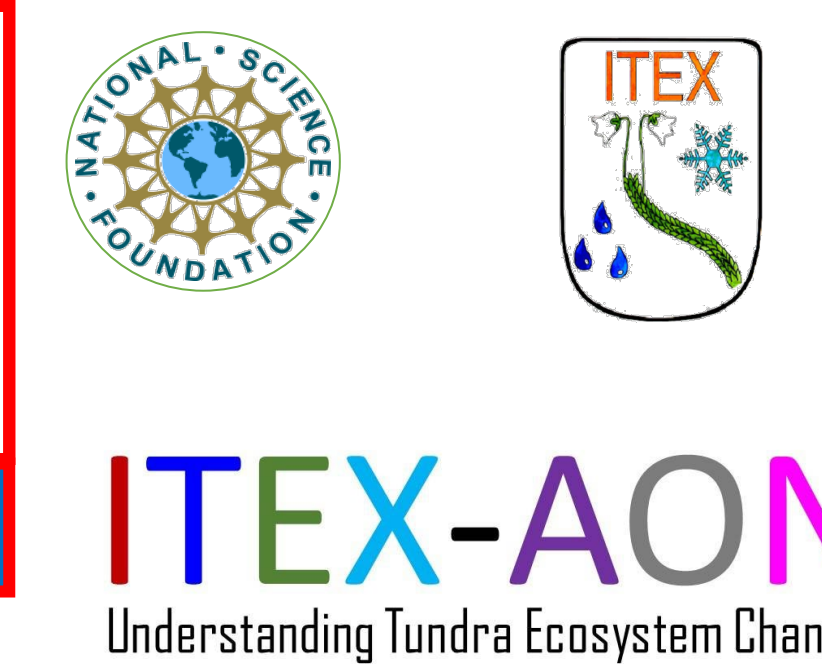




*Pedicularis sudetica*

# Changes in the Frequency of Flowering in Forbs Over Time

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## Introduction

- We have been monitoring flowering at sites in Atqasuk and Utqiagvik since the mid 1990s
- Previous work has focused on the timing of flowering and the numbers of flowers. Here, we look at the frequency of flowering
- Cold temperatures constrain flower and seed production (van der Kooij et al., 2019)
- With climate change raising global temperatures, the number of flowers produced for some species may be increasing (Barber et al., 2008)
- Thawing Degree Days (TDD) from the current and previous year provide temperature data and may help predict the number of flowers produced/reproductive effort in a given year (Barrett et al., 2015)

### Goal:

Examine how well changes in the flowering frequency of forbs are predicted by the following three abiotic variables:

- TDD of concurrent year
- TDD of previous year
- Year

### Questions:

- How is reproductive effort/forb flowering frequency changing?
- Which abiotic factor best predicts forb flowering effort?

## Methods

- 4 sites: Atqasuk Dry (AD), Atqasuk Wet (AW), Utqiagvik Dry (BD), & Utqiagvik Wet (BW)
- 48 plots in each site (24 control, 24 experimentally warmed)
- Recorded whether or not a species flowered in a plot each year
- Ran regressions with flowering frequency and year and the accumulated TDD for the summer of flowering and the previous summer



Figure 1. Study areas in Alaska, USA.

## Results/Discussion

Figures 2a, 2b, 2c, & 2d. Total number of plots each forb species flowered in each year, separated by site. Scale for Y-axis (number of plots) varies between sites. Color codes for species are in Table 1. Bold lines represent a significant annual trend as noted in Table 1. ■ = control plot ○ = experimental plot

