Melanie Shadix

Using leaf carbon isotope values to investigate plant response to high latitude climate change

submitted in partial fulfillment of the requirements for the degree of
Master of Science in Earth and Environmental Sciences
Department of Earth and Environmental Sciences
The University of Michigan

Accepted by:

Signature	Name	Date
	Nathan D. Sheldon	12 Nov 2020
	Selena Y. Smith	12 Nov 2020
Department Chair Signature	Marin K. Clark	12-18-2020

Earth and Environmental Sciences
UNIVERSITY OF MICHIGAN

Using leaf carbon isotope values to evaluate plant response to high latitude climate change

Melanie A. Shadix[1]
[1]University of Michigan Department of Earth and Environmental Sciences, 1100 N University Avenue, Ann Arbor MI 48109

The views expressed in this thesis are those of the author and do not reflect the official policy or position of the United States Air Force, Department of Defense, or the U.S. Government

Table of Contents

1. Abstract

As climate continues to change, more research is needed to understand how individual plant species will respond. This study uses leaf carbon isotope values as a lens to examine how high-latitude plant species in Alaska, Canada, and the northern United States are impacted by changes in water availability and increased temperature due to anthropogenic climate change. I found that Δ_{leaf} values of three individual species, *Juniperus communis*, *Betula glandulosa*, and *Eriophorum angustifolium* are *not* responding uniformly to climate. While none of the species has responded to increase [CO_2] over the period of 1923–2015, each species responded to multiple other climatic variables, specifically temperature and water availability, in ways not previously noted in studies of temperate and tropical systems. In particular, while meta-analytical studies of temperate and tropical indicated that Δ_{leaf} was lower at low precipitation, I found that the opposite was true for the high-latitude species. Meta-analytical studies also have found little or no change in Δ_{leaf} due to temperature, which is validated for sites where the mean annual temperature is >0°C. However, at colder sites Δ_{leaf} is negative correlated with temperature. This implies that studying leaf carbon isotope values of species on the edge of their growth range, under climatic extremes, may provide an opportunity to identify the climatic drivers that most affect a species under future climate change. This study suggests that some individual species growing at high latitudes may have a physiological advantage when faced with climate change, potentially broadening their growth range poleward, while other species may face a physiological disadvantage with a decreased chance of survival.

2. Introduction

Climate is shifting faster at higher latitudes than lower latitudes as anthropogenic emissions continue to accelerate (Settele et al., 2014). These high latitude environments are comprised of an ecosystem gradient from boreal forests to arctic tundra to polar desert environments where temperature and precipitation are increasing at a greater rate than in temperate environments (Diffenbaugh & Field, 2013). Higher temperatures caused by modern climate change will result in increased vapor pressure deficit (VPD), resulting in increased evaporative demand, especially in regions with lower water availability (Stocker et al., 2013; Novick et al., 2016). While many studies point to an increase in species distribution towards the poles with increased temperature and precipitation, the effect of this shift is often different amongst species, with the threat of some species not being able to adapt quickly enough to changing climate (Jump & Peñuelas, 2005; Parmesan & Hanley, 2015; Feeley et al., 2020). Modeled future vegetation growth at these latitudes predicts decreased growth (Boulanger et al., 2016) and some non-model-based land cover studies suggest there may be forest loss (Carpino et al, 2018). Overall, there is a need for more studies focusing on species' specific responses to climate change in more climatically stressed, arctic regions to determine how the distributions of taller, woody vegetation of the boreal forest and grasses, sedges, and shrubs of the tundra will continue to intersect and shift (Myers-Smith et al., 2011; Feeley et al., 2020).

Over the last 150 years, anthropogenic activity has also resulted in an increase in atmospheric CO_2 concentration from ~280 ppm up to ~420 ppm and decrease of the carbon isotope composition of the atmosphere ($\delta^{13}C_{atm}$ values) from -6.8 ‰ to -8.2 ‰ because the source carbon is isotopically depleted anthropogenic inputs (Keeling et al., 2001; Tans, 2020). Given the dependence on plants for atmospheric CO_2 and the record of $\delta^{13}C_{atm}$ values within plant leaf carbon isotope values ($\delta^{13}C_{leaf}$), leaf carbon isotope values may provide insight into the relative stress of plant species collected from this volatile region.

2.1 Carbon isotope discrimination in C_3 plants

$\delta^{13}C_{leaf}$ values in C_3 plants are a measure of the ratio of preferentially consumed ^{12}C in CO_2 over ^{13}C during photosynthesis. Leaf carbon isotope discrimination values (Δ_{leaf}) account for the main processes that result in isotopic fractionation within the leaves of a plant (see Eq. (1) below; Farquhar et al., 1989). Variables *a* and *b* represent known fractionation caused by diffusion of CO_2 and carboxylation due to the enzyme RuBisCo, respectively. While I assume fractionation due to RuBisCo to be constant in this case, the functionality of it may also be impacted by extreme climate relative to the tolerance of the plant (Galmés et al., 2010). Different concentrations of CO_2 outside the plant and within the plant are represented by c_a and c_i respectively. While $\delta^{13}C_{leaf}$ has been shown to track the decrease in the isotopic value of atmospheric CO_2 ($\delta^{13}C_{atm}$) from isotopically depleted fossil fuels burnt throughout Industrialization (e.g., Stein et al., 2019), previous studies have found that other environmental factors also impact carbon isotopic compositions of plants (Farquhar, 1989; O'Leary, 1993;

Arens et al., 2000; Diefendorf et al., 2010; Kohn, 2010; Schubert & Jahren, 2012; Sheldon et al., 2020).

Eq. (1)

$$\Delta_{leaf}\,(‰) = \frac{\delta^{13}C_{air} - \delta^{13}C_{leaf}}{1 + \frac{\delta^{13}C_{leaf}}{1000}} = a + (b - a)\frac{c_i}{c_a}$$

The connection between Δ_{leaf} and different climatic variables can, in part, be linked to the effects of environmental inputs that change stomatal conductance (i.e. the rate of CO_2 diffusion into, and water vapor out of, the stomata). Stomata are the main entry and exit point of gases in and out of a leaf, including carbon dioxide and water vapor (Lawson & Blatt, 2014). Individual species vary in maximum stomatal aperture sizes, response times, and photosynthetic capacities (Franks & Farquhar, 2007; Lawson & Blatt, 2014). While stomatal conductance is not specifically measured in Eq. (1), as c_i decreases due to a hypothetical stomatal closure, the pressure difference of CO_2 between the atmosphere (c_a) and the plant (c_i) increases, resulting in lower Δ_{leaf} values (Eq. (1); Figure 1). Therefore, to some extent, the known relationships between stomatal closure and external climatic variables, and variation in species' stomata and responses to climate variables, may provide insight into why a given species shows variable Δ_{leaf} values or into why another species does not seem to record the carbon isotope values of the atmosphere.

Generally, stomatal conductance increases in the presence of low CO_2 concentrations, high light, and low evaporative demand, and decreases under the opposite environmental pressures (Lawson & Blatt, 2014). Because I expect to see increased precipitation and warmer temperatures at high latitudes as climate changes, it is important to consider how water availability and variables such as VPD affect stomata. VPD is the difference between the moisture holding capacity of the atmosphere at a particular temperature and current atmospheric moisture level (Anderson, 1936). If VPD is high, then there will be greater evaporative demand on plants. Open stomata pose the risk of water loss due to evapotranspiration; therefore, low water availability can limit the range of stomatal conductance. When high VPD is coupled with higher water availability, there will likely be even lower stomatal conductance, limited within the range of stomatal conductances pre-set by water availability (Forseth & Ehleringer, 1983; Novick et al., 2016). Thus, high VPD conditions should result in lower Δ_{leaf} values (Figure 1).

Recently-studied climate parameters that have been proposed to drive Δ_{leaf} values in meta-analyses include latitude (Kohn, 2010), mean annual precipitation (MAP; Diefendorf et al., 2010), mean annual temperature (MAT; O'Leary, 1993), nitrogen availability (Sparks & Elheringer, 1997), soil water (Lavergne et al, 2020), and others, which is to be expected due to the known response of stomata to different climate variables and the link to internal concentration of CO_2 (variables summarized in Arens et al., 2000). While these previous studies prove useful for more temperate or tropical regions, they lack significant sample sizes from climatically stressed regions, such as higher latitude tundra regions. In addition, even at temperate latitudes the trends observed in meta-analyses are not replicated at the species level. For example, neither common gymnosperm nor angiosperm trees reveal a relationship between MAP and Δ_{leaf} (Stein et al., 2019; Sheldon et al., 2020). Furthermore, measurements of leaf carbon isotope values from natural populations, especially from higher latitudes, are sparse.

For this study, I compare Δ_{leaf} values to moisture (represented through soil drainage, MAP, and the average month precipitation of the collection month of the sample), temperature (represented through MAT and the average month temperature of the collection month of the sample), and a combination of both moisture and temperature: VPD. I deliberately selected localities that would be representative of stressed environments (lower water availability and higher evaporative demand) in an effort to directly test my hypothesis that species are likely to record a noticeable response to this climate through changes in leaf carbon isotope discrimination values. Specifically, I hypothesize that samples within a species collected from regions with the lowest precipitation and highest evaporative demand (represented by VPD) are likely to have lower Δ_{leaf} values compared to the average Δ_{leaf} collected from more temperate regions, implying that these climatic extremes are impacting photosynthesis of the plant and potentially impacting its survivability.

2.2 Regional Setting

This study focuses on samples of plant species growing at high latitudes (Figure 2), primarily within the following climatic regimes (from lower to higher latitudes): Boreal-Continental fully humid warm summer (Dfb), Boreal-Continental fully humid cool summer (Dfc), Boreal-Continental Steppe cool summer (Dsc), and Polar (ET) (Peel et al., 2007; Rubel & Kottek, 2010). These ecoregions are mainly snow or polar climates according to the Köppen-Geiger climate classification maps (Peel et al., 2007). According to Rubel & Kottek (2010), by 2100 the climate classification bands that these samples fall into are all expected to shift northward with nearly all samples from this study originally falling within ET, no longer falling within the ET. Dfb and Dfc will shift northward with some sample localities then falling into Boreal-Continental Fully Humid Hot Summer (Dfa). The majority of localities will experience warmer, wetter summers due to climate change (Rubel & Kottek, 2010; Stocker et al., 2013), implying that any observed relationships between Δ_{leaf} and temperature-related or moisture-related climatic variables could impact the relative survivability of the focal species in this study or of other similar plant-functional types.

While the majority of samples collected from higher latitudes are likely not affected by shade cover due to increased sparseness in ground cover, it is possible that the location of some samples within more forested areas have been impacted by shade from other canopies resulting in changes in leaf carbon isotope discrimination (McDowell et al., 2011).

3. Materials and Methods

3.1 Plant Species

The three species used in this study, *Juniperus communis*, *Eriophorum angustifolium*, and *Betula glandulosa*, were selected due to their similarly wide temporal and spatial distributions, their high sample numbers in herbaria, and their distinct growth habits. Original specimen collection dates range from 1923 to 2015. Each species' geographic range covers the variability of climate across higher latitudes. The latitudinal range of *J. communis* is 41.97 to 69.38 °N, 44.48 to 81.42 °N for *E. angustifolium*, and 47.67 to 71.51 °N for *B. glandulosa* (Figure 2).

Juniperus communis (gymnosperm, Cupressaceae) is a conifer that commonly grows as a shrub in the tundra (Hustich, 1953). At lower latitudes it may grow as a small tree and is often found as a tree in Europe. With a nearly circumpolar distribution *J. communis* is found scattered across the northern hemisphere in both boreal forests and at lower latitudes in places such as the Mediterranean (Hustich, 1953; Little, 1979; Tognetti et al., 2000; Farjon & Filer, 2013). This vast distribution and high frequency make *J. communis* a strong candidate for further study to compare responses of this taxon from higher, colder latitudes, to lower, warmer latitudes.

Also known as cottongrass or cottonsedge, *E. angustifolium* (angiosperm, Cyperaceae) is a sedge with a narrower, but more northern latitudinal distribution, compared to *J. communis*. It is generally found growing in anaerobic, undrained soils, commonly in wetlands and tundra

(Gebauer et al., 1998; eFloras, 2020). This species was chosen in order to represent fast growing, short statured herbaceous vegetation.

Commonly referred to as a dwarf birch, *B. glandulosa* (angiosperm, Betulaceae) is a deciduous shrub generally distributed throughout Alaska, Canada, and into parts of the lower 48 states of the United States (de Groot et al., 1997; USDA & NRCS, 2020). It can be found in the tundra and in boreal forests, growing in bogs, muskegs, and rocky slopes or on permafrost, as well as in subalpine montane ecosystems at lower latitudes (de Groot et al., 1997; eFloras, 2020). *Betula glandulosa* was selected in order to represent woody broad-leaved deciduous plant in contrast to the evergreen needle-leaved *J. communis*.

While the majority of samples collected from higher latitudes are likely not affected by shade due to the short stature and increased sparseness in ground cover, it is possible that the location of some samples within more forested areas have been impacted by shade from other canopies resulting in changes in leaf carbon isotope discrimination (Buchmann et al., 1997). I also expect that the general growth habit of the selected species, being shorter and more ground hugging, will limit potential canopy effects on Δ_{leaf} (McDowell et al., 2011).

3.2 Sample Collection, Preparation, and Leaf Carbon Isotope Value Measurement

For the measurement of $\delta^{13}C_{leaf}$, plant leaf samples were retrieved and analyzed from two different herbaria: the University of Michigan Herbarium (MICH; n = 35) and the National Herbarium of Canada at the Canadian Museum of Nature (CANL; n = 415). Additional $\delta^{13}C_{leaf}$ data of *E. angustifolium* specimens were collated from a prior publication (n = 6; Schell, 2016). Analyses of *Juniperus communis* (n = 141)*, Eriophorum angustifolium* (n = 156), and *Betula glandulosa* (n = 159) are collated in Supplemental Table 1.

To remove any surface residue, leaves of each sample were individually cleaned for 30 minutes in 20–40 mL of deionized water in an ultrasonic bath. Following cleaning, each sample was rinsed and placed into an oven at 50 °C for 48 h. After drying, each sample was shredded into smaller pieces using a razor blade and tweezers in order to maintain as much remaining leaf tissue as possible for analysis. Approximately 0.952 mg of the shredded leaf tissue samples were then loaded into tin capsules and placed into a Picarro Combustion Module with autosampler coupled to a Picarro G2201-i cavity ring-down spectrometer (CRDS) in order to measure $\delta^{13}C_{leaf}$ values of each sample. Output $\delta^{13}C_{leaf}$ values were calibrated using ten lab-calibrated acetanilide standards ($\delta^{13}C$ = -26.58‰), four IAEA-600 caffeine standards ($\delta^{13}C$ = -27.77‰), and four IAEA-CH6 sucrose standards ($\delta^{13}C$ = -10.45‰) in each run. Reproducibility was better than ±0.2‰ based upon standard replication.

3.3 Climate Data

Climate data was compiled from WorldClim 2 (Fick & Hijmans, 2017) including average monthly water vapor pressure (kPa), average monthly temperature (°C), and average monthly precipitation (mm) of the collection month of each sample, MAP (mm) and MAT (°C; Supplemental Methods). Raster files were uploaded into ArcMap and data from each climate variable layer was collected for each sample location. Soil data for specimens collected within Canada was sourced from Soil Landscapes of Canada (SCL) derived from V3.1 and V2.2 (Agriculture and Agri-Food Canada). Soil drainage polygons were matched with each sample point location to compile soil drainage data in ArcMap 10.7.0.10450. Soil drainage type for specimens collected within the United States was sourced from the National Resource Conservation Service's "websoilsurvey" (Soil Survey Staff). Canadian soil drainage codes and U.S. soil drainage codes were then reconciled in order to create standardized soil drainage bins based on how rapid or poorly drainage a soil was (Supplemental Methods). Atmospheric CO_2 concentrations (ppm) are from ice cores (pre-1958; Etheridge et al., 1998) and from Mauna Lao Observatory (1958 and later; Keeling et al., 2001).

To calculate Δ_{leaf} values (Eq. 1), I used $\delta^{13}C_{atm}$ values from direct measurement at Mauna Loa Observatory (Keeling et al., 2001) for samples after 1979, and from gas trapped in ice cores and firns prior to 1980 (Rubino et al., 2013). For samples that had no sampled $\delta^{13}C_{atm}$ value, I used a regression that interpolated between years with direct measurements of $\delta^{13}C_{atm}$ (Supplemental Methods).

3.4 VPD Calculation

$$\text{Eq. (2)}\quad ee_{ss} = 6.11 * 10^{\frac{7.5*TT}{237.3+TT}}$$

Average monthly collection VPD was calculated using Eq. (2) from National Weather Service (2020) for saturated vapor pressure. Actual vapor pressure pulled from WorldClim was then subtracted from saturated vapor pressure in order to calculate VPD (kPa). VPD bins were divided for each species to capture the variation in the means of subsets of samples within each species at relative "tipping points" (see section 5.1.2).

3.5 Data Analysis

Data were identified as outliers if they 1) appeared visually far away from the other data points and 2) their removal changed the R^2 value of linear regressions. Other methods for outlier analysis were considered but the isotope measurements did not follow a Gaussian distribution. For linear regressions, I calculated the partial least squares for the relationship between Δ_{leaf} and each climate variable. Non-linear relationships were best explained by an exponential function (based on my main assumption that Δ_{leaf} values may reflect stomatal conductance). Coefficients of determination (R^2 values) were calculated to determine how well Δ_{leaf} could be predicted given some climatic input. *P*-values from an ANOVA test were used to test for statistical significance. Values less than 0.001 were considered statistically significant. To examine the combinatorial effect of multiple climate or environmental variables, principle component analyses (PCAs) were performed in OriginPro 2020 9.7.0.185 for each species individually and for the three focal species in aggregate. Those results were used to identify additional combinations of variables for analysis.

4. Results

4.1 Summary of sample climate data

Over half of the samples (n = 249 of 456) were collected during the month of July, with an average monthly temperature of 13.22 °C for *Juniperus communis* (1σ ± 4.04), 9.19 °C for *Eriophorum angustifolium* (1σ ± 3.77), and 10.84 °C for *Betula glandulosa* (1σ ± 2.62).

4.2 Summary of Carbon Isotope Values ($\delta^{13}C_{leaf}$) and Isotopic Discrimination (Δ_{leaf})

Eriophorum angustifolium had the largest range of $\delta^{13}C_{leaf}$ and Δ_{leaf} values and the greatest standard deviation in comparison to the other non-sedge species (σ = 1.51 and σ = 1.46, respectively; Table 1.) All species had similar mean $\delta^{13}C_{leaf}$ and mean Δ_{leaf} values within 1‰ of one another.

4.3 $\delta^{13}C_{atm}$ vs. $\delta^{13}C_{leaf}$

The coefficients of determination for linear regressions between $\delta^{13}C_{atm}$ and $\delta^{13}C_{leaf}$ for *J. communis*, *E. angustifolium*, and *B. glandulosa* (angiosperm,) were modestly predictive at $R^2 = 0.23$ (p-value < 0.001), $R^2 = 0.11$ (p-value = 0.0016), and $R^2 = 0.29$ (p-value < 0.001), respectively. The slopes of $\delta^{13}C_{atm}$ and $\delta^{13}C_{leaf}$ for *B. glandulosa* (m = 1.39; angiosperm; Betulaceae; shrub) and *E. angustifolium* (m = 1.31; angiosperm; Cyperaceae; sedge), are nearly identical, whereas the slope of *J. communis* (gymnosperm; Cupressaceae; shrub) is slightly steeper (m = 1.90; Figure 3, Supplemental Table 2). Figure 4 plots the high latitude species from this study with previously published results from low- to mid-latitude tree species: *Pinus strobus* (gymnosperm; Pinaceae), *Populus tremuloides* (angiosperm; Salicaceae), *Thuja occidentalis* (gymnosperm; Cupressaceae), *Thuja plicata* (gymnosperm; Cupressaceae; Sheldon et al., 2020). There is not a clear grouping of either gymnosperm versus angiosperm slopes. Species of the Cupressaceae family have similar, relatively steeper slopes compared to the other species of different families (Figure 4, Supplemental Table 2).

4.4 Δ_{leaf} vs. MAP and Average Collection Month Precipitation and VPD

Juniperus communis was the only species to show a modest and statistically significant relationship between Δ_{leaf} and MAP ($R^2 = 0.15$, p-value < 0.001). Linear regressions showed no other higher R^2 values between Δ_{leaf} and MAP or Δ_{leaf} and average collection month precipitation; however, extremely low MAP resulted in higher carbon isotope discrimination values for every species (Figure 5 A1-3). The only higher R^2 value between Δ_{leaf} vs. average collection month VPD was for *E. angustifolium* ($R^2 = 0.19$, p-value < 0.001), where carbon isotopic discrimination values were lower (lower Δ_{leaf} values) at higher VPD levels, especially at lower monthly precipitation gradients (~40 mm; Figure 5 C2 and Figure 7). Variability in carbon isotope discrimination decreased for *J. communis* as VPD increased (Figure 5 C1, Figure 7). When Δ_{leaf} values are analyzed for *J. communis* across increasing MAP, increased soil drainage coupled with higher average collection month VPD may result in less variable Δ_{leaf} values (Figure 7, Supplemental Figure 1).

4.5 Δ_{leaf} vs. Latitude, MAT, and Average Collection Month Temperature

Juniperus communis was the only species to show statistically significant and predictive positive relationship between Δ_{leaf} and latitude (R^2 = 0.17, *p*-value < 0.001) where Δ_{leaf} increases with latitude. This trend is visible for all three species, but not statistically significant (Figure 6 A1) for the others. *Juniperus communis* was the only species with a statistically significant relationship between Δ_{leaf} and MAT (R^2 = 0.13, *p*-value < 0.001). In general, all species showed modestly increased carbon isotope discrimination with decreasing MAT (Figure 6 B1-3). The same trend is also found for Δ_{leaf} and average temperature of collection month, but only significantly for *E. angustifolium* (Figure 5; R^2 = 0.13, *p*-value < 0.001).

4.6 Δ_{leaf} and [CO_2]

R^2 values for linear regressions between Δ_{leaf} and [CO_2] were low and not statistically significant for *J. communis*, *E. angustifolium*, and *B. glandulosa* (R^2 = 0.0000012, *p*-value = 0.99, R^2 = 0.0011, *p*-value = 0.69, R^2 = 0.021, *p*-value = 0.068; Supplemental Figure 2).

4.7 Principle Components Analysis

The PCA analyses for each individual species and all species together resulted in the first two principle components explaining >50% of the variation in the data (Supplemental Table 3, Supplemental Table 4). Biplots of PC1 and PC2 show that there is variability in the strength of climatic variables and each species is affected differently (Figure 9, Figure 10). For individual species, principle component 1 (PC1; 39.40% variation) of *J. communis* has an eigenvalue of 2.76 with the majority of variability of values accounted for by MAT, average precipitation of collection month, and MAP (Supplemental Table 3), while PC2 (eigenvalue of 1.74; 24.90% variation) was most highly correlated with average temperature of the collection month and VPD. PC1 of *E. angustifolium* has an eigenvalue of 3.64 (52.03% variation), with variability driven by VPD, average temperature of collection month, MAT, average precipitation of collection month, and MAP while variability of PC2 (eigenvalue of 1.33; 19.01% variation) is driven by Δ_{leaf}, VPD, average precipitation of collection month, MAP, and drainage level (Supplemental Table 3). Finally, PC1 of *B. glandulosa* has an eigenvalue of 2.9 (42.05% variation) with variability driven by average temperature of collection month, MAT, average precipitation of collection month and drainage level, and PC2 has an eigenvalue of 1.73 (24.70%

of variation) with variability driven by VPD, average temperature of collection month, MAP and drainage level. (Supplemental Table 3).

The PCA of all species combined shows the variation in the relative effects of each climate variable on all three species (Figure 10). PC1 has an eigenvalue of 3.2 (45.77% of variation) with variability driven by VPD, average temperature of collection month, MAT, average precipitation of collection month, and MAP (see Supplemental Table 4 for coefficients). PC2 has an eigenvalue of 1.5 (21.56% of variation) with variability driven by VPD, average temperature of the collection month, MAP, and drainage level. The majority of the samples of *E. angustifolium* and *B. glandulosa* overlap, with samples of *E. angustifolium* more driven by Δ_{leaf}. In contrast, samples of *J. communis* are more driven by the variability accounted for in PC1, driven mainly by MAT and MAP (Figure 10, Supplemental Table 4). All three species appear to be driven by variability in VPD and drainage level to some extent described in PC2 (Figure 10, Supplemental Table 4).

5. Discussion

5.1 Leaf carbon isotopes in relation to carbon and the water cycle

5.1.1 $\delta^{13}C_{atm}$ vs. $\delta^{13}C_{leaf}$ values

Species have varying ranges of $\delta^{13}C_{leaf}$ and the coefficient of determination for the relationship between $\delta^{13}C_{leaf}$ vs. $\delta^{13}C_{atm}$ varies in strength (R^2) and statistical significance (*p*-value) based on species and plant functional type (Diefendorf et al., 2010; Stein et al., 2019; Sheldon et al., 2020). When the relationships between $\delta^{13}C_{atm}$ and $\delta^{13}C_{leaf}$ of the focal species in this study were compared to those demonstrated in Sheldon et al. (2020), the single genus in the same family (*Juniperus,* Cupressaceae) behaves similarly (Figure 4, Supplemental Table 3). This could be due to genetic similarities within the family that appear to hold true even in more extreme climates. Specifically, the similarity in stomatal shape and size may be a result of the similar carbon isotope measurements within the Cupressaceae family. While species may individually close their stomata more or less in relation to a change in a climatic variable, there may be stomatal similarities within the family, thus creating a homogenous limitation to the carbon that could be brought in by the plant across the family level (Peterson et al., 2010).

5.1.2 Δ_{leaf} and Water Availability: Precipitation and VPD

Two of the three species in this study showed noticeable response between Δ_{leaf} and precipitation (MAP or monthly precipitation); however, this response to water availability was not initially evident by linear regression (Figure 5 A1, B2, Supplemental Table 3, Figure 9, Figure 10). When the results of the PCA are considered in conjunction with the linear regressions, both MAP and average monthly precipitation appear to influence Δ_{leaf} values of both *J. communis* and *E. angustifolium* (Supplemental Table 3, Figure 9). The variation in responses to MAP or average monthly precipitation between species may be due to growth habit. Within the dataset, the faster growing sedge and *B. glandulosa* respond more to average monthly precipitation, but the slower growing coniferous shrub responds more to MAP (Supplemental Table 3, Figure 9).

Typically, Δ_{leaf} values are lower with decreased water availability because lower water availability causes stomatal closure, driving down internal carbon concentration (c_i). A meta-analysis by Diefendorf et al. (2010) proposed that Δ_{leaf} value logarithmically increase with increasing MAP and then level out (Supplemental Figure 2). However, this relationship is defined by only a few samples growing at low MAP, where n = 59 samples of n = 29 species of xeric woodland scrubland with MAP ~200–500 mm yr^{-1} (Diefendorf et al., 2010). This sample density was not high enough for any given single species to reflect the trend that I see in this data; for the highest sample number of one of the 29 species was n = 9. Moreover, the specimens categorized as xeric woodland scrubland are reflective of more mid-latitude desert climates. In contrast, at low MAP, the carbon isotope values of my focal species (*J. communis, E. angustifolium*) are demonstrably higher than expected at lower MAP based on the Diefendorf et al. (2010) model, and then appear to level out in a similar fashion (Figure 5, A1). This suggests that the relationship between Δ_{leaf} values and MAP is actually exponential and that paleoclimate reconstructions of MAP based on results from Diefendorf et al. (2010) should be approached with caution, as each species is likely to reflect a differing relationship between leaf carbon isotope values and water availability. Mesophyll conductance or even changes in carbon isotope fractionation by RuBisCo may be responsible for the difference in response to water availability between cold and temperate climatic regimes (Galmés et al., 2010; Sáez et al, 2018).

The inflection point where Δ_{leaf} values increase at low MAP or relative water threshold of when a plant begins to experience water stress may be the tipping point as to when a plant appears more vulnerable to other climatic variables. For example, the Δ_{leaf} values of *J. communis* are significantly higher at lower MAT when MAP is lower (Figure 8). Moreover, the isotopic composition of *J. communis* only appeared to be impacted by VPD when high VPD was coupled with low MAP and rapid soil drainage, resulting in a narrowed range of Δ_{leaf} values (Figure 7, Supplemental Figure 1). This may suggest that increased precipitation at high latitudes due to climate change would resolve some of the responses observed in leaf carbon isotope values to temperature or VPD. This observed relative precipitation threshold, in which each species begins to show a response to other climate variables, varies between each species. It is likely that this variation will result in incongruent responses of species to climate change.

As for the effect of VPD on carbon isotope discrimination, it is important to remember that the effect of transpiration due increased evaporative pressure from higher VPD may be greater at lower water potentials (Forseth & Ehleringer, 1983). Therefore, lower water availability coupled with higher evaporative demand could result in lower Δ_{leaf} values. This relationship was most evident for *E. angustifolium* in which the negative relationship between Δ_{leaf} and VPD appeared stronger when viewed in relation to lower monthly precipitations (~35 mm; Figures 5 C2, Figure 7). The relationship between Δ_{leaf} values and VPD was further confirmed within the PCA results where VPD and rising Δ_{leaf} values were inversely related. Sedges may be more impacted by higher VPD due to their fast growth rate during peak growth season—the time when VPD is likely the highest due to warmer temperatures. Overall, Δ_{leaf} values can be used to highlight the coupled role of water availability and VPD acting on these species at high latitudes.

As a last measurement of water availability, I considered soil drainage capacity. I cannot confidently describe how soil drainage level affected these plants. I hypothesized that soils classified as "rapidly draining" would increase the relative water stress of a plant, similar to the effect of low MAP or low average monthly precipitation. Plants collected from rapidly drained soils and high MAP or hight average monthly precipitation would be less water stressed, assuming precipitation was the dominate climatic driver. *Juniperus communis* may appear to show this in the aforementioned Supplemental Figure 1, where I observe decreased variability in Δ_{leaf} under higher VPD levels and more rapid drainage levels. Ultimately, data bin sizes are too small to be conclusive. The effect of soil drainage is only evident in PCA results; however, there are contradictory results for *J. communis* and *E. angustifolium*. This may be due to individual water demands of either species (see below). Future work focused on plants growing in low precipitation gradients, across different soil drainage areas, and under varying VPD levels would help constrain the interplaying demands of soil water availability versus atmospheric water demand on plants in high stress regions.

5.1.3 Δ_{leaf}, Temperature, and Latitude

Previous studies concluded that there is no relationship between MAT and Δ_{leaf} for species growing at more temperate latitudes (Sheldon et al., 2020). In contrast, species in this study from higher latitudes show that there is a relationship between MAT and Δ_{leaf}: as MAT increases, carbon isotope discrimination decreases. *Juniperus communis* is more responsive to MAT and *E. angustifolium* is more responsive to average collection month temperature (Figure 6 B1, B2, Figure 9, Supplemental Table 3). The higher Δ_{leaf} values of *J. communis* are clustered and less variable at lower MAT when MAP is lower, meaning that the effects of colder temperatures could be even greater on a plant when water is limited (Figure 8). The relationship between Δ_{leaf} values of *J. communis* and temperature may be explained by latitude; for decreasing temperatures and increasing latitude both result in Δ_{leaf} increases. The lack of clear patterns between Δ_{leaf} and latitude may mean that climatic responses of species noted in this study can be applied to the same species growing elsewhere in extreme environments.

