Supplementary Information

For: **Coupled dynamics of body mass and population growth in response to environmental change** by Arpat Ozgul, Dylan Z. Childs, Madan K. Oli, Kenneth B. Armitage, Daniel T. Blumstein, Lucretia E. Olson, Shripad Tuljapurkar, Tim Coulson

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Table S1. Statistical models and parameter estimates describing the relationship between August 1st body mass and demographic and trait transition rates. The models include the main effects of log-body mass x and period p (≥2000), and their interaction effect xp; values in parentheses are standard errors of parameter estimates. The predicted values are the survival probability S, reproduction probability R conditional on survival, litter size L conditional on reproduction, conditional mean of log-body mass next year G given current mass, and conditional mean of log-offspring body mass next year Q given current mass. Subscripts indicate the age classes that the functions apply to. Function $f(x \mid p)$ is a standard smoothing function of x including the interaction effect of p with the given degrees of freedom df for each level of p. Superscript * indicates significance (at α=0.05) of each term based on the likelihood ratio comparison with the reduced models. n indicates the corresponding sample sizes. Logit(Y) indicates binomial regression using logit link, whereas Log(E(Y)) indicates Poisson regression using log-transformed expected values.

Function	Model	Fitted GLM / GAM	n
Survival probability	Logit(S_1)	$-8.21_{(1.65)} +1.25_{(0.24)}\, x^* - 4.59_{(4.42)}\, p + 0.66_{(0.64)}\, xp$	927
	Logit(S_{2+})	$-17.80_{(2.30)} +2.31_{(0.29)}\, x^* - 14.90_{(4.71)}\, p^* + 1.91_{(0.59)}\, xp^*$	1401
Reproduction probability	Logit(R_2)	$3.89_{(9.44)} - 0.68_{(1.21)}\, x - 43.57_{(22.27)}\, p + 5.50_{(2.79)}\, xp^*$	273
	Logit(R_{3+})	$3.08_{(7.73)} - 0.39_{(0.96)}\, x - 22.01_{(13.26)}\, p + 2.73_{(1.63)}\, xp^*$	604
Litter size	Log(E(L_{2+}))	$- 5.07_{(1.94)} + 0.74_{(0.24)}\, x^* - 0.83_{(3.46)}\, p - 0.10_{(0.43)}\, xp$	358
Ontogenic growth	G_1	$7.84_{(0.01)} + 0.11_{(0.01)}\, p^* + f(x^* \mid p^*{}_{df:\, 5.08,\, 2.16})$	400
	G_2	$4.97_{(0.53)} + 0.39_{(0.07)}\, x^* - 1.17_{(1.19)}\, p + 0.14_{(0.15)}\, xp$	210
	G_{3+}	$1.66_{(0.29)} + 0.80_{(0.04)}\, x^* + 1.81_{(0.48)}\, p - 0.22_{(0.06)}\, xp^*$	501
Offspring mass	Q_{2+}	$1.99_{(0.98)} + 0.60_{(0.12)}\, x^* + 0.20_{(1.76)}\, p - 0.02_{(0.22)}\, xp$	339

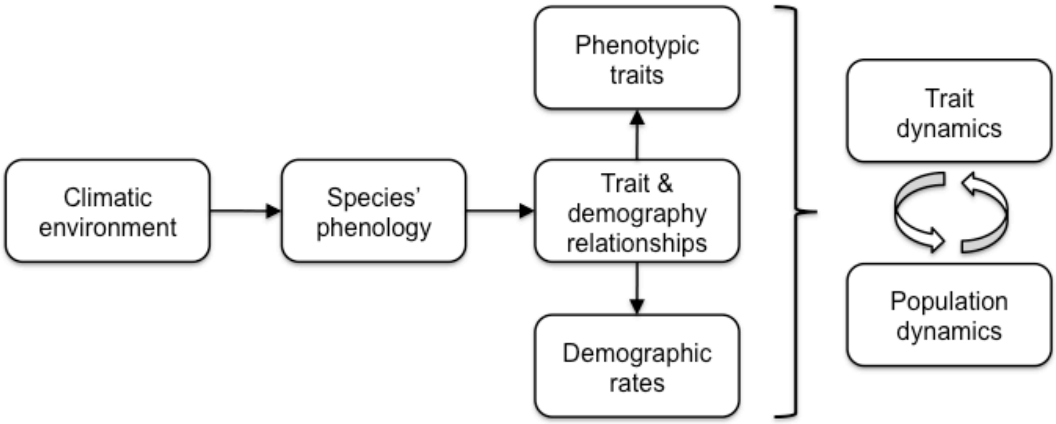

Figure S1. A change in the climatic environment can lead to a change in a species' phenology and in the relationship between traits and demographic rates. Such a change can have direct effects on the phenotypic traits (e.g., body size) and demographic rates (e.g., survival and reproduction). In this study, we demonstrate the exact mechanism through which these changes have lead to a remarkable shift in the joint dynamics of population size and trait distributions in a yellow-bellied marmot population.