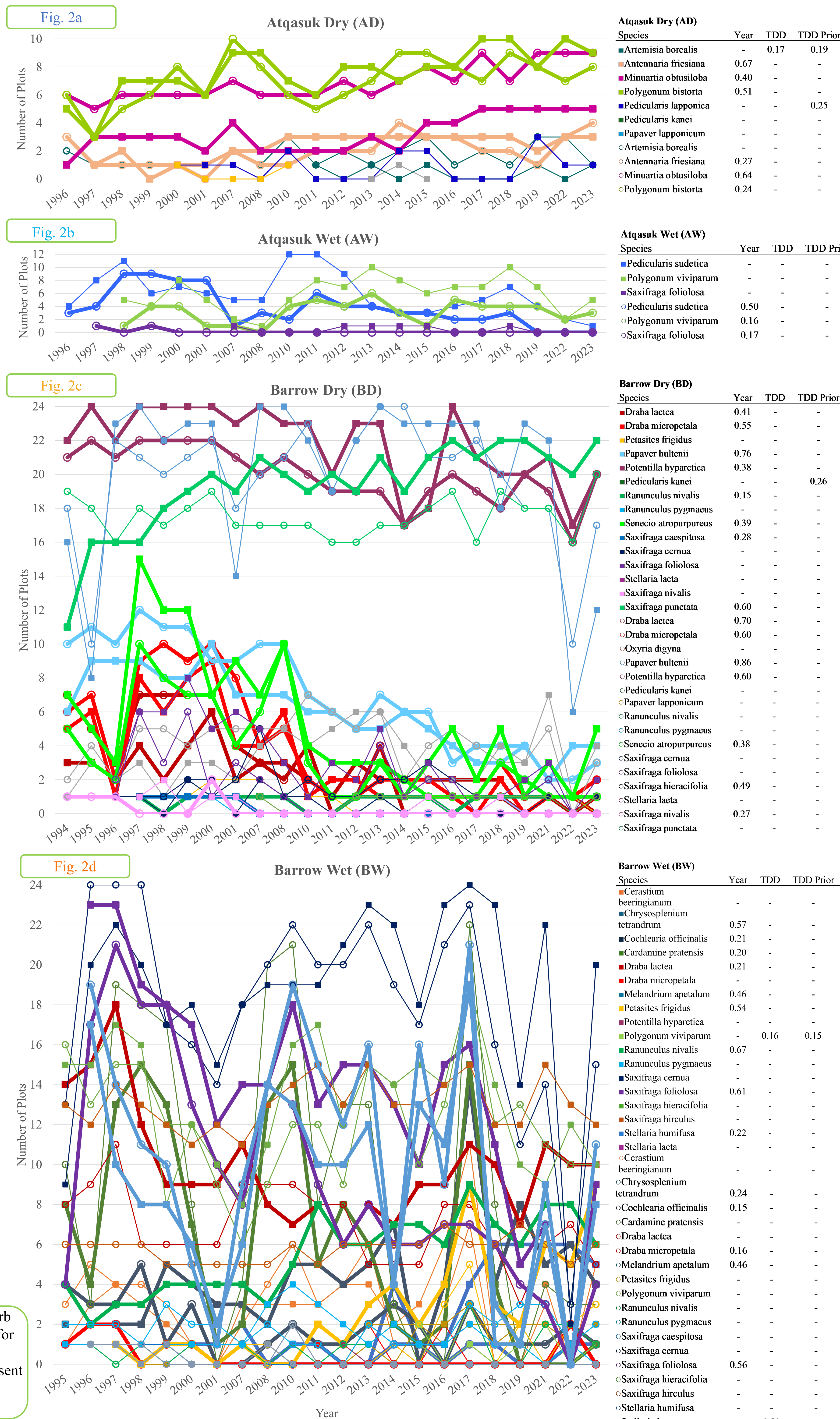
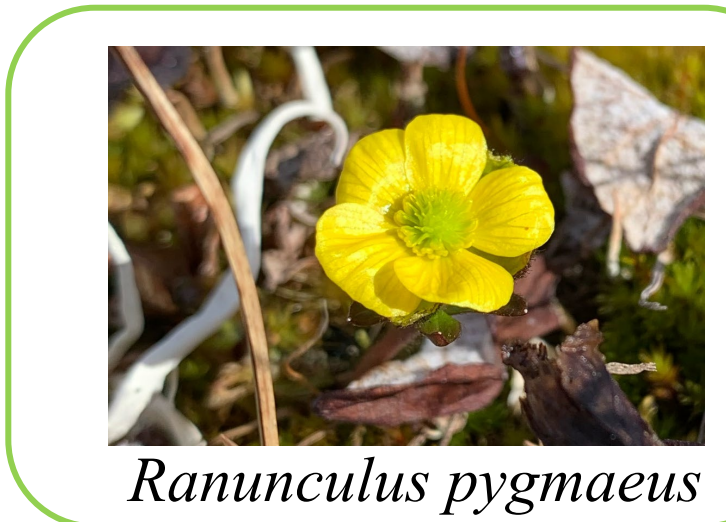


Table 1. Year, TDD, & TDD of previous year as predictors of flowering frequency across treatments & sites. R-squared values from regression are given when relationship is significant (p<0.05).