Differences in responses between species to different temporal measurements of temperature (monthly or annually) may be due to differences in growth habit, just as with precipitation. For example, the sedge could show a response to monthly temperature because of its rapid growth speed compared to the other plants studied. The growth speed of *E. angustifolium*, especially as a seedling, is considered quite fast (Phillips, 1954). In contrast, *J. communis* retains its leaves multiple years and is considered frost-resistant, meaning its growth season is likely longer than that of the sedge (Raatikainen & Tanska, 1993).

5.1.4 Δ_{leaf} and [CO_2]

The region of focus in this study is likely one with increased local concentrations of carbon dioxide relative to the atmosphere as a whole due to increased permafrost thaw and combined oxidation of methane (Negandhi et al., 2013) and due to increased fires in peatlands (Hugelius et al., 2020). Some workers (Schubert & Jahren, 2012; Schubert & Jahren, 2018) have proposed that Δ_{leaf} increases with increasing [CO_2], but these studies relied on fast growing weedy habit plants grown in growth chambers. At ground level, some species growing both near natural CO_2 vents and in growth chambers indicated increased leaf carbon isotope discrimination and decreased stomatal conductance with increased [CO_2] (Tognetti & Peñuelas, 2003; Tognetti et al., 2000). Therefore, species specific studies using ground level measurements of [CO_2] levels could be expected to show a relationship between Δ_{leaf} and [CO_2]. However, the overall effect of increased [CO_2] on vegetation may be limited due to limitations in nitrogen at higher latitudes (Atkin, 1996; Langley & Megonigal, 2010).

In contrast, other workers (Lomax et al., 2019) have found that moisture availability is more important than [CO_2] when growing the same fast growing weedy habitat species and Stein et al. (in press) recently used herbarium specimens to find that there was no relationship between Δ_{leaf} and rising atmospheric [CO_2] in seven species of temperate angiosperm and gymnosperm trees. Herein, I validate that result and further find that neither dwarf tree or shrubby species (*B. glandulosa* and *J. communis*, respectively) nor naturally grown weedy habit species *(E. angustifolium*) show a Δ_{leaf} response to rising atmospheric [CO_2] during Industrialization (Supplemental Figure 2), and caution against the use of Δ_{leaf} as a proxy for historical or geological reconstructions of atmospheric [CO_2].

5.2 Implications for Specific Species Growing Under High Latitude Climate Change

While analysis of certain species collected from the field in comparison to studies of expected responses to climate can prove helpful in identifying species-specific and universal climatic drivers, when a species has multiple climatic drivers that counteract one another, it may be impossible to initially determine any climatic drivers from single-variable regressions alone. Therefore, multiple stages of analysis may be necessary for individual species. In this study, PCA results supported the results from bivariate regressions that multiple drivers were at play in relation to leaf carbon isotope discrimination (Figure 5, Figure 6, Figure 9, Figure 10, Supplemental Table 3). Basic linear regressions between Δ_{leaf} and a climatic variable with low R^2 values are *not sufficient* to rule out a relationship between Δ_{leaf} of a species and a particular climatic variable. The following sections summarize the notable responses for each individual species and the implications of species responses for other species growing in similar ecosystems.

5.2.1 Juniperus communis

Based on current known climatic changes occurring at high latitudes and the response seen here, *J. communis* may continue to survive under increasing precipitation, given that the species appeared most impacted by lack of water availability (Figure 5, A1 and Supplemental Table 3). Increasing temperatures may benefit already existing *J. communis* plants, as they will likely increase the growth season of the species, but may negatively impact seed viability (Verheyen et al., 2009). While I cannot identify the spike in Δ_{leaf} values at the -10.0 to -5.0 °C mark (Figure 9) at MAP ~250–500 mm yr^{-1}, this temperature aligns with the reported minimum temperature where CO_2 is still sufficiently accrued (-4.9 °C) and the reported cutoff temperature for respiration (-9.0 °C) (Ungerson & Scherdin, 1965). In comparison to the other species, samples of *J. communis*, seemed affected the most by climate variables in terms of magnitude, which may also be due to leaf retention (Figure 10). Overall, physiologically, *J. communis* may be able to surive at even higher latiudes given its known resistance to embolism and near constant hydraulic efficiency at different latitudes (Unterholzner et al., 2020), drought tolerance, and tolerance to colder temperatures (Thomas et al., 2007*)*. In combination with the results of this study, this previous work suggests that *J. communis* and communities dominated by *J. communis* will likely be robust in the face of climate change.

5.2.2 Eriophorum angustifolium

E. angustifolium's strong response to VPD, with a decrease in Δ_{leaf}, parallels a response found in Gebauer et. al (1989) where *E. angustifolium* showed stomatal closure to increasing VPD even when the plant had sufficient water access; therefore, the plant worked to prevent evapotranspiration based water loss even when it wasn't necessarily water stressed. Δ_{leaf} values of *E. angustifolium* were lower at higher levels of VPD (Figure 5 C2 and Figure 7). Due to the connection between Δ_{leaf} and lower internal concentration of CO_2 from stomatal closure, this could indicate that samples of *E. angustifolium* did in fact close their stomata to increased VPD in an attempt to retain water. Increasing VPD due to higher temperatures in the arctic could disproportionally affect this species despite projected increased precipitation.

5.2.3 Betula glandulosa

Δ_{leaf} values of *Betula glandulosa* did not show any direct predictive relationships with climatic variables (Figure 5 and Figure 6). In contrast, PCA results for *B. glandulosa* showed that multiple climatic drivers were at play (Figure 9, Figure 10, Supplemental Table 3). The carbon isotope values of *B. glandulosa* are the most strongly correlated with the carbon isotope values of the atmosphere in this study (Figure 3) and have relatively lower variability of carbon isotope discrimination values of the three species (Table 1). While *B. glandulosa* may have some sort of leading response to more extreme climatic variables, it is possible that these responses simply are not captured by the sampling conducted within this study due to the fact that the majority of samples were collected during peak growth season or the fact that reproduction of *B. glandulosa* is restrained by colder temperatures (Myers-Smith et al., 2011). For these reasons, using Δ_{leaf} as a lens to understand how deciduous species respond to different climatic variables may be an avenue worth future investigation.

5.2.4 Projections for Future Climate Change

It is important to consider the implications of these species-specific climate-physiology relationships on spatial distributions as climate change progresses, as indiviual plant traits may provide insight into the effects of changing climate in colder, tundra biomes (Bjorkman et al., 2018; Myers-Smith et al., 2019) While species' ranges may broaden at the arctic treeline boundary (Inset Map of Figure 2; Ettinger & HilleRisLambers, 2013), congruent with documented trends of an increase in woody plants in the arctic (Post & Høye, 2013), each species may respond differently based on results observed in this study. I would expect the distribution of *J. communis* to spread northward, with a projected shift poleward of the leading edge of the treeline. Due to the similarity in slopes of $\delta^{13}C_{atm}$ and $\delta^{13}C_{leaf}$ between *J. communis* and other species of the Cupressaceae family, it is possible that other species of the Cupressaceae family growing in this region may also spread their distribution range poleward. However, predictions across taxonomy should be approached with caution, because growth responses to changes in climate have been shown to vary between species within the same genus (Riddle et al., 2014). The southernmost trailing edge of the growth range of *E. angustifolium* is likely to shift northwards, decreasing the range of the species lower latitudinal limits, due to potential negative effects of higher VPD from increased temperatures (Inset Map of Figure 2). Other herbaceous species may be predicted to respond similarly, but only if their responses to VPD and water parallel that of *E. angustifolium*. As for *Betula glandulosa* and other deciduous species, while PCA results show multiple potential drivers of Δ_{leaf}, results are not conclusive enough to predict the future shift or lack thereof. A study by Gamm et al. (2018) reports a decline in deciduous shrubs at high latitudes and also found a lack of any significant trend in Δ_{leaf} versus climate for *Betula nana*, so this may provide guidance for *B. glandulosa*, but further work is needed to verify the similarity of responses between different species in the genus *Betula*.

6. Conclusions

In this study, three species, *Juniperus* communis, *Eriophorum angustifolium*, and *Betula glandulosa* were used to understand better the impacts of climate change on individual species growing in boreal and tundra environments. Overall, I found that the shift in greater overall precipitation and likely increased VPD from rising temperatures due to climate change will not impact vegetation at high latitudes homogeneously. For two of these species, water was a key player in the extent to which either species respond to other changes in climate variables. Many of the relationships between Δ_{leaf} and climatic variables within this study were exacerbated when the precipitation level was too low for that plant—resulting in a potential spike in mesophyll conductance or change in the function of RuBisCo. In order to confirm relationships seen with water availability further, it is necessary to specifically sample these species growing in areas with higher water availability. In contrast, these species were not impacted by rising atmospheric [CO_2] levels. In order to understand further the potential impact of climate variables within climatically stressed regions, I suggest using climate data with higher spatial and temporal resolution. While this study includes large single species sample numbers, a higher sample size from lower latitudes and at similar latitudes with different longitudes should be collected in order to see if the current relationships between carbon isotope measurements and changes in carbon isotope discrimination hold up. While predictions can be made for the relative shift for coniferous shrubs, and sedges within this boreal forest to arctic tundra transition zone, more work is needed to understand the impacts of climate change on deciduous shrubs. Similar, multi-faceted studies must be conducted to see if these results hold true across plant families and for species of similar functional types in extreme climates. However, I note three key findings that are likely generalizable: 1) in agreement with previous studies of woody species, none of the three species studied here showed any Δ_{leaf} response to changing [CO_2], suggesting that isotope discrimination is a fundamental leaf trait; 2) response to environmental stressors is complex, but changing VPD has largely been overlooked and should be the subject of future work, and 3) trends observed in meta-analytical analyses of Δ_{leaf} from temperate and tropical latitudes do not apply to higher latitude settings, where I find a measurable influence of temperature on Δ_{leaf} that is absent at lower latitudes. Thus, leaf carbon isotope values may prove to be a key tool for studying species living at the edge of their range limits under changing climates.

7. Acknowledgements

I would like to thank my academic advisor Dr. Nathan Sheldon and Dr. Selena Smith, my second thesis reader. I would also like to thank Dr. Chris Deduke, Ph.D. the Botany Collection Technician and Jennifer Doubt, M.Sc. the Curator of Botany from the Canadian Museum of Nature (CANL). I would also like to thank Rich Rabeler and Tony Reznicek at the University of Michigan Herbarium (MICH) and Molly Ng for helping out in the herbarium. I would like to thank Rebekah Stein for inspiring MAS, running all the samples on the CRDS, and reading countless drafts. Thank you Allison Curley for teaching me how to use Adobe Illustrator and Eric Szymanski for helping me think about and process data. Finally, I would like to thank my mother for helping her sample 400+ plants at Canadian Museum of Nature’s (CANL) herbarium in Ottawa, Ontario Canada.

8. References Cited

Agriculture and Agri-Food Canada. "Soil Landscapes of Canada (SLC) derived from V3.1 and V2.2 – Cartographic 1M" Feature Layer. https://hub.arcgis.com/datasets/5457d3cb7e674de2b6adc20a2c33fba3?layer=3 (accessed 3 November 2020).

Anderson, D.B., 1936. Relative Humidity or Vapor Pressure Deficit. Ecology 17(2), 277–282. https://doi.org/10.2307/1931468

Arens, N.C., Hope Jahren, A., Amundson, R., 2000. Can C_3 plants faithfully record the carbon isotopic composition of atmospheric carbon dioxide? Paleobiology 26, 137–164. https://doi.org/10.1666/0094-8373(2000)026<0137:ccpfrt>2.0.co;2

Atkin, O.K., 1996. Reassessing the nitrogen relations of Arctic plants: A mini-review. Plant, Cell Environ. 19(6), 695–704. https://doi.org/10.1111/j.1365-3040.1996.tb00404.x

Bjorkman, A.D., Myers-Smith, I.H., Elmendorf, S.C. *et al.*, 2018. Plant functional trait change across a warming tundra biome. Nature 562**,** 57–62. https://doi.org/10.1038/s41586-018-0563-7

Boulanger, Y., Taylor, A.R., Price, D.T., Cyr, D., McGarrigle, E., Rammer, W., Sainte-Marie, G., Beaudoin, A., Guindon, L., Mansuy, N., 2017. Climate change impacts on forest landscapes along the Canadian southern boreal forest transition zone. Landsc. Ecol. 32(7), 1415–1431. https://doi.org/10.1007/s10980-016-0421-7

Buchmann, N., Guehl, J.M., Barigah, T.S., Ehleringer, J.R., 1997. Interseasonal comparison of CO2 concentrations, isotopic composition, and carbon dynamics in an Amazonian rainforest (French Guiana). Oecologia 110(1), 120-131. https://doi.org/10.1007/s004420050140

Carpino, O.A., Berg, A.A., Quinton, W.L., Adams, J.R., 2018. Climate change and permafrost thaw-induced boreal forest loss in northwestern Canada. Environ. Res. Lett. 13(8), 084018. https://doi.org/10.1088/1748-9326/aad74e

CAVM Team, 2003. Circumpolar Arctic Vegetation Map. (1:7,500,000 scale), Conservation of Arctic Flora and Fauna (CAFF) Map No. 1. U.S. Fish and Wildlife Service, Anchorage, Alaska. ISBN: 0-9767525-0-6, ISBN-13: 978-0-9767525-0-9

de Groot, W.J., Thomas, P.A., Wein, R.W., 1997. *Betula Nana L.* and *Betula Glandulosa Michx.* J. Ecol. 85(2), 241–264. https://doi.org/10.2307/2960655

Diefendorf, A.F., Mueller, K.E., Wing, S.L., Koch, P.L., Freeman, K.H., 2010. Global patterns in leaf ^{13}C discrimination and implications for studies of past and future climate. Proc. Natl. Acad. Sci. U. S. A. 107(13), 5738–5743. https://doi.org/10.1073/pnas.0910513107

Diffenbaugh, N.S., Field, C.B., 2013. Changes in ecologically critical terrestrial climate conditions. Science 341(6145), 486–492. https://doi.org/10.1126/science.1237123

eFloras, 2020. Published on the Internet http://www.efloras.org (accessed 10 November 2008) Missouri Botanical Garden, St. Louis, MO & Harvard University Herbaria, Cambridge, MA.

Etheridge, D.M., Steele, L.P., Langenfelds, R.L., Francey, R.J., Barnola, J.-M., Morgan, V.I., 1998. Historical CO_2 records from the Law Dome DE08, DE08-2, and DSS ice cores. In Trends: A Compendium of Data on Global Change. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tenn., U.S.A.

Ettinger, A.K., HilleRisLambers, J., 2013. Climate isn't everything: Competitive interactions and variation by life stage will also affect range shifts in a warming world. Am. J. Bot. 100(7), 1344–1355. https://doi.org/10.3732/ajb.1200489

Farjon, A., Filer, D., 2013. *An Atlas of the World's Conifers: An Analysis of their Distribution, Biogeography, Diversity and Conservation Status*. Brill, Leiden and Boston.

Farquhar, G.D., Ehleringer, J.R., Hubick, K.T., 1989. Carbon Isotope Discrimination and Photosynthesis. Annu. Rev. Plant Physiol. Plant Mol. Biol. 40(1), 503–537.

Feeley, K.J., Bravo-Avila, C., Fadrique, B., Perez, T.M., Zuleta, D., 2020. Climate-driven changes in the composition of New World plant communities. Nat. Clim. Chang. 10, 965–970. https://doi.org/10.1038/s41558-020-0873-2

Fick, S.E. and Hijmans, R.J., 2017. WorldClim 2: new 1-km spatial resolution climate surfaces for global land areas. Int. J. Climatol. 37(12), 4302–4315. https://doi.org/10.1002/joc.5086

Forseth, I.N., Ehleringer, J.R., 1983. Ecophysiology of two solar tracking desert winter annuals III. Gas exchange responses to light, CO2 and VPD in relation to long-term drought, Oecologia 58(1), 10–18. https://doi.org/10.1007/BF00377179

Franks, P.J., Farquhar, G.D., 2007. The mechanical diversity of stomata and its significance in gas-exchange control. Plant Physiol. 143(1), 78–87. https://doi.org/10.1104/pp.106.089367

Gamm, C.M., Sullivan, P.F., Buchwal, A., Dial, R.J., Young, A.B., Watts, D.A., Cahoon, S.M.P., Welker, J.M., Post, E., 2018. Declining growth of deciduous shrubs in the warming climate of continental western Greenland. J. Ecol. 106(2), 640–654. https://doi.org/10.1111/1365-2745.12882

Gebauer, R.L.E., Reynolds, J.F., Tenhunen, J.D., 1998. Diurnal patterns of CO_2 and H_2O exchange of the arctic sedges *Eriophorum angustifolium* and *E. vaginatum* (Cyperaceae). Am. J. Bot. 85(4), 592–599. https://doi.org/10.2307/2446442

Galmés, J., Ribas-Carbó, M., Medrano, H., Flexas, J., 2011. Rubisco activity in Mediterranean species is regulated by the chloroplastic CO_2 concentration under water stress. J. Exp. Bot. 62(2), 653–665. https://doi.org/10.1093/jxb/erq303

Hugelius, G., Loisel, J., Chadburn, S., Jackson, R.B., Jones, M., MacDonald, G., Marushchak, M., Olefeldt, D., Packalen, M., Siewert, M.B., Treat, C., Turetsky, M., Voigt, C., Yu, Z., 2020. Large stocks of peatland carbon and nitrogen are vulnerable to permafrost thaw. Proc. Natl. Acad. Sci. U. S. A. 117(34), 20438–20446. https://doi.org/10.1073/pnas.1916387117

Hustich, I.,1953. The Boreal Limits of Conifers. Arctic 6(2), 149–162. http://www.jstor.org/stable/40506572 (accessed 21 September 2020).

Jump, A.S., Peñuelas, J., 2005. Running to stand still: adaptation and the response of plants to rapid climate change. Ecol. Lett. 8(9), 1010–1020. https://doi.org/10.1111/j.1461-0248.2005.00796.x

Keeling, C.D., Piper, S.C., Bacastow, R.B., Whalen, M., Whorf, T.P., Heimann, M., Meijer, H.A., 2001. Exchanges of atmospheric CO_2 and $^{13}CO_2$ with the terrestrial biosphere and oceans from 1978 to 2000. I. Global aspects, SIO Reference Series, No. 01-06, Scripps Institution of Oceanography, San Diego, 88 pages.

Kohn, M.J., 2010. Carbon isotope compositions of terrestrial C3 plants as indicators of (paleo)ecology and (paleo)climate. Proc. Natl. Acad. Sci. U. S. A. 107(46), 19691–19695. https://doi.org/10.1073/pnas.1004933107

Langley, J.A., Megonigal, J.P., 2010. Ecosystem response to elevated CO_2 levels limited by nitrogen-induced plant species shift. Nature 466, 96–99. https://doi.org/10.1038/nature09176

Lavergne, A., Sandoval, D., Hare, V.J., Graven, H., Prentice, I.C., 2020. Impacts of soil water stress on the acclimated stomatal limitation of photosynthesis: Insights from stable carbon isotope data. Glob. Chang. Biol. 00, 1–15. https://doi.org/10.1111/gcb.15364

Lawson, T., Blatt, M.R., 2014. Stomatal size, speed, and responsiveness impact on photosynthesis and water use efficiency. Plant Physiol. 164(4), 1556–1570. https://doi.org/10.1104/pp.114.237107

Lomax, B.H., Lake, J.A., Leng, M.J., Jardine, P.E., 2019. An experimental evaluation of the use of $\Delta^{13}C$ as a proxy for palaeoatmospheric CO_2. Geochim. Cosmochim. Acta 247, 162–174. https://doi.org/10.1016/j.gca.2018.12.026

Little, E.L., 1979. Checklist of United States trees (native and naturalized). Agriculture handbook ; no. 541. Washington: D.C.: Forest Service, U.S. Dept. of Agriculture.

McDowell, N.G., Bond, B.J., Dickman, L.T., Ryan, M.G., Whitehead, D., 2011. Relationships Between Tree Height and Carbon Isotope Discrimination. Springer, Dordrecht, 255–286. https://doi.org/10.1007/978-94-007-1242-3_10

Myers-Smith, I.H., Forbes, B.C., Wilmking, M., Hallinger, M., Lantz, T., Blok, D., Tape, K.D., MacIas-Fauria, M., Sass-Klaassen, U., Lévesque, E., Boudreau, S., Ropars, P., Hermanutz, L., Trant, A., Collier, L.S., Weijers, S., Rozema, J., Rayback, S.A., Schmidt, N.M., Schaepman-Strub, G., Wipf, S., Rixen, C., Ménard, C.B., Venn, S., Goetz, S., Andreu-Hayles, L., Elmendorf, S., Ravolainen, V., Welker, J., Grogan, P., Epstein, H.E., Hik, D.S., 2011. Shrub expansion in tundra ecosystems: Dynamics, impacts and research priorities. Environ. Res. Lett. 6(4), 045509. https://doi.org/10.1088/1748-9326/6/4/045509

Myers-Smith, I.H., Thomas, H.J.D., Bjorkman, A.D., 2019. Plant traits inform predictions of tundra responses to global change. New Phytol. 221(4), 1742–1748. https://doi.org/10.1111/nph.15592

National Weather Service, 2020. Vapor Pressure. https://www.weather.gov/media/epz/wxcalc/vaporPressure.pdf (accessed 23 October 2020).

Negandhi, K., Laurion, I., Whiticar, M.J., Galand, P.E., Xu, X., Lovejoy, C., 2013. Small thaw ponds: An unaccounted source of methane in the Canadian high Arctic. PLoS One 8(11), e78204. https://doi.org/10.1371/journal.pone.0078204

Novick, K.A., Ficklin, D.L., Stoy, P.C., Williams, C.A., Bohrer, G., Oishi, A.C., Papuga, S.A., Blanken, P.D., Noormets, A., Sulman, B.N., Scott, R.L., Wang, L., Phillips, R.P., 2016. The increasing importance of atmospheric demand for ecosystem water and carbon fluxes. Nat. Clim. Chang. 6(11), 1023–1027. https://doi.org/10.1038/nclimate3114

O'Leary, M.H., 1993. Biochemical Basis of Carbon Isotope Fractionation, in: Stable Isotopes and Plant Carbon-Water Relations. Elsevier, Academic Press, 19–28. https://doi.org/10.1016/b978-0-08-091801-3.50009-x

Parmesan, C., Hanley, M.E., 2015. Plants and climate change: Complexities and surprises. Ann. Bot. 116(6), 849-864. https://doi.org/10.1093/aob/mcv169

Peel, M.C., Finlayson, B.L., McMahon, T.A., 2007. Updated world map of the Köppen-Geiger climate classification. Hydrol. Earth Syst. Sci. 11, 1633–1644. https://doi.org/10.5194/hess-11-1633-2007

Peterson, K.M., Rychel, A.L., Torii, K.U., 2010. Out of the mouths of plants: The molecular basis of the evolution and diversity of stomatal development. Plant Cell. 22(2), 296–306. https://doi.org/10.1105/tpc.109.072777

Phillips, M., 1954. Eriophorum Angustifolium Roth. *Journal of Ecology,* 42(2), 612–622. htpps://doi.org/10.2307/2256893

Post, E., Høye, T.T., 2013. Advancing the long view of ecological change in tundra systems. Introduction. Philos. Trans. R. Soc. Lond. B. Biol. Sci. 368(1624): 20120477 https://doi.org/10.1098/rstb.2012.0477

Raatikainen, M., Tanska, T., 1993. Cone and seed yields of the juniper (Juniperus communis) in southern and central Finland. Acta Botanica Fennica, 149, 27–39.

Riddle, J., Pederson, N., Stella, J.C., Leopold, D.J., 2014. Shifting climate sensitivity and contrasting growth trends in Juniperus species growing together at opposite range margins. Tree-Ring Res. 70(2), 101–111. https://doi.org/10.3959/1536-1098-70.2.101

Rubel, F., Kottek, M., 2010. Observed and projected climate shifts 1901-2100 depicted by world maps of the Köppen-Geiger climate classification. Meteorol. Zeitschrift 19(2), 135–141. https://doi.org/10.1127/0941-2948/2010/0430

Rubino, M., Etheridge, D.M., Trudinger, C.M., Allison, C.E., Battle, M.O., Langenfelds, R.L., Steele, L.P., Curran, M., Bender, M., White, J.W.C., Jenk, T.M., Blunier, T., Francey, R.J., 2013. A revised 1000 year atmospheric $\delta^{13}C$-CO_2 record from Law Dome and South Pole, Antarctica. J. Geophys. Res. Atmos. 118(15), 8482–8499. https://doi.org/10.1002/jgrd.50668

Sáez, P.L., Galmés, J., Ramírez, C.F., Poblete, L., Rivera, B.K., Cavieres, L.A., Clemente-Moreno, M.J., Flexas, J., Bravo, L.A., 2018. Mesophyll conductance to CO_2 is the most significant limitation to photosynthesis at different temperatures and water availabilities in Antarctic vascular species. Environ. Exp. Bot. 156, 279–287. https://doi.org/10.1016/j.envexpbot.2018.09.008

Schell, D., 2016. Arctic LTER 1988: $\delta^{13}C$ and $\delta^{15}N$ ratios measurement for *Eriophorum*, *Carex* and lichen species in water tracks at Toolik and Imnavait Creek ver 2. Environmental Data Initiative. https://doi.org/10.6073/pasta/d1771a19979f042e44a1813fe935c426 (Accessed 31 July 2020).

Schubert, B.A., Jahren, A.H., 2012. The effect of atmospheric CO_2 concentration on carbon isotope fractionation in C_3 land plants. Geochim. Cosmochim. Acta 96, 29–43. https://doi.org/10.1016/j.gca.2012.08.003

Schubert, B.A., Jahren, A.H., 2018. Incorporating the effects of photorespiration into terrestrial paleoclimate reconstruction. Earth-Science Rev. 177, 637–642 https://doi.org/10.1016/j.earscirev.2017.12.008

Settele, J., R. Scholes, R. Betts, S. Bunn, P. Leadley, D. Nepstad, J.T. Overpeck, and M.A. Taboada, 2014:Terrestrial and inland water systems. In: *Climate Change 2014: Impacts, Adaptation, and Vulnerability.Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of theIntergovernmental Panel on Climate Change* [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach,M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 271-359.

Sheldon, N.D., Smith, S.Y., Stein, R., Ng, M., 2020. Carbon isotope ecology of gymnosperms and implications for paleoclimatic and paleoecological studies. Glob. Planet. Change 184, 103060. https://doi.org/10.1016/j.gloplacha.2019.103060

Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Web Soil Survey. Available online at the following link: http://websoilsurvey.sc.egov.usda.gov/ (accessed 15 May 2020).

Sparks, J.P., Ehleringer, J.R., 1997. Leaf carbon isotope discrimination and nitrogen content for riparian trees along elevational transects. Oecologia 109(3), 362–367. https://doi.org/10.1007/s004420050094

Stein, R.A., Sheldon, N.D., Smith, S., 2019. Rapid response to anthropogenic climate change by Thuja occidentalis : implications for past climate reconstructions and future climate predictions. PeerJ 7, e7378. https://doi.org/10.7717/peerj.7378

Stein, R.A., Sheldon, N.D., Smith, S.Y., in press. C_3 plant carbon isotope discrimination does not respond to CO_2 concentration on decadal to centennial timescales. New Phytol. nph.17030. https://doi.org/10.1111/nph.17030

Stocker, T.F., D. Qin, G.-K. Plattner, L.V. Alexander, S.K. Allen, N.L. Bindoff, F.-M. Bréon, J.A. Church, U. Cubasch, S. Emori, P. Forster, P. Friedlingstein, N. Gillett, J.M. Gregory, D.L. Hartmann, E. Jansen, B. Kirtman, R. Knutti, K. Krishna Kumar, P. Lemke, J. Marotzke, V. Masson-Delmotte, G.A. Meehl, I.I. Mokhov, S. Piao, V. Ramaswamy, D. Randall, M. Rhein, M. Rojas, C. Sabine, D. Shindell, L.D. Talley, D.G. Vaughan and S.-P. Xie, 2013: Technical Summary. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Tans, P., 2020. NOAA/GML: Monthly Average Mauna Loa CO_2. https://www.esrl.noaa.gov/gmd/ccgg/trends/ (accessed 10 Nov 2020).

Thomas, P.A., El-Barghathi, M., Polwart, A., 2007. Biological Flora of the British Isles: Juniperus communis L. J. Ecol. 95(6), 1404–1440. https://doi.org/10.1111/j.1365-2745.2007.01308.x

Tognetti, R., Peñuelas, J., 2003. Nitrogen and carbon concentrations, and stable isotope ratios in Mediterranean shrubs growing in the proximity of a CO_2 spring. Biol. Plant. 46(3), 411–418. https://doi.org/10.1023/A:1024342606329

Tognetti, R., Raschi, A., Jones, M.B., 2000. Seasonal patterns of tissue water relations in three Mediterranean shrubs co-occurring at a natural CO_2 spring. Plant, Cell Environ. 23(12), 1341–1351. https://doi.org/10.1046/j.1365-3040.2000.00645.x

Ungerson, J., Scherdin, G., 1965. Untersuchungen über Photosynthese und Atmung unter Natürlichen Bedingungen Während des Winterhalbjahres bei *Pinus silvestris* L., *Picea excelsa* Link. und *Juniperus communis* L. Planta 67, 136–167. https://doi.org/10.1007/BF00385506

Unterholzner, L., Carrer, M., Bär, A., Beikircher, B., Dämon, B., Losso, A., Prendin, A.L., Mayr, S., 2020. Juniperus communis populations exhibit low variability in hydraulic safety and efficiency. Tree Physiol. tpaa103. https://doi.org/10.1093/treephys/tpaa103

USDA, NRCS, 2020. The PLANTS Database. http://plants.usda.gov (accessed 10 November 2020). National Plant Data Team, Greensboro, NC 27401-4901 USA.

