SUPPLEMENTARY FIGURES
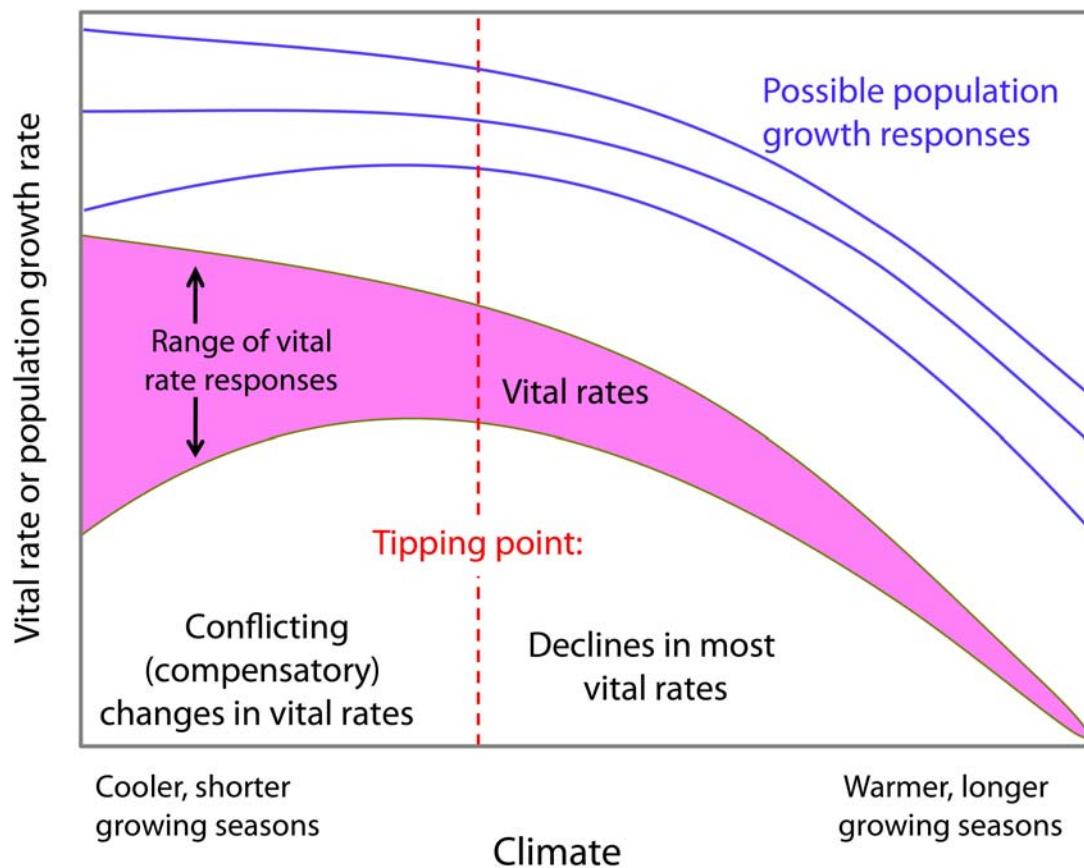

Supplementary Figure 1. Schematic diagram illustrating how populations showing demographic compensation can transition from stable or increasing numbers to decline as climate variables cross a tipping point, where one or more demographic rates involved in compensation shift from positive to negative responses to further climate change.

      While tipping points are likely to occur at low temperature as well, in light of rising global temperatures, we plot the expected patterns as climate shifts from moderate to high temperature conditions. Across a range of moderate climate conditions, some demographic ("vital") rates will rise and others will fall with increasing temperature, with compensatory changes leading to only small increases or decreases in population growth rates. However, further increases in temperature will result in declines in most or all vital rates. We refer to this as a climatic tipping point, beyond which population growth rates are expected to fall, leading to accelerating population declines. At range limits, these climate-driven effects may well be exacerbated by other

factors, including limited opportunities for dispersal between isolated populations, reducing the contribution of immigration to local population growth and hampering gene flow.