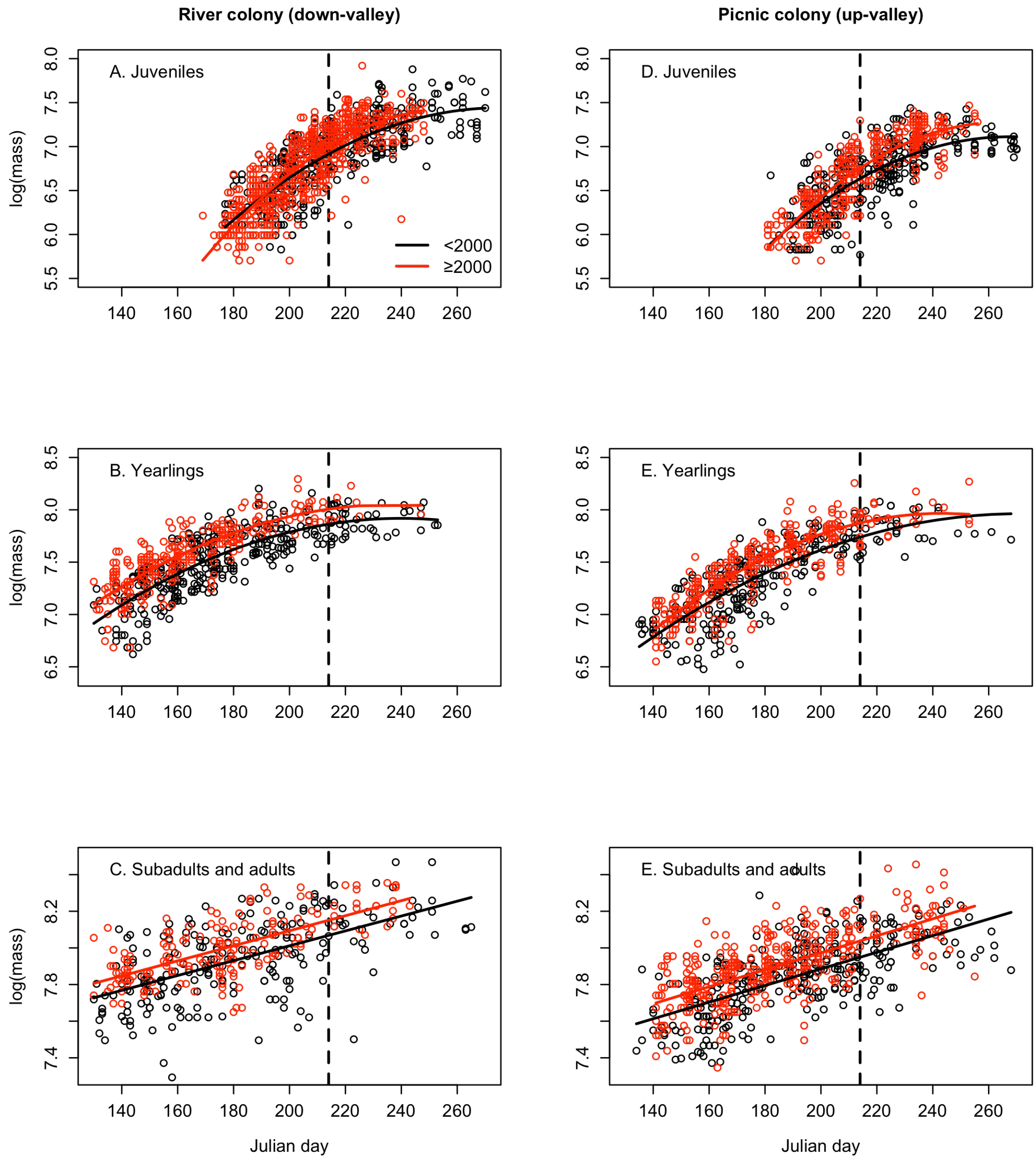

Figure S2. The relationship between day-of-year and log-body mass in two largest colony sites. The fitted mixed-effect models include quadratic relationship for juveniles and yearlings and linear relationship for older age classes. The vertical lines indicate August 1st (214th day-of-year), the date for which the body masses were estimated.