Verheyen, K., Adriaenssens, S., Gruwez, R., Michalczyk, I.M., Ward, L.K., Rosseel, Y., Van den Broeck, A., García, D., 2009. Juniperus communis: Victim of the combined action of climate warming and nitrogen deposition? Plant Biol. 11(s1), 49–59. https://doi.org/10.1111/j.1438-8677.2009.00214.x

9. Tables & Figures

9.1 Tables

	mean $\delta^{13}C$ (‰)	range $\delta^{13}C$ (‰)	σ $\delta^{13}C$ (‰)	mean Δ_{leaf} (‰)	range Δ_{leaf} (‰)	σ Δ_{leaf} (‰)
Juniperus communis	-26.76	-23.61 – -29.72	1.18	20.06	16.94 – 23.11	1.18
Eriophorum angustifolium	-27.11	-22.96 – -31.40	1.51	20.21	15.84 – 23.96	1.46
Betula glandulosa	-27.51	-24.56 – -30.75	1.20	20.60	17.91 – 23.14	1.07

Table 1. **Summary statistics for leaf carbon isotope measurements and leaf carbon isotope discrimination, where σ is equivalent to ± 1σ.**

9.2 Figures

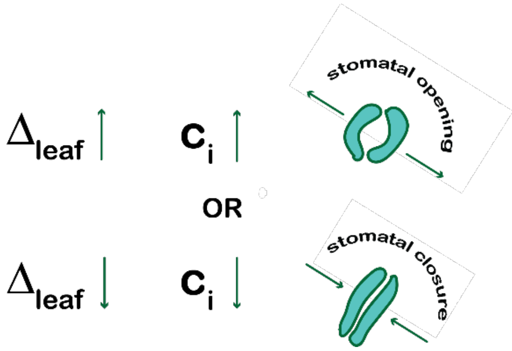


Figure 1. **Relationships between leaf carbon isotope discrimination values, internal concentration of carbon dioxide (c_i), and stomatal opening and closure.**

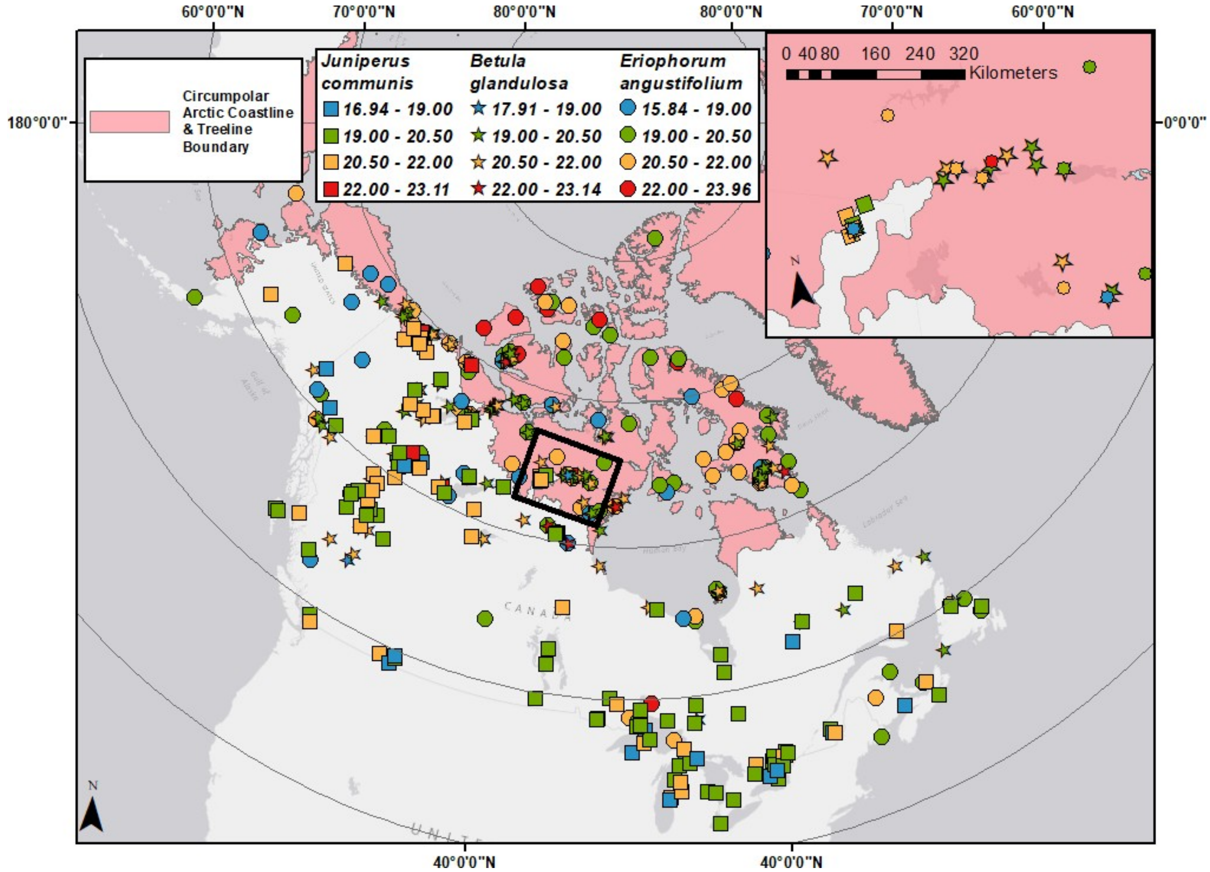


***Figure 2*. Sample locations and Δ_{leaf} values. Samples (n =453; this study and Shell (2016)) are divided by species (shape) and are color-coded by calculated Δ_{leaf} values (‰). The region in pink designates the circumpolar arctic land area where the treeline has ended to highlight the shift from trees to shorter stature vegetation (CAVM Team, 2003). The inset map highlights a region where samples were collected that fall along or near the treeline boundary; here we can predict how species may shift due to changes in climate. Basemap: World Light Gray Canvas Map, Esri, HERE, Garmin, © OpenStreetMap contributors, and the GIS user community; stereographic North Pole projection, WGS 1984.**

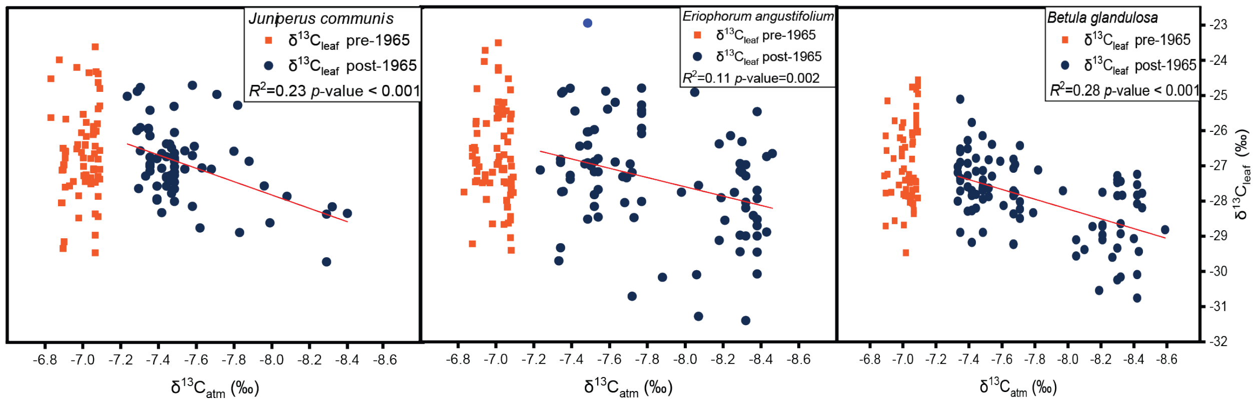


***Figure 3*. Leaf carbon isotope values ($\delta^{13}C_{leaf}$) of *Juniperus communis*, *Eriophorum angustifolium*, *and Betula glandulosa* vs. atmospheric carbon isotope values ($\delta^{13}C_{atm}$). Pre-1965 samples include all samples collected up to but not including the collection year 1966. The separation of data points was chosen based on the observed inflection point in $\delta^{13}C_{atm}$, where the rate of change in $\delta^{13}C_{atm}$ increased due to the acceleration of Industrialization. For specific inflection points and atmospheric carbon isotope measurements see Supplemental Methods.**

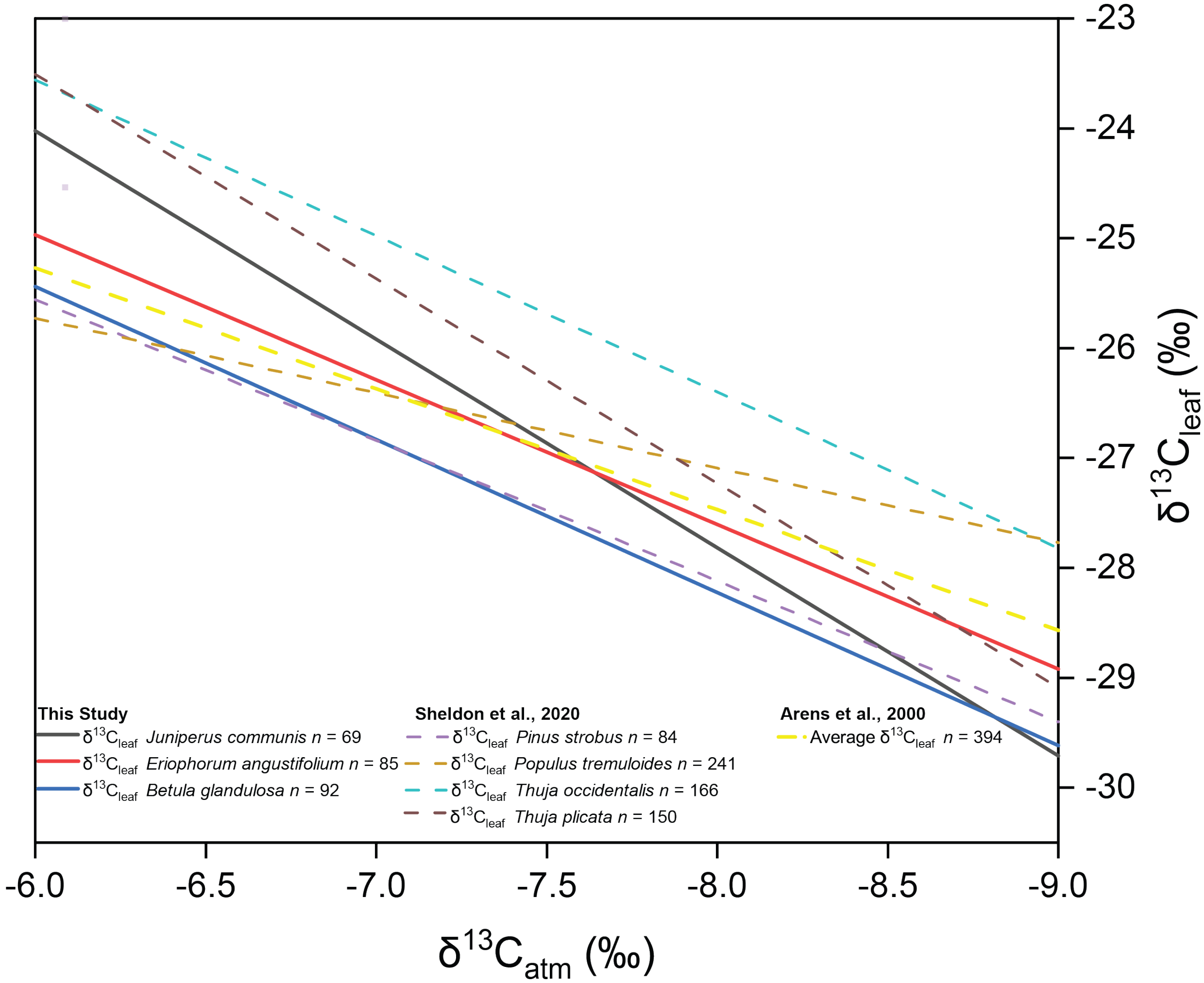


***Figure 4*. Species-level relationship between $\delta^{13}C_{leaf}$ and $\delta^{13}C_{atm}$. Results from this study for post-1965 samples (Figure 3) are compared to previous results from Sheldon et al. (2020) and generalized relationship proposed by Arens et al. (2000). Slopes for each regression can be found in Supplemental Table 1.**

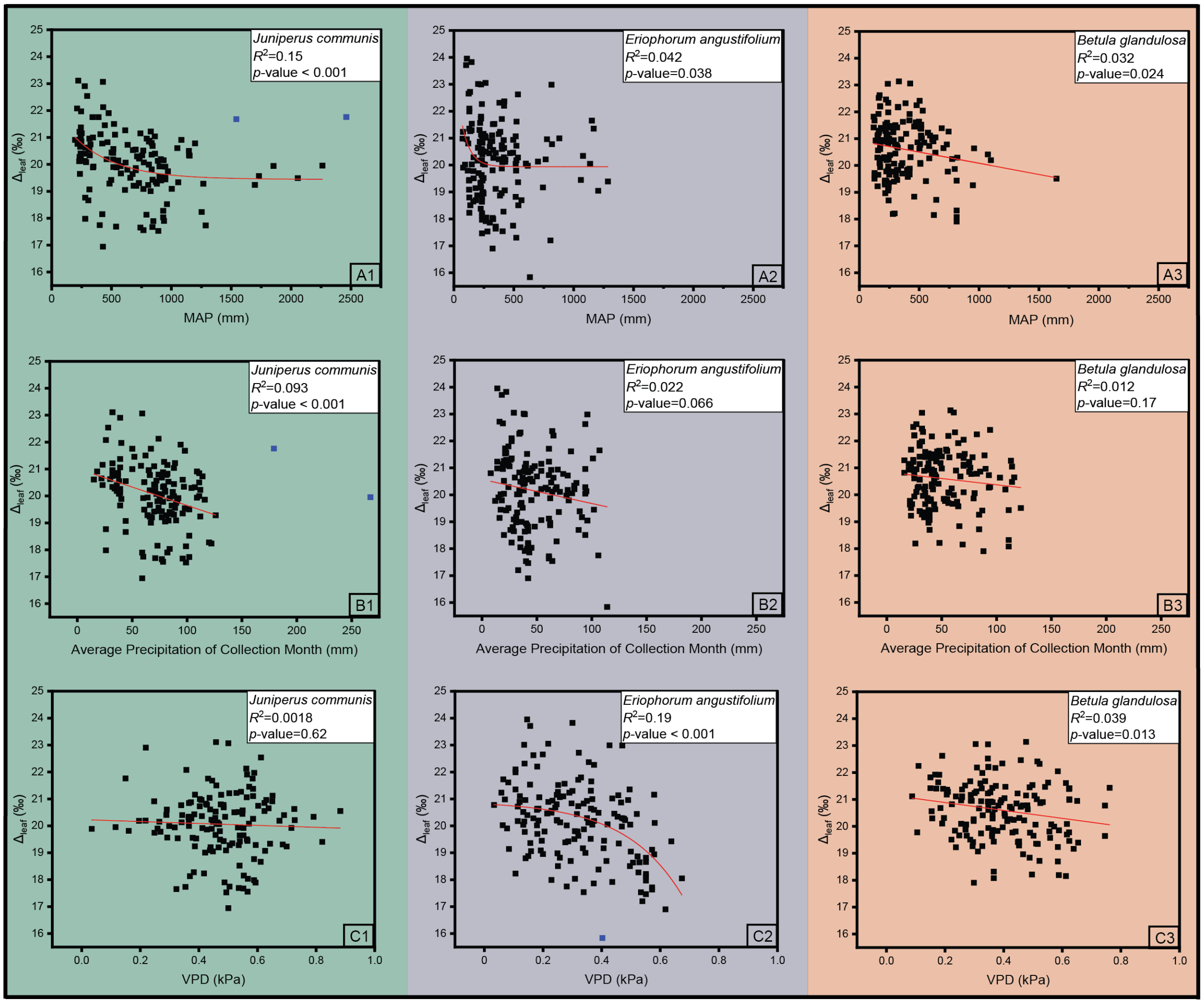


***Figure 5*: Compilation of all Δ_{leaf} vs MAP, average precipitation of collection month, and VPD for all 3 species used in this study. Blue highlighted samples are outliers.**

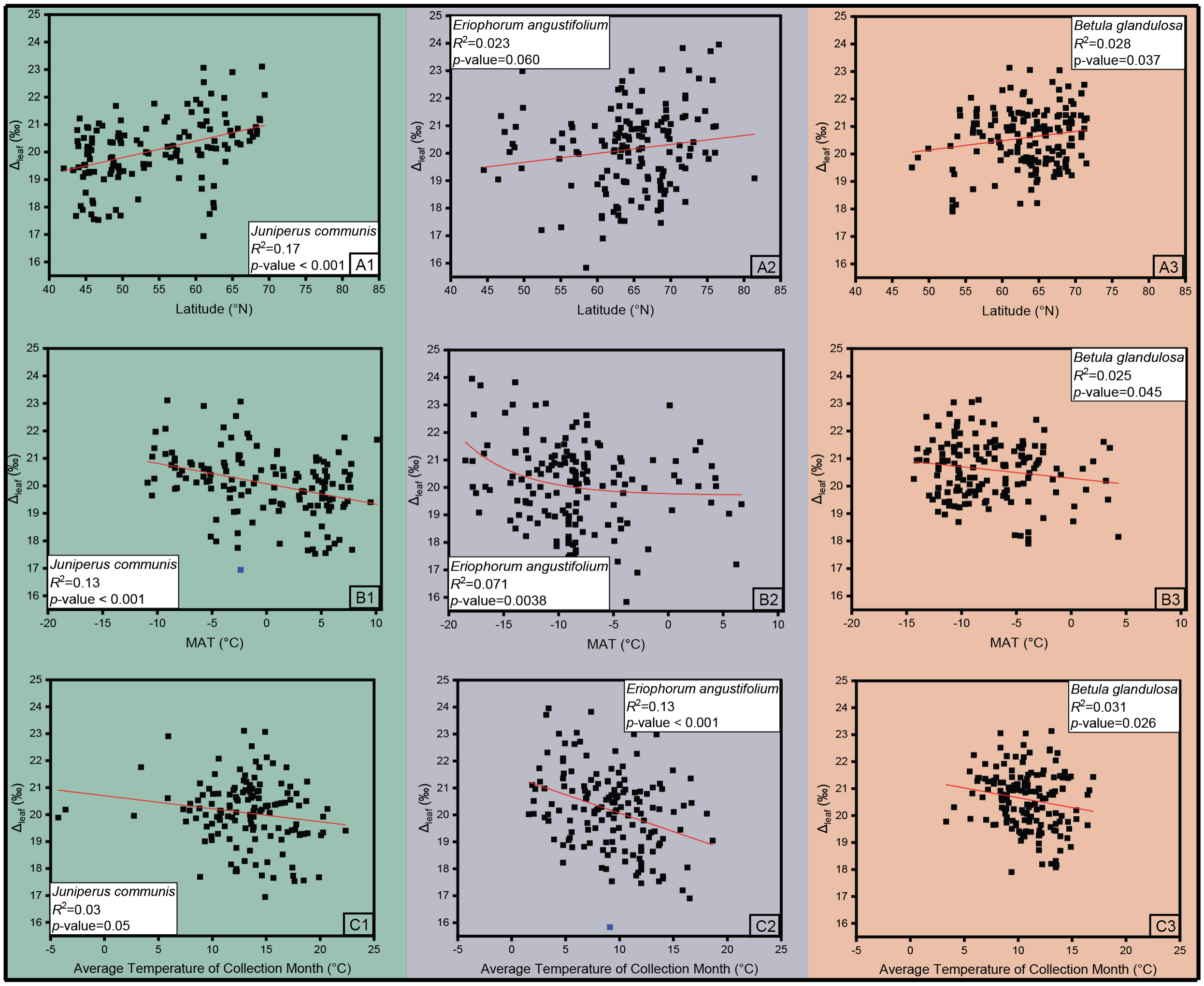


Figure 6**: Compilation of all Δ_{leaf} vs. latitude, MAT, and average temperature of collection month for all 3 species used in this study. Blue highlighted samples are outliers.**

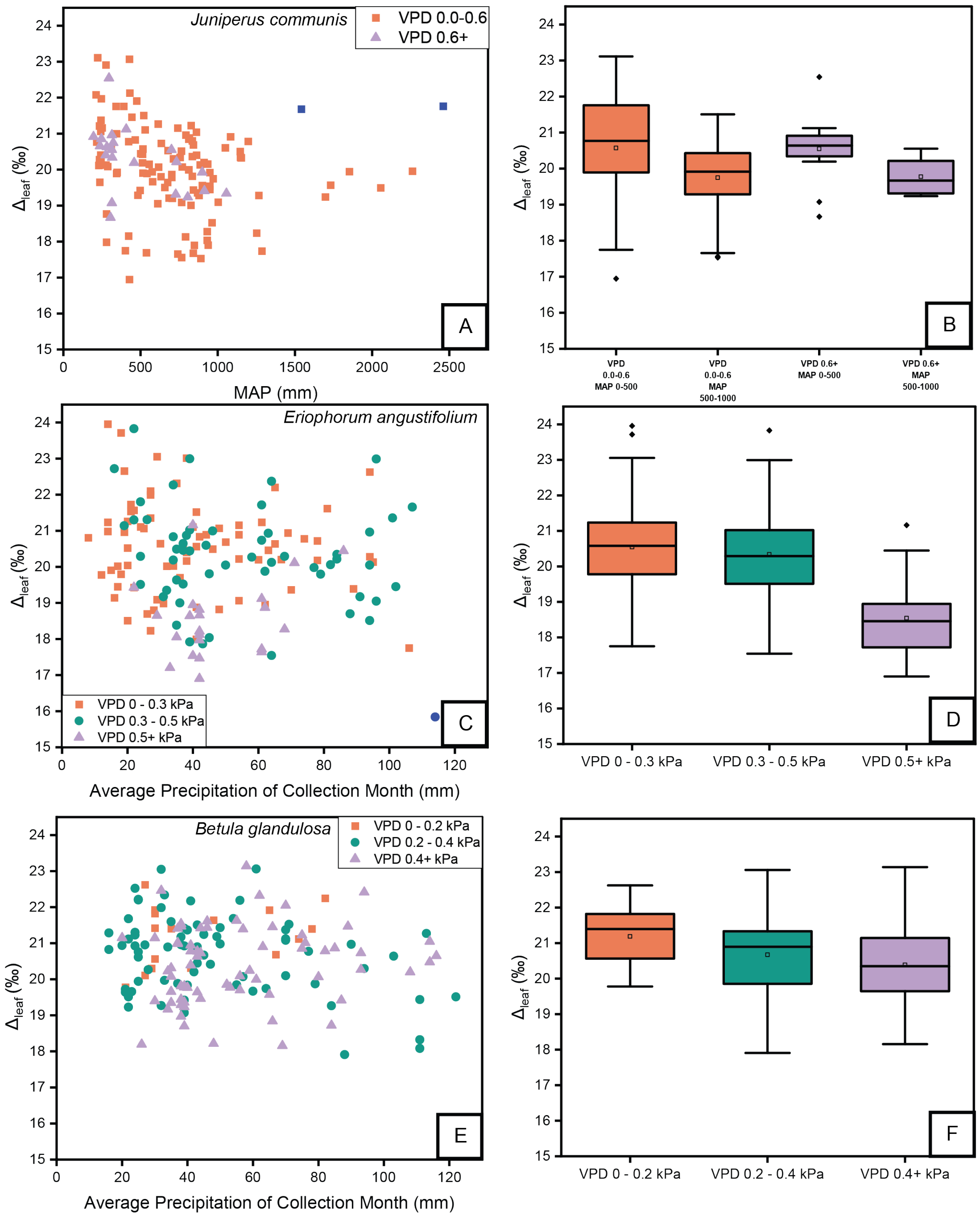


Figure 7. **Combined effects of MAP and VPD on Δ_{leaf}. VPD bins were selected based on relative data evenness. A) Δ_{leaf} vs. MAP for different average collection month VPD bins for *Juniperus communis*. B) Accompanying box and whisker plot for A highlighting the differences in the mean and variation about the mean leaf carbon isotope values for *Juniperus communis* when data are binned by VPD (kPa) and divided into two MAP groups: less than 500 mm and between 500 mm and 1000 mm yr^{-1}(n= 35, 66, 14, 6). C) Δ_{leaf} vs. collection month precipitation for different average collection month VPD bins for *Eriophorum angustifolium*. D) Accompanying box and whisker plot for C (n= 74, 56, 22 respectively). E) Δ_{leaf} vs. collection month precipitation for different average collection month VPD bins for *Betula glandulosa.* F) Accompanying box and whisker plot for E (n= 17, 72, 70). Blue highlighted samples are outliers.**

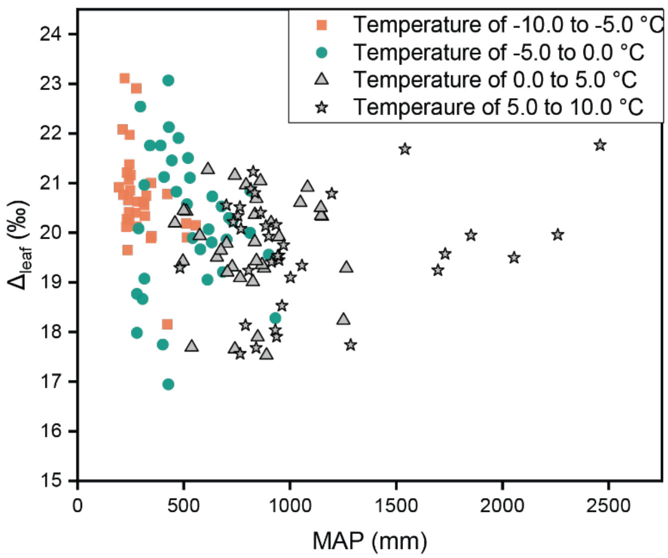


Figure 8. Juniperus communis **Δ_{leaf} versus MAP binned by MAT. For MAT < 0°C, Δ_{leaf} is strongly negatively correlated with MAP. In contrast, leaves collected from sites where MAT > 0°C show no relationship. See trendline in Figure 5 A1.**

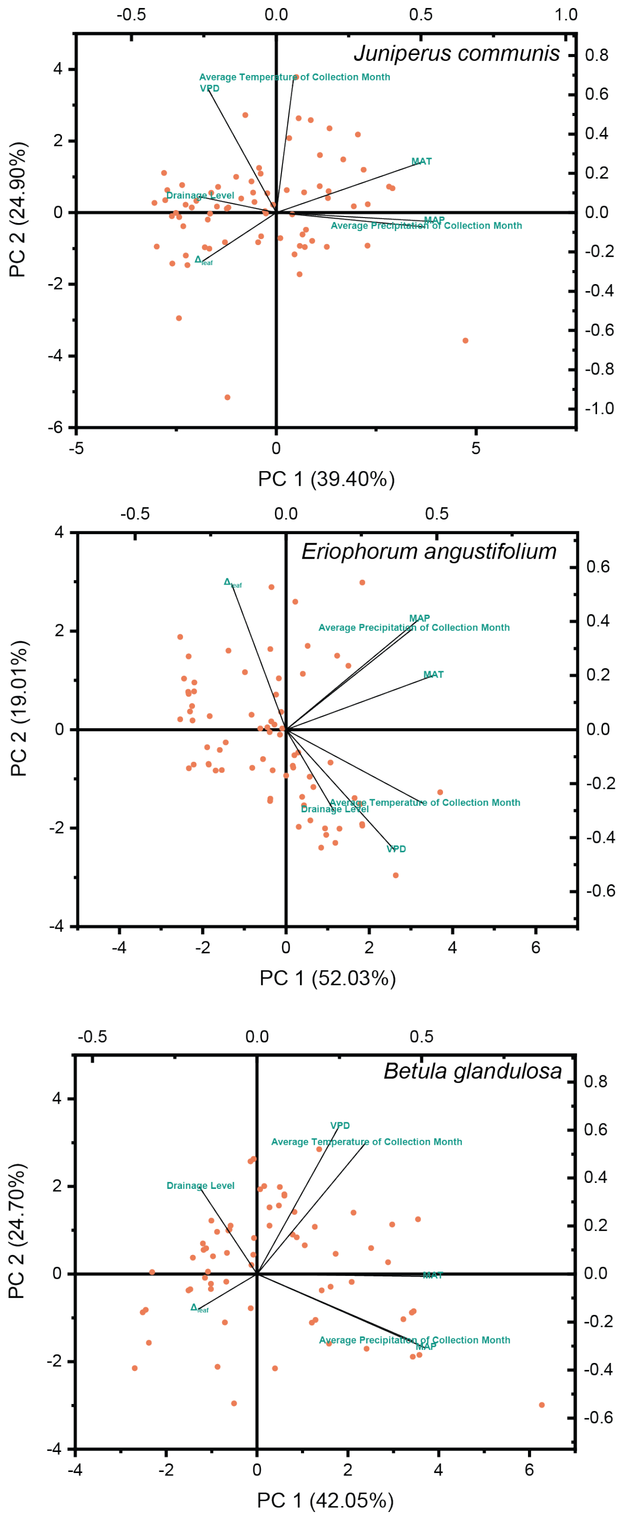


Figure 9. **Biplots for PCA results of *Juniperus communis*, *Eriophorum angustifolium*, and *Betula glandulosa* respectively.**

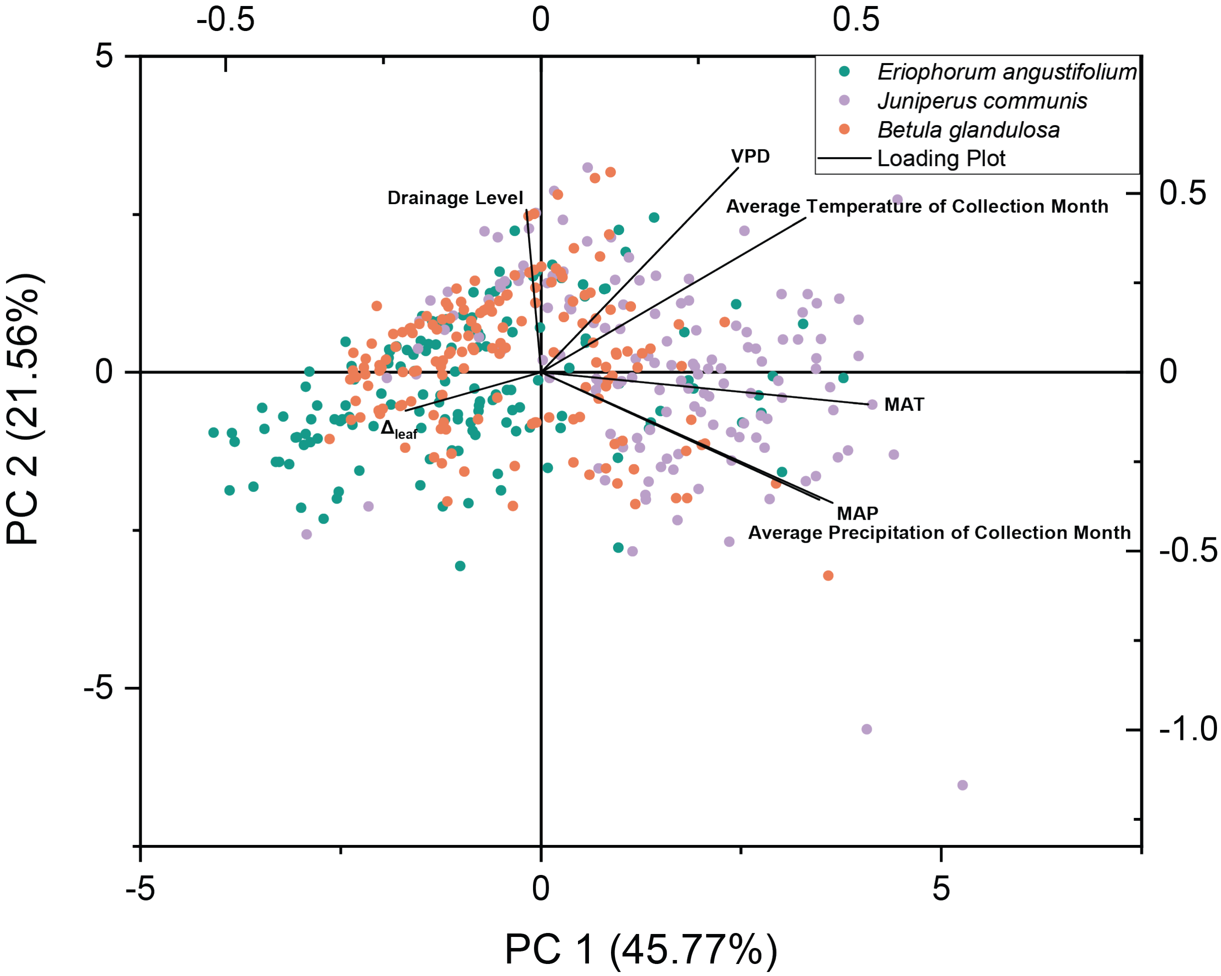


Figure 10. **Biplot of PCA when all three species and all climate variables are considered simultaneously.**

10. Appendix

I. Supplemental Methods

a. Climate Data

   i. In ArcMap, the National Geographic Basemap was used with a WGS 1984 coordinate system. Latitude and longitude coordinates of each individual plant sample used within this study were uploaded as a csv file and coordinate points were turned into a vector shapefile. The following data from WorldClim 2 were downloaded (Fick & Hijmans, 2017)

      1. Average Temperature for Months 3–12 (2.5m resolution)
         a. Pyramid Resampling Technique = Nearest Neighbor
         b. Pyramid Compression Type = Default
         c. Compression Quality = 75
         d. Unit = °C
      2. Water Vapor Pressure for Months 3–12 (2.5m resolution)
         a. Pyramid Resampling Technique = Nearest Neighbor
         b. Pyramid Compression Type = Default
         c. Compression Quality = 75
         d. Unit = kPa
      3. Bioclimatic Variables
         a. BIO1 (annual mean temperature) and BIO12 (annual precipitation)
         b. Pyramid Resampling Technique = Nearest Neighbor
         c. Pyramid Compression Type = Default
         d. Compression Quality = 75
         e. Units = °C and mm

   ii. Values from each climate layer were then extracted to each individual sample point using the Spatial Analyst Tool- Extraction and exported into an excel file.

b. Soil Data

   i. For samples with coordinates within Canada, the vector shapefile of sample locations was plotted onto the National Geographic Basemap, WGS 1984 Coordinate system. The following soil data was uploaded into ArcMap: Soil Landscapes of Canada (SCL) derived from V3.1 and V2.2 – Cartographic 1M (Agriculture and Agri-Food Canada). The sample points were joined to the soil data polygons. For this research only DRAINAGE_CODE was used from output shapefile. The attribute labels were: Very Rapidly Drained, Rapidly Drained, Well Drained, Moderately Well Drained, Imperfectly Drained, Poorly Drained and Very Poorly Drained. For samples with coordinates in the continental United States, soil drainage data from each sample coordinate was manually collected for each location (Soil Survey Staff). The attribute labels were: Excessively drained, Somewhat excessively drained, Well drained, Moderately well drained, Somewhat poorly drained, Poorly drained, and Very Poorly Drained. The codes for each country were combined into numbered bins represented by the numbers in parentheses in an attempt to reconcile the databases. Samples were given a code of 0 if they were listed as unclassified.