This conceptual model captures the general responses of vital rates for our study species in response to increasing temperature. At cooler, northern study sites, survival and recruitment are high and growth slow. In contrast, southern sites with more moderate temperatures show lower survival and recruitment but compensatory increases in growth and some fecundity rates. These opposing changes result in the prediction that over a range of moderate temperatures most populations of both species will show only small changes in population growth rates (Fig. 4), while further increases in temperature will cause increasingly rapid reductions in population growth. Note that for cooler temperatures than those included in our conceptual diagram, all vital rate values would again be expected to decline, as both survival and growth do in the coolest years of our study (Fig. 3), resulting in rapid declines in population growth below this lower tipping point as well (Fig. 4). In a warming climate, we expect most populations to be moving away from this lower tipping point and toward the upper one shown in the figure.
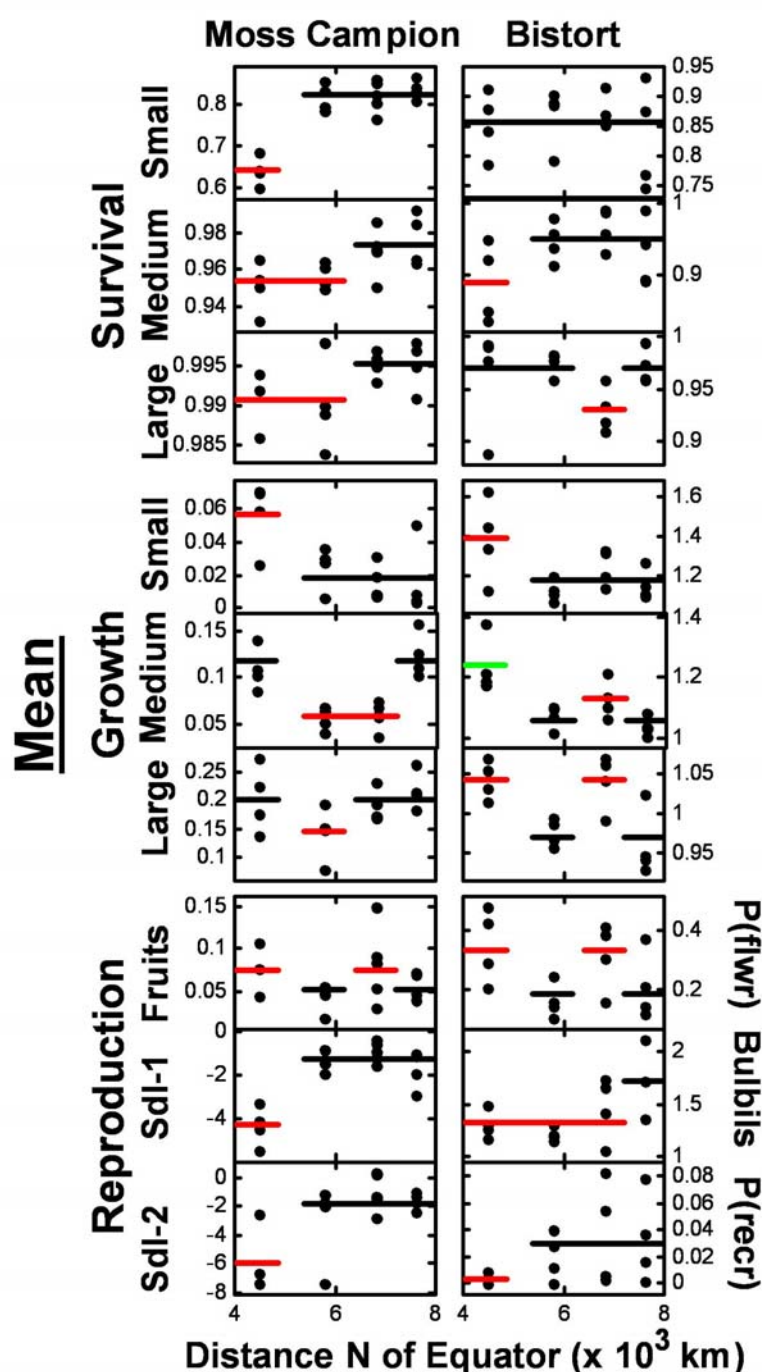
Supplementary Figure 2. Results from model selection analysis of regional differences in mean vital rates. Individual data points show the mean vital rates of each population. Horizontal bars indicate results for the best supported model of regional similarities and differences. Bars of the same color show a mean rate that did not differ across the regions they span, while bars of differing colors indicate differing mean rates in the best-supported model.
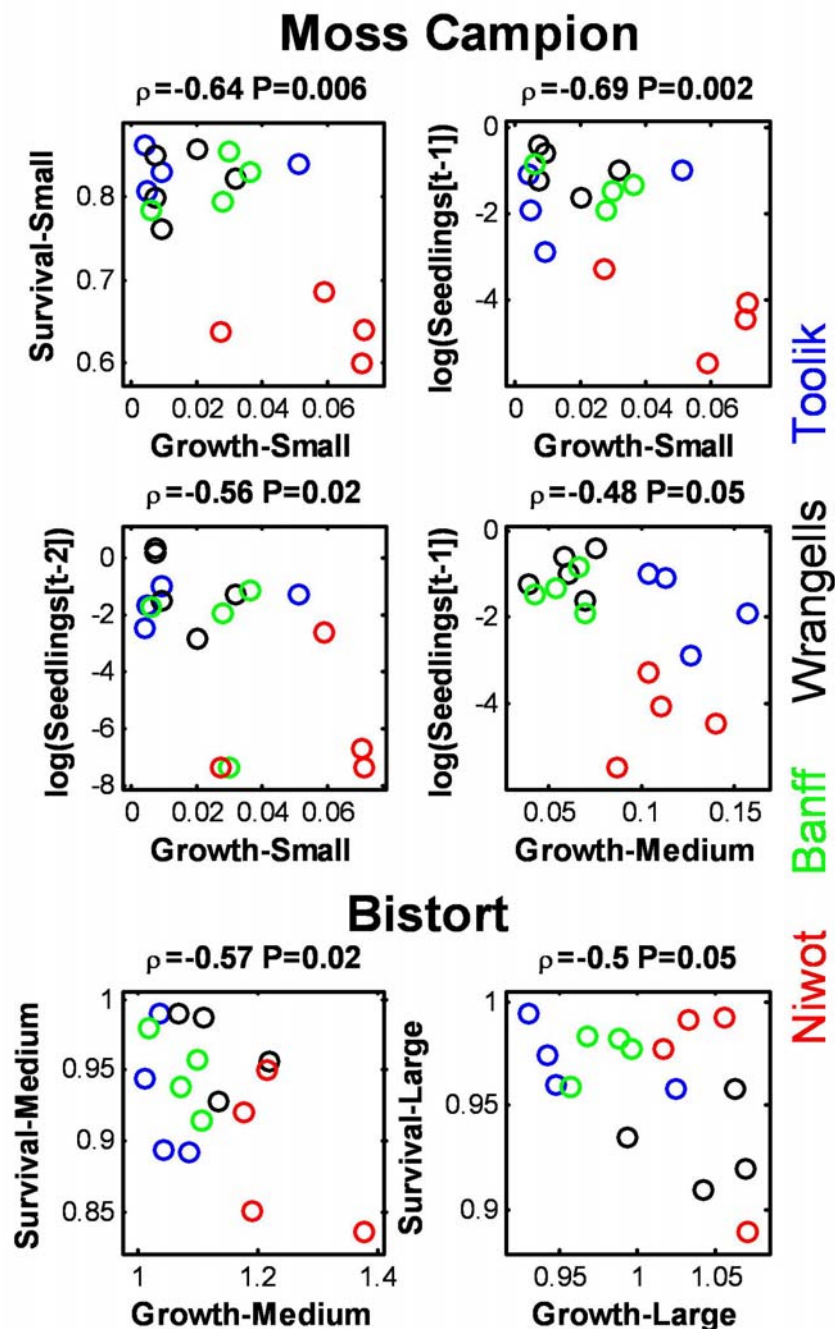
Supplementary Figure 3. Pearson correlation coefficients (ρ) between annual means of different vital rates among populations. All correlations between vital rates that were negative with $P \leq 0.05$ are shown. Colors indicate regions from south to north: red = Niwot Ridge; green = Banff N.P.; black =Wrangell Mountains; blue = Toolik Lake. P values are estimated assuming that that all populations are independent. However, replicate populations from the same region are likely to be non-independent to some extent, and thus these significance values should be viewed with caution.
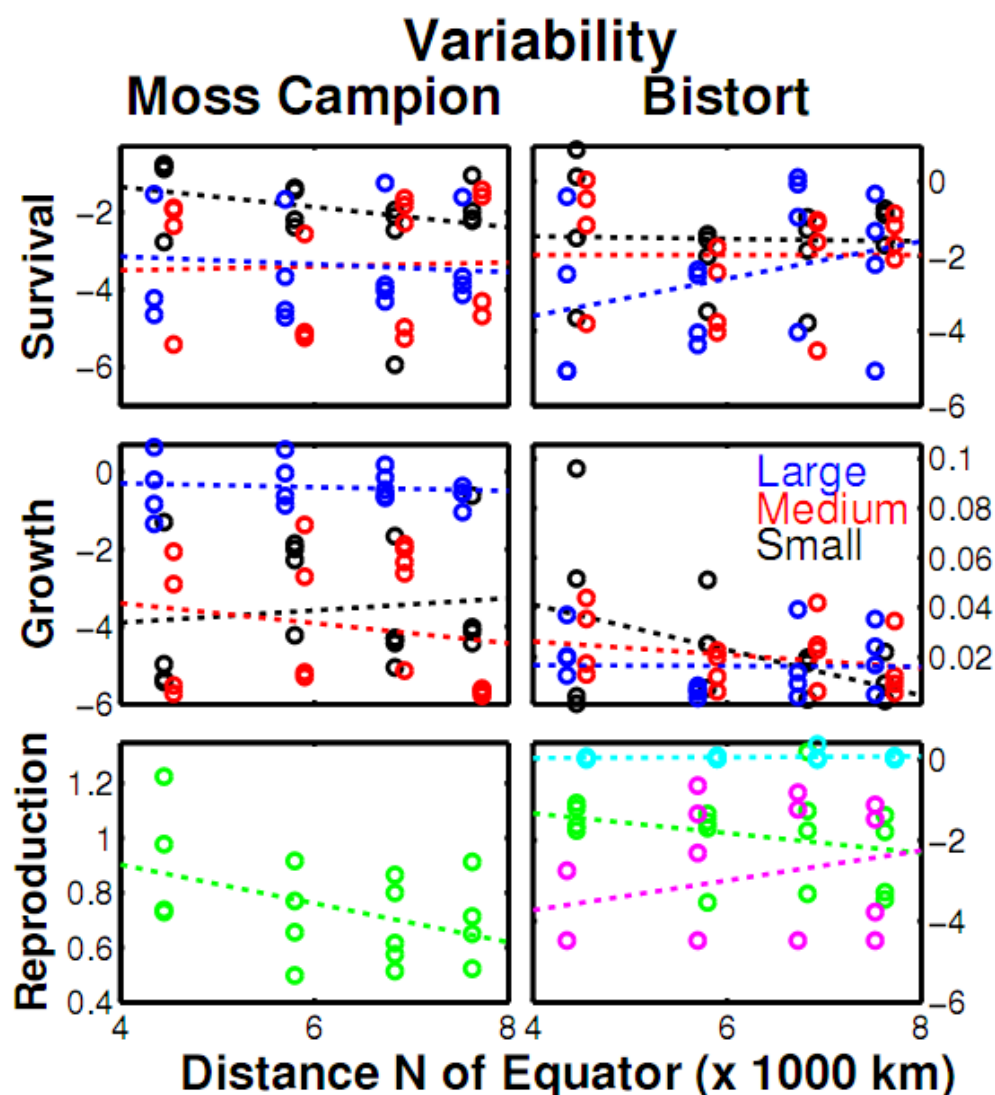
Supplementary Figure 4. Relative variability in vital rates for two tundra plant species along a latitudinal transect. Data points are relative variance (see *Supplementary Methods: Calculation of Vital Rates* for details) over 6 years for each population. For survival and growth, small, medium, and large plants are black, red, and blue, respectively. Correspondingly colored lines are linear regressions (regression statistics in Supplementary Table 2). Moss campion reproduction = fruits/ cm^2 of cushion (variability could not be estimated for moss campion seedlings per fruit); Bistort reproductive rates (fecundity and recruitment rates): green = probability of producing bulbils, blue = bulbils/(leaf area)$^{1/2}$, purple = probability that a bulbil recruits as a new plant one year later. Reproductive rates are shown on a log scale. For clarity, some data points are offset slightly in latitude. None of the regressions are statistically significant ($P > 0.05$).
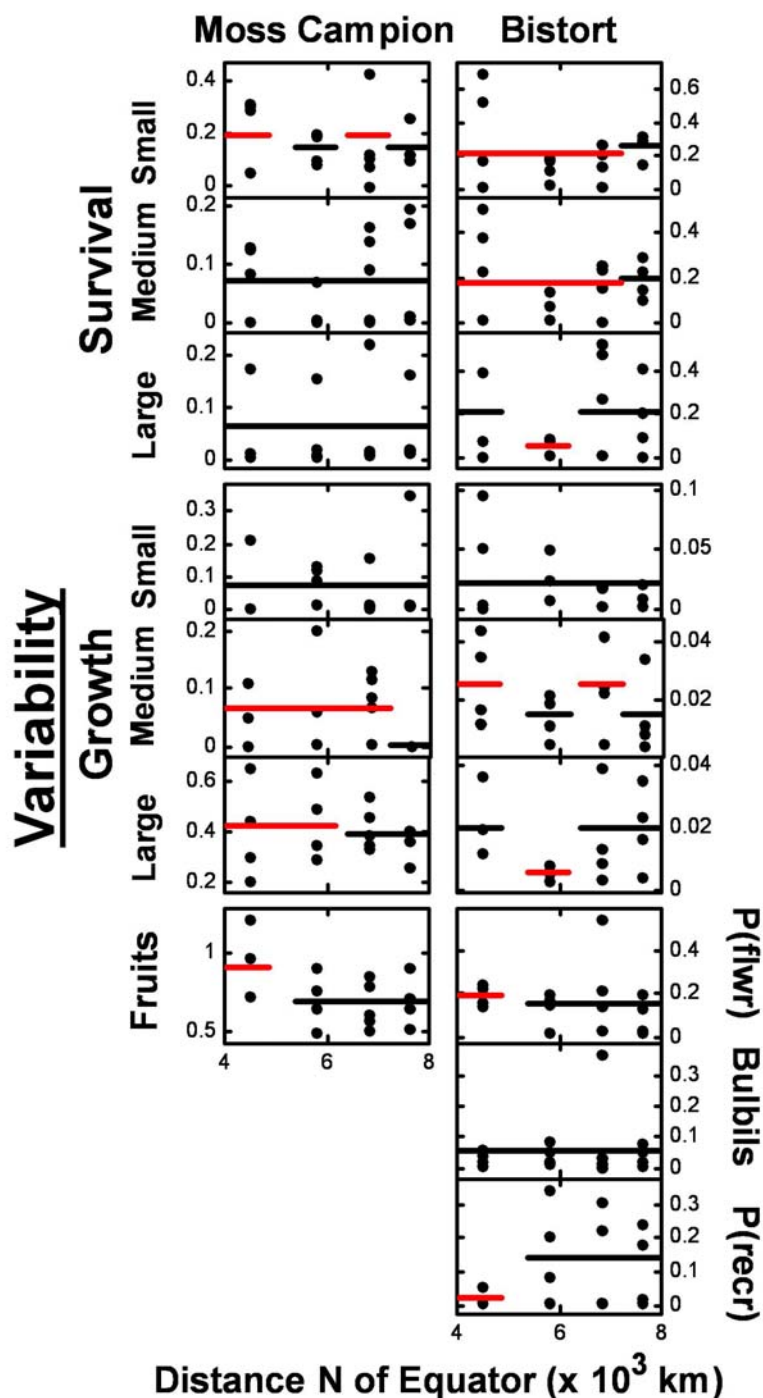
Supplementary Figure 5. Results from model selection analyses of regional differences in the variability of vital rates. Individual data points show the relative variance in vital rates of each population. Horizontal bars indicate results for the best supported model of regional similarities and differences. Bars of the same color show variabilities that did not differ across the regions they span, while bars of differing colors indicate differing variabilities in the best-supported model.
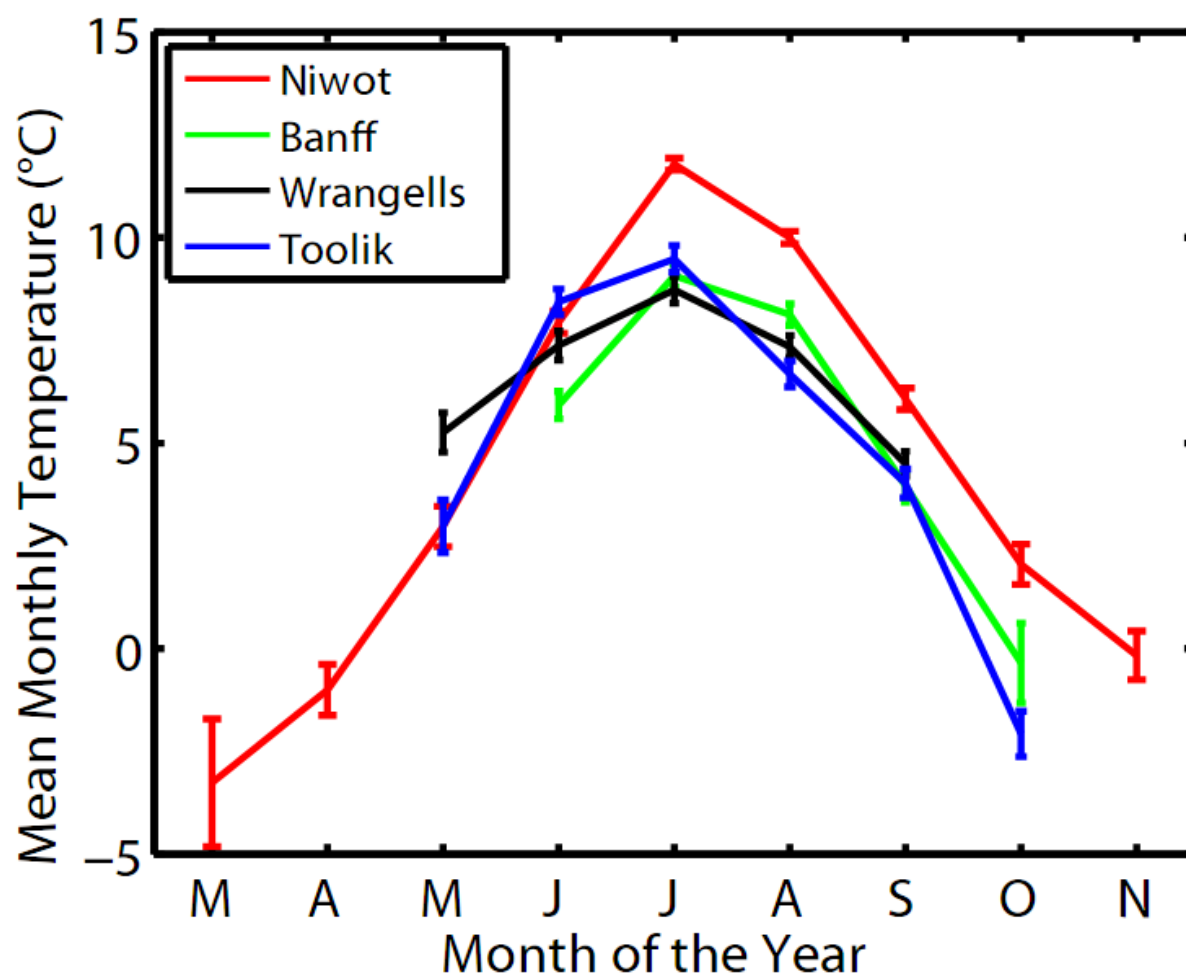
Supplementary Figure 6. Patterns of monthly temperatures (± 1 SEM) across the typical snow-free period in each study region.

