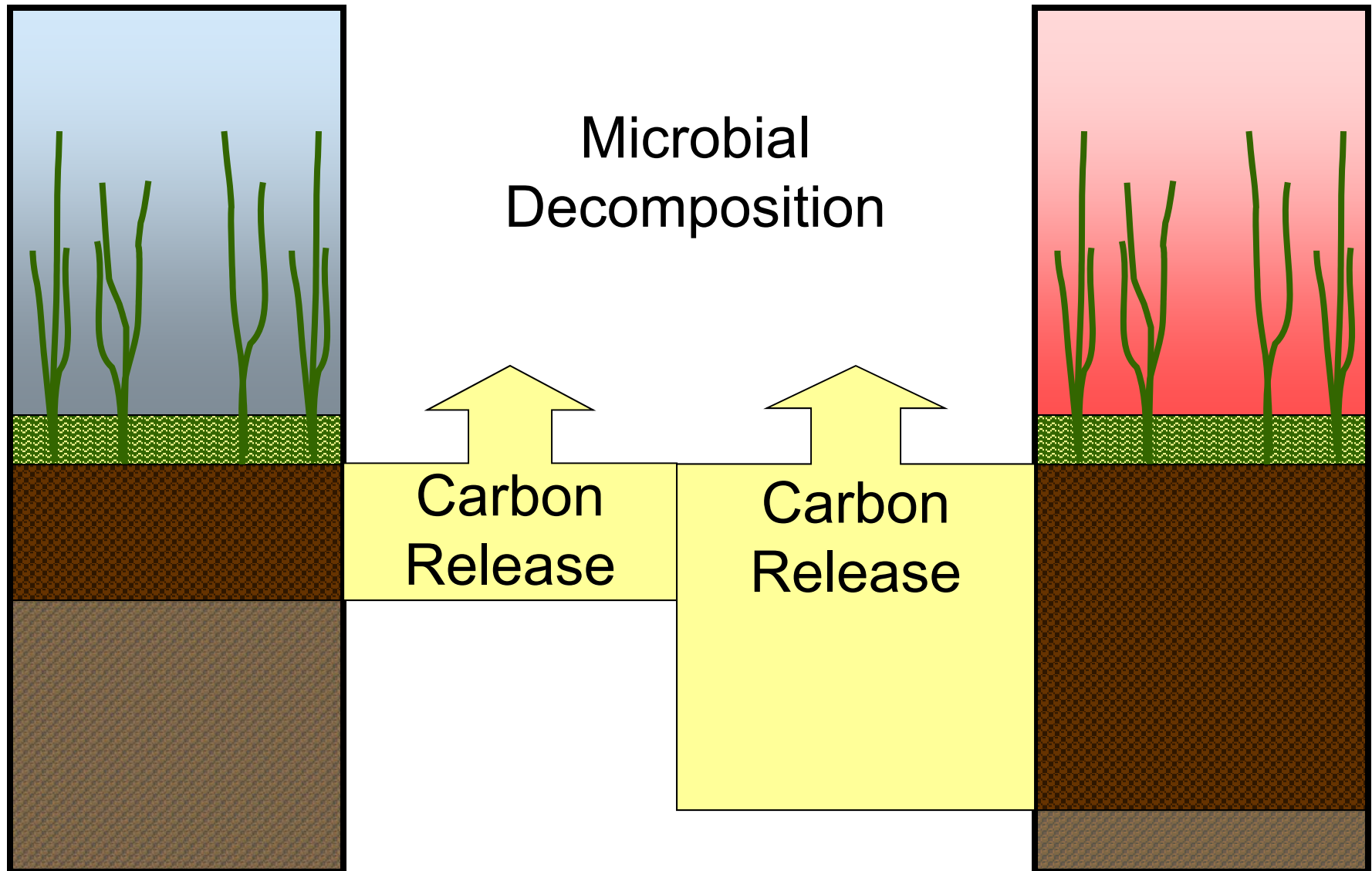


AK permafrost warmed  $\sim 2^{\circ}\text{C}$  in past 30 years (ACIA 2004)