1. Canadian Soil Drainage Codes
    a. (1) Very rapidly drained
    b. (1) Rapidly drained
    c. (2) Well drained
    d. (2) Moderately well drained
    e. (3) Imperfectly drained
    f. (4) Poorly drained
    g. (4) Very poorly drained
2. U.S. Soil Drainage Codes
    a. (1) Excessively drained
    b. (1) Somewhat excessively drained
    c. (2) Well drained
    d. (2) Moderately well drained
    e. (3) Somewhat poorly drained
    f. (4) Poorly drained
    g. (4) Very Poorly Drained

c. Calculating Vapor Pressure Deficit (VPD)
    i. VPD was calculated using Eq. (1) for saturated vapor pressure (National Weather Service, 2020).

$$Eq.\ (1)\quad e_s = 6.11 * 10^{\frac{7.5*T}{237.3+T}}$$

Where e_s is saturated vapor pressure (hPa) and T is temperature (°C). To calculate VPD, the actual vapor pressure pulled from Worldclim was subtracted from the saturated vapor pressure. Actual Vapor Pressure pulled was pulled from WorldClim 2, Monthly Average Water Vapor Pressure (kPa) (2.5m Resolution) for months 3 through 12. Temperature was pulled from WorldClim 2, Monthly Average Temperature (°C) (2.5m Resolution) for months 3 through 12. Each monthly VPD was linked to the corresponding month that the sample was collected in.

d. Accounting for missing $\delta^{13}C_{atm}$ values
    i. Two regressions were created in order to account for any yearly missing atmospheric measurements using $\delta^{13}C_{atm}$ measurements (Keeling et al., 2001; Rubino et al., 2013). For samples collected during the year of 1965 or earlier, $\delta^{13}C_{atm}$ values were assigned from Rubino et al. (2013). If samples collected from 1965 or earlier happened to not have a direct $\delta^{13}C_{atm}$ value that it corresponded to, values were extrapolated from a linear regression of all known measurements from Rubino et al. (2013) from 1898 to 1965 (y = -0.0049x + 2.5495). For samples collected in the year 1966 or later, $\delta^{13}C_{atm}$ values were assigned from a combination of measurements from Rubino et al (2013) and Keeling et al. (2001). For sample years without direct measurements a $\delta^{13}C_{atm}$ value was calculated

from the regression line of measured $\delta^{13}C_{atm}$ values from 1966 to 2018 (y = -0.0254x + 42.709). Two individually regression lines were used to select $\delta^{13}C_{atm}$ values, because the isotopic composition of the atmosphere, based on the measurements from Rubino et al. (2013) and Keeling et al. (2001) begins to become more negative around the 1965–1966 mark. To assign $\delta^{13}C_{atm}$ to each sample, the sample collection year and month was used to calculate the Julian calendar # that each sample was collected on Eq. (2).

$$\text{Eq. (2)}\ JJJJJJJJaaJJ\ CCaaJJeeJJCCaaCC = \frac{CCCCJJJJeeCCCCJJCCJJ\ MMCCJJCCh - 1}{12} + CCCCJJJJeeCCCCJJCCJJ\ YYeeaaCC$$

Sample collection day was not included within the Julian calendar number due to the fact that $\delta^{13}C_{atm}$ measurements were only at a monthly resolution post 1980, and that VPD was an average monthly measurement. Each Julian calendar # for each given sample was matched with the $\delta^{13}C_{atm}$ Julian calendar measurement it was closest to.

e. Calculating Δ_{leaf}

$$\text{Eq. (4)}\ \Delta = aa + (bb - aa)\frac{pp_{ii}}{pp_{aa}}$$ (Farquhar et al. 1989).

Where $aa = 4.4‰$ is fractionation due to diffusion of CO_2 and $bb = 27‰$ is fractionation due to carboxylation from the enzyme rubisco (Farquhar et al.,1989)

f. Supplemental Methods Citations

Agriculture and Agri-Food Canada. “Soil Landscapes of Canada (SLC) derived from V3.1 and V2.2 – Cartographic 1M” Feature Layer. https://hub.arcgis.com/datasets/5457d3cb7e674de2b6adc20a2c33fba3?layer=3 (accessed 3 November 2020).

Diefendorf, A.F., Mueller, K.E., Wing, S.L., Koch, P.L., Freeman, K.H., 2010. Global patterns in leaf ^{13}C discrimination and implications for studies of past and future climate. Proc. Natl. Acad. Sci. U. S. A. 107, 5738–5743. https://doi.org/10.1073/pnas.0910513107

Farquhar, G.D., Ehleringer, J.R., Hubick, K.T., 1989. Carbon Isotope Discrimination and Photosynthesis. Annu. Rev. Plant Physiol. Plant Mol. Biol. 40, 503–537.

Fick, S.E. and Hijmans, R.J., 2017. WorldClim 2: new 1-km spatial resolution climate surfaces for global land areas. Int. J. Climatol. 37, 4302-4315. https://doi.org/10.1002/joc.5086

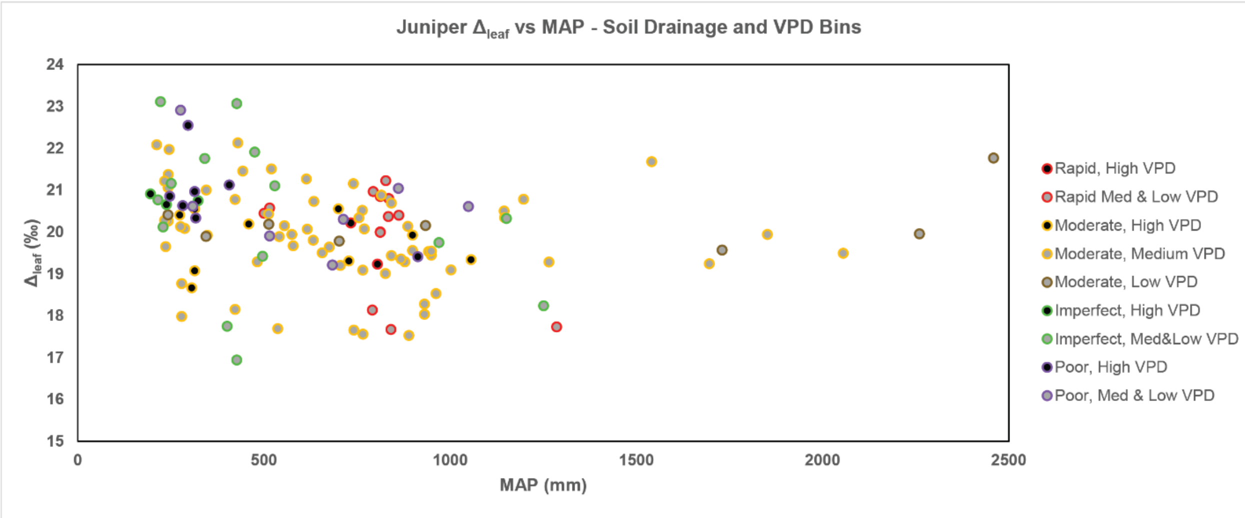
Keeling, C.D., Piper, S.C., Bacastow, R.B., Whalen, M., Whorf, T.P., Heimann, M., Meijer, H.A., 2001. Exchanges of atmospheric CO_2 and $^{13}CO_2$ with the terrestrial biosphere and oceans from 1978 to 2000. I. Global aspects, SIO Reference Series, No. 01-06, Scripps Institution of Oceanography, San Diego, 88 pages.

National Weather Service, 2020. Vapor Pressure. https://www.weather.gov/media/epz/wxcalc/vaporPressure.pdf (accessed 23 October 2020).

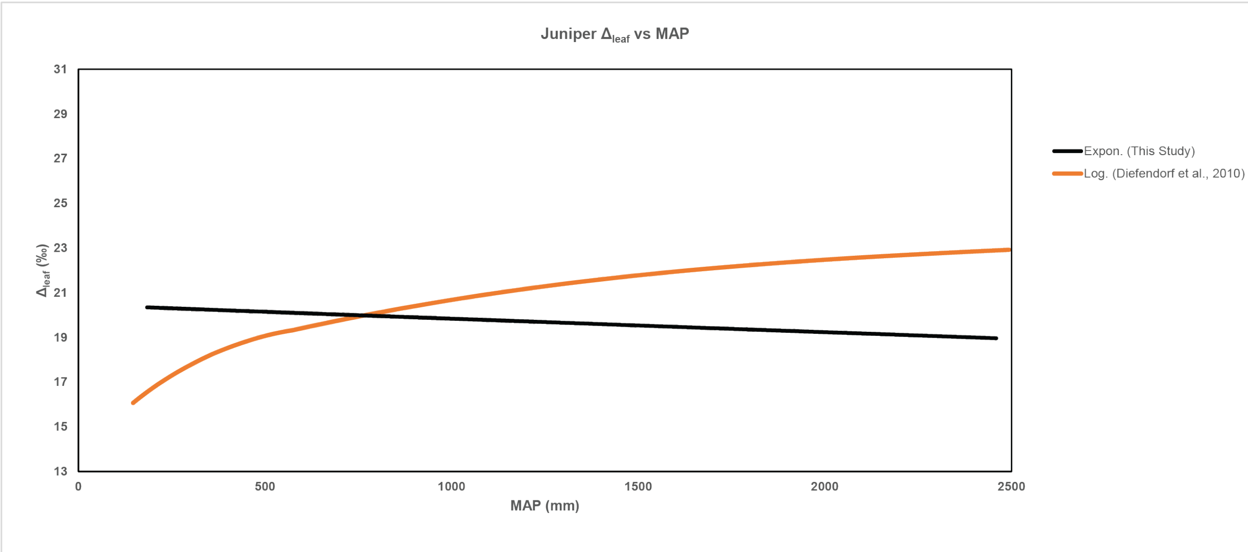
Rubino, M., Etheridge, D.M., Trudinger, C.M., Allison, C.E., Battle, M.O., Langenfelds, R.L., Steele, L.P., Curran, M., Bender, M., White, J.W.C., Jenk, T.M., Blunier, T., Francey, R.J., 2013. A revised 1000 year atmospheric $\delta^{13}C$-CO_2 record from Law Dome and South Pole, Antarctica. J. Geophys. Res. Atmos. 118, 8482–8499. https://doi.org/10.1002/jgrd.50668

Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Web Soil Survey. Available online at the following link: http://websoilsurvey.sc.egov.usda.gov/ (accessed 15 May 2020).

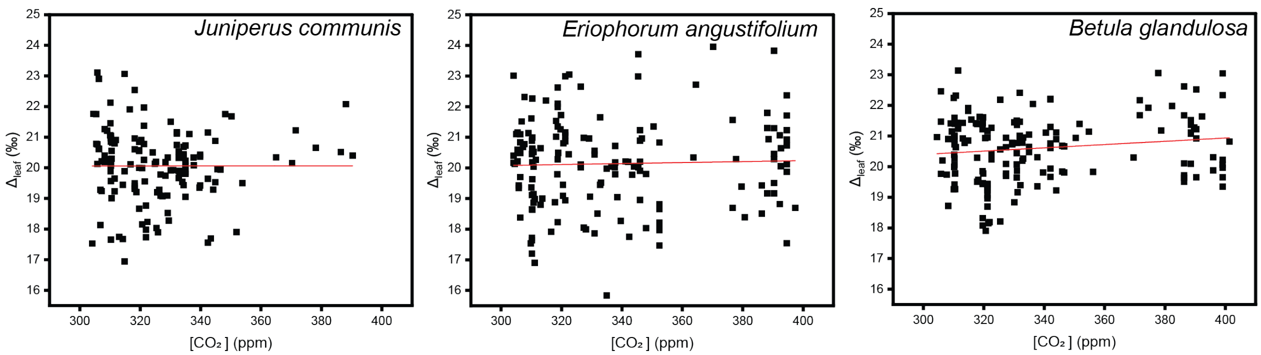
II. Supplemental Figures



***Supplemental Figure 1*. Δ_{leaf} vs. MAP with VPD and soil drainage bins for *Juniperus communis.* Drainage range from rapid drainage to poor drainage. Points filled with black indicate higher VPD levels.**



Supplemental Figure 2. **Exponential relationship of Δ_{leaf} vs. MAP for *Juniperus communis* in this study in comparison to the meta-analysis of multiple species from Diefendorf et al. (2010). Note the increase in Δ_{leaf} values of this study at lower MAP while Diefendorf et al. (2010) shows the opposite.**



Supplemental Figure 3. **Δ_{leaf} vs. [CO_2] for *Juniperus communis*, *Eriophorum angustifolium*, and *Betula glandulosa* respectively (R^2 = 1.21 x 10^{-6}, 0.0011, 0.021; *p*-value = not significant).**

III. Supplemental Tables

Genus, Species	Personal ID #	Collection Year	Collection Month	Collection Day	Herbarium	Collector	Collection #	Retrieval Date	Latitude (°N)	Longitude (°W)	MAP (mm yr-1)*	Monthly Average Precipitation (mm)*	MAT (°C)*	Monthly Avg Temperature (°C)	[CO_2] (ppm)	δ13Catm (‰)	δ13C atm (‰) Source****	δ13C leaf (‰)	VPD (kPa)*	Δleaf (‰)**	Soil Drainage Classification Level***
Juniperus communis	JCUMMAS1	1923	8	4	MICH	H.T. Darlinton		25-Nov-19	46.69	-89.73	889	99	4.42733	17.6	304.1	-6.876058333	EXTRAPOLATED	-23.99	0.493220567	17.53	2
Juniperus communis	JCUMMAS2	1929	9	6	MICH	J. H. Ehlers	4435	25-Nov-19	45.99	-84.95	791	99	5.57183	14.012	306.8	-6.832	Rubino et al. 2013 JGR Atmosphere	-24.52	0.369119439	18.14	1
Juniperus communis	JCUMMAS3	1930	7	20	MICH	R.R. Dreisbhach	6894	25-Nov-19	43.95	-83.27	733	66	7.4905	20.664	307.2	-6.90995	EXTRAPOLATED	-26.59	0.726815811	20.21	1
Juniperus communis	JCUMMAS4	1932	10		MICH	Sister Vincent dePaul McGivney	s.n.	25-Nov-19	43.84	-82.65	862	71	7.6065	9.936	308.2	-6.906437354	Rubino et al. 2013 JGR Atmosphere	-26.76	0.343076503	20.40	1
Juniperus communis	JCUMMAS5	1942	6	2	MICH	Sister M. Marcelline Horton, O.P.	3053	25-Nov-19	45.74	-85.53	769	72	6.02283	15.312	310.3	-6.968341667	EXTRAPOLATED	-26.51	0.460409523	20.08	2
Juniperus communis	JCUMMAS6	1942	7	14	MICH	Harold and Virginia Bailey	4293	25-Nov-19	48.11	-88.54	741	77	3.76417	15.652	310.3	-6.96875	EXTRAPOLATED	-24.20	0.323176417	17.66	2
Juniperus communis	JCUMMAS8	1948	8	9	MICH	Rogers McVaugh	9762	25-Nov-19	46.76	-85.02	861	88	4.5175	17.228	310.3	-7.042682429	Rubino et al. 2013 JGR Atmosphere	-27.50	0.4364674	21.04	4
Juniperus communis	JCUMMAS7	1948	5	12	MICH	Charles D. Richards	581	25-Nov-19	47.24	-88.61	793	65	4.784	9.692	310.3	-7.042682429	Rubino et al. 2013 JGR Atmosphere	-27.43	0.40841227	20.96	1
Juniperus communis	JCUMMAS9	1949	5	14	MICH	Charles D. Richards	1543	25-Nov-19	47.45	-88.10	826	67	4.27883	9.3	310.5	-7.002233333	EXTRAPOLATED	-25.53	0.421092923	19.01	2
Juniperus communis	JCUMMAS10	1952	6	20	MICH	Virginius H. Chase	12678	25-Nov-19	43.81	-86.43	835	74	7.73583	16.968	311.5	-7.017341667	EXTRAPOLATED	-27.25	0.474357588	20.80	1
Juniperus communis	JCUMMAS12	1952	7	12	MICH	Dale A. Zimmerman	641	25-Nov-19	44.90	-86.02	805	66	7.00867	20.084	311.5	-7.01775	EXTRAPOLATED	-25.76	0.699124965	19.23	1
Juniperus communis	JCUMMAS13	1955	8	3	MICH	W.J. Cody and J.M. Matte	9167	25-Nov-19	61.87	-121.37	401	60	-2.6605	14.58	313	-7.032858333	EXTRAPOLATED	-24.35	0.504261549	17.75	3
Juniperus communis	JCUMMAS14	1957	8	20	MICH	E.G. Voss	5312	25-Nov-19	43.65	-86.54	841	96	7.80983	19.876	314.2	-7.070889186	Rubino et al. 2013 JGR Atmosphere	-24.32	0.551442827	17.68	1
Juniperus communis	JCUMMAS20	1980	8	1	MICH	Brain T. Hazlett	1149	25-Nov-19	45.83	-84.60	755	78	5.5075	18.032	337.6	-7.47	Keeling et al. 2001	-27.25	0.489533464	20.34	2

Juniperus communis	JCUMMAS22	2002	8	3	MICH	Timothy L. Walters	8443	25-Nov-19	44.13	-85.53	827	89	6.58083	18.784	371.48	-7.99	Keeling et al. 2001	-28.61	0.52816872	21.23	1
Juniperus communis	JCUMMAS23	2007	5	15	MICH	Timothy L. Walters and Joel Schaeffer	11879	25-Nov-19	44.72	-85.52	764	61	7.1375	12.364	386.41	-8.4	Keeling et al. 2001	-28.34	0.535412038	20.52	2
Juniperus communis	JCCAMAS1	1924	3	5	CANL	H. M. Laing	436	7-Jan-2020	54.32	-130.32	2459	179	7.10614	3.38421	304.5	-6.887120112	Rubino et al. 2013 JGR Atmosphere	-28.04	0.149453675	21.77	2
Juniperus communis	JCCAMAS2	1926	7	23	CANL	M.O. Malte	593	7-Jan-2020	46.45	-62.00	1197	81	5.54028	17.8	305.4	-6.89035	EXTRAPOLATED	-27.11	0.427086576	20.79	2
Juniperus communis	JCCAMAS3	1926	7	15	CANL	Hugh M. Raup	113	7-Jan-2020	58.83	-110.83	391	67	-1.60667	16.872	305.4	-6.89035	EXTRAPOLATED	-28.04	0.583018205	21.76	0
Juniperus communis	JCCAMAS4	1927	7	19	CANL	Hugh M. Raup	118	6-Jan-2020	62.75	-109.10	276	38	-6.43333	14.424	305.8	-6.89525	EXTRAPOLATED	-26.49	0.46360567	20.13	2
Juniperus communis	JCCAMAS5	1927	8	24	CANL	A.E. & R.T. Porsild	3126	7-Jan-2020	68.33	-132.33	215	37	-8.69833	10.048	305.8	-6.895658333	EXTRAPOLATED	-27.10	0.339490723	20.77	3
Juniperus communis	JCCAMAS6	1927	7	18	CANL	A.E. & R.T. Porsild	2033	7-Jan-2020	69.00	-134.67	222	32	-9.088	12.928	305.8	-6.89525	EXTRAPOLATED	-29.33	0.458372331	23.11	3
Juniperus communis	JCCAMAS7	1928	9	1	CANL	A.E. & R.T. Porsild	3356	7-Jan-2020	64.97	-123.67	276	39	-5.75383	5.9	306.3	-6.900966667	EXTRAPOLATED	-29.14	0.218945481	22.91	4
Juniperus communis	JCCAMAS8	1928	6	16	CANL	A.E. & R.T. Porsild	3238	7-Jan-2020	64.95	-123.80	282	30	-5.75467	13.6	306.3	-6.899741667	EXTRAPOLATED	-26.97	0.725236725	20.63	4
Juniperus communis	JCCAMAS9	1928	5	11	CANL	A.E. & R.T. Porsild	3188	7-Jan-2020	64.92	-125.70	309	15	-5.2955	5.856	306.3	-6.899333333	EXTRAPOLATED	-26.96	0.438117288	20.61	4
Juniperus communis	JCCAMAS10	1929	7	23	CANL	P. Louis-Marie, O.C.; L. Laporte; & H. Dudemaine		6-Jan-2020	46.12	-71.57	1265	126	4.00167	18.508	306.8	-6.832	Rubino et al. 2013 JGR Atmosphere	-25.62	0.50504795	19.28	2
Juniperus communis	JCCAMAS11	1930	8	6 to 7	CANL	Jacques Rousseau	35334	7-Jan-2020	45.38	-61.50	1696	112	5.88056	18.1	307.2	-6.910358333	EXTRAPOLATED	-25.66	0.385922781	19.24	2
Juniperus communis	JCCAMAS12	1932	7	21	CANL	Hugh M. Raup & Ernst C. Abbe	4001	7-Jan-2020	56.05	-123.68	614	79	0.95883	12.904	308.2	-6.906437354	Rubino et al. 2013 JGR Atmosphere	-27.59	0.543231629	21.27	2
Juniperus communis	JCCAMAS13	1932	6	12	CANL	Hugh M. Raup & Ernst C. Abbe	3544	7-Jan-2020	56.13	-120.67	459	71	2.6185	14.572	308.2	-6.906437354	Rubino et al. 2013 JGR Atmosphere	-26.56	0.675003767	20.19	2
Juniperus communis	JCCAMAS14	1934	7	21	CANL	A.E. Porsild	7009	6-Jan-2020	68.67	-134.12	233	32	-8.65967	13.152	309	-6.92955	EXTRAPOLATED	-27.56	0.503174955	21.21	2
Juniperus communis	JCCAMAS15	1937	7	23	CANL	C.H.D. Clarke		6-Jan-2020	64.17	-104.08	242	39	-10.46683	13.48	310	-6.95017	Rubino et al. 2013	-27.43	0.563107102	21.06	2

																1241	JGR Atmosphere				
Juniperus communis	JCCAMAS16	1939	6	20	CANL	H.M. Laing	435	6-Jan-2020	52.83	-126.95	1730	74	5.38455	11.1458	310.3	-6.994140442	Rubino et al. 2013 JGR Atmosphere	-26.05	0.292138202	19.57	2
Juniperus communis	JCCAMAS17	1939	7	28	CANL	H.M. Raup & J.H. Soper	9603	7-Jan-2020	62.08	-127.58	555	87	-5.49917	10.716	310.3	-6.994140442	Rubino et al. 2013 JGR Atmosphere	-26.61	0.44812507	20.15	2
Juniperus communis	JCCAMAS18	1943	6	26	CANL	H.M Raup & D.S. Correll	10304	7-Jan-2020	57.23	-122.72	575	109	0.683	11.44	310.2	-6.973241667	EXTRAPOLATED	-26.39	0.53280933	19.94	2
Juniperus communis	JCCAMAS19	1944	6	2	CANL	A.E. Porsild	9039	6-Jan-2020	59.42	-126.17	443	52	-0.90417	13.028	310.1	-6.978141667	EXTRAPOLATED	-27.84	0.571359926	21.46	2
Juniperus communis	JCCAMAS20	1944	7	9	CANL	V.C. Wynne-Edwards	8423	7-Jan-2020	62.08	-123.33	430	74	-3.95167	15.036	310.1	-6.97855	EXTRAPOLATED	-28.48	0.561400233	22.13	2
Juniperus communis	JCCAMAS21	1947	7	12	CANL	Francis Harper	2295	7-Jan-2020	60.60	-99.80	348	60	-8.21967	13.82	310.2	-7.013360568	Rubino et al. 2013 JGR Atmosphere	-26.41	0.552091285	19.92	2
Juniperus communis	JCCAMAS22	1947	8	8	CANL	Francis Harper	2401	7-Jan-2020	60.60	-99.99	345	50	-8.41683	12.064	310.2	-7.013360568	Rubino et al. 2013 JGR Atmosphere	-27.44	0.403313355	21.00	2
Juniperus communis	JCCAMAS23	1947	10	20	CANL	Francis Harper	2543	7-Jan-2020	60.55	-100.19	344	40	-8.379	-4.296	310.2	-7.013360568	Rubino et al. 2013 JGR Atmosphere	-26.38	0.034385953	19.89	2
Juniperus communis	JCCAMAS24	1948	7	10	CANL	Hansford T. Shacklette	2905	7-Jan-2020	66.08	-118.03	233	34	-7.40017	11.608	310.3	-7.042682429	Rubino et al. 2013 JGR Atmosphere	-26.78	0.373927408	20.28	2
Juniperus communis	JCCAMAS25	1948	7	20	CANL	Hansford T. Shacklette	3112	7-Jan-2020	65.72	-118.90	247	37	-6.98633	14.12	310.3	-7.042682429	Rubino et al. 2013 JGR Atmosphere	-27.33	0.623568421	20.85	4
Juniperus communis	JCCAMAS26	1949	8	27	CANL	J. Ewan	18516	6-Jan-2020	49.38	-115.22	700	38	5.33333	17.22	310.5	-7.003458333	EXTRAPOLATED	-27.00	0.882272327	20.55	2
Juniperus communis	JCCAMAS27	1949	7	10	CANL	W.K.W. Baldwin	1593	7-Jan-2020	52.42	-80.25	713	104	-1	15	310.5	-7.00305	EXTRAPOLATED	-26.76	0.455842581	20.30	4
Juniperus communis	JCCAMAS28	1950	7	10	CANL	William H. Drury, Jr.	4214	6-Jan-2020	61.92	-154.42	465	82	-2.28217	12.836	310.7	-7.006340998	Rubino et al. 2013 JGR Atmosphere	-27.27	0.423817212	20.83	0
Juniperus communis	JCCAMAS29	1952	7	29	CANL	John S. Tener	119	6-Jan-2020	64.04	-103.85	236	39	-10.501	13.596	311.5	-7.01775	EXTRAPOLATED	-26.15	0.552030994	19.65	2
Juniperus communis	JCCAMAS30	1953	6	27	CANL	E.H. McEwen	54	6-Jan-2020	68.17	-131.47	195	18	-8.41383	11.968	311.9	-7.022241667	EXTRAPOLATED	-27.36	0.650424314	20.91	3
Juniperus	JCCAMAS31	1957	6	30	CANL	T.C. Brayshaw		6-Jan-	44.00	-77.13	949	74	7.39717	17.676	314.2	-7.071	Rubino et al.	-26.01	0.56529115	19.45	2

communis								2020									2013 JGR Atmosphere				
Juniperus communis	JCCAMAS32	1959	6	25	CANL	John W. Thieret & Robert J. Reich	4738	6-Jan-2020	61.07	-117.15	296	28	-2.8125	13.636	318.15	-7.066511729	Rubino et al. 2013 JGR Atmosphere	-28.96	0.611691761	22.55	4
Juniperus communis	JCCAMAS33	1959	6	25	CANL	John W. Thieret & Robert J. Reich	4769	6-Jan-2020	60.93	-117.72	314	32	-2.57767	13.712	318.15	-7.066511729	Rubino et al. 2013 JGR Atmosphere	-27.46	0.629432839	20.96	4
Juniperus communis	JCCAMAS34	1959	8	5	CANL	W.W. Jeffrey	404	7-Jan-2020	60.75	-123.97	541	75	-3.043	10.656	314.8	-7.066511729	Rubino et al. 2013 JGR Atmosphere	-26.43	0.443783533	19.89	2
Juniperus communis	JCCAMAS35	1959	8	21	CANL	W.W. Jeffrey	619	7-Jan-2020	61.03	-123.38	427	59	-2.39217	14.892	314.8	-7.066511729	Rubino et al. 2013 JGR Atmosphere	-29.46	0.500418099	23.07	3
Juniperus communis	JCCAMAS36	1959	7	1	CANL	W.W. Jeffrey	19	7-Jan-2020	60.03	-123.50	475	94	-1.75233	15.608	316.54	-7.066511729	Rubino et al. 2013 JGR Atmosphere	-28.35	0.563769827	21.91	3
Juniperus communis	JCCAMAS37	1959	8	22	CANL	W.W. Jeffrey	664a	7-Jan-2020	61.03	-123.38	427	59	-2.39217	14.892	314.8	-7.066511729	Rubino et al. 2013 JGR Atmosphere	-23.61	0.500418099	16.94	3
Juniperus communis	JCCAMAS38	1960	7	13	CANL	Yves Desmarais	1899	6-Jan-2020	50.23	-62.22	1049	96	1.47024	14.3	318.18	-7.05695	EXTRAPOLATED	-27.11	0.29047099	20.61	4
Juniperus communis	JCCAMAS39	1960	7	27	CANL	K. Beamish & F. Vrugtman	60913	6-Jan-2020	49.42	-123.08	2055	61	5.74783	13.072	318.18	-7.05695	EXTRAPOLATED	-26.04	0.47168429	19.49	2
Juniperus communis	JCCAMAS40	1960	7	28	CANL	H.J. Scoggan	14574	7-Jan-2020	43.27	-81.25	1056	86	7.142	20.256	318.18	-7.05695	EXTRAPOLATED	-25.90	0.642657648	19.34	2
Juniperus communis	JCCAMAS41	1960	7	25	CANL	W.K.W. Baldwin	8463	7-Jan-2020	50.10	-91.95	728	88	1.4395	18.816	318.18	-7.05695	EXTRAPOLATED	-25.87	0.685708997	19.31	2
Juniperus communis	JCCAMAS42	1960	7	25	CANL	H.J. Scoggan	14532	7-Jan-2020	41.97	-82.52	913	84	9.4955	22.344	318.18	-7.05695	EXTRAPOLATED	-25.96	0.820619512	19.41	4
Juniperus communis	JCCAMAS43	1960	6	25	CANL	A.E. & R.T. Porsild	21944	7-Jan-2020	59.00	-125.00	515	72	-0.521	12.244	319.59	-7.056541667	EXTRAPOLATED	-27.07	0.548914077	20.57	1
Juniperus communis	JCCAMAS44	1961	8	4	CANL	E. Kuyt	123	6-Jan-2020	64.33	-103.40	229	39	-10.89833	10.788	316.79	-7.062258333	EXTRAPOLATED	-26.64	0.365518901	20.12	3
Juniperus communis	JCCAMAS45	1962	7	7	CANL	P.M. Youngman & Gaston Tessier	46	6-Jan-2020	67.77	-136.03	314	44	-7.74233	13.296	319.61	-7.091484283	Rubino et al. 2013 JGR Atmosphere	-27.09	0.623869432	20.55	2
Juniperus communis	JCCAMAS47	1962	6	7	CANL	Lloyd A. Spetzman	5	6-Jan-2020	62.38	-140.87	422	73	-5.113	11.724	320.62	-7.091484283	Rubino et al. 2013 JGR Atmosphere	-24.80	0.55285257	18.15	2
Juniperus	JCCAMAS48	1962	7	8	CANL	Lloyd A.	10	6-Jan-	60.78	-136.47	306	44	-1.3145	13.476	319.61	-7.09148	Rubino et al.	-25.29	0.61070	18.67	2