Moss Campion

P = 0.94

Bistorts

P = 0.78

Distance N of Equator (x 1000 Km)
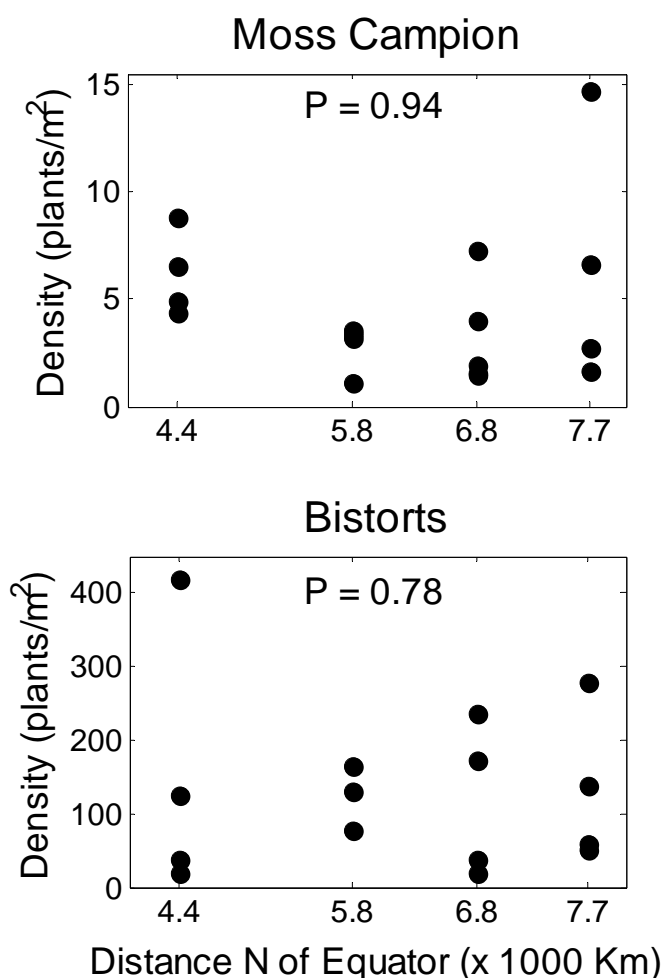
Supplementary Figure 7. Intra-specific densities show no trends with latitude. To test for confounding effects of density on performance, we estimated density of each species when populations were established in 2001. For moss campion, density estimates include all plants with 20 or more branch tips. For bistort, densities include all plants. In neither case is there any clear relationship with latitude, although populations at all latitudes show substantial variation in mean density. P values shown in the graphs represent the probability of a slope more divergent from zero in a regression of density vs. latitude with a random effect of region.
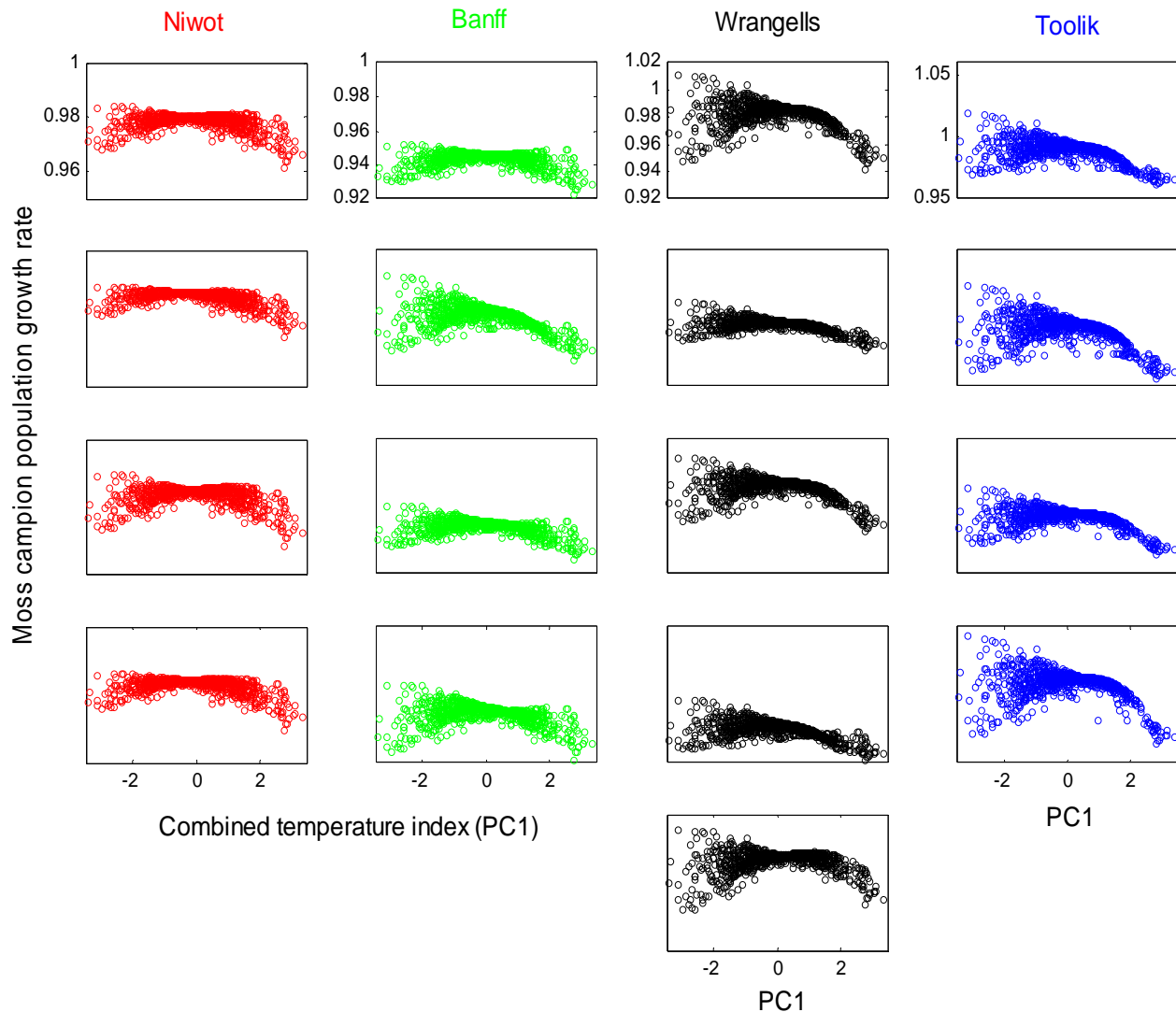
Supplementary Figure 8. Simulated moss campion population growth rates plotted against combined values of snow-free period and mean July temperature. Each panel shows 1000 estimates of the deterministic population growth rate for each population, each estimate based on a randomly generated pair of values of the climate variables. These pairs were simulated as a bivariate normal variable, using the observed means and correlations of snow-free period and July temperature and 1.5 times the observed variance in each variable (to better explore a broad range of weather conditions). The first principal component of climate, PC1, a linear, positive combination of the effects of July temperature and snow-free period, is used as the explanatory variable in these plots (see *Supplementary Methods: Analysis of Annual Climate Effects on Population Growth Rates*). Average PC1 values are highest in the southernmost region (Fig. 1d in main text). Axes for the panels showing populations in a given region (all those in a column) are scaled identically, as indicated in the top and bottom rows of panels.
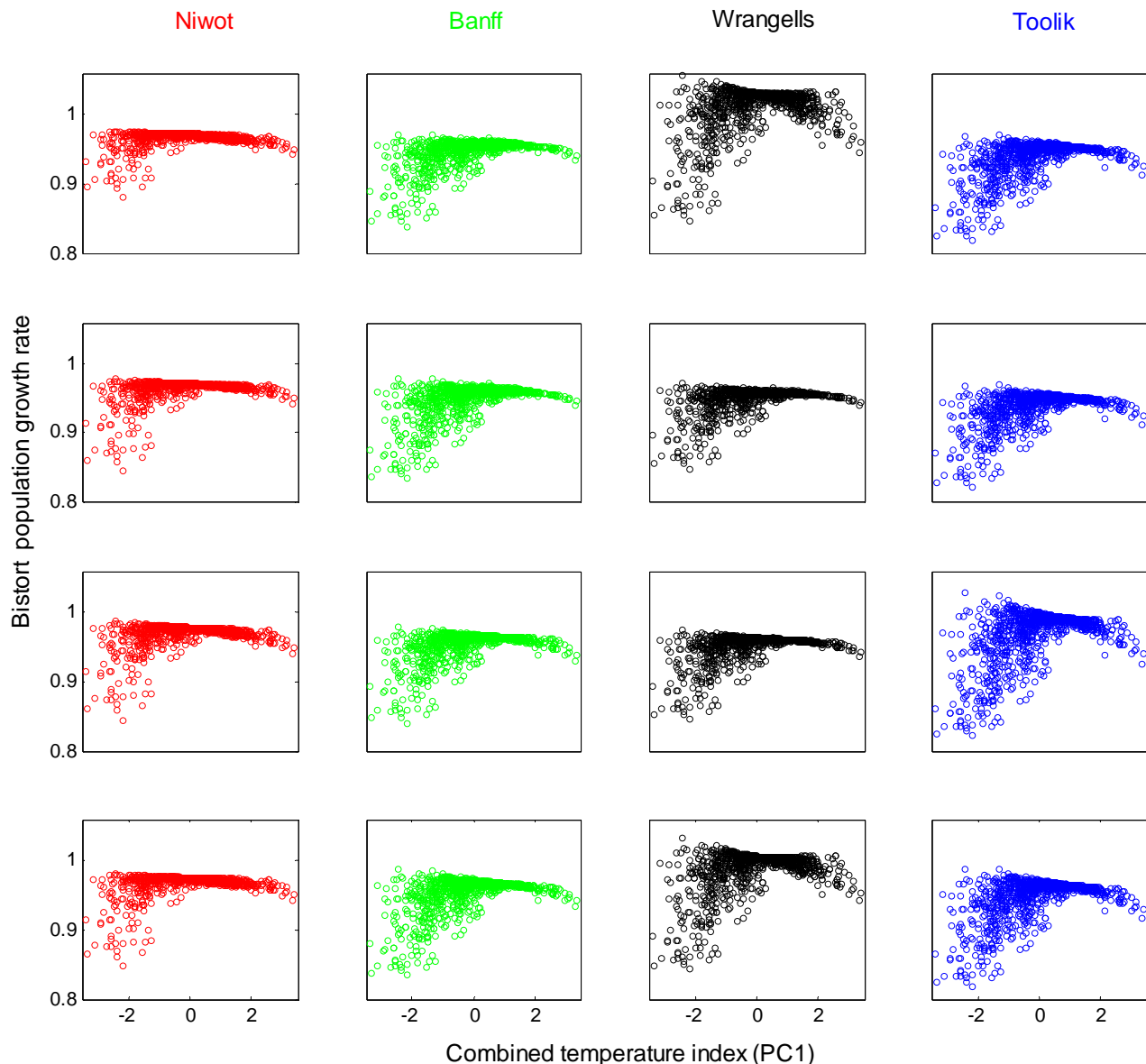
Supplementary Figure 9. Simulated bistort population growth rates plotted against combined values of snow-free period and mean July temperature. Each panel shows 1000 estimates of deterministic population growth rate for each population, each estimate based on a randomly generated pair of values of the climate variables. These pairs were simulated as a bivariate normal variable, using the observed means and correlations of snow-free period and July temperature and 1.5 times the observed variance in each variable (to better explore a broad range of weather conditions). The first principal component of climate, PC1, a linear, positive combination of the effects of July temperature and snow-free period, is used as the explanatory variable in these plots (see *Supplementary Methods: Analysis of Annual Climate Effects on Population Growth Rates*). Average PC1 values are highest in the southernmost region (Fig. 1d in main text). Axes for all panels in the figure are scaled identically.