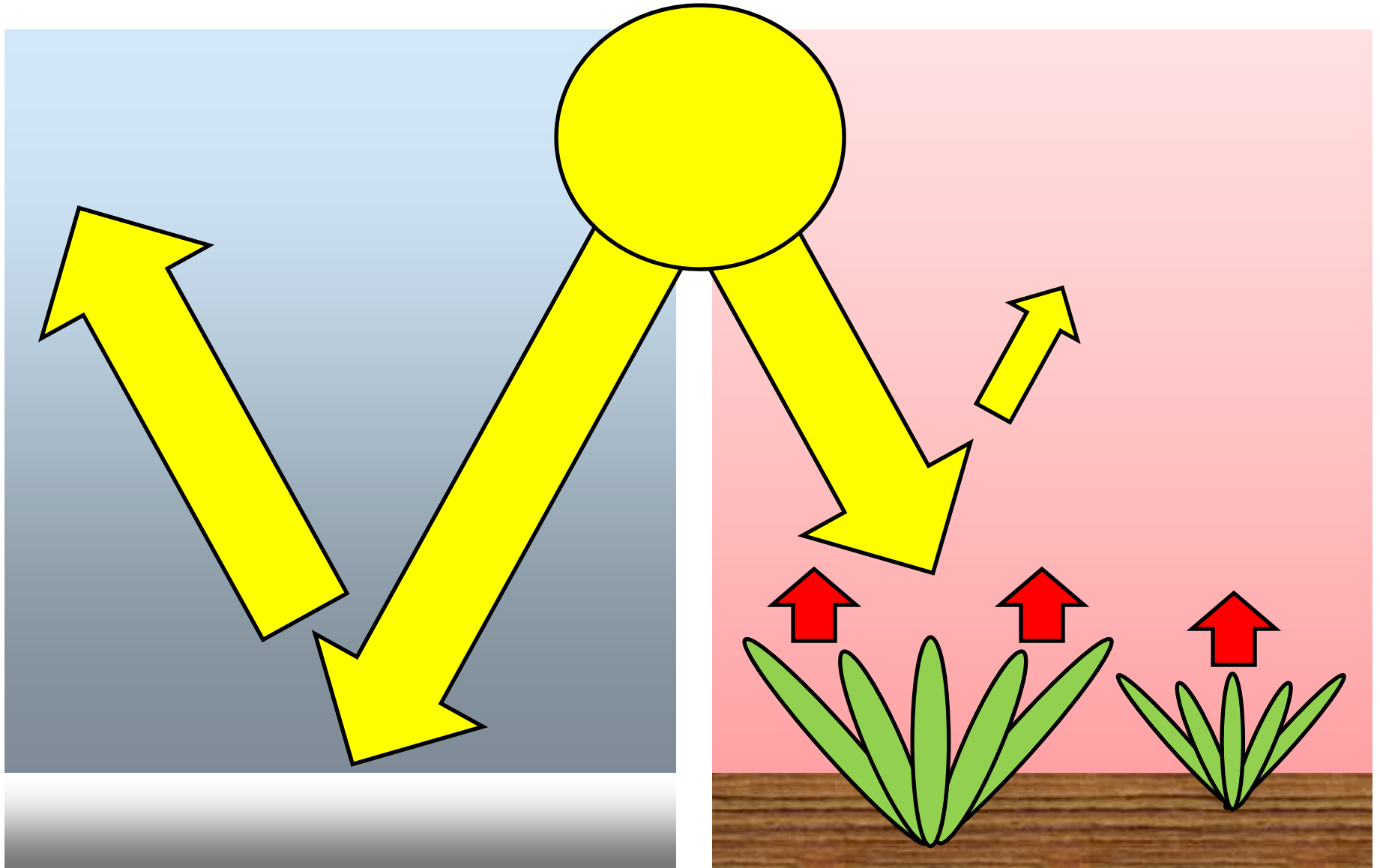
# Warmer soils impact C budget

**Cooler**

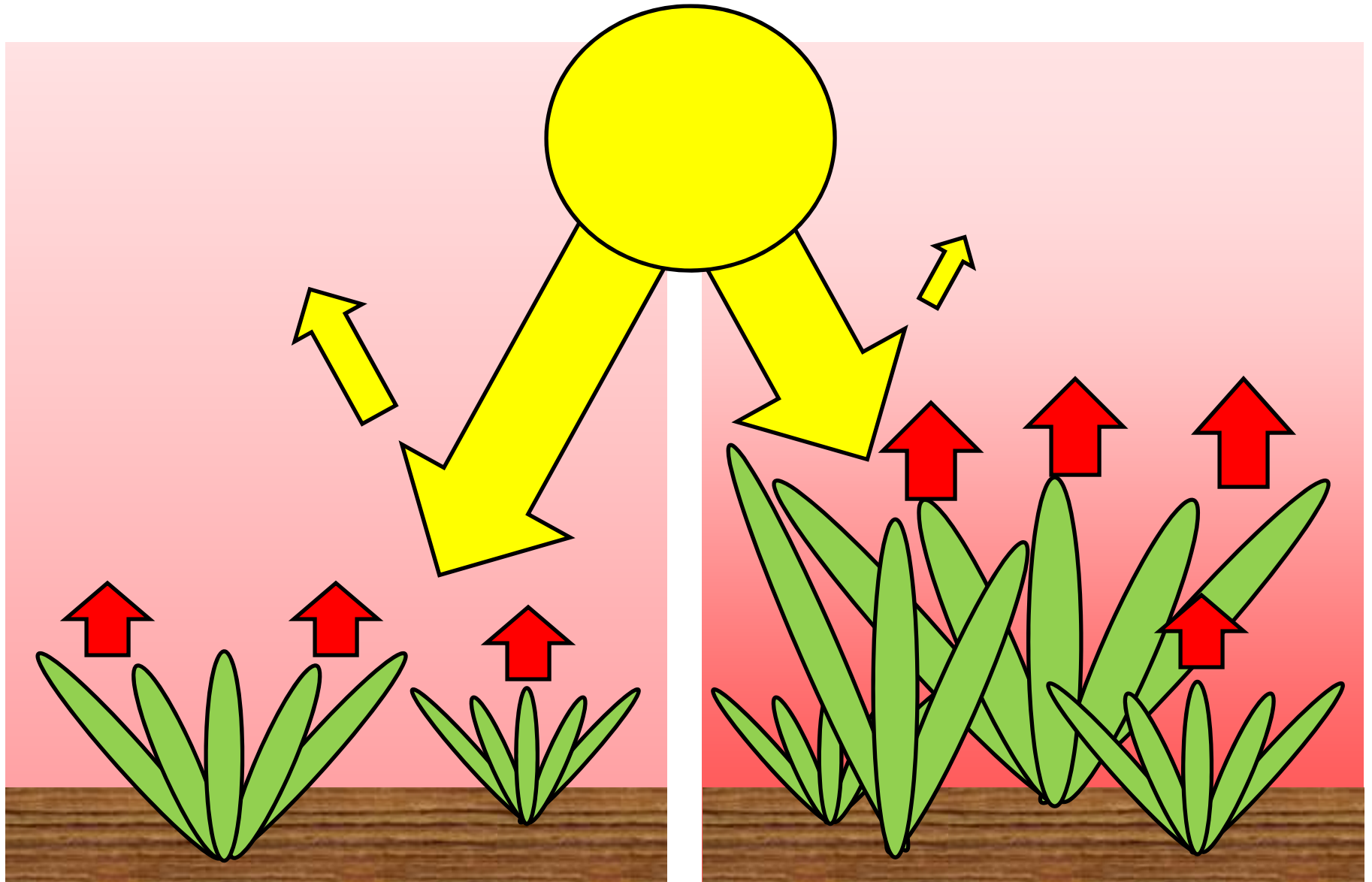
**Warmer**



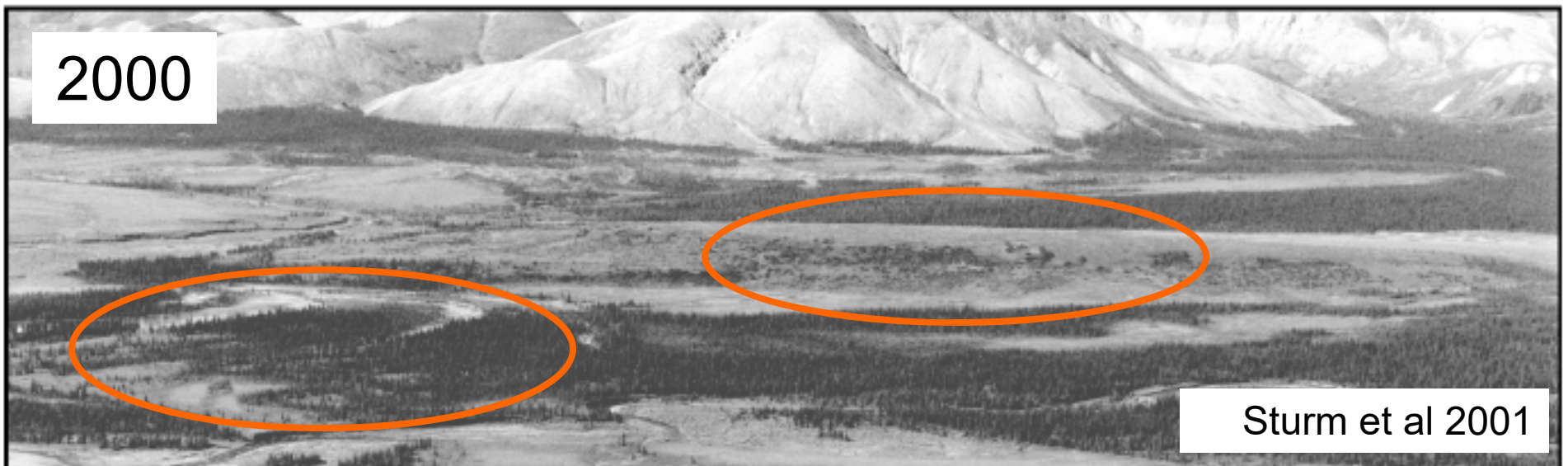
# Earlier snowmelt alters energy balance



# Changing plant cover alters energy balance



# Arctic vegetation is changing



Sturm et al 2001



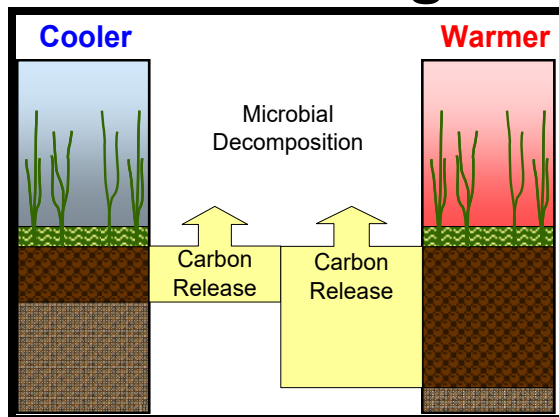
# Changing vegetation alters trophic interactions