communis						Spetzman		2020								4283	2013 JGR Atmosphere		4246		
Juniperus communis	JCCAMAS49	1962	7	3	CANL	W.K.W. Baldwin	9661	7-Jan-2020	53.20	-70.90	812	111	-3.905	13.48	319.61	-7.091484283	Rubino et al. 2013 JGR Atmosphere	-26.56	0.365907202	20.00	1
Juniperus communis	JCCAMAS50	1962	7	7	CANL	W.K.W. Baldwin	9699	7-Jan-2020	53.20	-70.90	812	111	-3.905	13.48	319.61	-7.091484283	Rubino et al. 2013 JGR Atmosphere	-27.37	0.365907202	20.85	1
Juniperus communis	JCCAMAS51	1962	6	30	CANL	W.K.W. Baldwin	9629	7-Jan-2020	53.20	-70.90	812	88	-3.905	9.384	320.62	-7.091484283	Rubino et al. 2013 JGR Atmosphere	-26.55	0.298543129	19.99	1
Juniperus communis	JCCAMAS52	1963	6	30	CANL	L. Hustich & P. Kallio	127	6-Jan-2020	53.58	-64.33	899	89	-3.36733	9.48	321.48	-7.055	Rubino et al. 2013 JGR Atmosphere	-26.10	0.378584005	19.56	2
Juniperus communis	JCCAMAS53	1964	8	5	CANL	W.K.W. Baldwin	10243	6-Jan-2020	51.28	-80.12	684	77	-0.32163	15.3952	318.69	-7.076958333	EXTRAPOLATED	-25.79	0.439730488	19.21	4
Juniperus communis	JCCAMAS54	1965	7	16	CANL	P.M. Youngman & G. Tessier	715	6-Jan-2020	64.70	-127.92	422	66	-6.84217	10.548	321.21	-7.08145	EXTRAPOLATED	-27.29	0.483774137	20.78	2
Juniperus communis	JCCAMAS55	1965	7	2	CANL	G.B. Rossbach	6432	6-Jan-2020	63.87	-104.03	245	40	-10.15817	14.02	321.21	-7.08145	EXTRAPOLATED	-28.43	0.588350371	21.97	2
Juniperus communis	JCCAMAS56	1965	6	23	CANL	G.B. Rossbach	6300	6-Jan-2020	62.45	-114.35	279	26	-4.62267	12.216	321.87	-7.081041667	EXTRAPOLATED	-25.37	0.588289061	18.77	2
Juniperus communis	JCCAMAS57	1965	6	23	CANL	G.B. Rossbach	6300	6-Jan-2020	62.45	-114.35	279	26	-4.62267	12.216	321.87	-7.081041667	EXTRAPOLATED	-24.62	0.588289061	17.98	2
Juniperus communis	JCCAMAS58	1965	7	3	CANL	G.B. Rossbach	6457	6-Jan-2020	63.95	-103.88	243	39	-10.26833	13.904	321.21	-7.08145	EXTRAPOLATED	-26.80	0.584739406	20.27	2
Juniperus communis	JCCAMAS59	1965	7	3	CANL	G.B. Rossbach	6457	6-Jan-2020	63.95	-103.88	243	39	-10.26833	13.904	321.21	-7.08145	EXTRAPOLATED	-27.86	0.584739406	21.37	2
Juniperus communis	JCCAMAS60	1965	6	16	CANL	P.R. Roberts & B. Pugh	65-711	7-Jan-2020	45.73	-64.70	1286	102	5.69625	17.48	321.87	-7.081041667	EXTRAPOLATED	-24.38	0.354033462	17.74	1
Juniperus communis	JCCAMAS61	1966	7	20	CANL	V. Blais, Cl. Hamel, A. Legault	11,441	6-Jan-2020	45.88	-71.50	1251	122	3.7155	15.096	322.38	-7.235	Rubino et al. 2013 JGR Atmosphere	-25.02	0.417213723	18.24	3
Juniperus communis	JCCAMAS62	1967	6	12	CANL	Samuel Brisson & Claude Hamel	12,213	6-Jan-2020	45.82	-71.35	1145	111	4.2465	18.7	324.09	-7.333	Rubino et al. 2013 JGR Atmosphere	-27.28	0.520811836	20.50	2
Juniperus communis	JCCAMAS63	1968			CANL	R.T. Porsild	1519	6-Jan-2020										-25.28			
Juniperus communis	JCCAMAS64	1968	6	26	CANL	W.S. Dickinson	330	6-Jan-2020	44.28	-77.78	931	84	6.657	17.42	325.36	-7.288783333	EXTRAPOLATED	-24.88	0.566877882	18.04	2

Juniperus communis	JCCAMAS65	1968	9	7	CANL	J.E. Cruise	10854	7-Jan-2020	45.15	-78.85	1083	109	4.5345	13.064	320.33	-7.295133333	EXTRAPOLATED	-27.63	0.247297281	20.92	0
Juniperus communis	JCCAMAS66	1968	5	2	CANL	C.E. Garton	10770	7-Jan-2020	48.35	-89.25	705	68	3.5665	9.912	325.57	-7.286666667	EXTRAPOLATED	-25.99	0.467509919	19.20	2
Juniperus communis	JCCAMAS67	1969	7	31	CANL	J. Nagy & W. Blais	2460	6-Jan-2020	49.08	-114.02	848	59	1.18733	12.148	325.88	-7.305	Rubino et al. 2013 JGR Atmosphere	-24.76	0.593131886	17.90	0
Juniperus communis	JCCAMAS68	1969	6	25	CANL	C.E. Garton	11804	7-Jan-2020	49.38	-88.87	765	83	1.1125	13.956	326.71	-7.305	Rubino et al. 2013 JGR Atmosphere	-25.90	0.492113911	19.09	2
Juniperus communis	JCCAMAS69	1969	6	1	CANL	C.E. Garton	11602	7-Jan-2020	48.38	-88.95	702	78	3.4005	12.1	326.71	-7.305070711	Rubino et al. 2013 JGR Atmosphere	-26.56	0.269059542	19.78	2
Juniperus communis	JCCAMAS70	1970			CANL	Keith Winterhalder		6-Jan-2020	45.70	-82.38	844		5.50283					-24.49			1
Juniperus communis	JCCAMAS71	1971	7	5	CANL	G.W Argus & W.N. Chunys	7921	6-Jan-2020	60.78	-116.58	314	44	-2.679	16.404	327.36	-7.347751263	Rubino et al. 2013 JGR Atmosphere	-25.93	0.625478234	19.07	2
Juniperus communis	JCCAMAS72	1971	5	7	CANL	P.M. Catling, L. Gad, H. Saifi, & S. McKay		7-Jan-2020	44.62	-79.02	1002	90	5.68967	11.592	328.93	-7.347751263	Rubino et al. 2013 JGR Atmosphere	-25.95	0.437681241	19.10	2
Juniperus communis	JCCAMAS73	1972	6	7	CANL	D.E. Reid	325	6-Jan-2020	65.67	-128.80	317	32	-5.78983	15.128	329.09	-7.356148164	Rubino et al. 2013 JGR Atmosphere	-27.14	0.79115039	20.34	4
Juniperus communis	JCCAMAS74	1972	10	17	CANL	M.J. Shchepanek	762	7-Jan-2020	45.23	-76.92	911	80	4.71733	7.296	325.2	-7.356148164	Rubino et al. 2013 JGR Atmosphere	-27.01	0.217920713	20.20	0
Juniperus communis	JCCAMAS75	1972	9	28	CANL	M.J. Shchepanek	722	7-Jan-2020	45.18	-76.55	886	87	5.08567	13.816	324.84	-7.356148164	Rubino et al. 2013 JGR Atmosphere	-26.95	0.34088043	20.13	2
Juniperus communis	JCCAMAS76	1972	5	18	CANL	M.J. Shchepanek	452	7-Jan-2020	45.17	-77.33	949	84	4.15217	10.412	330.07	-7.356148164	Rubino et al. 2013 JGR Atmosphere	-26.74	0.411859716	19.92	0
Juniperus communis	JCCAMAS77	1972	6	22	CANL	M.J. Shchepanek & E. Haber	581	7-Jan-2020	44.97	-76.72	962	102	5.03983	16.512	329.09	-7.356148164	Rubino et al. 2013 JGR Atmosphere	-25.41	0.538349697	18.53	2
Juniperus communis	JCCAMAS78	1972	8	31	CANL	M.J. Shchepanek, E. Haber, & G. Savage	687	7-Jan-2020	45.43	-77.10	878	81	4.66667	18.244	326.32	-7.356148164	Rubino et al. 2013 JGR Atmosphere	-26.14	0.536062735	19.29	2

Juniperus communis	JCCAMAS79	1973	6	16	CANL	N.A. Skoglund	795x	6-Jan-2020	61.45	-121.25	407	58	-2.5815	14.4	332.07	-7.392841953	Rubino et al. 2013 JGR Atmosphere	-27.93	0.651056145	21.12	4
Juniperus communis	JCCAMAS80	1973	6	25	CANL	S.L. Welsh & J.K. Rigby	12080	6-Jan-2020	68.73	-136.32	251	23	-9.25833	8.848	332.07	-7.392841953	Rubino et al. 2013 JGR Atmosphere	-27.96	0.386671841	21.16	3
Juniperus communis	JCCAMAS81	1973	6	20	CANL	D.F. Murray	3670	6-Jan-2020	67.42	-153.72	323	32	-5.97067	11.608	332.07	-7.392841953	Rubino et al. 2013 JGR Atmosphere	-27.57	0.602327408	20.75	3
Juniperus communis	JCCAMAS82	1973	7	17	CANL	M.J. Shchepanek	780	7-Jan-2020	45.37	-76.03	899	92	5.293	20.272	330.87	-7.392841953	Rubino et al. 2013 JGR Atmosphere	-26.79	0.715407295	19.93	2
Juniperus communis	JCCAMAS83	1974	8	8	CANL	E. Haber & J. Bergeron	2421	6-Jan-2020	52.12	-72.50	931	120	-2.66033	12.984	329.39	-7.4826114	Rubino et al. 2013 JGR Atmosphere	-25.30	0.382646462	18.28	2
Juniperus communis	JCCAMAS84	1975	10	17	CANL	Kathleen Pryer	131	6-Jan-2020	45.54	-75.99	970	90	5.0825	7.548	328.34	-7.417906395	Rubino et al. 2013 JGR Atmosphere	-26.64	0.248509077	19.75	3
Juniperus communis	JCCAMAS85	1975	10	15	CANL	R. Rosie	104	7-Jan-2020	61.57	-124.82	513	36	-5.218	-3.62	328.34	-7.417906395	Rubino et al. 2013 JGR Atmosphere	-27.06	0.195580819	20.19	2
Juniperus communis	JCCAMAS86	1975	8	23	CANL	R. Rosie	105	7-Jan-2020	61.43	-129.33	520	62	-4.19317	10.224	330.06	-7.417906395	Rubino et al. 2013 JGR Atmosphere	-28.32	0.459293474	21.51	2
Juniperus communis	JCCAMAS87	1976	7	2	CANL	J.L. Riley & D.A. Hoy	3244	6-Jan-2020	48.58	-86.30	835	91	3.23283	13.528	333.05	-7.442709622	Rubino et al. 2013 JGR Atmosphere	-26.73	0.160748974	19.82	0
Juniperus communis	JCCAMAS88	1976	6	20	CANL	A.W. Dugal	297	6-Jan-2020	49.67	-99.28	500	88	2.73967	16.732	334.33	-7.442709622	Rubino et al. 2013 JGR Atmosphere	-27.33	0.548410355	20.45	1
Juniperus communis	JCCAMAS89	1976	6	11	CANL	G.A. Shea	11,010	7-Jan-2020	49.45	-83.40	842	77	0.6195	13.76	334.33	-7.442709622	Rubino et al. 2013 JGR Atmosphere	-27.56	0.484339289	20.69	2
Juniperus communis	JCCAMAS90	1976	6	11	CANL	G.A. Shea	11,013	7-Jan-2020	49.45	-83.40	842	77	0.6195	13.76	334.33	-7.442709622	Rubino et al. 2013 JGR Atmosphere	-26.37	0.484339289	19.44	2
Juniperus communis	JCCAMAS91	1976	6	13	CANL	R.R. Riewe & J. Marsh	16	7-Jan-2020	67.33	-126.42	242	23	-7.98183	7.94	334.33	-7.442709622	Rubino et al. 2013 JGR Atmosphere	-27.30	0.288721558	20.41	2
Juniperus communis	JCCAMAS92	1977	7	28	CANL	G.W. Argus & E.	10134	6-Jan-2020	57.33	-123.93	702	116	-3.38233	8.48	334.92	-7.485	Rubino et al. 2013 JGR	-26.82	0.427087623	19.87	0

						Haber											Atmosphere				
Juniperus communis	JCCAMAS93	1977	7	20	CANL	John M. Gillett & M. Boudreau	17301	6-Jan-2020	56.55	-126.42	632	73	-1.68233	10.696	334.92	-7.485	Rubino et al. 2013 JGR Atmosphere	-26.76	0.471209245	19.81	2
Juniperus communis	JCCAMAS94	1977	8	5	CANL	G.W. Argus & E. Haber	10641	6-Jan-2020	57.75	-124.78	678	83	-3.70017	8.672	332.75	-7.485	Rubino et al. 2013 JGR Atmosphere	-27.45	0.456811517	20.53	0
Juniperus communis	JCCAMAS95	1977	7	30	CANL	John M. Gillett & M. Boudreau	17578	6-Jan-2020	57.68	-126.78	612	80	-2.9855	9.944	334.92	-7.485	Rubino et al. 2013 JGR Atmosphere	-26.04	0.447732669	19.05	0
Juniperus communis	JCCAMAS96	1977	7	19	CANL	G.W. Argus & E. Haber	10757	6-Jan-2020	58.45	-124.88	634	114	-3.82917	9.1	334.92	-7.485	Rubino et al. 2013 JGR Atmosphere	-27.64	0.402591729	20.73	2
Juniperus communis	JCCAMAS97	1977	7	29	CANL	G.W. Argus & E. Haber	10192	6-Jan-2020	56.90	-123.80	729	112	-3.19917	8.796	334.92	-7.485	Rubino et al. 2013 JGR Atmosphere	-27.17	0.442680219	20.23	0
Juniperus communis	JCCAMAS98	1977	8	5	CANL	John M. Gillett & M. Boudreau	17784	6-Jan-2020	57.87	-126.40	578	66	-2.32983	9.968	332.75	-7.485	Rubino et al. 2013 JGR Atmosphere	-26.63	0.456902967	19.67	2
Juniperus communis	JCCAMAS99	1977	7	25	CANL	John M. Gillett & M. Boudreau	17477	6-Jan-2020	57.43	-126.80	616	77	-2.18017	10.804	334.92	-7.485	Rubino et al. 2013 JGR Atmosphere	-27.01	0.468898829	20.07	2
Juniperus communis	JCCAMAS100	1977	8	5	CANL	M.J. Shchepanek & D. White	2805	7-Jan-2020	49.80	-56.32	1151	107	2.906	14.94	332.75	-7.485	Rubino et al. 2013 JGR Atmosphere	-27.26	0.36446452	20.33	3
Juniperus communis	JCCAMAS101	1977	6	16	CANL	L.R. Williams	74	7-Jan-2020	55.73	-97.83	529	70	-2.4605	13.48	336.27	-7.485	Rubino et al. 2013 JGR Atmosphere	-28.00	0.584707102	21.11	3
Juniperus communis	JCCAMAS102	1977	8	12	CANL	J.L. Riley	7491	7-Jan-2020	55.87	-86.77	515	75	-5.08551	11.8435	332.75	-7.485	Rubino et al. 2013 JGR Atmosphere	-26.85	0.258569663	19.90	4
Juniperus communis	JCCAMAS103	1979	9	19	CANL	J.M Gillett & M.J. Shchepanek	18474	7-Jan-2020	44.88	-77.17	949	98	5.06833	13.832	333.91	-7.54	Rubino et al. 2013 JGR Atmosphere	-26.57	0.327324112	19.54	2
Juniperus communis	JCCAMAS104	1979	7	1	CANL	R. Rosie	740	7-Jan-2020	60.27	-134.18	287	38	-1.16983	12.204	337.73	-7.54	Rubino et al. 2013 JGR Atmosphere	-27.08	0.570765471	20.08	2
Juniperus communis	JCCAMAS105	1980	7	7	CANL	S. Clayden & C. Lefrançois (s.n.)	80-356	6-Jan-2020	48.52	-79.52	868	96	1.26133	16.972	339.56	-7.59	Keeling et al. 2001	-26.43	0.513648048	19.36	2
Juniperus	JCCAMAS106	1982	8	15	CANL	D.F. Brunton &	3837	6-Jan-	48.33	-83.75	834	79	1.55017	15.792	339.81	-7.46	Keeling et	-27.27	0.41038	20.37	1

communis						J. Harper		2020									al. 2001		8696		
Juniperus communis	JCCAMAS107	1982	8	8	CANL	M.J. Shchepanek & A.W. Dugal	4549	6-Jan-2020	51.93	-98.80	512	70	0.82233	16.384	339.81	-7.46	Keeling et al. 2002	-27.33	0.383903299	20.43	2
Juniperus communis	JCCAMAS108	1982	8	13	CANL	M.J. Shchepanek & A.W. Dugal	4802	6-Jan-2020	52.92	-98.78	496	70	0.45867	17.356	339.81	-7.46	Keeling et al. 2003	-26.37	0.5396461	19.42	3
Juniperus communis	JCCAMAS109	1982	5	20	CANL	J. Campbell-Snelling & M. Chambers	179	6-Jan-2020	49.57	-113.73	482	64	5.50633	10.516	344.14	-7.8	Keeling et al. 2001	-26.58	0.593456559	19.29	2
Juniperus communis	JCCAMAS110	1982	6	17	CANL	J. Campbell-Snelling & M. Chambers	145	6-Jan-2020	49.72	-113.77	537	71	4.19933	8.864	343.35	-7.71	Keeling et al. 2001	-24.96	0.535902572	17.69	2
Juniperus communis	JCCAMAS111	1983	8	11	CANL	M.J. Shchepanek & A. Dugal	5399	6-Jan-2020	49.75	-91.18	740	82	0.94667	16.392	342.38	-7.58	Keeling et al. 2001	-28.14	0.476052955	21.16	2
Juniperus communis	JCCAMAS112	1983	8	14	CANL	M.J. Shchepanek & A. Dugal	5509	6-Jan-2020	48.78	-93.03	675	86	2.94917	17.772	342.38	-7.58	Keeling et al. 2002	-26.70	0.539164455	19.64	2
Juniperus communis	JCCAMAS113	1983	8	11	CANL	Claude Potvin		6-Jan-2020	46.07	-83.93	766	78	5.37767	18.468	342.38	-7.58	Keeling et al. 2001	-24.71	0.566114771	17.56	2
Juniperus communis	JCCAMAS114	1985	12	10	CANL	F.W. Schueler	15904	6-Jan-2020	53.50	-132.50	2260	267	6.86167	2.72	345.56	-7.63	Keeling et al. 2001	-27.05	0.115477528	19.96	2
Juniperus communis	JCCAMAS115	1985	7	13	CANL	M.J. Shchepanek & A.W. Dugal	6787	7-Jan-2020	53.50	-132.25	1852	64	7.65333	13.6	346.56	-7.68	Keeling et al. 2001	-27.08	0.317636725	19.94	2
Juniperus communis	JCCAMAS116	1986	9	24	CANL	M.J. Shchepanek & A.W. Dugal	7430	6-Jan-2020	45.30	-76.33	815	78	5.20917	14.288	344.85	-7.47	Keeling et al. 2001	-27.77	0.372404686	20.88	2
Juniperus communis	JCCAMAS117	1986	9	9	CANL	M.J. Shchepanek, A.W. Dugal, & G. Watson	7295	6-Jan-2020	44.75	-76.53	942	101	6.03017	14.8	344.85	-7.47	Keeling et al. 2002	-26.49	0.390402312	19.53	2
Juniperus communis	JCCAMAS118	1986	5	9	CANL	F.W. Schueler	16157	6-Jan-2020	49.08	-122.63	1541	98	10.08683	12.552	350.21	-7.83	Keeling et al. 2001	-28.88	0.445270259	21.68	2
Juniperus communis	JCCAMAS119	1987	8	7	CANL	T. Lockhart		6-Jan-2020	60.58	-111.87	341	50	-3.25983	14.348	348.1	-7.62	Keeling et al. 2001	-28.75	0.431144433	21.76	3
Juniperus communis	JCCAMAS120	1987	5	21	CANL	M.J. Shchepanek, A.W. Dugal, &	7539	6-Jan-2020	44.55	-77.12	937	82	6.216	12.26	351.85	-7.82	Keeling et al. 2001	-25.27	0.487215933	17.90	0

						L.M. Ley															
Juniperus communis	JCCAMAS121	1988	6	22	CANL	M.J. Shchepanek & A.W. Dugal	8227	6-Jan-2020	48.70	-93.12	656	102	3.0115	16.128	353.79	-7.88	Keeling et al. 2001	-26.86	0.563734876	19.50	2
Juniperus communis	JCCAMAS122	1996	6	30	CANL	René Charest & Luc Brouillet	96-24	6-Jan-2020	48.65	-53.94	1146	97	4.46319	11.5889	364.97	-8.08	Keeling et al. 2001	-27.86	0.365957162	20.34	2
Juniperus communis	JCCAMAS123	2002	10		CANL	Drouin, Guy, J. Xia, & M. Hajibabaei		6-Jan-2020	45.43	-75.82	934	80	5.35117	7.884	370.25	-7.96	Keeling et al. 2001	-27.56	0.264650403	20.15	2
Juniperus communis	JCCAMAS124	2003	6	3	CANL	Myrna Pokiak	1	6-Jan-2020	68.30	-133.53	238	22	-8.3895	12.184	378.13	-8.29	Keeling et al. 2001	-28.36	0.637694364	20.65	3
Juniperus communis	JCCAMAS125	2009	7	25	CANL	L.J. Gillespie, L.L. Consaul, & R.D. Bull	9290	6-Jan-2020	69.38	-123.09	212	26	-9.25617	10.584	388.07	-8.29	Keeling et al. 2001	-29.72	0.356837406	22.08	2
Juniperus communis	JCCAMAS126	2010	7	28	CANL	J.M. Saarela, R.D. Bull, & P.C. Sokoloff	1526	6-Jan-2020	62.53	-114.36	274	36	-5.14733	16.068	390.33	-8.32	Keeling et al. 2001	-28.15	0.690326438	20.40	2
Eriophorum angustifolium	EAUMMAS1	1926	8	1	MICH	J. Dewey Soper	125891	4-Nov-19	64.00	-72.50	374	54	-8.954	8.00800004	305.4	-6.890758333	EXTRAPOLATED	-26.57	0.246883519	20.22	2
Eriophorum angustifolium	EAUMMAS2	1931	7	30	MICH	Carl O. Grassl	4336	4-Nov-19	47.33	-85.78	818	74	3.95867	12.5319996	307.7	-6.981575868	Rubino et al. 2013 JGR Atmosphere	-27.20	0.032961189	20.78	0
Eriophorum angustifolium	EAUMMAS3	1947	7	28	MICH	R. McGregor		25-Nov-19	69.28	-146.00	162	29	-8.461	10.4960003	310.2	-7.013360568	Rubino et al. 2013 JGR Atmosphere	-25.20	0.528960731	18.65	2
Eriophorum angustifolium	EAUMMAS5	1948	7	5	MICH	Hansford T. Shacklette	2825	4-Nov-19	66.08	-118.03	233	44	-7.40017	11.6079998	310.3	-7.042682429	Rubino et al. 2013 JGR Atmosphere	-27.08	0.373927408	20.59	2
Eriophorum angustifolium	EAUMMAS6	1948	8	17	MICH	W.S. Benninghoff	2596	4-Nov-19	66.50	-147.00	233	39	-5.48883	13.0880003	310.3	-7.042682429	Rubino et al. 2013 JGR Atmosphere	-25.21	0.506859588	18.64	3
Eriophorum angustifolium	EAUMMAS8	1970	7	11	MICH	W.J. Cody	18803	4-Nov-19	62.33	-122.22	404	71	-3.94767	15.0279999	326.34	-7.3417	EXTRAPOLATED	-26.91	0.580919945	20.11	4
Eriophorum angustifolium	EAUMMAS10	1972	6	6	MICH	C.E. Garton	14906	4-Nov-19	48.85	-89.95	777	94	0.67783	13.9399996	329.09	-7.356148164	Rubino et al. 2013 JGR Atmosphere	-27.74	0.49045848	20.96	2
Eriophorum angustifolium	EAUMMAS11	1979	7		MICH	R.A. Sims	2677A	4-Nov-19	55.17	-82.33	521	78	-4.96666	9.7	337.73	-7.54	Rubino et al. 2013 JGR	-27.18	0.113858998	20.18	4

																	Atmosphere				
Eriophorum angustifolium	EAUMMAS13	1979	7		MICH	R.A. Sims	2664A	4-Nov-19	54.80	-82.33	519	79	-4.11583	12.2639999	337.73	-7.54	Rubino et al. 2013 JGR Atmosphere	-26.81	0.31759159	19.80	4
Eriophorum angustifolium	EAUMMAS14	1979	7		MICH	R.A. Sims	2652A	4-Nov-19	55.17	-82.33	521	78	-4.96666	9.7	337.73	-7.54	Rubino et al. 2013 JGR Atmosphere	-27.68	0.113858998	20.72	4
Eriophorum angustifolium	EAUMMAS15	1979			MICH	Tass Kelso, JoAnn Flock and Miriam Colson	291	25-Nov-19	65.80	-168.00	337		-6.23125			-7.54	Rubino et al. 2013 JGR Atmosphere	-28.46		21.53	4
Eriophorum angustifolium	EAUMMAS16	1980	6	14	MICH	C.E. Garton	19446	25-Nov-19	48.67	-89.08	766	84	0.9635	13.6800003	341.17	-7.69	Keeling et al. 2001	-27.35	0.480169393	20.21	2
Eriophorum angustifolium	EAUMMAS17	1980	7	1	MICH	W.J. Cody	26629	4-Nov-19	64.62	-138.30	414	68	-6.71833	10.5080004	339.56	-7.59	Keeling et al. 2001	-25.40	0.525178023	18.27	2
Eriophorum angustifolium	EAUMMAS19	1983	6	17	MICH	C.E. Garton	22144	25-Nov-19	49.75	-87.77	814	96	0.11417	13.4239998	345.32	-7.88	Keeling et al. 2001	-30.17	0.470275002	22.99	2
Eriophorum angustifolium	EAUMMAS21	2000	7	12	MICH	S.S. Talbot & W.B. Schofield	024-25	4-Nov-19	57.16	-158.10	515	50	2.727	11.9799995	343.98	-8.07	Keeling et al. 2001	-27.57	0.367932663	20.05	
Eriophorum angustifolium	EAUMMAS22	2001			MICH	M.J. Oldham & D.A. Sutherland	25883	4-Nov-19	55.05	-83.67	520		-4.62083			-8.05	Keeling et al. 2001	-24.92		17.30	4
Eriophorum angustifolium	EAUMMAS24	2004	6	13	MICH	Doug Goldman, Barbra Gravendeel and Tanya Livshultz	2855	4-Nov-19	44.48	-67.60	1285	89	6.66932	13.2454996	379.55	-8.29	Keeling et al. 2001	-27.16	0.276083081	19.39	4
Eriophorum angustifolium	EAUMMAS25	2005	7	12	MICH	B.A. Bennett, P. Seccombe-Hett, J. Ryder, S. Thompson & D. Mahoney	05-0433	25-Nov-19							380.66	-8.24	Keeling et al. 2001	-26.15		18.39	
Eriophorum angustifolium	EAUMMAS26	2010	7	7	MICH	Alan. R. Batten, Carolyn L. Parker	2010-97		62.60	-150.17	743	91	0.32367	12.724	390.33	-8.32	Keeling et al. 2001	-26.98	0.336179052	19.17	
Eriophorum angustifolium	EACAMAS1	1923	8	31	CANL	J. Dewey Soper		8-Jan-2020	72.50	-78.52	202	38	-14.1803	4.3702	304.1	-6.876058333	EXTRAPOLATED	-29.22	0.135375178	23.02	0
Eriophorum	EACAMAS2	1923	8	22	CANL	J. Dewey		8-Jan-	72.70	-77.98	197	38	-14.38824	4.3882399	304.1	-6.87605	EXTRAPOLATED	-26.51	0.13601	20.17	0

angustifolium						Soper		2020								8333			8349		
Eriophorum angustifolium	EACAMAS3	1923	8	19	CANL	J. Dewey Soper		8-Jan-2020	73.08	-84.55	237	38	-14.1875	3.7	304.1	-6.876058333	EXTRAPOLATED	-26.74	0.146501207	20.41	0
Eriophorum angustifolium	EACAMAS4	1924	8	17	CANL	J. Dewey Soper		7-Jan-2020	65.67	-65.75	701	95	-8.18	7.66666	304.5	-6.887120112	Rubino et al. 2013 JGR Atmosphere	-26.49	0.25850208	20.13	2
Eriophorum angustifolium	EACAMAS5	1925	6	26	CANL	J. Dewey Soper		7-Jan-2020	66.67	-70.00	318	24	-10.61389	1.9	305	-6.967579619	Rubino et al. 2013 JGR Atmosphere	-27.49	0.120833396	21.11	0
Eriophorum angustifolium	EACAMAS6	1926	8	1	CANL	J. Dewey Soper		7-Jan-2020	64.00	-72.50	374	54	-8.954	8.0080004	305.4	-6.890758333	EXTRAPOLATED	-27.46	0.246883519	21.15	2
Eriophorum angustifolium	EACAMAS7	1926	7	3	CANL	J. Dewey Soper		8-Jan-2020	64.23	-76.54	401	37	-8.64954	6.87778	305.4	-6.89035	EXTRAPOLATED	-26.93	0.179345633	20.60	0
Eriophorum angustifolium	EACAMAS8	1927	6		CANL	Porsild, A. Erling; Porsild, R.Thorbjörn	1886	9-Jan-2020	68.33	-133.50	238	22	-8.3895	12.184	305.8	-6.894841667	EXTRAPOLATED	-25.82	0.637694364	19.43	3
Eriophorum angustifolium	EACAMAS9	1927	7	18	CANL	Porsild, A. Erling; Porsild, R.Thorbjörn	2053	9-Jan-2020	69.00	-134.67	222	32	-9.088	12.9280005	305.8	-6.89525	EXTRAPOLATED	-25.75	0.458372331	19.35	3
Eriophorum angustifolium	EACAMAS10	1928	8	15	CANL	M.O. Malte		7-Jan-2020	64.25	-82.83	206	36	-10.95117	7.0079999	306.3	-6.900558333	EXTRAPOLATED	-26.09	0.180719534	19.70	4
Eriophorum angustifolium	EACAMAS11	1928	8	6	CANL	Porsild, A. Erling; Porsild, R.Thorbjörn	5219	9-Jan-2020	66.33	-118.50	227	42	-7.693	10.3479996	306.3	-6.900558333	EXTRAPOLATED	-27.17	0.297272905	20.84	2
Eriophorum angustifolium	EACAMAS12	1928	8	2	CANL	Porsild, A. Erling; Porsild, R.Thorbjörn	5099	9-Jan-2020	66.37	-120.58	234	40	-7.343	10.0080004	306.3	-6.900558333	EXTRAPOLATED	-27.43	0.268992968	21.10	2
Eriophorum angustifolium	EACAMAS13	1928	7	11	CANL	Porsild, A. Erling; Porsild, R.Thorbjörn	5024	9-Jan-2020	66.82	-121.00	223	35	-7.80033	11.8479996	306.3	-6.90015	EXTRAPOLATED	-26.84	0.388982201	20.49	2
Eriophorum angustifolium	EACAMAS14	1928	7	11	CANL	Porsild, A. Erling; Porsild, R.Thorbjörn	5028	9-Jan-2020	66.82	-121.00	223	35	-7.80033	11.8479996	306.3	-6.90015	EXTRAPOLATED	-24.82	0.388982201	18.38	2
Eriophorum angustifolium	EACAMAS15	1929	7	10	CANL	J. Dewey Soper		8-Jan-2020	65.58	-73.52	326	41	-10.07717	7.848	306.8	-6.832	Rubino et al. 2013 JGR	-27.76	0.252040475	21.52	4