SUPPLEMENTARY METHODS

Biology of the Study Species

Silene acaulis (Caryophyllaceae; "moss campion") is a long-lived cushion plant found in alpine and arctic tundra throughout the circumboreal zone (Hultén 1974). Each cushion has a single taproot, and branches do not root adventitiously, so individuals are easy to distinguish. Moss campion flowers are insect pollinated and produce fruits at the end of the growing season. *Polygonum viviparum* (Polygonaceae; "bistort") is a circumboreal geophyte. Each ramet consists of 1-4 basal leaves and 0-2 inflorescences that arise from a single unbranched rhizome (Diggle 1997). Bistort produce asexual bulbils instead of flowers at most inflorescence nodes (Bauert 1993, Diggle et al. 1998). Dispersed bulbils may root to produce new recruits ("bulblings"), which is the only form of reproduction we have observed at any of our sites.

Selection of Study Populations

From 2001 to 2006 we followed plants in each of 16 bistort and 17 moss campion populations arrayed across 4 regions: Niwot Ridge Long-Term Ecological Research (LTER) Site (Colorado), Banff National Park (Alberta, Canada), Wrangell Mountains (south-central Alaska), and Toolik Lake LTER Site (northern Alaska) (Fig. 1). In each region, we chose study populations based on several criteria. First, populations were placed sufficiently far apart as to render significant seed or bulbil dispersal extremely unlikely over yearly or decadal time-scales. The minimum distance between study populations of either species is ~300 meters. Detailed mapping of moss campion seedlings has shown that very few seedlings are found >10cm from the edge of parent plants. Bistort bulbils are even larger than moss campion seeds and like them have no dispersal mechanisms other than gravity. Second, in each region we sought to place populations in areas with the full range of typical local growing conditions. In particular, we deliberately placed half the populations in each region in more mesic and the other half in more xeric conditions (analyses have shown no significant effects of these microsite conditions on vital rates). Finally, logistical constraints (between- population travel times and the availability of secure research sites) led us to cluster populations at each latitude into relatively narrow regions. In some regions, the placement of our study populations makes them truly distinct, with few or no conspecifics in intervening areas. However, for other regions, plants of both species occur extremely widely, such that some of our study populations are not discrete population units. We do not think that this is likely to influence our results, and represents the reality that demarcating distinct study areas for widely occurring species is always a somewhat arbitrary decision.

Field Methods

In our field censuses, we assessed the demographic fate of marked individuals every year for 5 annual transitions. Every plant encountered along randomly located transects in each of the populations that we established in 2001 was mapped and marked with a permanent metal tag (large moss campion plants) or a color-coded

plastic toothpick (small moss campion and all bistort), resulting in >300 individually mapped and marked plants in each population. We relocated marked plants in 2002-2006, and recorded survival, size, and reproductive output. We also quantified recruitment of new individuals and added these new individuals to our set of annually monitored plants. Altogether, our study included 35,386 individual plant-years for moss campion and 23,980 for bistort.

Moss campion cushions extend by the addition of new branch tips that appear at the surface of the cushion. We measured plant size by counting branch tips or (for plants with 20 or more branch tips) by photographing plants in the field with digital cameras and then applying image analysis software to determine the two-dimensional area of the cushion. We measured reproductive output for moss campion by counting the number of fruits (which are retained to the end of the growing season). Each year we also searched for and mapped new recruits within a 10cm radius of 10-20 randomly chosen focal plants large enough to reproduce in each population.

For every bistort plant, we counted the number of leaves and measured the length and width of the longest leaf in each year; the product of the estimated area of the largest leaf and leaf number then provides an excellent prediction of total leaf area (linear regression with zero intercept, $r^2 = 0.98$, n=51). We estimated the number of bulbils on bistort plants by measuring the length of the bulbil-producing portion of each inflorescence and then used a regression of bulbil number on length ($r^2 = 0.49$, n=415). To quantify the translation from bulbils to new recruits, each year we searched for, marked, and followed new bulblings in recruitment plots located along every transect.

Calculation of Vital Rates

To calculate vital rates, we first divided plants into size classes. "Small" moss campion plants include seedlings and those with a single branch tip, "medium" plants had 2-19 branch tips, and "large" plants had >19 branch tips. "Small" bistort are plants with estimated total leaf area <25 mm^2 (corresponding to the 30th percentile of all plants), "medium" bistort have leaf area of 25 mm^2 to 84 mm^2 (corresponding to the 50th percentile of all plants), and "large" bistort have greater than 84 mm^2 leaf area. The square-root of estimated leaf area of bistort provides better estimates of demographic fates than do the raw estimates, so we used this transformed size measure in all analyses for this species.

For both species, survival was simply the proportion of plants alive at one census that were still alive at the next census. For moss campion, growth was estimated as the proportion of plants advancing to the next larger size class over 1 year. Because this plant grows slowly and transitions between wide size classes are rare, for this purpose and for the purpose of constructing projection matrices we used a finer division of size classes that we had employed in earlier work (Morris and Doak 2005), and present the averaged growth probabilities for all sub-classes within our small, medium, and large size ranges. No plants were ever seen to grow more than 1 sub-class in 1 year. Moss campion fecundity was estimated by dividing the number of fruits on large plants by the cushion area to yield fruits per cm^2 of cushion (small plants never produced seeds, and

reproduction by medium plants was extremely rare). For bistort, we measured growth as the proportional change in square-root leaf area from one year to the next, and we quantified two aspects of fecundity: the fraction of large plants that produced an inflorescence (which bears bulbils) in a given year (small and medium plants virtually never reproduce), and the estimated number of bulbils per square-root leaf area for plants that did produce an inflorescence.