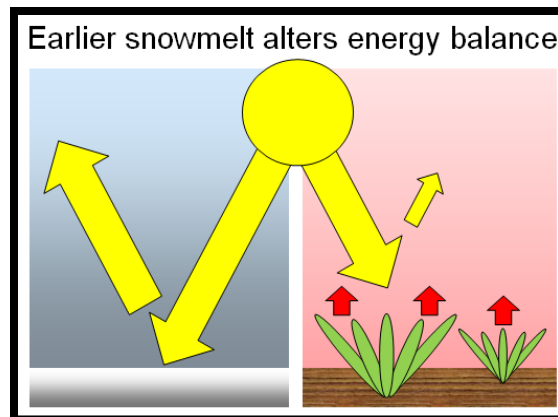
# Importance of Arctic plants



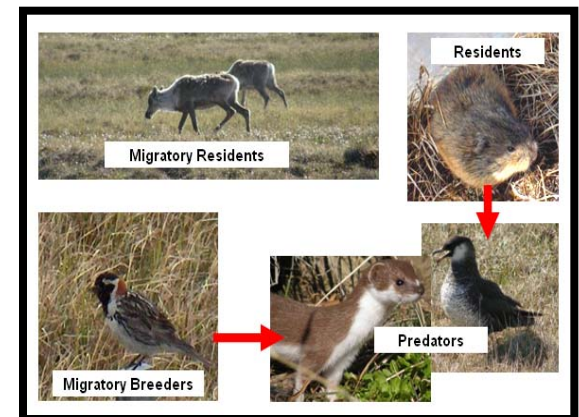
## Carbon Budget



## Energy Balance



## Trophic Interactions



# How will warming impact Arctic plants?



# Warming on Arctic plants

## Findings of previous studies

### Growth



- Earlier Greenup
- Longer leaves

### Reproduction



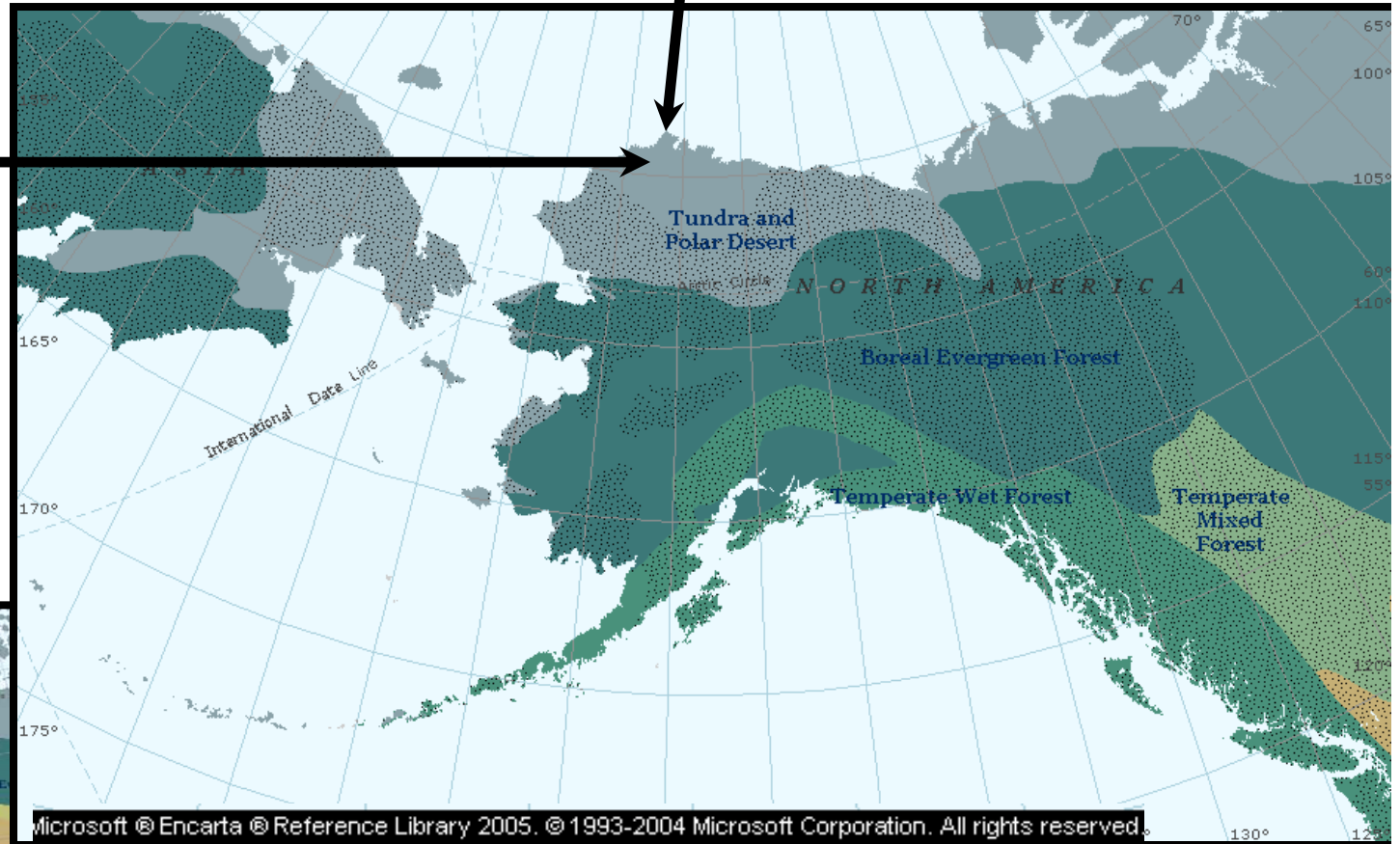
- Earlier flowering
- More flowers
- Longer Inflorescences