																	Atmosphere				
Eriophorum angustifolium	EACAMAS16	1930	8		CANL	Porsild, A. Erling	5753	9-Jan-2020	62.50	-97.00	300	50	-10.87867	9.8000002	307.2	-6.910358333	EXTRAPOLATED	-27.04	0.241969361	20.69	2
Eriophorum angustifolium	EACAMAS17	1931	6	26	CANL	J. Dewey Soper	s.n.	8-Jan-2020	62.82	-69.92	380	35	-7.37719	3.3105299	307.7	-6.981575868	Rubino et al. 2013 JGR Atmosphere	-28.66	0.136981987	22.31	2
Eriophorum angustifolium	EACAMAS18	1934	6	20	CANL	Porsild, A. Erling	6954	9-Jan-2020	68.69	-134.13	227	19	-8.67667	10.0120001	309	-6.929141667	EXTRAPOLATED	-27.49	0.45652237	21.14	2
Eriophorum angustifolium	EACAMAS19	1936	7	28	CANL	C.H.D. Clarke		7-Jan-2020	63.68	-107.12	279	40	-8.963	13.6560001	309.8	-6.93904564	Rubino et al. 2013 JGR Atmosphere	-24.05	0.533725667	17.54	2
Eriophorum angustifolium	EACAMAS20	1937	7	27	CANL	V.C. Wynne-Edwards	7247	7-Jan-2020	61.33	-64.89	535	70	-4.97708	5.5500002	310	-6.950171241	Rubino et al. 2013 JGR Atmosphere	-25.81	0.156657621	19.36	2
Eriophorum angustifolium	EACAMAS21	1937	8	1	CANL	V.C. Wynne-Edwards	7272	8-Jan-2020	61.83	-65.75	522	81	-6.4245	5.54	310	-6.950171241	Rubino et al. 2013 JGR Atmosphere	-27.96	0.081227799	21.62	0
Eriophorum angustifolium	EACAMAS22	1938	8	11	CANL	Laing, H.M.	455	9-Jan-2020	52.37	-126.07	805	33	6.19167	15.8439999	310.2	-6.943381051	Rubino et al. 2013 JGR Atmosphere	-23.74	0.538768247	17.20	2
Eriophorum angustifolium	EACAMAS23	1938	No Month		CANL	Carroll, J.		9-Jan-2020	64.42	-108.90	261		-9.46533			-6.943381051	Rubino et al. 2013 JGR Atmosphere	-27.44		21.08	2
Eriophorum angustifolium	EACAMAS24	1938	8	17	CANL	E.W. Manning	162	8-Jan-2020	65.45	-77.45	305	44	-9.41417	5.5999999	310.2	-6.943381051	Rubino et al. 2013 JGR Atmosphere	-27.26	0.119812439	20.89	4
Eriophorum angustifolium	EACAMAS25	1947	7	28	CANL	Harper, Francis	2363	9-Jan-2020	60.61	-99.93	348	61	-8.43683	14.0279999	310.2	-7.013360568	Rubino et al. 2013 JGR Atmosphere	-24.23	0.571981578	17.64	2
Eriophorum angustifolium	EACAMAS26	1947	7	23	CANL	Harper, Francis	2348	9-Jan-2020	60.61	-99.94	348	61	-8.43683	14.0279999	310.2	-7.013360568	Rubino et al. 2013 JGR Atmosphere	-24.30	0.571981578	17.72	2
Eriophorum angustifolium	EACAMAS27	1947	7	8	CANL	Harper, Francis	2275	9-Jan-2020	60.61	-99.94	348	61	-8.43683	14.0279999	310.2	-7.013360568	Rubino et al. 2013 JGR Atmosphere	-25.64	0.571981578	19.12	2
Eriophorum angustifolium	EACAMAS28	1947	6	20	CANL	Francis Harper	2221	8-Jan-2020	60.61	-99.94	348	37	-8.43683	9.3999996	310.2	-7.013360568	Rubino et al. 2013 JGR Atmosphere	-26.92	0.443013582	20.46	2
Eriophorum angustifolium	EACAMAS29	1948	6	24	CANL	Raup, Hugh M.; Drury Jr., Willia	13203	9-Jan-2020	59.63	-136.47	880	46	-1.41367	7.796	310.3	-7.042682429	Rubino et al. 2013 JGR Atmosphere	-27.46	0.367880503	21.00	2

						m H.; Raup, K.A.															
Eriophorum angustifolium	EACAMAS30	1948	8	1	CANL	C. Thacker	47	7-Jan-2020	63.75	-68.52	419	65	-8.74635	6.9375	310.3	-7.042682429	Rubino et al. 2013 JGR Atmosphere	-27.12	0.18037623	20.64	2
Eriophorum angustifolium	EACAMAS31	1948	7	5	CANL	Shacklette, Hansford T.	2825	9-Jan-2020	66.08	-118.03	233	34	-7.40017	11.6079998	310.3	-7.042682429	Rubino et al. 2013 JGR Atmosphere	-28.67	0.373927408	22.27	2
Eriophorum angustifolium	EACAMAS32	1948	7	4	CANL	Shacklette, Hansford T.	2819	9-Jan-2020	66.08	-118.03	233	34	-7.40017	11.6079998	310.3	-7.042682429	Rubino et al. 2013 JGR Atmosphere	-26.69	0.373927408	20.19	2
Eriophorum angustifolium	EACAMAS33	1948	7	5	CANL	Shacklette, Hansford T.	2825	9-Jan-2020	66.10	-119.00	231	35	-7.404	11.1999998	310.3	-7.042682429	Rubino et al. 2013 JGR Atmosphere	-26.16	0.32066696	19.64	4
Eriophorum angustifolium	EACAMAS34	1950	7	31	CANL	Scoggan, H.J.; Baldwin, William K.W.	8338	9-Jan-2020	60.00	-98.17	384	62	-8.059	13.6440001	310.7	-7.006340998	Rubino et al. 2013 JGR Atmosphere	-25.40	0.522505069	18.87	3
Eriophorum angustifolium	EACAMAS35	1950	6	30	CANL	Kelsall, John P.; McEwen, E.H.	26	9-Jan-2020	66.83	-108.03	180	16	-11.26533	5.39200002	310.7	-7.006340998	Rubino et al. 2013 JGR Atmosphere	-25.66	0.083951625	19.15	2
Eriophorum angustifolium	EACAMAS36	1950	6	13	CANL	V.C. Wynne-Edwards	8814	8-Jan-2020	69.83	-70.67	242	20	-12.72917	2.0439999	310.7	-7.006340998	Rubino et al. 2013 JGR Atmosphere	-26.52	0.132494592	20.04	2
Eriophorum angustifolium	EACAMAS37	1950	6	29	CANL	V.C. Wynne-Edwards	8864	7-Jan-2020	69.83	-70.67	242	20	-12.72917	2.0439999	310.7	-7.006340998	Rubino et al. 2013 JGR Atmosphere	-26.97	0.132494592	20.52	2
Eriophorum angustifolium	EACAMAS38	1951	7	1	CANL	Lindsey, Alton A.	109	9-Jan-2020	60.72	-115.78	322	42	-2.82817	16.5	311.1	-7.01285	EXTRAPOLATED	-23.52	0.617715809	16.91	3
Eriophorum angustifolium	EACAMAS39	1951	7	24	CANL	D.K. Brown	886	8-Jan-2020	63.60	-84.08	238	31	-10.94256	8.75	311.1	-7.01285	EXTRAPOLATED	-25.51	0.24915595	18.98	4
Eriophorum angustifolium	EACAMAS40	1952	7	28	CANL	Brown, D.K.	1341	9-Jan-2020	60.97	-101.33	330	58	-8.45883	13.0799999	311.5	-7.01775	EXTRAPOLATED	-26.75	0.476071758	20.27	2
Eriophorum angustifolium	EACAMAS42	1955	8	8	CANL	J.S. Tener	336	8-Jan-2020	65.67	-102.08	205	37	-11.9565	9.6960001	313	-7.032858333	EXTRAPOLATED	-27.12	0.363535588	20.64	2
Eriophorum angustifolium	EACAMAS43	1955	8	21	CANL	Mrs. P.F. Cooper	244	7-Jan-2020	68.63	-95.87	128	28	-14.39936	5.6076899	313	-7.032858333	EXTRAPOLATED	-25.36	0.14029851	18.80	2
Eriophorum angustifolium	EACAMAS44	1956	7	14	CANL	Macpherson, Andrew H.	69	9-Jan-2020	68.53	-89.83	243	36	-13.61015	9.3217402	313.6	-7.03735	EXTRAPOLATED	-25.55	0.344480894	19.00	3
Eriophorum angustifolium	EACAMAS45	1959	8	11	CANL	A.E. Porsild	21523	7-Jan-2020	63.75	-68.52	419	65	-8.74635	6.9375	314.8	-7.066511729	Rubino et al. 2013 JGR Atmosphere	-28.63	0.18037623	22.20	2

Eriophorum angustifolium	EACAMAS46	1959	7	19	CANL	Wood, Raymond D.		9-Jan-2020	68.22	-135.00	266	39	-8.7045	13.0799999	316.54	-7.066511729	Rubino et al. 2013 JGR Atmosphere	-24.55	0.436071658	17.92	3
Eriophorum angustifolium	EACAMAS47	1960	7	10	CANL	McAllister, Donald E.		9-Jan-2020	68.22	-135.00	266	39	-8.7045	13.0799999	318.18	-7.05695	EXTRAPOLATED	-27.50	0.436071658	21.02	3
Eriophorum angustifolium	EACAMAS48	1960	7	7	CANL	Beschel	10717	8-Jan-2020	74.68	-94.83	149	21	-16.50196	4.8294101	318.18	-7.05695	EXTRAPOLATED	-27.99	0.155778629	21.54	2
Eriophorum angustifolium	EACAMAS49	1961	6	24	CANL	Macpherson, Elizabeth	248	9-Jan-2020	64.45	-99.00	226	21	-11.38133	2.556	319.77	-7.061441667	EXTRAPOLATED	-28.18	0.064453262	21.73	2
Eriophorum angustifolium	EACAMAS50	1961	7	6	CANL	J.S. Tener & C.R. Harington	73	8-Jan-2020	75.15	-99.73	115	18	-17.5215	5.4000001	318.57	-7.06185	EXTRAPOLATED	-26.33	0.205250885	19.79	2
Eriophorum angustifolium	EACAMAS51	1962	7	12	CANL	Steve Stephens	1021	8-Jan-2020	69.12	-105.05	137	20	-13.92887	8.8999996	319.61	-7.091484283	Rubino et al. 2013 JGR Atmosphere	-27.77	0.250675827	21.27	2
Eriophorum angustifolium	EACAMAS52	1962	6	15	CANL	Barry, T.W.	347	9-Jan-2020	69.70	-129.00	119	8	-10.62083	7.0583301	320.62	-7.091484283	Rubino et al. 2013 JGR Atmosphere	-27.33	0.246189845	20.80	3
Eriophorum angustifolium	EACAMAS53	1963	8	1	CANL	P.J. Webber	303	7-Jan-2020	69.90	-76.90	194	41	-12.61717	4.7719998	317.77	-7.055	Rubino et al. 2013 JGR Atmosphere	-25.45	0.149595536	18.88	2
Eriophorum angustifolium	EACAMAS54	1964	8	7	CANL	I.A. McLaren	80	8-Jan-2020	63.40	-64.75	534	94	-7.48233	5.8280001	318.69	-7.076958333	EXTRAPOLATED	-29.05	0.167121503	22.63	2
Eriophorum angustifolium	EACAMAS55	1964	8	20	CANL	I.A. McLaren	141	7-Jan-2020	63.40	-64.75	534	94	-7.48233	5.8280001	318.69	-7.076958333	EXTRAPOLATED	-26.82	0.167121503	20.28	2
Eriophorum angustifolium	EACAMAS56	1964	8	6	CANL	Lambert, J.D.H.		9-Jan-2020	71.98	-125.20	128	27	-12.96339	4.7642899	318.69	-7.076958333	EXTRAPOLATED	-27.84	0.1061896	21.36	2
Eriophorum angustifolium	EACAMAS57	1964	8	5	CANL	Lambert, J.D.H.		9-Jan-2020	71.98	-125.20	128	27	-12.96339	4.7642899	318.69	-7.076958333	EXTRAPOLATED	-28.45	0.1061896	22.00	2
Eriophorum angustifolium	EACAMAS58	1964	8	13	CANL	Lambert, J.D.H.		9-Jan-2020	71.98	-125.20	128	27	-12.96339	4.7642899	318.69	-7.076958333	EXTRAPOLATED	-24.86	0.1061896	18.23	2
Eriophorum angustifolium	EACAMAS59	1964	7	30	CANL	Lambert, J.D.H.		9-Jan-2020	71.98	-125.20	128	17	-12.96339	7.0785699	320.44	-7.07655	EXTRAPOLATED	-26.02	0.195445376	19.45	2
Eriophorum angustifolium	EACAMAS60	1964	8	10	CANL	Lambert, J.D.H.		9-Jan-2020	71.98	-125.20	128	27	-12.96339	4.7642899	318.69	-7.076958333	EXTRAPOLATED	-28.55	0.1061896	22.10	2
Eriophorum angustifolium	EACAMAS61	1964	7	18	CANL	G.R. Brassard	1560b	8-Jan-2020	81.42	-76.92	127	29	-17.25341	3.9272699	320.44	-7.07655	EXTRAPOLATED	-25.68	0.19209123	19.09	2
Eriophorum angustifolium	EACAMAS62	1965	7	3	CANL	Rossbach, G.B.	6465	9-Jan-2020	63.95	-103.87	247	40	-10.34167	13.7360001	321.21	-7.08145	EXTRAPOLATED	-27.66	0.579084389	21.16	2
Eriophorum angustifolium	EACAMAS63	1965	7	3	CANL	Rossbach, G.B.	6465	9-Jan-2020	63.95	-103.87	247	40	-10.34167	13.7360001	321.21	-7.08145	EXTRAPOLATED	-25.54	0.579084389	18.95	2
Eriophorum	EACAMAS64	1965	8	1	CANL	G.B. Rossbach	6989	8-Jan-	64.32	-96.05	266	46	-11.62317	9.3039999	318.87	-7.08185	EXTRAPOLATED	-27.02	0.22860	20.50	2

angustifolium								2020								8333			8827		
Eriophorum angustifolium	EACAMAS65	1965	7	18	CANL	G.B. Rossbach	6706	8-Jan-2020	64.67	-98.57	225	39	-12.09233	11.3280001	321.21	-7.08145	EXTRAPOLATED	-29.40	0.426812456	23.00	2
Eriophorum angustifolium	EACAMAS66	1965	7	11	CANL	G.B. Rossbach	6622	7-Jan-2020	64.67	-99.88	215	38	-11.51867	11.908	321.21	-7.08145	EXTRAPOLATED	-27.38	0.466493657	20.87	2
Eriophorum angustifolium	EACAMAS67	1965	7	28	CANL	Hainault, Robert	3844	7-Jan-2020	70.00	-68.58	238	25	-12.781	4.8720002	321.21	-7.08145	EXTRAPOLATED	-27.56	0.187219974	21.06	2
Eriophorum angustifolium	EACAMAS68	1966	7	22	CANL	Baldwin, William K.W.; MacPherson, J.	10527	9-Jan-2020	53.97	-106.08	468	86	0.5325	16.6760006	322.38	-7.234932478	Rubino et al. 2013 JGR Atmosphere	-27.13	0.520044199	20.45	2
Eriophorum angustifolium	EACAMAS69	1967	7	26	CANL	P.J. Webber	1277	7-Jan-2020	68.83	-68.50	263	29	-11.16111	6.03333	322.54	-7.333113852	Rubino et al. 2013 JGR Atmosphere	-29.70	0.217562037	23.05	2
Eriophorum angustifolium	EACAMAS70	1970	7	8	CANL	G.R. Parker	SP-70-97B	7-Jan-2020	64.20	-85.00	258	32	-11.66733	9.0159998	326.34	-7.3417	EXTRAPOLATED	-26.82	0.28085256	20.02	0
Eriophorum angustifolium	EACAMAS71	1970	7	21	CANL	D.A. Gill	16	7-Jan-2020	75.72	-98.42	123	19	-17.7275	4.9359999	326.34	-7.3417	EXTRAPOLATED	-29.33	0.19909511	22.66	2
Eriophorum angustifolium	EACAMAS72	1971	7	17	CANL	Argus, George W.; Chunys, W.N.	8041	9-Jan-2020	62.57	-115.10	269	35	-4.917	16.2999992	327.36	-7.347751263	Rubino et al. 2013 JGR Atmosphere	-24.95	0.673956633	18.05	2
Eriophorum angustifolium	EACAMAS73	1971	7	1	CANL	M. Kuc		8-Jan-2020	76.13	-108.12	72	14	-18.49659	3.036364	327.36	-7.347751263	Rubino et al. 2013 JGR Atmosphere	-27.75	0.069967091	20.98	2
Eriophorum angustifolium	EACAMAS74	1972	7		CANL	Gillett, John M.	16466	9-Jan-2020	62.82	-92.08	327	41	-8.4869	8.7428598	328.04	-7.356148164	Rubino et al. 2013 JGR Atmosphere	-24.90	0.228613866	18.00	2
Eriophorum angustifolium	EACAMAS75	1973	7	23	CANL	Gillett, John M.	16195	9-Jan-2020	62.20	-95.67	299	43	-10.18317	11.724	330.87	-7.392841953	Rubino et al. 2013 JGR Atmosphere	-24.81	0.37285257	17.86	2
Eriophorum angustifolium	EACAMAS76	1973	7	23	CANL	Gillett, John M.	16256	9-Jan-2020	62.40	-94.22	295	39	-10.21833	10.7959995	330.87	-7.392841953	Rubino et al. 2013 JGR Atmosphere	-27.28	0.31540866	20.44	0
Eriophorum angustifolium	EACAMAS77	1973	7	17	CANL	Gillett, John M.	16063	9-Jan-2020	62.82	-92.08	327	41	-8.4869	8.7428598	330.87	-7.392841953	Rubino et al. 2013 JGR Atmosphere	-27.39	0.228613866	20.56	2
Eriophorum angustifolium	EACAMAS78	1974	8	31	CANL	Jean-Louis Blouin		8-Jan-2020	66.92	-64.75	424	54	-9.3815	5.276	329.39	-7.4826114	Rubino et al. 2013 JGR Atmosphere	-26.05	0.159139719	19.06	0
Eriophorum angustifolium	EACAMAS79	1975	7	30	CANL	Talbot, Stephen	T5099-	9-Jan-2020	61.17	-124.55	538	94	-4.309	11.2480001	331.9	-7.417906395	Rubino et al. 2013 JGR Atmosphere	-25.46	0.496511621	18.51	0

Eriophorum angustifolium	EACAMAS80	1976	7	19	CANL	Edlund, Sylvia A.	755	8-Jan-2020	65.76	-94.13	247	37	-13.7615	9.9320002	333.05	-7.442709622	Rubino et al. 2013 JGR Atmosphere	-26.45	0.362748573	19.52	2
Eriophorum angustifolium	EACAMAS81	1977	8	10	CANL	Shchepanek, Michael J.; White, D.	2952	9-Jan-2020	49.65	-54.75	1060	102	3.90114	15.6317997	332.75	-7.485	Rubino et al. 2013 JGR Atmosphere	-26.42	0.408296353	19.45	0
Eriophorum angustifolium	EACAMAS82	1977	8	8	CANL	Shchepanek, Michael J.; White, D.	2912	9-Jan-2020	49.83	-56.30	1151	107	2.906	14.9399996	332.75	-7.485	Rubino et al. 2013 JGR Atmosphere	-28.52	0.36446452	21.66	3
Eriophorum angustifolium	EACAMAS83	1977	7	28	CANL	Gillett, John M.; Boudreau, Mireille J.	17548	9-Jan-2020	57.43	-126.80	616	77	-2.18017	10.8039999	334.92	-7.485	Rubino et al. 2013 JGR Atmosphere	-26.92	0.468898829	19.98	2
Eriophorum angustifolium	EACAMAS84	1977	7	21	CANL	Argus, George W.; Haber, Erich	10859	9-Jan-2020	58.45	-124.88	634	114	-3.82917	9.1000004	334.92	-7.485	Rubino et al. 2013 JGR Atmosphere	-22.96	0.402591729	15.84	2
Eriophorum angustifolium	EACAMAS85	1978	7	26	CANL	Forsythe, J.A.	920	9-Jan-2020	48.02	-64.50	1136	94	4.34167	18.1000004	336.54	-7.502	Rubino et al. 2013 JGR Atmosphere	-27.01	0.497592681	20.05	4
Eriophorum angustifolium	EACAMAS86	1980	8	21	CANL	Edlund, Sylvia A.	s.n.	8-Jan-2020	74.72	-94.97	149	34	-16.6655	1.592	337.6	-7.47	Keeling et al. 2001	-26.96	0.06232288	20.03	2
Eriophorum angustifolium	EACAMAS87	1981	8	13	CANL	Shchepanek, Michael J.; Dugal, Albert W.	3965	9-Jan-2020	46.47	-62.22	1204	96	5.52054	18.6357002	338.43	-7.49	Keeling et al. 2001	-26.04	0.499263416	19.05	2
Eriophorum angustifolium	EACAMAS88	1982	7	28	CANL	J.M. Gillett	19106	7-Jan-2020	63.75	-68.52	419	60	-8.74635	7.9000001	342.06	-7.67	Keeling et al. 2001	-27.32	0.24831221	20.20	2
Eriophorum angustifolium	EACAMAS89	1982	6	27	CANL	Edlund, Sylvia A.	33	9-Jan-2020	71.12	-118.07	163	12	-12.32662	3.4111099	343.35	-7.71	Keeling et al. 2001	-26.96	0.137633184	19.78	2
Eriophorum angustifolium	EACAMAS90	1983	8	30	CANL	Talbot, Stephen	003-2	9-Jan-2020	62.83	-163.42	494	106	-1.8415	11.54	342.38	-7.58	Keeling et al. 2002	-24.89	0.280990415	17.75	2
Eriophorum angustifolium	EACAMAS91	1984	7	26	CANL	Edlund, Sylvia A.	420	9-Jan-2020	75.43	-113.50	101	18	-17.13042	3.1949999	345.39	-7.72	Keeling et al. 2001	-30.71	0.156062965	23.72	0
Eriophorum angustifolium	EACAMAS92	1984	7	4	CANL	Edlund, Sylvia A.	24	9-Jan-2020	76.03	-113.08	93	17	-17.817	3.368	345.39	-7.72	Keeling et al. 2002	-27.20	0.179234898	20.02	0
Eriophorum angustifolium	EACAMAS93	1985	7	12	CANL	Edlund, Sylvia A.	137	9-Jan-2020	75.80	-114.80	106	19	-17.8465	2.1919999	346.56	-7.68	Keeling et al. 2001	-28.05	0.139626652	20.96	0
Eriophorum angustifolium	EACAMAS94	1986	8	18	CANL	S.G. Aiken, C. Campbell, & E. Robinson	86-374	7-Jan-2020	63.73	-68.45	428	67	-8.94278	6.6866698	345.9	-7.52	Keeling et al. 2001	-27.18	0.184143988	20.21	2
Eriophorum angustifolium	EACAMAS95	1986	8	14	CANL	S.G. Aiken, C. Cam	86-286	7-Jan-2020	63.77	-68.98	397	62	-9.06975	7.2347798	345.9	-7.52	Keeling et al. 2001	-25.98	0.199743903	18.96	2

						pbell, & E. Robinson															
Eriophorum angustifolium	EACAMAS96	1986	7	12	CANL	J.D. Jacobs & L. Maus		8-Jan-2020	65.95	-71.30	322	45	-10.19213	8.3500004	347.94	-7.63	Keeling et al. 2001	-25.21	0.308947908	18.04	4
Eriophorum angustifolium	EACAMAS97	1986	7	12	CANL	J.D. Jacobs & L. Maus		7-Jan-2020	65.95	-71.30	322	45	-10.19213	8.3500004	347.94	-7.63	Keeling et al. 2002	-26.90	0.308947908	19.80	4
Eriophorum angustifolium	EACAMAS98	1986	8	9	CANL	S.G. Aiken, C. Campbell, & E. Robinson	86-201	7-Jan-2020	66.03	-71.20	320	54	-10.38385	6.7937498	345.9	-7.52	Keeling et al. 2001	-27.83	0.218064471	20.89	4
Eriophorum angustifolium	EACAMAS99	1986	8	8	CANL	S.A. Edlund	287	8-Jan-2020	72.56	-105.40	77	15	-16.27133	3.0439999	345.9	-7.52	Keeling et al. 2001	-26.89	0.077578899	19.91	2
Eriophorum angustifolium	EACAMAS100	1986	8	13	CANL	S.A. Edlund	379	8-Jan-2020	73.68	-106.60	75	14	-16.80391	2.625	345.9	-7.52	Keeling et al. 2001	-28.16	0.058070935	21.24	2
Eriophorum angustifolium	EACAMAS101	1988	8	21	CANL	Haber, Erich; Bristow, Valerie N.	3885	9-Jan-2020	46.84	-66.69	1167	101	2.47833	16.5919991	350.43	-7.73	Keeling et al. 2001	-28.48	0.495534211	21.35	3
Eriophorum angustifolium	EACAMAS102	1988	7	12	CANL	Aiken, Susan	88-217	9-Jan-2020	68.97	-137.27	238	34	-9.82895	11.41579	352.38	-7.77	Keeling et al. 2001	-28.02	0.33826839	20.84	3
Eriophorum angustifolium	EACAMAS103	1996	7	15	CANL	Charest, René; Brouillet, Luc	96-1030	9-Jan-2020	48.43	-54.14	1078	84	4.2885	15.9519997	363.65	-7.98	Keeling et al. 2001	-27.76	0.454442985	20.34	2
Eriophorum angustifolium	EACAMAS104	1999	7	2	CANL	Aiken, Susan	99-201	9-Jan-2020	73.84	-119.96	134	16	-14.86867	6.3439999	364.47	-8.06	Keeling et al. 2001	-30.10	0.321913141	22.72	2
Eriophorum angustifolium	EACAMAS105	2000	7	24	CANL	Gillespie, Lynn; Consaul, Laurie L.	6858	9-Jan-2020	76.56	-118.86	108	14	-17.88882	3.4157901	370.12	-8.07	Keeling et al. 2001	-31.28	0.145406549	23.96	2
Eriophorum angustifolium	EACAMAS106	2003	7	16	CANL	Pokiak, Myrna	26	9-Jan-2020	69.35	-124.07	218	22	-9.48939	9.9181805	376.61	-8.18	Keeling et al. 2001	-29.12	0.27343411	21.57	2
Eriophorum angustifolium	EACAMAS107	2003	7	22	CANL	Salokangas, Raila	26	9-Jan-2020	70.76	-117.75	183	26	-11.9145	8.4560003	376.61	-8.18	Keeling et al. 2002	-26.39	0.294483873	18.70	0
Eriophorum angustifolium	EACAMAS108	2004	7	8	CANL	Peterson, Paul M.; Saarela, Jeffery M.; Smith, S.F.	18479	9-Jan-2020	60.99	-138.50	417	68	-3.29567	10.1239996	377.76	-8.19	Keeling et al. 2001	-27.92	0.469777858	20.29	2
Eriophorum angustifolium	EACAMAS109	2008	7	13	CANL	Gillespie, Lynn J.; Saarela, Jeffery M.; Consaul, Laurie L.; Bull, Roger D.	7913	8-Jan-2020	68.66	-110.71	125	22	-12.637	9.408	386.25	-8.3	Keeling et al. 2001	-27.20	0.2856493	19.43	2