To quantify moss campion recruitment, we regressed the number of new seedlings appearing near each focal plant each year against the number of fruits produced by that plant 1 and 2 years previously, which allowed us to estimate the average emergence of seedlings from seeds that had spent 1 and 2 winters in the soil. Earlier studies (Morris and Doak 2005) showed that very few seeds live longer than 2 years in the soil. Because we used data from all years in these regressions, we were unable to estimate year-to-year variability in these two vital rates. For bistort, we measured recruitment as the proportion of all bulbils produced within a recruitment plot that appeared in the plot as a bulbling the following year.

While moss campion is a gynodioecious species, we have found no evidence of differing growth or survival rates for female vs. hermaphrodite plants (Morris and Doak 1998), so we simply average the vital rates for the two sexes (including fruit production, which does differ sharply between the sexes) to arrive at a single-sex description of each vital rate.

We also estimated relative temporal process variability in each vital rate. For rates that represent probabilities (survival rates, probability of reproducing, and probability for moss campion of growing to a larger size class) we express variability as the SD divided by the maximum possible SD given the mean (Morris and Doak 2004). This rescaling accounts for the fact that the variability of a random variable that must lie between zero and one is increasingly constrained as the mean approaches zero or one. For all other rates, we use the coefficient of variation as a measure of variability. These relative variabilities thus allow us to examine among-region differences in variability per se as distinct from differences in vital rate means. All estimates are based on variances that were first corrected for sampling variation using the method of Kendall (1998) for vital rates bounded by zero and one (e.g., survival) and the method of White (2000) otherwise.

Statistical Analysis of Vital Rates

We used two approaches to test for geographic patterns in the means and relative temporal variances of each of the nine vital rates described in the text. For all these tests, we used the estimated mean or variability for each population as a single data point, resulting in either four or five samples per region. Because populations are clustered spatially across our latitudinal gradient, and hence do not experience independent weather or other environmental effects (e.g., geologic parent material and co-occurring species assemblages), they are likely to be non-independent to some degree.

First, we tested for general latitudinal trends in vital rates using linear regressions of the means and variabilities of vital rates on latitude, expressed as

distance from the equator (Fig. 2, Supplementary Fig. 4, Supplementary Table 2). To reduce the number of tests, we first performed analysis of covariance (ANCOVA) on similar types of vital rates (i.e., all survival rates, all growth rates), using latitude as a continuous variable, size class of plant (e.g., small, medium, and large plants) as a categorical variable, and a latitude x size interaction (results in Supplementary Table 1). If the interaction term was not significant ($P > 0.05$, indicating that the different sized plants responded similarly to latitude), we used the main effect of latitude to assess linear patterns in demography across the ranges. However, if the latitude x size interaction was significant, we performed linear regressions to separately assess linear responses to latitude for the vital rate of each size class (results in Supplementary Table 2). We performed similar analyses on the set of reproductive rates (fecundity and recruitment rates) for each species, including type of rate and the interaction of type with latitude (results in Supplementary Tables 1 and 2). To improve normality, rates that represented proportions (e.g., survival rates, proportion growing to the next size class, probability of producing an inflorescence) were logit-transformed and rates that represented counts (e.g., seedlings per fruit) were log-transformed prior to analysis.

However, as vital rates did not always vary linearly with latitude, we also used the model selection approach described below to test in a more flexible manner for differences between regions. In the text, we give priority to the model selection results when the two methods yield conflicting results.

To ask if the mean of a particular vital rate for the replicate populations from a region differed from the means of populations in other regions, we used an Akaike Information Criterion (AIC)-based maximum likelihood model selection approach (Burnham and Anderson 2002). First, we grouped the 4 regions into all 14 possible combinations of 1, 2, 3, or 4 groups (for example, the 7 possible combinations of regions **T**oolik Lake, **W**rangell Mountains, **B**anff National Park, and **N**iwot Ridge into 2 groups are: **T/WBN**, **TW/BN**, **TWB/N**, **TB/WN**, **TN/WB**, **TBN/W** and **TWN/B**). For each grouping, we then computed the likelihood of the observed deviations between all populations and their group means. For vital rates that are bounded between zero and one (e.g., survival, probability of growth, probability of recruitment), the means are also bounded. For such rates, we assumed the population-specific vital rates were beta-distributed around the group mean when calculating the likelihood. For vital rates not bounded by 1 (e.g., mean fruits per cm^2, proportional change in size), we assumed population values were normally distributed around group means. For normally distributed rates, we assumed equal variance for all groups. For beta-distributed rates, we explored three scenarios: equal variances in all groups, equal relative variances (variance divided by its maximum possible value given the group mean), and relative variance a linear function of the group mean. We report results using the latter assumption, as it always outperformed the others. Finally, we used the likelihoods to compute the Akaike Information Criterion corrected for small sample size (AICc, Hurvitch and Tsai 1989) for each grouping, where the number of parameters is the number of group means plus the number of variance parameters estimated, and chose the grouping with the lowest AICc value as the most parsimonious range-wide pattern

of demography. In these analyses, vital rate estimates that were zero were replaced by one-half the smallest non-zero value observed for any population.

　　　Results of these analyses (Supplementary Fig. 2) are largely in agreement with those of our linear regressions. In particular, populations at Niwot Ridge, our southernmost region, generally have lower survival and higher growth rates of small or medium plants than do the other populations. However, these results also show other differences between regions. For example, bulbil production of bistort at the northernmost population is higher than at any other region, and growth of medium moss campion is lowest at the two central regions and higher at the extremes.

　　　We applied the same procedure to assess regional differences in relative temporal variance in each rate (Supplementary Fig. 5). We found higher variability in moss campion fruit production and in bistort flowering probability at the southern range limit. However, other rates, most notably, bulbil establishment, has both a low mean and very low variability at the southernmost sites.

　　　Finally, we also applied these models to the stochastic population growth rates, for which we assumed a normal distribution of population values (Fig. 3).

Construction of Matrix Models

　　　To obtain estimates of stochastic population growth rates for each population, we first used our data to construct separate population matrices for each of the five observed annual transitions for each population. For these analyses, we fit multiple models of each vital rate (survival, mean growth, variance in growth, and reproductive rates) as a continuous function of size for each time interval. We then selected the most appropriate function (e.g., plant growth rate as an asymptotic function of size vs. a linear function of size) using AIC criteria (Gross et al. 2006, Morris and Doak 2002). We then constructed a size-based matrix model for each transition by discretizing values from these continuous functions. Second, to arrive at a stochastic population growth rate estimate for each population, we used the approximation of Tuljapurkar (1990), accounting for the mean, variance, and covariance structure of matrix elements across annual transitions, and assuming that environmental states (as represented by the separate projection matrices) were independently and identically distributed among years.

　　　In these analyses, we assume that immigration or emigration from our populations is trivial compared to the effects of local dynamics. This assumption is warranted by the very low dispersal distances we observe. An unpublished genetic analysis of moss campion (Mikhaylova, Gusarova, and Brochmann, unpublished data) shows low differentiation of populations that could imply higher rates of dispersal than our observations suggest. However, the long generation time of moss campion also means that even very low rates of immigration -- rates that are likely to be of only minor demographic importance – could suffice to prevent substantial among-population genetic differentiation. In any case, our method of searching for new recruits within our study plots will include any recruits arising from immigration in our estimates of per-propagule recruitment probabilities, thus implicitly accounting for movement effects on population growth rates.

Possible Explanations for Latitudinal Patterns in Demography

While we attribute latitudinal trends in vital rates in large part to the effects of temperature, multiple factors undoubtedly contribute to the demographic patterns we document. The clearest declines in individual performance near the southern range limit are in the survival of small plants and propagules in the process of becoming established (an exception is the survival of small bistort). Because they have not yet extended their roots deep into the soil, propagules and small plants may be especially likely to succumb to high temperatures, particularly if accompanied by dry conditions. In contrast, small plants that do survive enjoy faster growth in the south. Higher temperatures (Fig. 1c) and longer growing seasons (Fig. 1b) may increase growth by enhancing the rate and duration of metabolic and developmental processes. Other possible causes of higher growth rates in the south include greater photosynthetically active radiation during the summer season (McGuire et al. 2002), higher nutrient availability due to more rapid nutrient cycling (Hobbie 1996) (with anthropogenic nitrogen deposition adding to or even overwhelming this effect; Bowman et al 2006), and trends in community composition or interaction strengths with latitude. While we cannot rule out these alternative explanations, spatial and temporal patterns in survival and growth, especially for smaller plants, are largely consistent with temperature effects, perhaps interacting with other ecological and climatic factors, but are not consistent with latitudinal patterns in precipitation (Fig. 1e) or intraspecific competition, as we discuss next.

A possible complicating factor in our analyses would be consistent differences in plant density across latitudes, which could either represent an indirect route for climate effects on individual plant performance or could arise for other reasons and simply confound our interpretation of latitudinal patterns in performance. We do not have the community-level data to calculate abundance of all plant species at our study sites. However, we can calculate the average intra-specific density in each population in 2001 when the plots were established. For moss campion, density estimates include only large plants (as we cannot be certain that we found all smaller plants). For bistort, densities include plants of all sizes (as their higher densities – see Supplementary Figure 7 – meant we could exhaustively search smaller areas to achieve our desired number of plants). In neither case is there a significant relationship with latitude, although populations at all latitudes show substantial variation in mean density (Supplementary Figure 7).

We also tested for effects of intraspecific density on vital rates using general linear mixed models, with mean annual survival and growth as the dependent variables, size class and density as fixed effects, and region as a random effect. None of these 4 regressions (2 vital rates x 2 species) was significant ($P \geq 0.14$ in all cases). Similar regressions of reproductive rates vs. density (with no size class effect) also were not significant ($P \geq 0.09$ in all cases). Taken together, these non-significant results and the absence of a latitudinal density trend suggest that intra-specific competition is not likely to be driving our observed latitudinal patterns in vital rates. As we note above, we have also not collected the data needed to determine whether the species composition

of the surrounding community shows systematic differences between regions, but we have not observed any obvious trends in vegetative cover that would suggest such effects.