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

# Study Sites

**Barrow**  
71°18'N  
156°40'W

**Atqasuk**  
70°29'N  
157°25'W



**Barrow Dry**



**Barrow Wet**



**Atqasuk Dry**



**Atqasuk Wet**



# Warming 1-3°C using open-top chambers



# Traits Measured

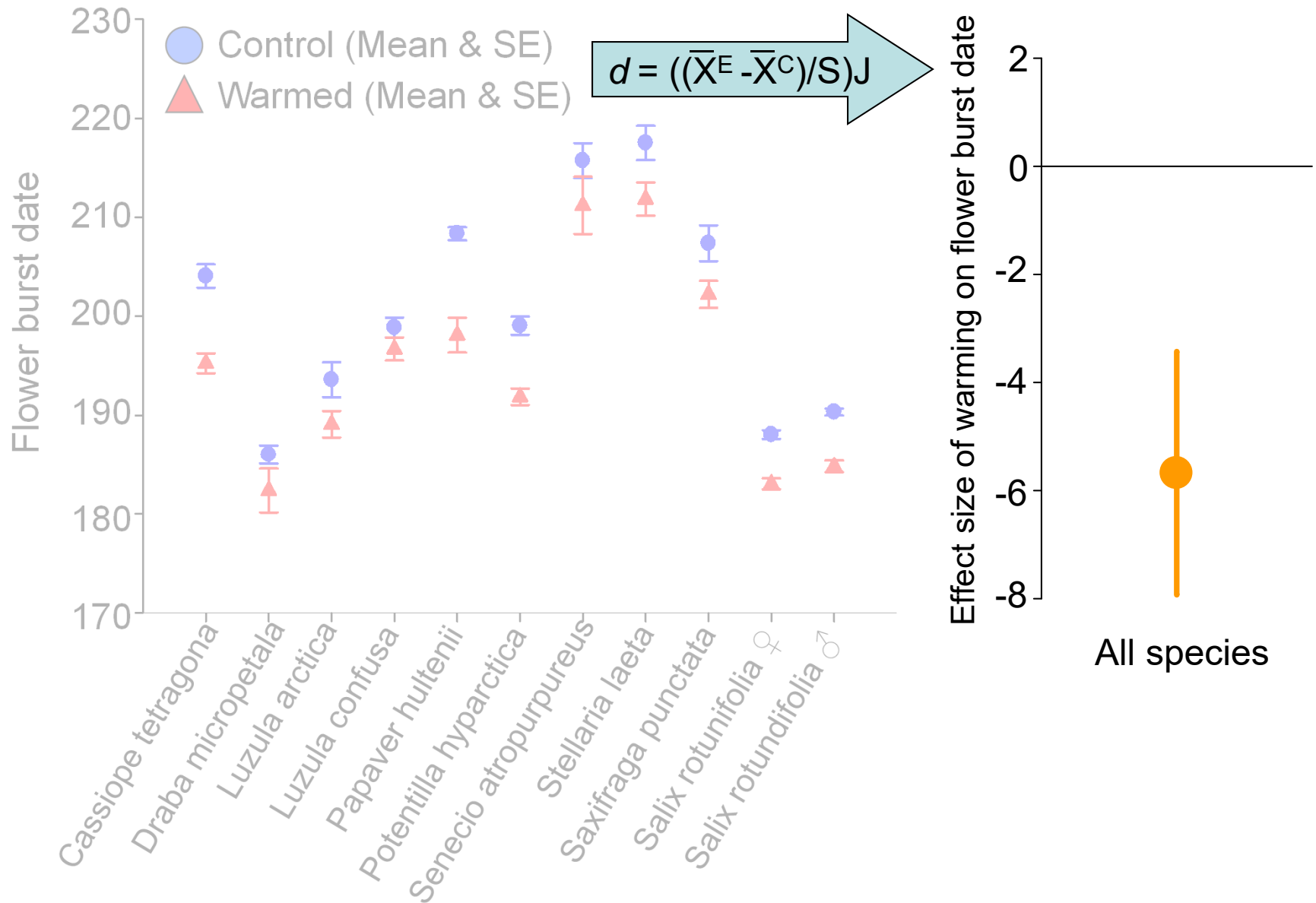