*Ranunculus pygmaeus*



*Melandrium apetalum*

- Reproductive effort trends:
  - AD site had minor increases in forb flowering across a couple of species (*Polygonum bistorta* & *Minuartia obtusiloba*) (Fig. 2a)
  - At the AW site, *Polygonum viviparum* flowering is variable over the years and *Pedicularis sudetica* stops flowering almost entirely (Fig. 2b)
  - BD site displayed large declines in forb flowering across many species (*Senecio atropurpureus*, *Papaver hultenii*, *Draba lactea*, & *Draba micropetala* all decreasing; *Saxifraga foliolosa* nearly fully stops flowering) (Fig. 2c)
  - BW site showed variable flowering patterns between years for many species (collective decrease in 2001, increase in 2017, and decrease in 2022) (Fig. 2d)
- Linear regression findings (Table 1)
  - Year is the best predictor
  - Significant relationship between year as a predictor and flowering frequency across many species and sites
  - Temperature, expressed as TDD and TDD of the previous year, was not correlated with flowering frequency except for a few cases (not a good predictor)
- On the whole, there have been no major changes in forb flowering/reproductive effort besides at the BD site
  - Follow-up question: is cover decreasing as forb flowering decreases? Or is cover constant while species reduce energy invested in flowering?
    - Referring to cover data, BD forb cover appears to be relatively nondirectional. Thus, at the BD site, forbs are shifting effort away from reproduction but not decreasing in cover

Overall, the changes in flowering frequency and further examination of resulting trends help to illustrate the dynamics of reproduction effort as climate change rapidly impacts the Arctic. Forbs are of particular interest because many visitors enjoy seeing showy flowers as part of the tundra landscape.

## Acknowledgements

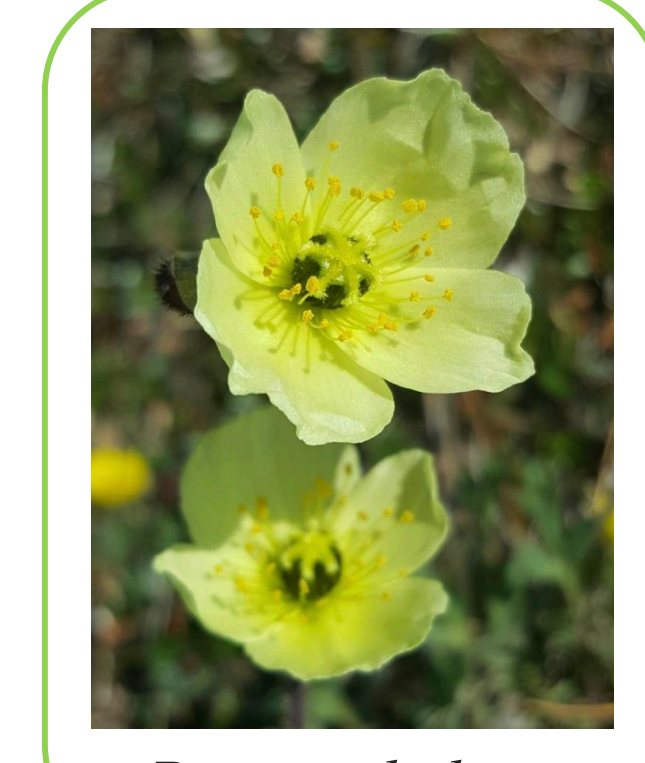
We would like to thank the National Science Foundation, UIC Science, and the International Tundra Experiment Arctic Observatory Network for making this research possible. We also owe many thanks to the communities of Atqasuk and Utqiagvik and the Arctic Ecology Program crew.

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*Minuartia obtusiloba*



*Papaver hultenii*