Our interpretation of the latitudinal patterns as arising from temperature differences, and the hypothesis that our southern study populations may face future climatic tipping points, could also be complicated by past adaptation to higher temperatures in the south or by future evolution of heat tolerance in a warming climate (Davis and Shaw 2001, Martin and McKay 2004, Comps et al. 2001). Three pieces of evidence appear to argue against substantial adaptation of southern populations to higher temperatures. First, surveys of molecular markers across the range of moss campion indicate that genetic differentiation between northern and southern populations is low overall in North America (explaining just 11% of AFLP variation; Mikhaylova, Gusarova, and Brochmann, unpublished data), although there could still be latitudinal clines at specific genes. Second, we do not see evidence of different optimal annual temperatures for growth or survival across our study regions (Fig. 3). Finally, the entirely clonal reproduction of bistort and very long generation times of moss campion would argue against the likelihood of rapid in-situ adaptation to on-going climate change.

Sources and Analysis of Climate Data

We use three measures of climate to characterize the conditions for each region or population in each year: a) length of the snow-free period during which plants can grow (a population-specific metric) (Figure 1b and Supplementary Figure 6); b) Mean July temperature, a region-specific metric, which characterizes peak temperatures during the growing season in each region (Figure 1c and Supplementary Figure 6); and, c) total precipitation during the average snow-free period in a given region, a region-specific metric (Figure 1e). The first two of these we consider to be measurements of temperature. Mean July temperature characterizes the mid-growing season peak temperatures at all our study regions (Supplementary Fig. 6) . Along with peak temperatures, the length of the snow-free period is also of clear importance in characterizing the growing season (Supplementary Fig. 6), and is also dependent on temperature conditions, including temperature during the winter, spring, and fall. Indeed, snow-melt timing, which controls the beginning of the snow-free period, has been shown to be one of the most sensitive and ecologically relevant aspects of climate warming in montane and high-latitude systems (e.g., Inouye 2008, Hinzman et al. 2005).

We determined the average snow-free period for each population in each year of our study using the National Snow and Ice Data Center's MODIS/Terra Snow Cover 8-Day L3 Global 0.05Deg CMG (MOD10C2) Maximum Snow Extent data set (Hall et al. 2006). As our basic data set, we used the first dates for each eight day period for each pixel containing a study population and determined whether the corresponding pixels and time periods had any snow-free days. Pixel size for these snow cover data is 500x500 m, so in some cases, more than one of our populations fell within the same pixel. To estimate the mean number of snow-free days for each region (Fig. 1a), we

used each unique pixel containing one or more populations only once, and determined the mean and standard error of the mean of the number of snow-free days for each region across pixels and years (Fig. 1b). In a two-way ANOVA of number of snow-free days on region, year, and region*year, all terms were highly significant (p < 10^{-10} for region and interaction terms).

To characterize July temperatures for each region in each year of the study, we used data from the nearest weather stations in comparable habitats to our study populations. Our southernmost and northernmost regions are both Long Term Ecological Research sites, so we used daily mean temperature data from the most appropriate stations at these sites (Niwot Ridge Saddle for Niwot Ridge, and the Toolik Field Station Met for Toolik Lake). For Banff National Park, we used data from the "Upper Parker Ridge" met station (Environment Canada, National Climate Data and Information Archive: /www.climate.weatheroffice.ec.gc.ca).

For the Wrangell Mountains, the only appropriate climate data come from a new weather station in the Western Regional Climate Center network ("Gates Glacier": http://wrcc.dri.edu) for which the first full year of data came from 2006. Because data from this station only overlapped with one year of our study, we had to use additional information to construct annual estimates of snow-free temperatures for our Wrangell Mountains sites. First, we regressed daily mean temperatures from the Gates Glacier station on temperatures from three nearby stations (all at lower elevations: the Klawasi, Gulkana, and May Creek stations; another nearby station, McCarthy, did not add significantly to predictive power) using all days with overlapping data during the typical snow-free period (May 1 to October 31 for all years of available data). This regression has high predictive power ($r^2 = 0.92$), so we then used it to estimate daily temperature for the Gates Glacier site during the study period (2001-2006). For days during these years when one or more of the three stations had no data, we used similar regressions that omitted the missing station, but all of which had good predictive power ($r^2 > 0.85$).

To estimate the total precipitation during the snow-free season for each region, we first took the averages of the first and last snow-free dates across the relevant MODIS/Terra snow cover data pixels to determine an average snow-free period across populations in each region for each year. Ideally, we would then sum the total precipitation recorded at the most appropriate weather station over these time periods. However, missing data complicated this analysis. For Toolik Lake and Niwot Ridge, with very few missing data, we first generated a daily average precipitation value, calculated for all days without missing data, in each month with snow-free days in a given year. We then multiplied these daily values by the number of days of each month that were within the snow-free period, summing over all months to arrive at the snow-free precipitation estimate. The closest weather station to our Banff sites with sufficient precipitation data to perform this procedure is Lake Louise, so we used data from this site for these calculations. Finally, for the Wrangell Mountains, we first constructed a monthly prediction of average daily precipitation for the Gates site, using data from the Klawasi and Gulkana stations ($r^2 = 0.29$), and then used the resulting predictions to estimate annual precipitation values.

Analysis of Annual Climate Effects on Vital Rates

To test for temperature and precipitation effects on annual survival, growth, and reproductive rates, we used the vital rate estimate for each population as a single data point and fit a series of alternative explanatory models to each size-specific rate. For moss campion, we were only able to test effects on one reproductive rate, fruit production, as we did not have annual estimates of the other two rates, as explained above (see *Calculation of Vital Rates*). Two rates, recruitment probabilities and probabilities of bulbil production for bistort, were logit-transformed for these analyses. For each vital rate, we fit 36 mixed models that included all possible combinations of mean July temperature and snow-free period as linear and quadratic fixed effects (plus models with neither of these variables), crossed with precipitation (included in the model or not) as a linear fixed effect, and with either region only or both region and population as random intercepts, assuming normally distributed errors (Supplemental Table 3). These alternative models included combinations of both linear and squared terms for the two temperature variables, due to the obviously non-linear effects of snow-free days and mean July temperatures on at least some vital rates (Fig. 3). In these analyses, we used the snow-free period, mean July temperature, and precipitation values that corresponded to the majority of the transition period for each vital rate (e.g., since our census of plants occurs towards the end of each growing season, for the 2001-2002 transition we used data on the 2002 snow-free period, precipitation during that period, and mean temperature in July 2002).

AIC comparisons of the alternative models for each vital rate showed that for most rates either snow-free period, mean July temperature, or both are included in the best-supported model (Supplementary Tables 3 and 4). For only 3 of 16 vital rates across the two species does one of the models that do not include either temperature-driven variable have the lowest AIC: growth of medium and large moss campion and survival of large bistort. One rate (moss campion fruit production) experienced simple, negative effects of temperature and one rate (small moss campion growth) showed overall positive effects. For the remaining eight rates, unimodal responses to one temperature variable or mixed responses to the two climate variables were supported (e.g., medium bistort survival responds positively to snow-free period and negatively to July temperature). In contrast to the widespread evidence of temperature effects, the best-supported models for only two rates (bistort bulbil production and survival of small bistort) included precipitation. Eleven relationships between snow-free period or mean July temperature that were included in the best-supported models also have individual model coefficients with $P < 0.05$ (Supplementary Table 4); these relationships are shown in Fig. 3 of the main article.

As discussed in the main text, most relationships between vital rates and snow-free period or mean July temperature in these best-supported models are in accordance with latitudinal patterns in the vital rate means (compare Fig. 3 with Fig. 2 and Supplemental Fig. 2). However, several of climate effects are more complicated or are not addressed in the main text:
- Survival of medium bistort is lower at Niwot Ridge, the southern site, than at the three more northern sites (Supplemental Fig. 2). Snow-free period has a positive

linear effect on medium bistort survival (Fig. 3g), in opposition to the latitude pattern, but mean July temperature has a negative linear effect (Fig. 3c), in accordance with the latitudinal pattern. Using the regional means of the two climate variables, we can predict that jointly they will result in lower and roughly equal survival of small bistort in the two more southerly regions (Niwot and Banff), the highest survival in the Wrangell Mountains, and intermediate survival at Toolik Lake, the northernmost site. These patterns accord well with the geographic variation seen in this vital rate (Fig. 2).

- Like many of the growth and survival rates, bistort bulbil production is a quadratic function of snow-free period. Using the model coefficients and the mean snow-free values for each region, the model predicts that climate effects alone will yield the highest bulbil production at Niwot, with only marginally lower rates at the two Alaskan sites, and considerably lower reproductive output at Banff. Note that these and other predictions of average vital rate responses simply use regional mean snow-free period across populations and years, and thus do not fully account for nonlinearities in mean responses due to quadratic climate effects (i.e., Jensen's inequality). These predictions correspond partially, but not completely, to the complex latitudinal pattern in this vital rate (Fig. 2 and Supplemental Fig. 2).

- Opposing linear and non-linear effects of the two temperature variables on moss campion fruit production jointly predict lowest fruit production at Niwot, but no clear linear trend with latitude. While our geographic analyses also show no linear latitudinal trends in this rate (Supplementary Table 2), these results still only partially correspond with the mixed latitudinal pattern of fruit production (Supplemental Fig. 2).

- Finally, several of the best-supported climate models for other vital rates accord well with latitudinal patterns, but do not feature coefficients for these effects that are, by the usual hypothesis-testing conventions, significant ($p < 0.05$). These include bistort recruitment, which is lowest in the south where mean snow-free period is longest and has a best-supported predictive model that includes a negative effect of snow-free period on this rate, but with $p= 0.0956$. Similarly, survival of large moss campion is lower in the south, and linear and quadratic effects of snow-free period correspond with this geographic pattern, but the coefficients in these models are not significant. In these cases, which put the conclusions of model-selection criteria and those of simple significance testing at odds, we have given the greater weight to the AIC results, although in Fig. 3 we only present the full model predictions for vital rates that also have significant coefficients for temperature variables.

Overall, our results support the general expectation that most vital rates will show an optimum at intermediate temperatures (Fig. 3, Supplementary Table 4). In addition, as each model also included either region or region and population as random intercepts, thus factoring out differences among sites that were unrelated to temperature, the inclusion of one or both temperature-related climate variables in the

majority of best-supported models suggests that temperature is an important driver of the patterns in demography we see across time and space.