**Flower Burst (*P. kanei*)**

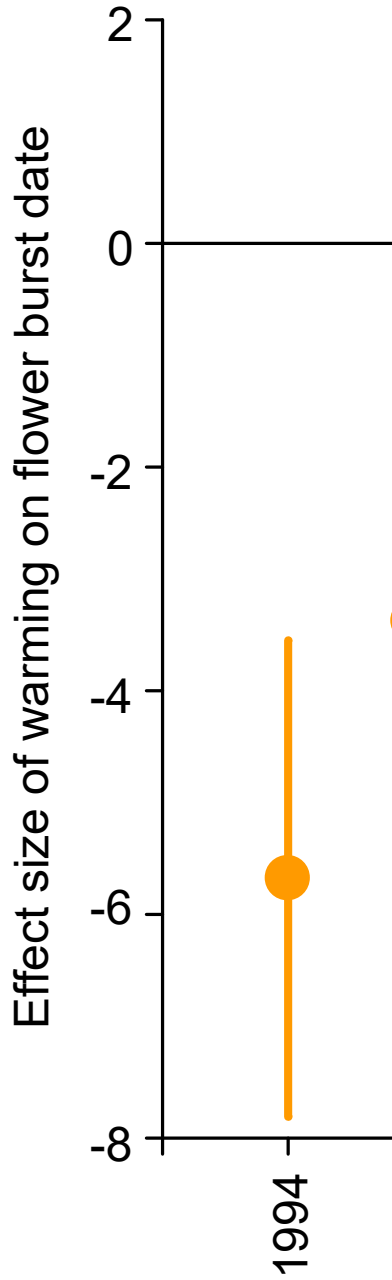


# Meta-analysis: Calculating effect sizes

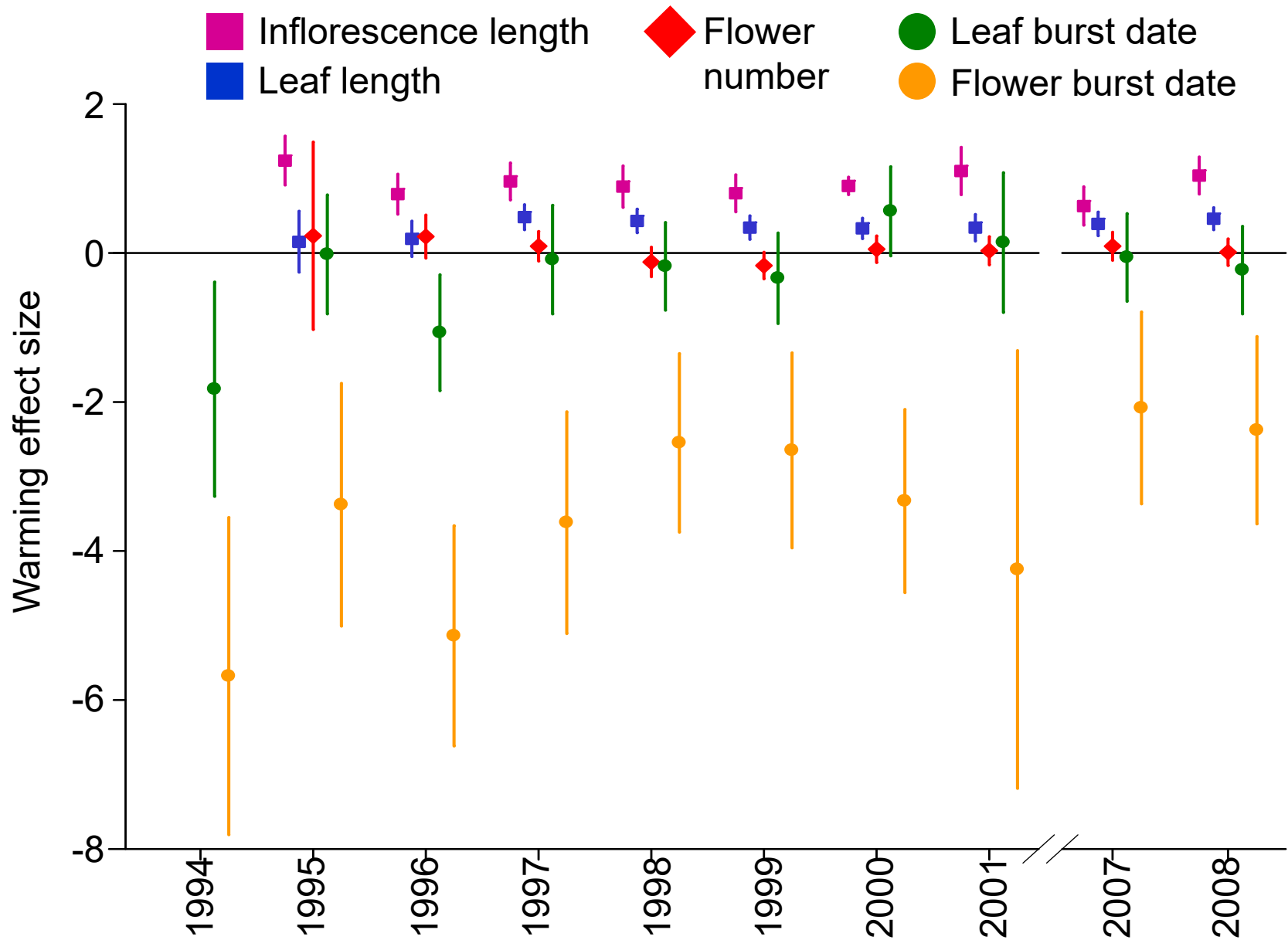
## Barrow Dry site 1994



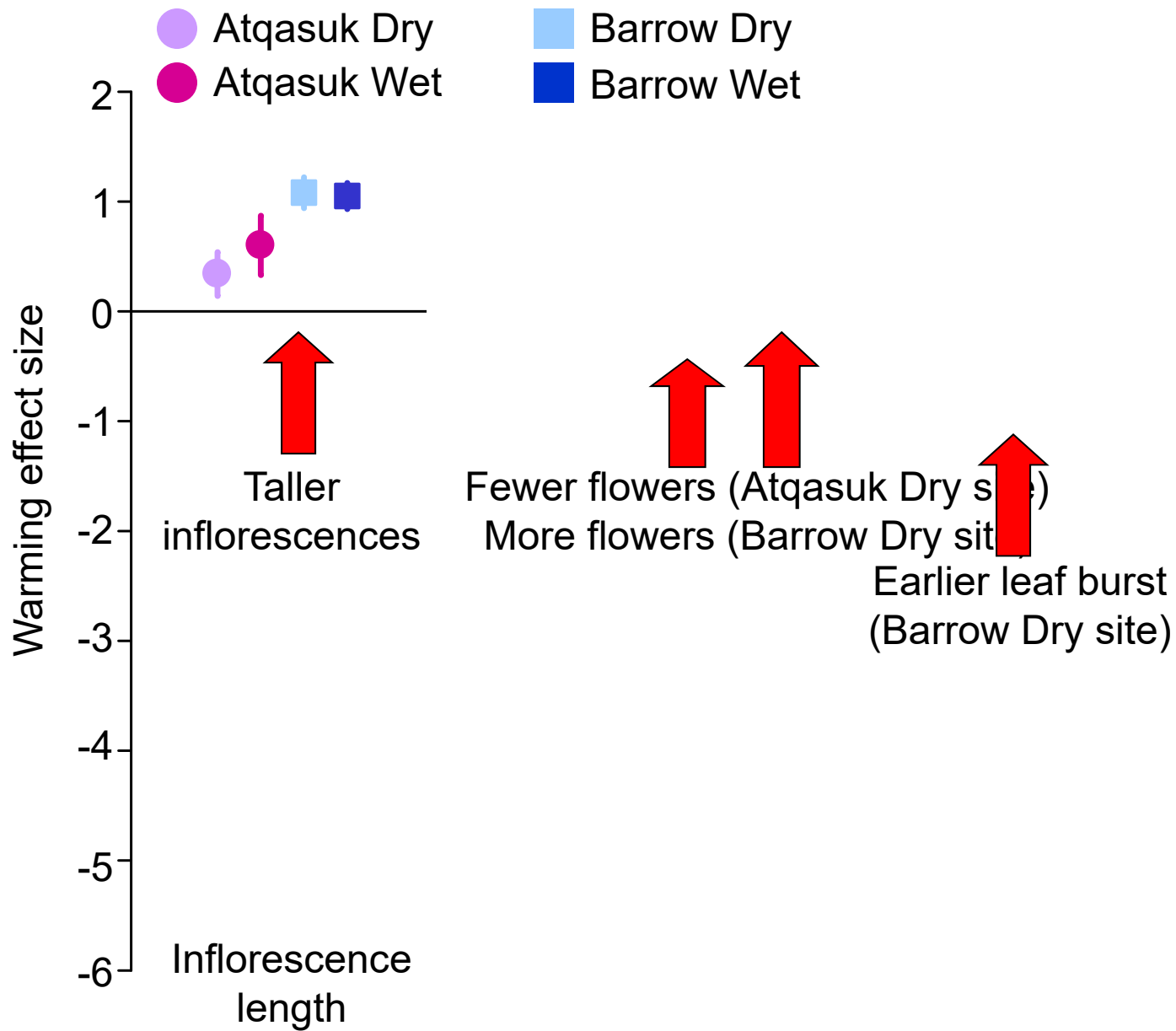
# Example: Earlier flowering at Barrow Dry site