Eriophorum angustifolium	EACAMAS110	2008	7	26	CANL	Gillespie, Lynn J.; Saarela, Jeffery M.; Consaul, Laurie L.; Bull, Roger D.	8406	8-Jan-2020	69.12	-105.06	137	20	-13.92887	8.8999996	386.25	-8.3	Keeling et al. 2001	-26.32	0.250675827	18.51	2
Eriophorum angustifolium	EACAMAS111	2009	7	21	CANL	Gillespie, Lynn J.; Saarela, Jeffery M.; Consaul, Laurie L.; Bull, Roger D.; Boxwell, Janet; Hunter, Chris	9145	9-Jan-2020	68.87	-122.82	226	31	-9.627	10.3240004	388.07	-8.29	Keeling et al. 2001	-26.95	0.406858136	19.17	2
Eriophorum angustifolium	EACAMAS112	2009	7	1	CANL	Gillespie, Lynn J.; Saarela, Jeffery M.; Consaul, Laurie L.; Bull, Roger D.; Boxwell, Janet; Hunter, C.	8691	9-Jan-2020	69.32	-124.01	225	24	-9.36345	10.2954998	388.07	-8.29	Keeling et al. 2002	-29.45	0.329687155	21.80	2
Eriophorum angustifolium	EACAMAS113	2009	7	23	CANL	Gillespie, Lynn J.; Consaul, Laurie L.; Bull, Roger D.	9182	9-Jan-2020	69.40	-123.05	213	26	-9.25683	10.4399996	388.07	-8.29	Keeling et al. 2003	-28.98	0.363022807	21.31	2
Eriophorum angustifolium	EACAMAS114	2010	6	26	CANL	Laurie Consaul, Morgan Ip, Don Charette, Emily Kattuk, Christine Ekidlak, Betsy Meeko, Louisa Ippak, Johnny Narlik, Mary	3693	8-Jan-2020	56.43	-79.16	515	48	-4.3755	6.7160001	392.24	-8.43	Keeling et al. 2001	-26.75	0.257193111	18.82	2

						Narlik, Sarah Uppik, Lucassie Ippak, Joe Kavik, Shirley Ippak, Ronnie Ippak, & Mina Inuktaulk															
Eriophorum angustifolium	EACAMAS115	2010	6	26	CANL	Laurie Consaul, Morgan Ip, Don Charette, Emily Kattuk, Christine Ekidlak, Betsy Meeko, Louisa Ippak, Johnny Narlik, Mary Narlik, Sarah Uppik, Lucassie Ippak, Joe Kavik, Shirley Ippak, Ronnie Ippak, & Mina Inuktaulk	3696a	8-Jan-2020	56.43	-79.16	515	48	-4.3755	6.7160001	392.24	-8.43	Keeling et al. 2002	-28.89	0.257193111	21.07	2
Eriophorum angustifolium	EACAMAS116	2010	8	10	CANL	Laurie Consaul, Emily Kattuk, Betsy Meeko, Don Charette	4017	8-Jan-2020	56.56	-79.24	495	69	-4.27292	10.5249996	388.52	-8.21	Keeling et al. 2001	-28.55	0.232220334	20.94	2
Eriophorum angustifolium	EACAMAS117	2010	7	5	CANL	Laurie Consaul & Emily Kattuk	3957	8-Jan-2020	56.68	-79.33	493	63	-4.49167	9.533333	390.33	-8.32	Keeling et al. 2001	-28.20	0.214447762	20.46	2

Eriophorum angustifolium	EACAMAS118	2010	7	14	CANL	Gillespie, Lynn J.; Saarela, Jeffery M.; Doubt, Jennifer; Bull, Roger D.; Sokoloff, Paul C.	9777	9-Jan-2020	71.21	-116.37	164	24	-13.36867	8.3280001	390.33	-8.32	Keeling et al. 2002	-28.04	0.350107086	20.29	0
Eriophorum angustifolium	EACAMAS119	2010	7	9	CANL	Gillespie, Lynn J.; Saarela, Jeffery M.; Doubt, Jennifer; Bull, Roger D.; Sokoloff, Paul C.	9552	9-Jan-2020	71.51	-117.34	164	24	-13.00783	7.7519999	390.33	-8.32	Keeling et al. 2003	-27.30	0.30670814	19.51	2
Eriophorum angustifolium	EACAMAS120	2010	7	7	CANL	Gillespie, Lynn J.; Saarela, Jeffery M.; Doubt, Jennifer; Bull, Roger D.; Sokoloff, Paul C.	9489	9-Jan-2020	71.62	-115.44	146	22	-13.9505	7.35200002	390.33	-8.32	Keeling et al. 2004	-29.00	0.300250385	21.30	0
Eriophorum angustifolium	EACAMAS121	2010	7	7	CANL	Gillespie, Lynn J.; Saarela, Jeffery M.; Doubt, Jennifer; Bull, Roger D.; Sokoloff, Paul C.	9458	9-Jan-2020	71.62	-115.44	146	22	-13.9505	7.35200002	390.33	-8.32	Keeling et al. 2005	-31.40	0.300250385	23.83	0
Eriophorum angustifolium	EACAMAS122	2011	7	20	CANL	Sloan, Heather Cray	219	9-Jan-2020	69.57	-138.95	200	30	-10.88917	9	392.59	-8.36	Keeling et al. 2001	-28.42	0.184410724	20.65	3
Eriophorum angustifolium	EACAMAS123	2012	8	15	CANL	Ponomarenko, Serguei	NH-12-264	9-Jan-2020	62.22	-128.48	600	82	-5.99283	7.6560001	392.54	-8.26	Keeling et al. 2001	-27.76	0.420215695	20.06	2
Eriophorum angustifolium	EACAMAS124	2012	7	20	CANL	Saarela, Jeffery M.; Gillespie, Lynn J.; Sokoloff, Paul	2642	8-Jan-2020	62.85	-69.89	386	61	-7.37	8.91199997	394.52	-8.38	Keeling et al. 2001	-29.00	0.290001592	21.24	2

						C.; Bull, Roger D.																	
Eriophorum angustifolium	EACAMAS125	2012	7	15	CANL	Saarela, Jeffery M.; Gillespie, Lynn J.; Sokoloff, Paul C.; Bull, Roger D.	2462	8-Jan-2020	62.98	-69.72	400	61	-7.64167	9.2360001	394.52	-8.38	Keeling et al. 2002	-29.45	0.320048245	21.71	2		
Eriophorum angustifolium	EACAMAS126	2012	7	15	CANL	Saarela, Jeffery M.; Gillespie, Lynn J.; Sokoloff, Paul C.; Bull, Roger D.	2452	8-Jan-2020	62.98	-69.72	400	61	-7.64167	9.2360001	394.52	-8.38	Keeling et al. 2003	-28.53	0.320048245	20.74	2		
Eriophorum angustifolium	EACAMAS127	2012	7	12	CANL	Saarela, Jeffery M.; Gillespie, Lynn J.; Sokoloff, Paul C.; Bull, Roger D.	2388	8-Jan-2020	63.11	-69.72	400	62	-8.221	9.4639997	394.52	-8.38	Keeling et al. 2004	-27.71	0.33930752	19.88	2		
Eriophorum angustifolium	EACAMAS128	2012	7	6	CANL	Saarela, Jeffery M.; Gillespie, Lynn J.; Sokoloff, Paul C.; Bull, Roger D.	2125	8-Jan-2020	63.16	-69.65	406	64	-8.581	9.276	394.52	-8.38	Keeling et al. 2005	-25.48	0.338398912	17.54	2		
Eriophorum angustifolium	EACAMAS129	2012	7	6	CANL	Saarela, Jeffery M.; Gillespie, Lynn J.; Sokoloff, Paul C.; Bull, Roger D.	2151	8-Jan-2020	63.17	-69.65	415	63	-8.421	9.5080004	394.52	-8.38	Keeling et al. 2006	-28.71	0.349620865	20.93	2		
Eriophorum angustifolium	EACAMAS130	2012	7	4	CANL	Saarela, Jeffery M.; Gillespie, Lynn J.; Sokoloff, Paul C.; Bull, Roger D.	2110	8-Jan-2020	63.24	-69.61	420	64	-8.37767	9.6040001	394.52	-8.38	Keeling et al. 2007	-30.08	0.356118018	22.37	2		

Eriophorum angustifolium	EACAMAS131	2012	7	2	CANL	Saarela, Jeffery M.; Gillespie, Lynn J.; Sokoloff, Paul C.; Bull, Roger D.	2000	8-Jan-2020	63.25	-69.60	427	64	-8.41133	9.6079998	394.52	-8.38	Keeling et al. 2008	-27.94	0.354439659	20.12	2
Eriophorum angustifolium	EACAMAS132	2013	7	19	CANL	Ponomarenko, Sergueі	KL062	9-Jan-2020	61.01	-139.31	564	88	-3.749	9.4519997	397.37	-8.46	Keeling et al. 2001	-26.66	0.415950937	18.70	0
Betula glandulosa	BGCAMAS1	1924	8	24	CANL	Soper, J. Dewey		9-Jan-2020	64.98	-66.47	608	90	-8.274305491	7.1916699	304.5	-6.887120112	Rubino et al. 2013 JGR Atmosphere	-27.28	0.254601928	20.97	2
Betula glandulosa	BGCAMAS2	1927	7	9	CANL	Raup, Hugh M.	587	10-Jan-2020	62.58	-111.52	271	40	-6.080666589	14.6079998	305.8	-6.89525	EXTRAPOLATED	-26.15	0.48966669	19.77	0
Betula glandulosa	BGCAMAS3	1927	7	17	CANL	Raup, Hugh M.	582	10-Jan-2020	62.72	-109.17	275	38	-6.440666442	13.868	305.8	-6.89525	EXTRAPOLATED	-27.77	0.40542805	21.47	2
Betula glandulosa	BGCAMAS4	1927	7	18	CANL	Porsild, A. Erling; Porsild, R.Thorbjörn	2074	10-Jan-2020	69.00	-134.67	222	32	-9.08800008	12.9280005	305.8	-6.89525	EXTRAPOLATED	-28.71	0.458372331	22.46	3
Betula glandulosa	BGCAMAS5	1928	8	6	CANL	Porsild, A. Erling; Porsild, R.Thorbjörn	5231	10-Jan-2020	66.33	-118.50	227	42	-7.69299988	10.3479996	306.3	-6.900558333	EXTRAPOLATED	-26.57	0.297272905	20.20	2
Betula glandulosa	BGCAMAS6	1931	7	1	CANL	Soper, J. Dewey		9-Jan-2020	63.17	-69.92	409	64	-9.37366674	8.9200001	307.7	-6.981575868	Rubino et al. 2013 JGR Atmosphere	-26.21	0.322619162	19.74	2
Betula glandulosa	BGCAMAS7	1932	7	13	CANL	Raup, Hugh M.; Abbe, Ernst C.	3759	10-Jan-2020	56.02	-123.65	642	84	0.182499967	11.9160004	308.2	-6.906437354	Rubino et al. 2013 JGR Atmosphere	-25.16	0.52203	18.72	2
Betula glandulosa	BGCAMAS8	1932	8	2	CANL	Raup, Hugh M.; Abbe, Ernst C.	4261	10-Jan-2020	56.03	-122.72	618	63	1.994166549	13.4040003	308.2	-6.906437354	Rubino et al. 2013 JGR Atmosphere	-27.24	0.533468081	20.91	2
Betula glandulosa	BGCAMAS9	1934	8	10	CANL	Porsild, A. Erling	7216	10-Jan-2020	68.67	-134.12	233	39	-8.65966678	10.2080002	309	-6.929958333	EXTRAPOLATED	-27.75	0.325159708	21.42	2
Betula glandulosa	BGCAMAS10	1935	6	25	CANL	Porsild, A. Erling	7374	10-Jan-2020	68.67	-134.12	233	20	-8.65966678	9.8439999	309.4	-6.975653303	Rubino et al. 2013 JGR Atmosphere	-27.54	0.476353085	21.15	2
Betula glandulosa	BGCAMAS11	1937	7	12	CANL	Porsild, A. Erling	34	10-Jan-2020	53.45	-55.78	947	84	0.279166766	11.8999996	310	-6.950171241	Rubino et al. 2013 JGR Atmosphere	-25.72	0.293757657	19.27	0

Betula glandulosa	BGCAMAS12	1937	8	4	CANL	Wynne-Edwards, V.C.	7385	9-Jan-2020	62.95	-66.00	477	82	-7.02	5.88	310	-6.950171241	Rubino et al. 2013 JGR Atmosphere	-28.56	0.109658996	22.25	2
Betula glandulosa	BGCAMAS13	1938	7	31	CANL	Dutilly, Arthème H.		10-Jan-2020	64.50	-97.00	255	41	-12.22150003	11.1440001	310.2	-6.943381051	Rubino et al. 2013 JGR Atmosphere	-26.79	0.404129905	20.39	2
Betula glandulosa	BGCAMAS14	1939	7	24	CANL	Raup, Hugh M.; Soper, James H.	9585	10-Jan-2020	62.07	-127.50	509	80	-4.885499901	12.8559999	310.3	-6.994140442	Rubino et al. 2013 JGR Atmosphere	-26.53	0.508559899	20.06	2
Betula glandulosa	BGCAMAS15	1939	7	18	CANL	Raup, Hugh M.; Soper, James H.	9510	10-Jan-2020	62.08	-127.58	583	93	-5.997166699	8.6920004	310.3	-6.994140442	Rubino et al. 2013 JGR Atmosphere	-26.72	0.421134042	20.27	2
Betula glandulosa	BGCAMAS16	1939	7	3	CANL	Raup, Hugh M.; Soper, James H.	9341	10-Jan-2020	62.08	-127.58	583	93	-5.997166699	8.6920004	310.3	-6.994140442	Rubino et al. 2013 JGR Atmosphere	-27.16	0.421134042	20.73	2
Betula glandulosa	BGCAMAS17	1939	7	18	CANL	Raup, Hugh M.; Soper, James H.	9502	10-Jan-2020	62.08	-127.58	555	87	-5.49916651	10.7159996	310.3	-6.994140442	Rubino et al. 2013 JGR Atmosphere	-25.91	0.44812507	19.42	2
Betula glandulosa	BGCAMAS18	1947	8	31	CANL	Harper, Francis	2457	9-Jan-2020	60.61	-99.94	348	50	-8.436833408	11.9359999	310.2	-7.013360568	Rubino et al. 2013 JGR Atmosphere	-27.42	0.392272211	20.98	2
Betula glandulosa	BGCAMAS19	1947	7	6	CANL	Harper, Francis	2268	10-Jan-2020	60.61	-99.94	348	61	-8.436833408	14.0279999	310.2	-7.013360568	Rubino et al. 2013 JGR Atmosphere	-26.48	0.571981578	20.00	2
Betula glandulosa	BGCAMAS20	1948	7	13	CANL	Shacklette, Hansford T.	2943	10-Jan-2020	65.72	-118.90	247	37	-6.986333365	14.1199999	310.3	-7.042682429	Rubino et al. 2013 JGR Atmosphere	-27.48	0.623568421	21.01	4
Betula glandulosa	BGCAMAS21	1948	7	20	CANL	Shacklette, Hansford T.	3110	10-Jan-2020	65.72	-118.90	247	37	-6.986333365	14.1199999	310.3	-7.042682429	Rubino et al. 2013 JGR Atmosphere	-27.86	0.623568421	21.41	4
Betula glandulosa	BGCAMAS22	1948	7	19	CANL	Shacklette, Hansford T.	3101	10-Jan-2020	65.72	-118.90	247	37	-6.986333365	14.1199999	310.3	-7.042682429	Rubino et al. 2013 JGR Atmosphere	-27.45	0.623568421	20.99	4
Betula glandulosa	BGCAMAS23	1948	7	3	CANL	Shacklette, Hansford T.	2797	10-Jan-2020	66.10	-119.00	231	35	-7.403999877	11.1999998	310.3	-7.042682429	Rubino et al. 2013 JGR Atmosphere	-28.03	0.32066696	21.60	4
Betula glandulosa	BGCAMAS24	1948	7	27	CANL	Shacklette, Hansford T.	3203	10-Jan-2020	66.47	-118.08	224	34	-7.929833266	11.6280003	310.3	-7.042682429	Rubino et al. 2013 JGR Atmosphere	-27.37	0.388937078	20.89	2

Betula glandulosa	BGCAMAS26	1949	7	21	CANL	Porsild, A. Erling	17099	10-Jan-2020	66.13	-122.50	257	39	-6.923833362	13.8520002	310.5	-7.00305	EXTRAPOLATED	-26.27	0.622980891	19.78	2
Betula glandulosa	BGCAMAS27	1949	7	26	CANL	Porsild, A. Erling	17170	9-Jan-2020	67.83	-115.09	240	32	-10.65032058	10.4153996	310.5	-7.00305	EXTRAPOLATED	-25.78	0.326792448	19.27	3
Betula glandulosa	BGCAMAS28	1949	8	8	CANL	Porsild, A. Erling	17274	10-Jan-2020	70.74	-117.77	180	35	-11.84886361	6.2818198	310.5	-7.003458333	EXTRAPOLATED	-27.81	0.170173025	21.40	2
Betula glandulosa	BGCAMAS29	1950	7	12	CANL	Schwedland, J.		10-Jan-2020	53.87	-58.95	957	103	-1.34453129	12.5187998	310.7	-7.006340998	Rubino et al. 2013 JGR Atmosphere	-27.09	0.369202453	20.64	0
Betula glandulosa	BGCAMAS30	1950	7	31	CANL	Scoggan, Homer J.; Baldwin, William K.W.	8354	9-Jan-2020	60.00	-98.17	384	62	-8.059000023	13.6440001	310.7	-7.006340998	Rubino et al. 2013 JGR Atmosphere	-28.69	0.522505069	22.32	3
Betula glandulosa	BGCAMAS31	1951	7	19	CANL	Lindsey, Alton A.	340	10-Jan-2020	64.42	-124.80	302	46	-4.752000076	16.948	311.1	-7.01285	EXTRAPOLATED	-27.85	0.761506688	21.43	2
Betula glandulosa	BGCAMAS32	1952	7	28	CANL	Brown, D.K.	1350	9-Jan-2020	60.97	-101.33	330	58	-8.458833379	13.0799999	311.5	-7.01775	EXTRAPOLATED	-29.47	0.476071758	23.14	2
Betula glandulosa	BGCAMAS33	1952	7	20	CANL	Irvine, B.R.	1222	9-Jan-2020	62.92	-96.88	283	45	-10.67233334	10.6120005	311.5	-7.01775	EXTRAPOLATED	-27.67	0.300824545	21.24	2
Betula glandulosa	BGCAMAS34	1955	8	25	CANL	Beckett, Eva	43	10-Jan-2020	63.33	-90.75	262	50	-10.69739576	9.4125004	313	-7.032858333	EXTRAPOLATED	-27.86	0.360807037	21.43	0
Betula glandulosa	BGCAMAS35	1955	8		CANL	Tener, Dr. John S.	388	9-Jan-2020	65.13	-104.58	219	39	-11.27833341	10.2880001	313	-7.032858333	EXTRAPOLATED	-27.39	0.356241179	20.93	3
Betula glandulosa	BGCAMAS36	1956	7	14	CANL	Hustich, I.		10-Jan-2020	56.00	-87.63	508	77	-4.825500026	13.2360001	313.6	-7.03735	EXTRAPOLATED	-27.25	0.382299083	20.78	4
Betula glandulosa	BGCAMAS37	1958	7	23	CANL	Pruitt Jr., William O.	36	9-Jan-2020	64.72	-100.25	217	38	-11.30133317	12.2799997	315.86	-7.04715	EXTRAPOLATED	-27.98	0.497895182	21.54	2
Betula glandulosa	BGCAMAS38	1959	8	5	CANL	Jeffrey, W.W.	405	10-Jan-2020	60.75	-123.97	541	75	-3.043000057	10.6560001	314.8	-7.066511729	Rubino et al. 2013 JGR Atmosphere	-27.35	0.443783533	20.86	2
Betula glandulosa	BGCAMAS39	1959	8	10	CANL	Porsild, A. Erling	21535	9-Jan-2020	63.75	-68.52	419	65	-8.746354194	6.9375	314.8	-7.066511729	Rubino et al. 2013 JGR Atmosphere	-28.37	0.18037623	21.92	2
Betula glandulosa	BGCAMAS40	1959	8	22	CANL	Barry, T.W.	442	10-Jan-2020	69.70	-129.00	119	30	-10.62083346	7.9583302	314.8	-7.066511729	Rubino et al. 2013 JGR Atmosphere	-28.27	0.150057108	21.82	3
Betula glandulosa	BGCAMAS41	1960	6	25	CANL	Porsild, A. Erling; Porsild, R.Thorbjörn	22029	10-Jan-2020	59.00	-126.00	573	75	-2.576666673	8.6040001	319.59	-7.056541667	EXTRAPOLATED	-27.69	0.44724863	21.22	0
Betula glandulosa	BGCAMAS42	1960	7	15	CANL	Arnold, E.W.	29	10-Jan-2020	64.00	-128.00	404	65	-5.871666837	13	318.18	-7.05695	EXTRAPOLATED	-26.12	0.558613725	19.58	2
Betula glandulosa	BGCAMAS43	1960	6	26	CANL	Arnold, E.W.	22	10-Jan-	64.00	-128.00	404	52	-5.87	11.0319996	319.59	-7.05654	EXTRAPOLATED	-26.39	0.58870	19.85	2

								2020					1666837			1667			3965		
Betula glandulosa	BGCAMAS44	1961	7	25	CANL	Maini, J.S.; Swan, M.A.	502	10-Jan-2020	61.00	-105.00	363	55	-7.021333589	14.3079996	318.57	-7.06185	EXTRAPOLATED	-28.08	0.551315534	21.63	3
Betula glandulosa	BGCAMAS45	1961	6	27	CANL	Macpherson, Elizabeth	303	9-Jan-2020	64.45	-99.00	224	21	-11.27033342	3.312	319.77	-7.061441667	EXTRAPOLATED	-26.32	0.104957626	19.78	2
Betula glandulosa	BGCAMAS46	1962	6	29	CANL	Baldwin, William K.W.	9612	10-Jan-2020	53.20	-70.90	812	88	-3.905000011	9.3839998	320.62	-7.091484283	Rubino et al. 2013 JGR Atmosphere	-24.56	0.298543129	17.91	1
Betula glandulosa	BGCAMAS47	1962	7	9	CANL	Baldwin, William K.W.	9716	10-Jan-2020	53.20	-70.90	812	111	-3.905000011	13.4799995	319.61	-7.091484283	Rubino et al. 2013 JGR Atmosphere	-26.02	0.365907202	19.44	1
Betula glandulosa	BGCAMAS48	1962	7	24	CANL	Baldwin, William K.W.	9844	10-Jan-2020	53.20	-70.90	812	111	-3.905000011	13.4799995	319.61	-7.091484283	Rubino et al. 2013 JGR Atmosphere	-24.73	0.365907202	18.08	1
Betula glandulosa	BGCAMAS49	1962	7	24	CANL	Baldwin, William K.W.	9845	10-Jan-2020	53.20	-70.90	812	111	-3.905000011	13.4799995	319.61	-7.091484283	Rubino et al. 2013 JGR Atmosphere	-24.96	0.365907202	18.32	1
Betula glandulosa	BGCAMAS50	1962	7	5	CANL	Youngman, Philip M.; Tessier, Gaston D.	10	10-Jan-2020	67.77	-136.03	314	44	-7.742333328	13.2959995	319.61	-7.091484283	Rubino et al. 2013 JGR Atmosphere	-26.05	0.623869432	19.46	2
Betula glandulosa	BGCAMAS51	1962	7	16	CANL	Youngman, Philip M.; Tessier, Gaston D.	92	10-Jan-2020	67.77	-136.03	314	44	-7.742333328	13.2959995	319.61	-7.091484283	Rubino et al. 2013 JGR Atmosphere	-27.91	0.623869432	21.42	2
Betula glandulosa	BGCAMAS52	1962	8	10	CANL	Barry, T.W.	236	10-Jan-2020	69.70	-129.00	119	30	-10.62083346	7.9583302	317.4	-7.091484283	Rubino et al. 2013 JGR Atmosphere	-27.91	0.150057108	21.42	3
Betula glandulosa	BGCAMAS53	1963	8	5	CANL	Cain, Roy F.		10-Jan-2020	47.67	-59.13	1645	122	3.343666635	14.7159996	317.77	-7.055	Rubino et al. 2013 JGR Atmosphere	-26.06	0.221702702	19.51	0
Betula glandulosa	BGCAMAS54	1963	8	8	CANL	Hustich, I., Kallio, P.	885	10-Jan-2020	52.92	-66.18	817	94	-3.923333434	12.2159996	317.77	-7.055	Rubino et al. 2013 JGR Atmosphere	-26.81	0.361889061	20.30	4
Betula glandulosa	BGCAMAS55	1963	6	8	CANL	Brayshaw, Thomas C.; Merilees, W. J.		10-Jan-2020	53.68	-122.75	621	69	4.284833342	13.5439997	321.48	-7.055	Rubino et al. 2013 JGR Atmosphere	-24.76	0.612365852	18.16	2
Betula glandulosa	BGCAMAS56	1963	7	15	CANL	Brayshaw, Thomas C.; Merilees, W. J.		10-Jan-2020	54.18	-125.72	471	46	2.941166751	14.316	319.74	-7.055	Rubino et al. 2013 JGR Atmosphere	-28.06	0.612160568	21.61	2

Betula glandulosa	BGCAMAS57	1963	8	27	CANL	Auclair, Allan	535	10-Jan-2020	54.25	-122.63	687	57	3.507166502	14.6199999	317.77	-7.055	Rubino et al. 2013 JGR Atmosphere	-27.85	0.622555982	21.39	2
Betula glandulosa	BGCAMAS58	1964	7	14	CANL	Lambert, J.D.H.	s.n.	9-Jan-2020	69.12	-104.57	135	20	-14.0868332	9.50800004	320.44	-7.07655	EXTRAPOLATED	-27.44	0.322820865	20.94	2
Betula glandulosa	BGCAMAS59	1965	6	23	CANL	Rossbach, G.B.	6319	10-Jan-2020	62.45	-114.37	279	26	-4.622666592	12.2159996	321.87	-7.081041667	EXTRAPOLATED	-24.82	0.588289061	18.20	2
Betula glandulosa	BGCAMAS60	1965	7	3	CANL	Rossbach, G.B.	6464	10-Jan-2020	63.95	-103.88	243	39	-10.26833348	13.9040003	321.21	-7.08145	EXTRAPOLATED	-25.31	0.584739406	18.70	2
Betula glandulosa	BGCAMAS61	1965	7	3	CANL	Rossbach, G.B.	6464	10-Jan-2020	63.95	-103.88	243	39	-10.26833348	13.9040003	321.21	-7.08145	EXTRAPOLATED	-25.82	0.584739406	19.23	2
Betula glandulosa	BGCAMAS62	1965	7	10	CANL	Rossbach, G.B.	6611	9-Jan-2020	64.55	-100.45	213	38	-11.12833324	11.9639997	321.21	-7.08145	EXTRAPOLATED	-26.01	0.452054943	19.44	2
Betula glandulosa	BGCAMAS63	1965	7	10	CANL	Rossbach, G.B.	6611	9-Jan-2020	64.55	-100.45	213	38	-11.12833324	11.9639997	321.21	-7.08145	EXTRAPOLATED	-25.88	0.452054943	19.29	2
Betula glandulosa	BGCAMAS64	1965	7	19	CANL	Rossbach, G.B.	6711	9-Jan-2020	64.60	-98.65	225	39	-11.53916674	10.0719995	321.21	-7.08145	EXTRAPOLATED	-26.00	0.295473048	19.42	2
Betula glandulosa	BGCAMAS65	1965	7	11	CANL	Rossbach, G.B.	6616	9-Jan-2020	64.67	-99.88	215	38	-11.51866676	11.908	321.21	-7.08145	EXTRAPOLATED	-25.56	0.466493657	18.97	2
Betula glandulosa	BGCAMAS66	1965	7	25	CANL	Rossbach, G.B.	6773	9-Jan-2020	64.73	-98.00	227	38	-11.74566669	9.94400002	321.21	-7.08145	EXTRAPOLATED	-27.46	0.287732669	20.96	2
Betula glandulosa	BGCAMAS67	1965	7	21	CANL	Rossbach, G.B.	6773	9-Jan-2020	64.73	-98.00	227	38	-11.74566669	9.94400002	321.21	-7.08145	EXTRAPOLATED	-27.67	0.287732669	21.17	2
Betula glandulosa	BGCAMAS68	1965	7	27	CANL	Rossbach, G.B.	6834	9-Jan-2020	64.78	-97.02	239	39	-12.146	10.2559996	321.21	-7.08145	EXTRAPOLATED	-25.66	0.311964774	19.07	2
Betula glandulosa	BGCAMAS69	1967	7	14	CANL	Argus, George W.; Chunys, W.N.	6760	10-Jan-2020	59.58	-135.48	1072	47	-0.944666699	10.8240004	322.54	-7.333113852	Rubino et al. 2013 JGR Atmosphere	-27.19	0.328225622	20.41	0
Betula glandulosa	BGCAMAS70	1967	7	14	CANL	Argus, George W.; Chunys, W.N.	6760	10-Jan-2020	59.78	-136.45	774	59	-1.690500011	9.58800003	322.54	-7.333113852	Rubino et al. 2013 JGR Atmosphere	-27.03	0.434432134	20.24	2
Betula glandulosa	BGCAMAS71	1967	7	21-22	CANL	David F. Murray, Barbara M. Murray	983	10-Jan-2020	61.62	-141.97	744	113	-5.198166711	7.18800002	322.54	-7.333113852	Rubino et al. 2013 JGR Atmosphere	-28.00	0.354779492	21.27	2
Betula glandulosa	BGCAMAS72	1971	7	15	CANL	Brayshaw, Thomas C.; Barrett, D.		10-Jan-2020	59.40	-133.57	501	43	1.035166715	12.2679996	327.36	-7.347751263	Rubino et al. 2013 JGR Atmosphere	-27.42	0.481967334	20.64	2
Betula glandulosa	BGCAMAS73	1971	7	27	CANL	Brayshaw, Thomas C.; Barrett, D.		10-Jan-2020	59.77	-136.60	738	53	-1.38866667	11.0240002	327.36	-7.347751263	Rubino et al. 2013 JGR Atmosphere	-26.60	0.429604624	19.77	2
Betula glandulosa	BGCAMAS74	1971	7	5	CANL	Argus, George W.;	7928	10-Jan-2020	61.42	-117.40	287	41	-2.947333282	16.5919991	327.36	-7.347751263	Rubino et al. 2013 JGR	-27.72	0.650734211	20.95	2