Analysis of Annual Climate Effects on Population Growth Rates

As up to three climate variables influence different vital rates in myriad ways, we integrated these effects into a single measure of population-level responses to climate. Specifically, we constructed demographic models for each species that were based on the best-supported models for each vital rate (Supplementary Tables 3 and 4) and then estimated population growth rates over a range of correlated values of snow-free period and mean July temperature.

We began by constructing a separate matrix for each population and year, as we had one climate variable, snow-free period, that was population-by-year specific, and as random effects of population, as well as region, were present in the best predictive models for at least some vital rates. To construct the matrices, we incorporated the best-supported models of climate-dependent (and size-specific) vital rates (Supplementary Table 3) into the framework already described for constructing matrix models for the two species (see *Construction of Matrix Models* above). This merging of approaches required two simplifications. First, we assigned vital rates for each of the multiple size classes in the matrix based on the corresponding rates from the three broader size classes that we used in our analysis of climate effects on annual vital rates (the limits of the broader size classes sometimes corresponded exactly to the limits of one of the finer size classes in the matrix, and when they did not, we averaged the rates appropriately). A second issue arises because our climate models that predict growth rates of individual bistort only make predictions about part of the growth process (the mean ratio of size next year to size this year). For bistort, construction of a matrix of growth probabilities requires estimates of both the mean size at the end of each census interval, given initial size, and the variance around this mean ending size. To make the climate-driven population model, we simply used the originally-estimated growth variances for each size class in each population and year, in combination with the climate-driven mean size ratio (which allowed us to estimate mean ending size). For moss campion, this issue was moot: small plant growth is a simple binomial probability, and because there were no temperature effects on growth of medium or large plants, we used the originally estimated growth probabilities for these classes.

We next had to define a wide range of reasonable combinations of climate values, for each of which we could then parameterize a distinct projection matrix for each population and year. As we are interested in temperature effects, and as precipitation does not show a latitudinal trend across our sites (Fig. 1e), we used the actual value of precipitation for each population and year. Snow-free period and mean July temperature covary (Pearson's r = 0.54), so we picked 1000 random combinations of these two values from a bivariate normal distribution, using the observed correlation and mean values of the two variables, and variances for each inflated by 50% over the observed values (to generate a broader range of values than those seen in our limited data set). We then used these 1000 pairs of temperature variates to generate a separate population matrix for each population-by-year combination.

To summarize these results (80,000 individual matrices for bistort and 85,000 for moss campion), we first averaged the five annual matrices for each population and then used the dominant eigenvalue of this average matrix (λ) as our measure of population performance for a given pair of July temperature and snow free period values. While we could have estimated a stochastic growth rate from the five matrices for any one population, each set of five matrices uses the same pair of climate variables, so they are more appropriately viewed as replicate matrices for the same set of temperature conditions rather than a realization of the full effects of year-to-year variation in climate (including temperature).

Because snow-free period and mean July temperatures are correlated, and because they affect different sets of vital rates, we plot the λ values from the average matrices against the first principal component score for the two climate values. Since there are only two variables, the weightings of contributions to this score of the standardized values of snow-free period and mean July temperature are identical and equal to 0.8778. This principal component score, PC1, explains 77% of the variation in these two climate measures.

Supplementary Figures 8 and 9 show all of the λ values for each population of the two species. Figure 3l,m in the main article shows robust LOWESS (Local regression using weighted linear least squares with a 1st degree polynomial model, assigning weights to points based on deviation from mean tendencies, and fit with a window of 20% of the data points) fits to the set of λ values for each population. For both species, intermediate PC1 values lead to the highest population growth rates, and for the majority of populations, over a range of intermediate temperatures there are relatively flat responses to temperature change. In contrast, at increasingly higher or lower temperatures (i.e., higher or lower PC1 scores) population growth rates fall more steeply, suggesting the presence of tipping points in population performance.

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SUPPLEMENTARY TABLES

Supplementary Table 1. Results of ANCOVAs of mean vital rates (survival, growth, or reproduction) on distance (x 1000 km) north of the equator ("Dist") and either size class (small, medium, or large plants, for survival and growth) or type of rate (for three fecundity and recruitment rates, for reproduction). Purple: $P < 0.05$; yellow: $0.05 < P < 0.1$.

Moss Campion Survival (logit-transformed)

Source	d.f.	Sum Sq	Mean Sq	F	Prob>F
Size	2	124.3556	62.1778	295.9939	0
Dist	1	6.0346	6.0346	28.7275	2.7525e-6
Size*Dist	2	0.034336	0.017168	0.081727	0.92166
Error	45	9.4529	0.21006		

Moss Campion Growth (logit-transformed)

Source	d.f.	Sum Sq	Mean Sq	F	Prob>F
Size	2	52.5404	26.2702	83.3378	7.7716e-16
Dist	1	1.9739	1.9739	6.262	0.016037
Size*Dist	2	5.1752	2.5876	8.2087	9.1351e-4
Error	45	14.1852	0.31523		

Moss Campion Reproduction (log-transformed)

Source	d.f.	Sum Sq	Mean Sq	F	Prob>F
Rate Type	2	7.1159	3.558	1.985	0.14923
Dist	1	45.3278	45.3278	25.2883	8.3589e-6
Rate*Dist	2	26.7746	13.3873	7.4687	0.0015815
Error	45	80.6599	1.7924		

Supplementary Table 1 (cont.):

Bistort Survival (logit-transformed)

Source	d.f.	Sum Sq	Mean Sq	F	Prob>F
Size	2	22.6816	11.3408	17.2833	3.3374e-6
Dist	1	0.13028	0.13028	0.19854	0.65819
Size*Dist	2	2.5118	1.2559	1.914	0.16014
Error	42	27.5592	0.65617		

Bistort Growth (untransformed)

Source	d.f.	Sum Sq	Mean Sq	F	Prob>F
Size	2	0.39419	0.19709	21.725	3.3287e-7
Dist	1	0.12275	0.12275	13.5301	6.6194e-4
Size*Dist	2	0.022931	0.011465	1.2638	0.29311
Error	42	0.38103	0.0090722		

Bistort Reproduction (logit- or log-transformed)

Source	d.f.	Sum Sq	Mean Sq	F	Prob>F
Rate Type	2	222.7629	111.3814	105.0729	0
Dist	1	4.1946	4.1946	3.957	0.053216
Type*Dist	2	9.298	4.649	4.3857	0.018631
Error	42	44.5217	1.06		

Supplementary Table 2. Results of separate linear regressions of size class-specific vital rate means and variabilities vs. distance north of the Equator (x 1000 km). Regressions for means are shown in Fig. 2, and regressions for variabilities are shown in Supplementary Fig. 4. Vital rate means were transformed as indicated prior to analysis. Variabilities could not be estimated for moss campion seedlings per fruit. Purple: $P < 0.05$; yellow: $0.05 < P < 0.1$.

Moss campion

Vital rate	Means			Variabilities		
	Intercept	Slope	P value	Intercept	Slope	P value
Survival-small (logit)	0.4134	0.059	0.0000	-0.2960	-0.261	0.3350
Survival-medium (logit)	0.9111	.0085	0.0035	-3.7053	0.052	0.8846
Survival-large (logit)	0.9826	.0017	0.0448	-2.7318	-0.102	0.7134
Growth-small (logit)	0.1084	-0.013	0.0028	-4.5290	0.158	0.6422
Growth-medium (logit)	0.0815	.0008	0.9189	-2.3515	-0.260	0.4880
Growth-large (logit)	0.1511	.0060	0.5566	-0.1020	-0.048	0.6765
Fruits per cm^2 cushion (log)	-2.97	0.0167	0.8782	1.1856	-0.0708	0.0746
Seedlings per fruit in year (t-1) (log)	-7.47	0.876	0.0015			
Seedlings per fruit in year (t-2) (log)	-12.32	1.537	0.0021			

Supplementary Table 2 (cont.)

Bistort

Vital rate	Means			Variabilities		
	Intercept	Slope	P value	Intercept	Slope	P value
Survival-small (logit)	1.9888	-0.0207	0.8345	0.4201	-0.0308	0.4365
Survival-medium (logit)	1.0787	0.3049	0.1429	0.3146	-0.0216	0.4899
Survival-large (logit)	4.4579	-0.1528	0.4515	-0.1012	0.0439	0.2831
Growth-small	1.5924	-0.0591	0.0662	0.0778	-0.0092	0.0863
Growth-medium	1.4406	-0.0516	0.0047	0.0369	-0.0027	0.3353
Growth-large	1.1100	-0.0169	0.0922	0.0172	-0.0001	0.9607
Prob(bulbils produced) (logit)	-0.8181	-0.0999	0.3296	-0.6346	-0.2314	0.2203
Bulbils per (leaf area)$^{1/2}$ (log)	-0.1826	0.0847	0.0280	-3.1498	-0.0209	0.9287
Bulblings per bulbil (logit)	-9.5500	0.7610	0.0529	-5.1254	0.3360	0.2900

Supplementary Table 3. AIC values for mixed models fitted to 7 annual vital rates for moss campion and 9 annual vital rates for bistort. All models included a random intercept for region or both region and population (values for the best model are shown). MTJ and MTJ2 are mean temperature in July (°C) and its square, SP and SP2 are snow-free period (days) and its square, Prec. is total precipitation (mm) during the snow-free period, and Pop is population nested within region. For each vital rate, the model with the lowest AIC is highlighted in green.