# All sites by trait and year (Effect sizes and 95% CI's)



# Warming effect by trait and site (Effect sizes and 95% CI's)



# Growth Forms



**Evergreen Shrub** (*C. tetragona*)



**Deciduous Shrub** (*S. pulchra*)

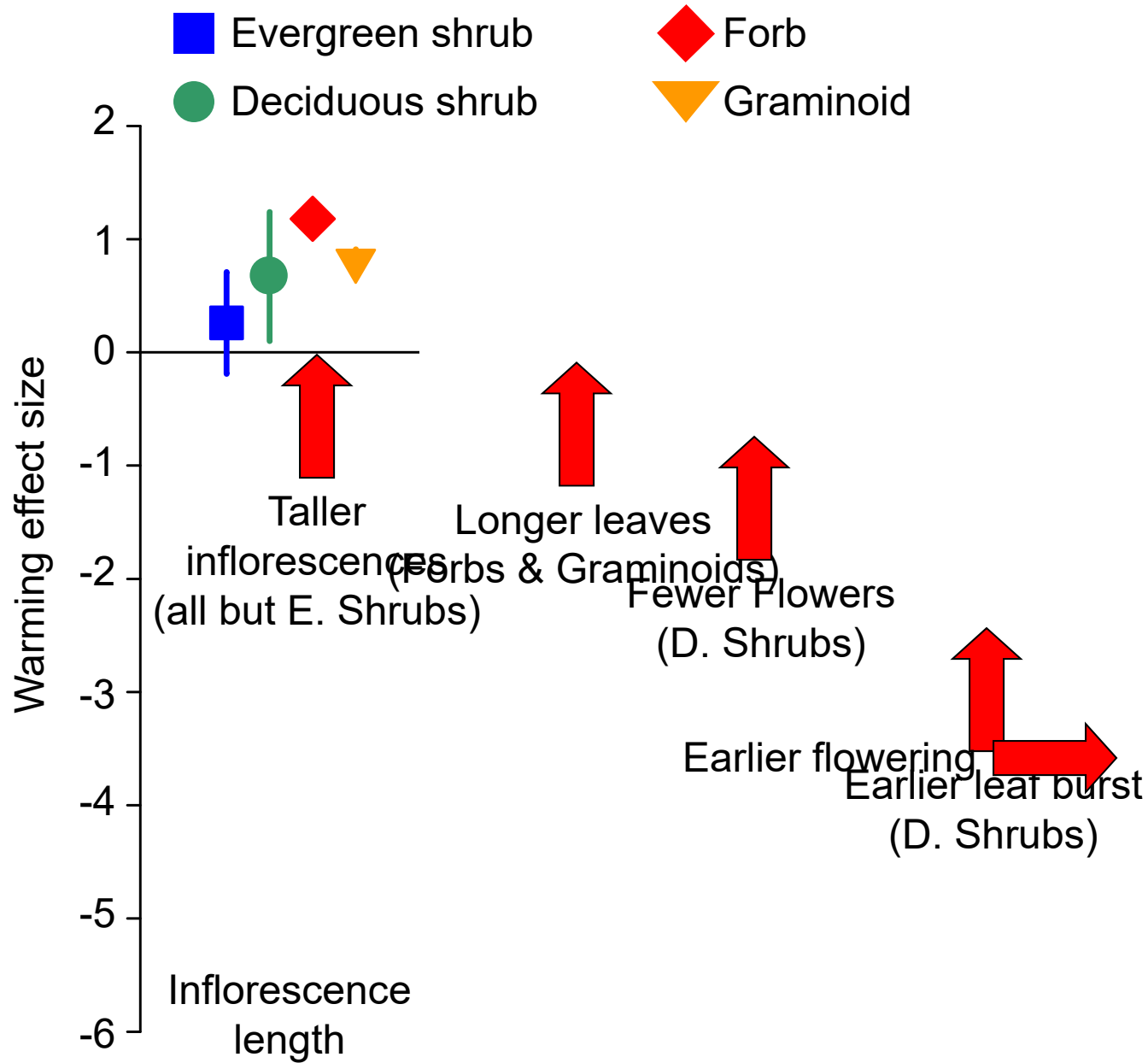


**Graminoid** (*C. stans*)



**Forb** (*S. hieracifolia*)

# Warming effect by trait and growth form (Effect sizes and 95% CI's)



# 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