						Chunys, W.N.											Atmosphere				
Betula glandulosa	BGCAMAS75	1971	8	20	CANL	Ohenoja, Esteri	17	9-Jan-2020	62.80	-92.08	322	56	-10.44236107	9.76111103	325.43	-7.347751263	Rubino et al. 2013 JGR Atmosphere	-28.89	0.308809564	22.19	2
Betula glandulosa	BGCAMAS76	1971	8	12	CANL	Dabbs, Don L.	173	10-Jan-2020	64.75	-125.50	293	48	-5.151000024	13.0559998	325.43	-7.347751263	Rubino et al. 2013 JGR Atmosphere	-25.11	0.496510545	18.22	4
Betula glandulosa	BGCAMAS77	1971	7	17	CANL	Argus, George W.; Chunys, W.N.	8034	10-Jan-2020	64.90	-127.18	358	56	-6.011333307	13.4840002	327.36	-7.347751263	Rubino et al. 2013 JGR Atmosphere	-26.52	0.615510151	19.70	2
Betula glandulosa	BGCAMAS78	1971	7	16	CANL	Argus, George W.; Chunys, W.N.	8015	10-Jan-2020	64.90	-127.18	358	56	-6.011333307	13.4840002	327.36	-7.347751263	Rubino et al. 2013 JGR Atmosphere	-26.90	0.615510151	20.09	2
Betula glandulosa	BGCAMAS79	1971	8	2	CANL	MacInnes, K.L.		10-Jan-2020	69.43	-132.93	155	30	-10.27735504	8.5	325.43	-7.347751263	Rubino et al. 2013 JGR Atmosphere	-27.35	0.154105812	20.57	3
Betula glandulosa	BGCAMAS80	1973	7	23	CANL	Gillett, John M.	16200	10-Jan-2020	62.20	-95.67	299	43	-10.1831666	11.724	330.87	-7.392841953	Rubino et al. 2013 JGR Atmosphere	-28.29	0.37285257	21.51	2
Betula glandulosa	BGCAMAS81	1973	7	21	CANL	Gillett, John M.	16124	10-Jan-2020	62.28	-95.50	299	43	-10.17033333	11.552	330.87	-7.392841953	Rubino et al. 2013 JGR Atmosphere	-27.28	0.362071655	20.45	2
Betula glandulosa	BGCAMAS82	1973	7	29	CANL	Gubbe, D.	296 (75)	10-Jan-2020	65.88	-128.08	305	43	-6.203666586	16.4319992	330.87	-7.392841953	Rubino et al. 2013 JGR Atmosphere	-26.52	0.745607834	19.64	4
Betula glandulosa	BGCAMAS83	1973	7	29	CANL	Gubbe, D.	276 (79)	10-Jan-2020	65.88	-128.08	305	43	-6.203666586	16.4319992	330.87	-7.392841953	Rubino et al. 2013 JGR Atmosphere	-27.60	0.745607834	20.78	4
Betula glandulosa	BGCAMAS84	1973	6	19	CANL	Welsh, S.L.	11937	10-Jan-2020	67.73	-136.37	288	30	-7.870833298	11.1719999	332.07	-7.392841953	Rubino et al. 2013 JGR Atmosphere	-26.28	0.653796412	19.40	2
Betula glandulosa	BGCAMAS85	1973	7	10	CANL	L. Hettinger	236	10-Jan-2020	68.25	-144.17	171	35	-8.134166523	8.8079996	330.87	-7.392841953	Rubino et al. 2013 JGR Atmosphere	-26.93	0.562000272	20.08	3
Betula glandulosa	BGCAMAS86	1974	8	24	CANL	Gubbe, D.; Burr, D.	603	10-Jan-2020	65.82	-128.25	313	44	-6.108833341	11.9879999	329.39	-7.4826114	Rubino et al. 2013 JGR Atmosphere	-27.64	0.458272084	20.73	4
Betula glandulosa	BGCAMAS87	1974	8	30	CANL	Gubbe, D.; Burr, D.	675	10-Jan-2020	65.85	-128.13	297	41	-6.054666683	12.8959999	329.39	-7.4826114	Rubino et al. 2013 JGR Atmosphere	-27.69	0.465252079	20.78	2

Betula glandulosa	BGCAMAS88	1974	7	29	CANL	Rigby, J.K.	258	10-Jan-2020	67.03	-126.08	243	34	-7.537333307	14.5600004	331.18	-7.4826114	Rubino et al. 2013 JGR Atmosphere	-26.15	0.638517983	19.16	4
Betula glandulosa	BGCAMAS89	1975	8	10	CANL	Argus, George W.; White, David J.	9815	10-Jan-2020	58.98	-109.33	457	66	-2.54716668	14.868	330.06	-7.417906395	Rubino et al. 2013 JGR Atmosphere	-25.77	0.488200314	18.84	1
Betula glandulosa	BGCAMAS90	1975	8	10	CANL	Argus, George W.; White, David J.	9819	10-Jan-2020	58.98	-109.33	457	66	-2.54716668	14.868	330.06	-7.417906395	Rubino et al. 2013 JGR Atmosphere	-28.26	0.488200314	21.45	1
Betula glandulosa	BGCAMAS91	1975	7	15	CANL	Talbot, Stephen	T5026-6	10-Jan-2020	61.12	-123.78	503	94	-3.198166595	12.9160004	331.9	-7.417906395	Rubino et al. 2013 JGR Atmosphere	-29.18	0.514801576	22.41	2
Betula glandulosa	BGCAMAS92	1975	7	11	CANL	Talbot, Stephen	T5007	10-Jan-2020	61.22	-123.62	468	89	-3.317666675	13.908	331.9	-7.417906395	Rubino et al. 2013 JGR Atmosphere	-28.28	0.540752226	21.47	2
Betula glandulosa	BGCAMAS93	1975	7	26	CANL	Talbot, Stephen	T5056	10-Jan-2020	61.37	-125.35	485	85	-4.338500097	13.1239996	331.9	-7.417906395	Rubino et al. 2013 JGR Atmosphere	-27.70	0.524809054	20.86	2
Betula glandulosa	BGCAMAS94	1975	7	1	CANL	Rosie, R.M.	12	10-Jan-2020	61.43	-129.33	520	76	-4.193166678	11.8879995	331.9	-7.417906395	Rubino et al. 2013 JGR Atmosphere	-27.84	0.512654341	21.01	2
Betula glandulosa	BGCAMAS95	1976	8	8	CANL	Shea, Garry A.	10888	10-Jan-2020	48.48	-83.37	795	79	1.338499967	15.3879995	330.94	-7.442709622	Rubino et al. 2013 JGR Atmosphere	-26.78	0.36332201	19.87	1
Betula glandulosa	BGCAMAS96	1976	8	11	CANL	Edlund, Sylvia A.	947	10-Jan-2020	67.53	-94.05	200	40	-14.02016662	6.95200001	330.94	-7.442709622	Rubino et al. 2013 JGR Atmosphere	-28.20	0.206870692	21.36	4
Betula glandulosa	BGCAMAS97	1976	7	17	CANL	Edlund, Sylvia A.	702	10-Jan-2020	67.58	-94.33	199	27	-13.83866655	9.1719999	333.05	-7.442709622	Rubino et al. 2013 JGR Atmosphere	-27.81	0.291022673	20.95	4
Betula glandulosa	BGCAMAS98	1976	7	13	CANL	Edlund, Sylvia A.	622	10-Jan-2020	67.66	-94.33	194	28	-14.35100001	8.89999996	333.05	-7.442709622	Rubino et al. 2013 JGR Atmosphere	-27.16	0.297475827	20.26	2
Betula glandulosa	BGCAMAS99	1977	8	7	CANL	Shchepanek, Michael J.; White, D.	2887	10-Jan-2020	49.90	-55.80	1097	108	3.143000015	15.3760004	332.75	-7.485	Rubino et al. 2013 JGR Atmosphere	-27.13	0.411975598	20.20	0
Betula glandulosa	BGCAMAS100	1977	6	16	CANL	Williams, L.R.	70	10-Jan-2020	55.73	-97.83	529	70	-2.460499915	13.4799995	336.27	-7.485	Rubino et al. 2013 JGR Atmosphere	-28.89	0.584707102	22.05	3

Betula glandulosa	BGCAMAS101	1977	8	1	CANL	Argus, George W.; Haber, Erich	10412	10-Jan-2020	56.90	-123.80	729	82	-3.199166672	8.54	332.75	-7.485	Rubino et al. 2013 JGR Atmosphere	-27.69	0.48080851	20.78	0
Betula glandulosa	BGCAMAS102	1977	7	25	CANL	Argus, George W.; Haber, Erich	9976	10-Jan-2020	57.33	-123.93	702	116	-3.382333353	8.4799995	334.92	-7.485	Rubino et al. 2013 JGR Atmosphere	-27.57	0.427087623	20.65	0
Betula glandulosa	BGCAMAS103	1977	7	19	CANL	Argus, George W.; Haber, Erich	10753	10-Jan-2020	58.45	-124.88	634	114	-3.829166719	9.1000004	334.92	-7.485	Rubino et al. 2013 JGR Atmosphere	-27.95	0.402591729	21.05	2
Betula glandulosa	BGCAMAS104	1977	7	20	CANL	Argus, George W.; Haber, Erich	10807	10-Jan-2020	58.45	-124.88	634	114	-3.829166719	9.1000004	334.92	-7.485	Rubino et al. 2013 JGR Atmosphere	-27.40	0.402591729	20.48	2
Betula glandulosa	BGCAMAS105	1979	7	13	CANL	Cooper, P.F	1035	10-Jan-2020	68.96	-139.61	212	39	-9.344333219	10.224	337.73	-7.54	Rubino et al. 2013 JGR Atmosphere	-26.39	0.510893474	19.36	2
Betula glandulosa	BGCAMAS106	1979	7	11	CANL	Cooper, P.F	855	10-Jan-2020	69.17	-139.24	206	35	-9.236666654	10.96	337.73	-7.54	Rubino et al. 2013 JGR Atmosphere	-27.30	0.453221202	20.31	2
Betula glandulosa	BGCAMAS107	1980	7	19	CANL	Cooper, P.F	1319	10-Jan-2020	68.75	-139.44	237	38	-9.213666717	11.684	339.56	-7.59	Keeling et al. 2001	-26.87	0.556015198	19.81	2
Betula glandulosa	BGCAMAS108	1981	7	20	CANL	Gillett, John M.	18691	10-Jan-2020	69.45	-133.03	152	22	-10.19625002	10.5799999	340.49	-7.61	Keeling et al. 2001	-28.13	0.236896742	21.11	3
Betula glandulosa	BGCAMAS109	1982	7	20	CANL	Gillett, John M.	18968	9-Jan-2020	63.75	-68.52	419	60	-8.746354194	7.9000001	342.06	-7.67	Keeling et al. 2001	-26.81	0.24831221	19.67	2
Betula glandulosa	BGCAMAS110	1982	7	18	CANL	Edlund, Sylvia A.	437	10-Jan-2020	70.80	-117.44	173	25	-12.10800022	8.9399996	342.06	-7.67	Keeling et al. 2002	-27.07	0.347764256	19.94	0
Betula glandulosa	BGCAMAS111	1982	7	18	CANL	Edlund, Sylvia A.	435	10-Jan-2020	70.80	-117.44	173	25	-12.10800022	8.9399996	342.06	-7.67	Keeling et al. 2003	-29.22	0.347764256	22.20	0
Betula glandulosa	BGCAMAS112	1982	7	18	CANL	Edlund, Sylvia A.	433	10-Jan-2020	70.80	-117.44	173	25	-12.10800022	8.9399996	342.06	-7.67	Keeling et al. 2004	-27.71	0.347764256	20.61	0
Betula glandulosa	BGCAMAS113	1982	7	18	CANL	Edlund, Sylvia A.	436	10-Jan-2020	70.80	-117.44	173	25	-12.10800022	8.9399996	342.06	-7.67	Keeling et al. 2005	-27.85	0.347764256	20.76	0
Betula glandulosa	BGCAMAS114	1982	7	18	CANL	Edlund, Sylvia A.	434	10-Jan-2020	70.80	-117.44	173	25	-12.10800022	8.9399996	342.06	-7.67	Keeling et al. 2006	-29.24	0.347764256	22.22	0
Betula glandulosa	BGCAMAS115	1982	7	30	CANL	Edlund, Sylvia A.	577	10-Jan-2020	71.51	-117.33	164	24	-13.00783344	7.7519999	342.06	-7.67	Keeling et al. 2007	-28.37	0.30670814	21.30	2
Betula glandulosa	BGCAMAS116	1983	7	15	CANL	Argus, George W.	11126	10-Jan-2020	56.13	-74.53	590	74	-4.565999973	9.6079998	343.98	-7.71	Keeling et al. 2001	-28.23	0.087639559	21.12	1
Betula glandulosa	BGCAMAS117	1983	7	29	CANL	Edlund, Sylvia A.	399	9-Jan-2020	64.30	-96.05	266	43	-11.62316679	11.1000004	343.98	-7.71	Keeling et al. 2002	-28.02	0.362262095	20.90	2
Betula glandulosa	BGCAMAS118	1983	7	23	CANL	Edlund, Sylvia A.	631	10-Jan-2020	69.45	-133.03	152	22	-10.19625002	10.5799999	343.98	-7.71	Keeling et al. 2003	-26.43	0.236896742	19.22	3

Betula glandulosa	BGCAMAS119	1985	7	24	CANL	Jacobs, J.D.		9-Jan-2020	65.93	-71.37	319	45	-10.28233317	8.44400002	346.56	-7.68	Keeling et al. 2001	-27.77	0.315982929	20.67	4
Betula glandulosa	BGCAMAS120	1985	7	16	CANL	Ironside, Gary		9-Jan-2020	66.72	-64.02	398	39	-8.741500037	9.47599998	346.56	-7.68	Keeling et al. 2002	-26.96	0.440664791	19.81	2
Betula glandulosa	BGCAMAS121	1986	8	16	CANL	Aiken, Susan; Campbell, Carol A.; Robinson, Elizabeth	86-331	9-Jan-2020	63.73	-68.45	428	67	-8.942777865	6.68666698	345.9	-7.52	Keeling et al. 2001	-27.63	0.184143988	20.68	2
Betula glandulosa	BGCAMAS122	1986	8	6	CANL	Aiken, Susan; Campbell, Carol A.; Robinson, Elizabeth	86-087	9-Jan-2020	65.95	-71.30	322	55	-10.19212965	7.02222201	345.9	-7.52	Keeling et al. 2002	-26.83	0.233698959	19.84	4
Betula glandulosa	BGCAMAS123	1988	8	19	CANL	Haber, Erich; Bristow, Valerie N.	3824	10-Jan-2020							350.43	-7.52	Keeling et al. 2003	-27.88		20.94	
Betula glandulosa	BGCAMAS124	1989	8	20	CANL	Aiken, Susan	89-065	9-Jan-2020	63.45	-67.25	508	78	-8.659000038	6.37599999	351.67	-7.71	Keeling et al. 2001	-28.50	0.193231317	21.40	2
Betula glandulosa	BGCAMAS125	1990	7	5	CANL	Consaul, Laurie L.; Aiken, Susan	863	10-Jan-2020	69.47	-140.98	155	30	-10.29950007	10.8760004	354.81	-7.79	Keeling et al. 2001	-28.33	0.504724638	21.14	2
Betula glandulosa	BGCAMAS126	1991	7	26	CANL	Brunton, Daniel F.; McIntosh, Karen L.	10490	9-Jan-2020	62.89	-92.20	312	40	-10.46666656	10.6000004	356.17	-7.82	Keeling et al. 2001	-27.12	0.37860103	19.83	2
Betula glandulosa	BGCAMAS127	2001	7	23	CANL	Aiken, Susan; Brysting, Anne	01-012	10-Jan-2020	58.75	-93.85	417	54	-6.922000056	12.3559999	371.62	-8.05	Keeling et al. 2001	-29.10	0.336256363	21.68	3
Betula glandulosa	BGCAMAS128	2001	7	27	CANL	Aiken, Susan; Brysting, Anne	01-053	9-Jan-2020	62.80	-92.10	322	41	-10.44236107	10.5166998	371.62	-8.05	Keeling et al. 2002	-29.57	0.371515951	22.17	2
Betula glandulosa	BGCAMAS129	2001	8	6	CANL	Aiken, Susan; Brysting, Anne	01-0477	10-Jan-2020	69.50	-133.00	150	29	-10.29734852	8.4818201	369.55	-7.97	Keeling et al. 2001	-27.71	0.156097563	20.30	3
Betula glandulosa	BGCAMAS130	2003	8	12	CANL	Pokiak, Myrna	47	10-Jan-2020	69.40	-133.00	159	30	-10.14296867	8.6875	374.48	-8.1	Keeling et al. 2001	-29.38	0.166266294	21.92	3
Betula glandulosa	BGCAMAS131	2004	7	5	CANL	Aiken, Susan; LeBlanc, Michelle	04-002	9-Jan-2020	63.76	-68.46	423	61	-9.060833367	8.35599999	377.76	-8.19	Keeling et al. 2001	-30.54	0.304595735	23.06	2
Betula glandulosa	BGCAMAS132	2005	8	4	CANL	Archambault, Annie	AA 269	9-Jan-2020	62.85	-69.87	390	49	-7.534500008	7.73600001	378.67	-8.15	Keeling et al. 2001	-28.72	0.205556647	21.18	2

Betula glandulosa	BGCAMAS133	2006	7	10	CANL	Davis, Jonathan	0623	9-Jan-2020	67.82	-115.09	240	32	-10.65032058	10.4153996	382.28	-8.27	Keeling et al. 2001	-29.60	0.326792448	21.98	3
Betula glandulosa	BGCAMAS134	2008	7	28	CANL	Burt, Page M.	s.n.	9-Jan-2020	66.84	-108.03	168	27	-11.09166661	10.5	386.25	-8.3	Keeling et al. 2001	-30.24	0.19009972	22.62	2
Betula glandulosa	BGCAMAS135	2008	7	2	CANL	Burt, Page M.	s.n.	9-Jan-2020	66.84	-108.03	168	27	-11.09166661	10.5	386.25	-8.3	Keeling et al. 2002	-27.85	0.19009972	20.11	2
Betula glandulosa	BGCAMAS136	2008	7	10	CANL	Gillespie, Lynn J.; Saarela, Jeffery M.; Consaul, Laurie L.; Bull, Roger D.	7805	9-Jan-2020	68.61	-112.57	126	21	-12.16783338	9.7880001	386.25	-8.3	Keeling et al. 2003	-27.48	0.360193581	19.72	2
Betula glandulosa	BGCAMAS137	2008	7	6	CANL	Gillespie, Lynn J.; Saarela, Jeffery M.; Consaul, Laurie L.; Bull, Roger D.	7599	9-Jan-2020	68.62	-112.58	126	21	-12.16783338	9.7880001	386.25	-8.3	Keeling et al. 2004	-27.40	0.360193581	19.64	2
Betula glandulosa	BGCAMAS138	2008	7	12	CANL	Gillespie, Lynn J.; Saarela, Jeffery M.; Consaul, Laurie L.; Bull, Roger D.	7855	9-Jan-2020	68.66	-110.71	125	22	-12.63699988	9.408	386.25	-8.3	Keeling et al. 2005	-29.34	0.2856493	21.68	2
Betula glandulosa	BGCAMAS139	2008	7	13	CANL	Gillespie, Lynn J.; Saarela, Jeffery M.; Consaul, Laurie L.; Bull, Roger D.	7919	9-Jan-2020	68.66	-110.71	125	22	-12.63699988	9.408	386.25	-8.3	Keeling et al. 2006	-27.28	0.2856493	19.51	2
Betula glandulosa	BGCAMAS140	2009	6	27	CANL	Gillespie, Lynn J.; Saarela, Jeffery M.; Consaul, Laurie L.; Bull, Roger D.	8556	10-Jan-2020	69.35	-124.07	218	16	-9.48939992	6.2090902	389.62	-8.4	Keeling et al. 2001	-29.07	0.209937269	21.29	2
Betula glandulosa	BGCAMAS141	2010	8	10	CANL	Consaul, Laurie L.; Kattuk, Emily; Meeko,	4024	9-Jan-2020	56.46	-79.14	515	71	-4.37549971	10.9239998	388.52	-8.21	Keeling et al. 2001	-29.10	0.268089583	21.52	2

						Betsy; Charette, Don															
Betula glandulosa	BGCAMAS142	2010	8	10	CAN L	Consaul, Laurie L.; Kattuk, Emily; Meeko, Betsy; Charette, Don	4033	9-Jan-2020	56.48	-79.15	515	70	-4.487166618	10.8079996	388.52	-8.21	Keeling et al. 2002	-28.96	0.258043892	21.37	2
Betula glandulosa	BGCAMAS143	2010	8	10	CAN L	Consaul, Laurie L.; Kattuk, Emily; Meeko, Betsy; Charette, Don	4034	9-Jan-2020	56.49	-79.13	515	70	-4.487166618	10.8079996	388.52	-8.21	Keeling et al. 2003	-28.72	0.258043892	21.12	2
Betula glandulosa	BGCAMAS144	2010	8	10	CAN L	Consaul, Laurie L.; Kattuk, Emily; Meeko, Betsy; Charette, Don	4038	9-Jan-2020	56.50	-79.13	515	70	-4.487166618	10.8079996	388.52	-8.21	Keeling et al. 2004	-28.68	0.258043892	21.08	2
Betula glandulosa	BGCAMAS145	2010	8	10	CAN L	Consaul, Laurie L.; Kattuk, Emily; Meeko, Betsy; Charette, Don	4013	9-Jan-2020	56.50	-79.18	507	70	-4.351992831	10.7912998	388.52	-8.21	Keeling et al. 2005	-27.75	0.255003383	20.10	2
Betula glandulosa	BGCAMAS146	2010	6	23	CAN L	Consaul, Laurie L.; Tsujimoto, Megumu; Ip, Morgan; Charette, Don; Kattuk, Emily; Ekidlak, Christine	3623	9-Jan-2020	56.55	-79.18	497	48	-4.429861096	5.5	392.24	-8.43	Keeling et al. 2001	-29.43	0.176845419	21.64	2
Betula glandulosa	BGCAMAS147	2010	7	14	CAN L	Gillespie, Lynn J.; Saarela, Jeffery M.; Doubt,	9819	10-Jan-2020	71.19	-116.41	162	24	-13.20050002	8.3479996	390.33	-8.32	Keeling et al. 2001	-30.16	0.345998595	22.52	0

						Jennifer; Bull, Roger D.; Sokoloff, Paul C.															
Betula glandulosa	BGCAMAS148	2010	7	14	CANL	Gillespie, Lynn J.; Saarela, Jeffery M.; Doubt, Jennifer; Bull, Roger D.; Sokoloff, Paul C.	9807	10-Jan-2020	71.19	-116.41	162	24	-13.20050002	8.34799996	390.33	-8.32	Keeling et al. 2002	-28.65	0.345998595	20.92	0
Betula glandulosa	BGCAMAS149	2010	7	13	CANL	Gillespie, Lynn J.; Saarela, Jeffery M.; Doubt, Jennifer; Bull, Roger D.; Sokoloff, Paul C.	9744	10-Jan-2020	71.21	-116.39	162	24	-13.20050002	8.34799996	390.33	-8.32	Keeling et al. 2003	-28.93	0.345998595	21.23	0
Betula glandulosa	BGCAMAS150	2010	7	10	CANL	Gillespie, Lynn J.; Saarela, Jeffery M.; Doubt, Jennifer; Bull, Roger D.; Sokoloff, Paul C.	9623	10-Jan-2020	71.48	-117.36	156	23	-12.95362332	7.69999998	390.33	-8.32	Keeling et al. 2004	-27.44	0.273978781	19.66	2
Betula glandulosa	BGCAMAS151	2012	6	30	CANL	Saarela, Jeffery M.; Gillespie, Lynn J.; Sokoloff, Paul C.; Bull, Roger D.	1919	9-Jan-2020	63.25	-69.61	420	37	-8.37766691	5.55999999	395.88	-8.45	Keeling et al. 2001	-27.78	0.269687797	19.88	2
Betula glandulosa	BGCAMAS153	2012	6	29	CANL	Saarela, Jeffery M.; Gillespie, Lynn J.; Sokoloff, Paul C.; Bull, Roger D.	1908	9-Jan-2020	63.75	-68.48	426	41	-8.834090924	4.0454502	395.88	-8.45	Keeling et al. 2003	-28.19	0.196125152	20.31	2

Betula glandulosa	BGCAMAS154	2014	7	7	CANL	Saarela, Jeffery M.; Sokoloff, Paul C.; Bull, Roger D.	3525	10-Jan-2020	67.26	-115.52	246	35	-9.695000097	12.1719999	399.07	-8.42	Keeling et al. 2001	-27.24	0.516572757	19.35	2
Betula glandulosa	BGCAMAS155	2014	7	1	CANL	Saarela, Jeffery M.; Sokoloff, Paul C.; Bull, Roger D.	3132	9-Jan-2020	67.43	-115.63	249	35	-9.695666547	12.092	399.07	-8.42	Keeling et al. 2002	-27.54	0.501915311	19.66	2
Betula glandulosa	BGCAMAS156	2014	7	8	CANL	Saarela, Jeffery M.; Sokoloff, Paul C.; Bull, Roger D.	3644	10-Jan-2020	67.52	-115.61	244	34	-9.853833289	11.7200003	399.07	-8.42	Keeling et al. 2003	-28.08	0.46968848	20.23	2
Betula glandulosa	BGCAMAS157	2014	7	16	CANL	Saarela, Jeffery M.; Sokoloff, Paul C.; Bull, Roger D.	4106	10-Jan-2020	67.74	-115.38	240	33	-10.36516655	11.1759996	399.07	-8.42	Keeling et al. 2004	-27.83	0.396549075	19.97	3
Betula glandulosa	BGCAMAS158	2014	7	12	CANL	Saarela, Jeffery M.; Sokoloff, Paul C.; Bull, Roger D.	3826	10-Jan-2020	67.74	-115.37	241	33	-10.38499979	11.0559998	399.07	-8.42	Keeling et al. 2005	-30.09	0.395204127	22.34	3
Betula glandulosa	BGCAMAS159	2014	7	23	CANL	Saarela, Jeffery M.; Sokoloff, Paul C.; Bull, Roger D.	4280	10-Jan-2020	67.80	-115.24	237	32	-10.72133331	10.684	399.07	-8.42	Keeling et al. 2006	-30.76	0.34658068	23.05	3
Betula glandulosa	BGCAMAS160	2014	6	29	CANL	Saarela, Jeffery M.; Sokoloff, Paul C.; Bull, Roger D.	3044	9-Jan-2020	67.82	-115.11	240	16	-10.65032058	5.7384601	401.31	-8.59	Keeling et al. 2001	-28.82	0.223214382	20.83	3
Betula glandulosa	BGCAMAS161	2015	8	13	CANL	Gavin, Megan; Irkok, Ancilla		9-Jan-2020	61.11	-94.09	289	57	-9.265530159	10.7545004	399	-8.33	Keeling et al. 2001	-27.84	0.271833847	20.07	4
Genus, Species	**Personal ID #**	**Collection Year**	**Collection Month**	**Collection Day**		**Source**			**Latitude (°N)**	**Longitude (°W)**	**MAP (mm yr-1)***	**Monthly Average Precipitation (mm)***	**MAT (°C)***	**Monthly Avg Temperature (°C)**	**$[CO_2]$ (ppm)**	**δ13 Catm (‰)**	**δ13C atm (‰) Source****	**δ13C leaf (‰)**	**VPD (kPa)***	**Δleaf (‰)****	**Soil Draingage Classification Level*****

Eriophorum angustifolium	EATKMAS1	1988	7	2		Schell, 2016			68.633333	-149.6333333	234	42	-9.097	12.004	352.38	-7.77	Keeling et al. 2001	-25.946	0.550951888	18.66015642	
Eriophorum angustifolium	EATKMAS2	1988	7	2		Schell, 2016			68.633333	-149.6333333	234	42	-9.097	12.004	352.38	-7.77	Keeling et al. 2001	-25.521	0.550951888	18.21588767	
Eriophorum angustifolium	EATKMAS3	1988	7	2		Schell, 2016			68.633333	-149.6333333	234	42	-9.097	12.004	352.38	-7.77	Keeling et al. 2001	-26.098	0.550951888	18.81914197	
Eriophorum angustifolium	EATKMAS4	1988	7	15		Schell, 2016			68.633333	-149.6333333	234	42	-9.097	12.004	352.38	-7.77	Keeling et al. 2001	-25.287	0.550951888	17.9714439	
Eriophorum angustifolium	EATKMAS5	1988	7	15		Schell, 2016			68.633333	-149.6333333	234	42	-9.097	12.004	352.38	-7.77	Keeling et al. 2001	-24.806	0.550951888	17.46934456	
Eriophorum angustifolium	EATKMAS6	1988	7	15		Schell, 2016			68.633333	-149.6333333	234	42	-9.097	12.004	352.38	-7.77	Keeling et al. 2001	-25.434	0.550951888	18.12499102	
**JCCAMAS 45 & JCCAMAS 46 are combined*																					

Supplemental Table 1. **Summary of data sample data.**

	Species	Equation of Line	R^2	P-value
This Study	*Juniperus communis*	$y = 1.90x - 12.64$	0.23	<0.001
	Eriophorum angustifolium	$y = 1.31x - 17.07$	0.11	0.002
	Betula glandulosa	$y = 1.39x - 17.09$	0.28	<0.001
Sheldon et al., 2020	*Pinus strobus*	$y = 1.28x - 17.88$	0.13	<0.001
	Populus tremuloides	$y = 0.68x - 21.65$	0.12	<0.001
	Thuja occidentalis	$y = 1.42x - 15.04$	0.43	<0.001
	Thuja plicata	$y = 1.86x - 12.35$	0.50	<0.001
Arens et al., 2000	*Compilation of Species*	$y = 1.10x - 18.67$	0.34	<0.001

Supplemental Table 2. **Summary of regressions plotted in Figure 4. Equations of lines for species in this study are from Figure 3.**

		Eigenvalue	Percentage of Variance
PCA Results	**PC1**	2.76	39.40%
Juniperus communis	**PC2**	1.74	24.90%
Extraced Eigenvectors		Coefficients of PC1	Coefficients of PC 2
Δ_{leaf} (‰)		-0.25	-0.25
VPD (kPa)		-0.23	0.63
Average Temperature of Collection Month (°C)		0.06	0.68
MAT (°C)		0.50	0.25
Average Precipitation of Collection Month (mm)		0.51	-0.07
MAP (mm)		0.54	-0.04
Drainage Level		-0.27	0.08
		Eigenvalue	Percentage of Variance
PCA Results	**PC1**	3.64	52.03%
Eriophorum angustifolium	**PC2**	1.33	19.01%
Extraced Eigenvectors		Coefficients of PC1	Coefficients of PC 2
Δ_{leaf} (‰)		-0.18	0.54
VPD (kPa)		0.36	-0.45
Average Temperature of Collection Month (°C)		0.46	-0.27
MAT (°C)		0.48	0.20
Average Precipitation of Collection Month (mm)		0.42	0.37
MAP (mm)		0.44	0.41
Drainage Level		0.16	-0.30
		Eigenvalue	Percentage of Variance
PCA Results	**PC1**	2.94	42.05%
Betula glandulosa	**PC2**	1.73	24.70%
Extraced Eigenvectors		Coefficients of PC1	Coefficients of PC 2
Δ_{leaf} (‰)		-0.18	-0.15
VPD (kPa)		0.25	0.61
Average Temperature of Collection Month (°C)		0.33	0.55
MAT (°C)		0.53	-0.01
Average Precipitation of Collection Month (mm)		0.48	-0.28
MAP (mm)		-0.18	0.36
Drainage Level		0.42	-0.35

***Supplemental Table 3*. Compilation of PCA results for individual species. All coefficients are rounded up. Values equal to or greater than ±0.3 are highlighted in green.**

		Eigenvalue	Percentage of Variance
	PC1	3.2	45.77%
Combined PCA Results	**PC2**	1.5	21.56%
Extraced Eigenvectors		Coefficients of PC1	Coefficients of PC 2
Δ_{leaf} (‰)		-0.22	-0.11
VPD (kPa)		0.31	0.57
Average Temperature of Collection Month (°C)		0.42	0.43
MAT (°C)		0.52	-0.09
Average Precipitation of Collection Month (mm)		0.44	-0.36
MAP (mm)		0.46	-0.37
Drainage Level		-0.02	0.45

***Supplemental Table 4*. Results of compiled species PCA.**