Moss Campion

MTJ	MTJ2	SP	SP2	Prec.	Pop	Survival Small	Survival Medium	Survival Large	Growth Small	Growth Medium	Growth Large	Fruits per area
x	x	x	x	x	x	-140.0	-364.0	-563.6	-293.8	-290.8	-58.9	-228.2
x	x	x	x		x	-142.0	-365.4	-565.5	-295.8	-292.1	-60.6	-229.9
x	x	x		x	x	-138.3	-360.5	-562.3	-295.8	-292.6	-60.3	-225.5
x	x	x			x	-140.3	-362.4	-564.3	-297.8	-293.8	-61.8	-227.1
x		x	x	x	x	-141.0	-363.0	-563.5	-291.5	-292.7	-60.5	-229.3
x		x	x		x	-143.0	-364.4	-565.5	-293.4	-294.1	-62.2	**-231.0**
x		x		x	x	-138.3	-357.2	-563.3	-293.4	-294.4	-62.1	-227.4
x		x			x	-140.3	-359.2	-565.3	-295.4	-295.7	-63.7	-228.9
x	x			x	x	-139.0	-361.5	-558.7	-295.8	-294.4	-62.0	-227.4
x	x				x	-140.8	-363.5	-560.3	-297.6	-295.8	-63.4	-228.9
x				x	x	-139.0	-358.2	-560.0	-293.3	-296.2	-63.8	-229.3
x					x	-140.8	-360.2	-561.7	-295.0	-297.7	-65.3	-230.7
		x	x	x	x	-141.5	-363.9	-565.4	-290.9	-294.6	-61.7	-216.4
		x	x		x	-143.4	-365.4	-567.4	-292.9	-296.0	-63.5	-218.2
		x		x	x	-139.0	-358.2	-565.2	-292.9	-296.3	-63.4	-215.0
		x			x	-141.0	-360.1	-567.2	-294.9	-297.7	-65.1	-216.6
				x	x	-138.7	-357.7	-561.5	-290.5	-298.2	-65.4	-216.0
					x	-140.5	-359.7	-563.1	-292.3	-299.7	-67.1	-217.2
x	x	x	x	x		-142.0	-365.7	-565.5	-295.8	-292.2	-60.9	-226.3
x	x	x	x			-144.0	-367.0	-567.5	-297.8	-293.6	-62.6	-228.1
x	x	x		x		-140.3	-362.2	-564.3	-297.8	-294.0	-62.3	-224.8
x	x	x				-142.3	-364.1	-566.3	**-299.8**	-295.3	-63.8	-226.5
x		x	x	x		-143.0	-364.7	-565.4	-293.5	-294.1	-62.5	-227.5
x		x	x			-145.0	-366.1	-567.4	-295.4	-295.5	-64.2	-229.3
x		x		x		-140.3	-359.1	-565.2	-295.4	-295.8	-64.1	-226.7
x		x				-142.3	-361.0	-567.2	-297.4	-297.2	-65.7	-228.3
x	x			x		-141.0	-363.3	-560.6	-297.8	-295.8	-64.0	-226.8
x	x					-142.8	-365.3	-562.3	-299.6	-297.3	-65.4	-228.3
x				x		-141.0	-360.1	-562.0	-295.3	-297.7	-65.8	-228.6
x						-142.8	-362.1	-563.7	-297.0	-299.2	-67.3	-230.1
		x	x	x		-143.5	-365.6	-567.3	-292.9	-296.0	-63.7	-217.4
		x	x			**-145.4**	**-367.1**	**-569.3**	-294.9	-297.5	-65.5	-219.2
		x		x		-141.0	-360.0	-567.2	-294.9	-297.8	-65.4	-216.2
		x				-143.0	-362.0	-569.2	-296.9	-299.2	-67.1	-217.9
				x		-140.7	-359.6	-563.5	-292.5	-299.7	-67.4	-217.6
						-142.5	-361.6	-565.1	-294.3	**-301.2**	**-69.1**	-218.7

Supplementary Table 3 (cont.)

Bistort

| \-\- Terms included in model \-\- | | | | | | Survival | | | Growth | | | Bulbils per (leaf area)$^{1/2}$ | Recruit-ment | Probability that bulbils are produced |
MTJ	MTJ2	SP	SP2	Prec.	Pop	Small	Medium	Large	Small	Medium	Large			
x	x	x	x	x	x	-110.9	-144.6	***	34.3	-48.9	-99.4	48.8	314.9	191.3
x	x	x	x		x	-111.1	-146.5	-179.2	32.4	-50.8	-101.4	53.8	314.2	189.6
x	x	x		x	x	-109.6	-145.5	-179.7	39.8	-43.7	-92.8	52.7	313.2	189.6
x	x	x			x	-108.8	-147.5	-181.2	37.9	-45.5	-94.6	55.5	312.8	188.0
x		x	x	x	x	-112.0	-146.4	-179.6	36.3	-50.7	-100.2	47.5	314.7	190.1
x		x	x		x	-112.2	-148.3	-181.1	34.3	-52.7	-102.2	52.3	314.2	188.3
x		x		x	x	-111.5	-147.1	-181.6	38.9	-44.8	-91.7	50.7	312.8	188.8
x		x			x	-110.7	-149.0	-183.1	37.0	-46.6	-93.3	53.5	312.4	187.1
x	x			x	x	-106.4	-139.9	-181.5	39.0	-45.2	-94.7	50.9	313.7	190.2
x	x				x	-104.4	-141.8	-182.8	37.0	-47.1	-96.4	54.2	312.6	188.2
x				x	x	-108.3	-141.4	-183.4	38.1	-46.2	-93.6	48.9	313.4	189.2
x					x	-106.4	-143.3	-184.6	36.2	-48.1	-95.2	52.3	312.3	187.2
		x	x	x	x	-113.6	-145.7	-181.6	36.6	-52.5	-102.2	**45.8**	313.6	188.3
		x	x		x	-113.9	-147.0	-183.1	34.7	-54.4	-104.2	50.6	313.2	186.5
		x		x	x	-113.1	-146.7	-183.6	40.0	-46.2	-93.7	48.9	311.7	187.0
		x			x	-112.5	-148.3	-185.1	38.0	-48.1	-95.3	51.8	**311.4**	**185.3**
				x	x	-110.1	-142.3	-185.4	39.8	-47.4	-95.6	47	313.9	187.9
					x	-107.9	-143.7	-186.5	37.8	-49.3	-97.1	50.3	312.7	185.9
x	x	x	x	x		-111.5	-146.4	-179.7	32.4	-50.9	-101.4	52.3	332.6	204.3
x	x	x	x			-111.3	-148.4	-181.2	**30.5**	-52.8	-103.4	56.2	331.3	202.4
x	x	x		x		-110.5	-147.5	-181.7	37.8	-45.7	-94.8	55.7	330.6	202.3
x	x	x				-109.2	-149.5	-183.2	35.9	-47.5	-96.6	57.6	329.3	200.4
x		x	x	x		-112.6	-148.2	-181.6	34.4	-52.7	-102.2	50.9	332.5	203.0
x		x	x			-112.3	-150.2	-183.1	32.4	-54.7	-104.2	54.6	331.2	201.1
x		x		x		-112.4	-149.0	-183.6	36.9	-46.8	-93.7	53.7	330.6	201.1
x		x				-111.1	**-150.9**	-185.1	35.0	-48.6	-95.3	55.6	329.2	199.2
x	x			x		-108.3	-141.9	-183.5	37.0	-47.2	-96.7	54.1	329.1	201.3
x	x					-106.3	-143.8	-184.8	35.0	-49.1	-98.4	56.6	327.7	199.3
x				x		-110.2	-143.3	-185.4	36.1	-48.2	-95.6	52.1	329.2	200.0
x						-108.3	-145.2	-186.6	34.2	-50.1	-97.2	54.7	327.6	198.0
		x	x	x		**-114.0**	-147.4	-183.6	34.7	-54.5	-104.2	49.1	332.1	201.1
		x	x			-113.9	-148.8	-185.1	32.9	**-56.4**	**-106.2**	52.9	330.8	199.2
		x		x		-113.9	-148.5	-185.6	38.0	-48.2	-95.7	51.9	330.1	199.1
		x				-112.9	-150.1	-187.1	36.0	-50.1	-97.3	53.9	328.8	197.3
				x		-112.1	-144.2	-187.4	37.8	-49.4	-97.6	50.2	329.7	198.3
						-109.8	-145.6	**-188.5**	35.8	-51.3	-99.1	52.7	328.1	196.3

*** Model fitting procedure did not converge.

Supplementary Table 4. Parameter coefficients and significance values for best-supported mixed model of each vital rate with annual estimates. Model terms as in Table 3. The second line of each fixed effect shows the significance value for the coefficient (italicized and shaded if $P > 0.05$). All regressions with significant ($P > 0.05$) SP, SP2, MTJ, and/or MTJ2 terms are illustrated in Fig. 3.

Moss Campion

Vital Rate	Inter-cept	SP	SP2	MJT	MJT2	Prec.	Standard Deviations of Random Effects:		
							Region	Pop	Residual
Survival small	0.580 *0.0003*	3.94 E-3 *0.0872*	-1.79 E-5 *0.0391*				0.0582		0.0920
Survival medium	0.877 *<0.0001*	1.57 E-3 *0.0118*	-6.70 E-6 *0.0044*				0.00314		0.0262
Survival large	0.990 *<0.0001*	1.88 E-4 *0.3224*	-1.10 E-6 *0.1400*				0.00195		0.00786
Growth small	0.223 *0.113*	2.72 E-4 *0.1487*		-0.0529 *0.0601*	2.97 E-3 *0.0325*		9.50E-07		0.0387
Growth medium	0.0881 *<0.0001*						0.0288		0.0374
Growth large	0.190 *<0.0001*						1.98E-06		0.156
Fruits per area	0.140 *0.147*	2.47 E-3 *0.0659*	-9.92 E-6 *0.0472*	-0.0222 *<0.0001*			0.0293	0.0245	0.0513

Supplementary Table 4 (cont.)

Bistort

Vital Rate	Inter-cept	SP	SP2	MJT	MJT2	Prec.	Standard Deviations of Random Effects:		
							Region	Pop	Residual
Survival small	0.752 *0.0006*	3.26 E-3 *0.2876*	-1.57 E-5 *0.1647*			-2.67 E-4 *0.1647*	3.30E-07		0.110
Survival medium	0.946 *<0.0001*	1.28 E-3 *0.0051*		-0.017 *0.0274*			0.0176		0.0872
Survival large	0.961 *<0.0001*						0.00699		0.0714
Growth small	1.24 *0.218*	0.0226 *0.0056*	-7.80 E-5 *0.0083*	-0.355 *0.0925*	0.0199 *0.0567*		7.33E-06		0.268
Growth medium	0.224 *0.453*	0.0136 *0.0031*	-4.84 *0.0038*				0.0736		0.153
Growth large	0.358 *0.104*	0.0105 *0.0019*	-4.03 E-5 *0.0012*				0.0367		0.114
Bulbils per (leaf area)$^{1/2}$	-0.270 *0.624*	0.0184 *0.0245*	-6.67E-5 *0.0257*			1.43 E-3 *0.0100*	0.101	0.147	0.264
Recruitment	-3.54 *0.0002*	-0.0122 *0.0734*					0.000280	1.23	1.35
Prob(bulbils produced)	-0.565 *0.211*	-5.25 E-3 *0.0956*					0.383	0.491	0.610