ACIA 2004. Impacts of a Warming Arctic: Arctic Climate Impact Assessment. Cambridge University Press.

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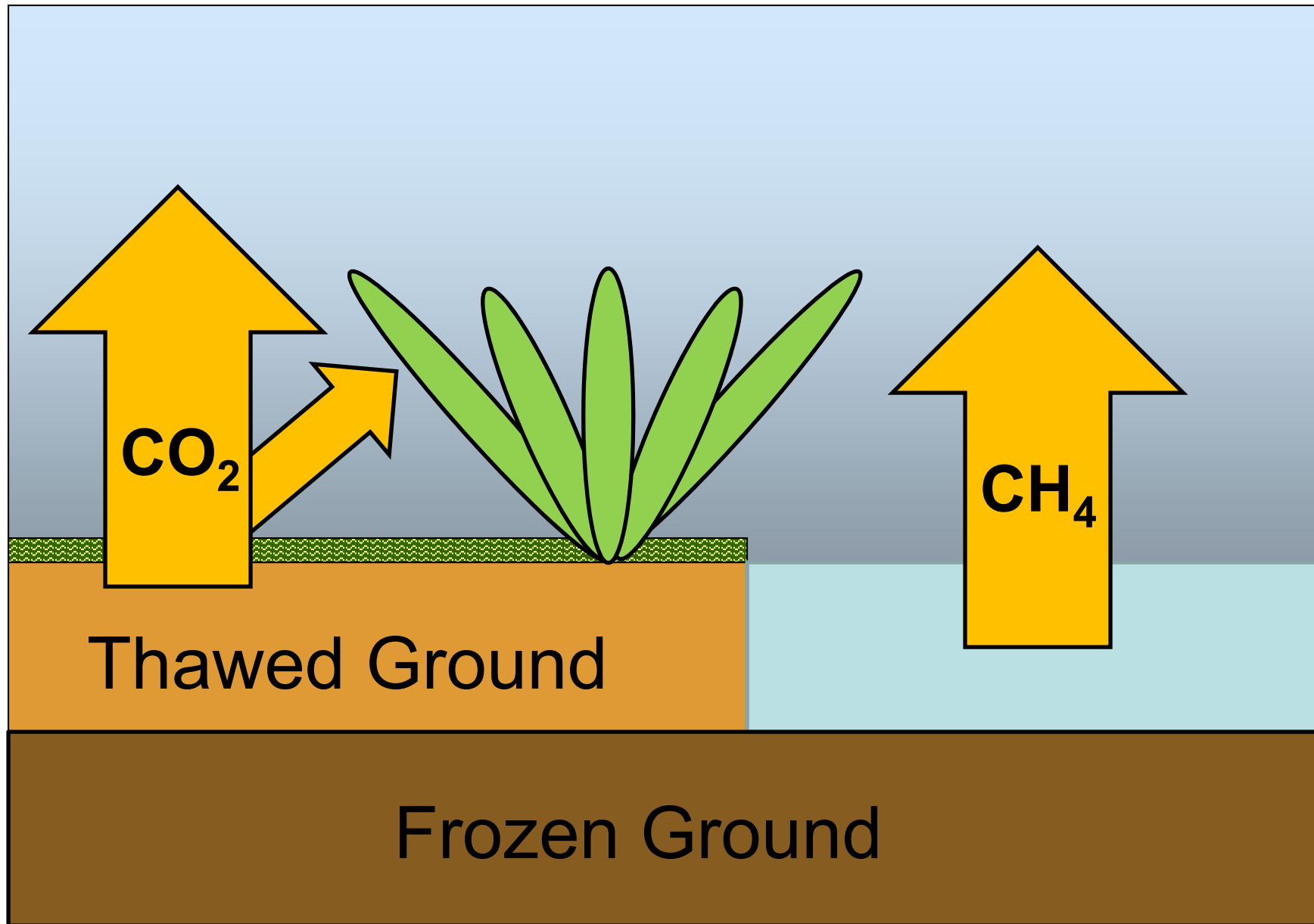


Questions?





# Warming soils will impact C budget



# The Arctic Tundra

**Vegetation Layer**  
(Mosses, grasses, and other plants)

**Active Layer**  
(Seasonally thawed soil)

**Permafrost**  
(Permanently frozen soil)