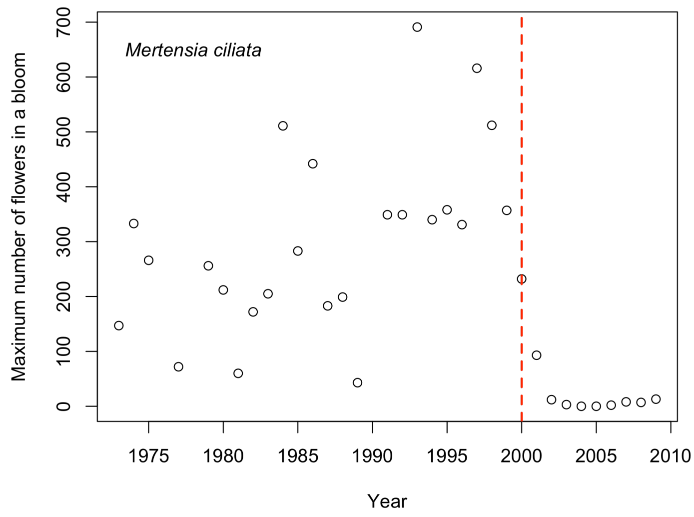

Figure S3. There has been a sharp decline in the maximum number of flowers in a bloom of the blue bell, *Mertensia ciliata*, suggesting a general environmental shift in the study area during the last decade (David Inouye, unpublished data).

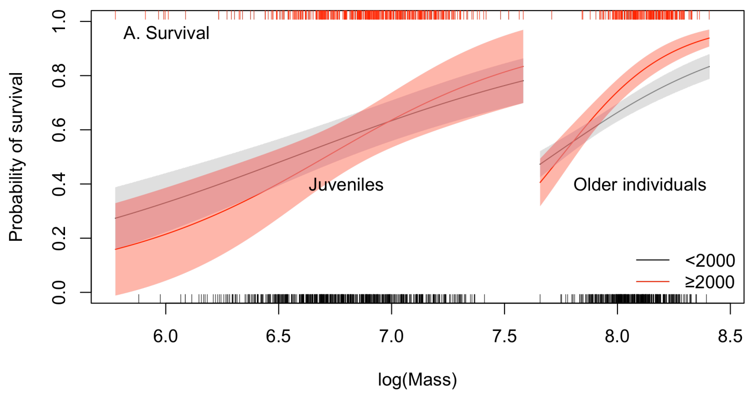

Figure S4. The relationship between body mass and survival for <2000 and ≥2000 years. Shaded areas indicate the 95% confidence intervals, and rugs above and below the graph represent the distribution of the body mass data.

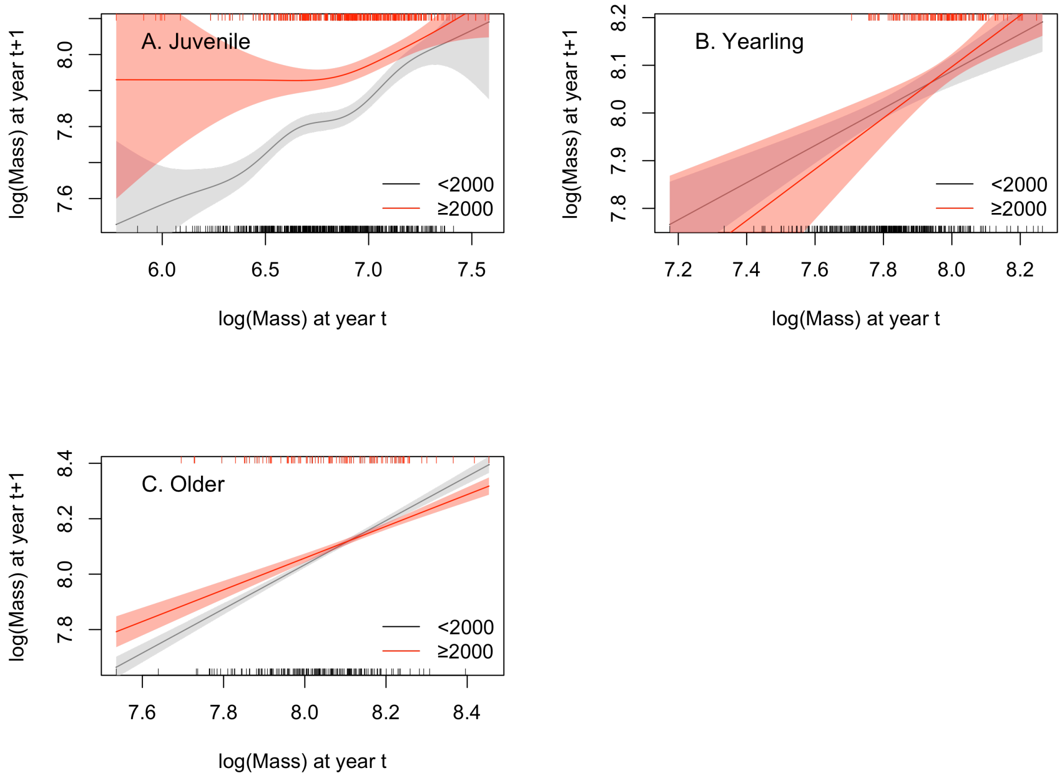

Figure S5. The relationship between body mass and age-specific growth for <2000 and ≥2000 years. Shaded areas indicate the 95% confidence intervals, and rugs above and below the graph represent the distribution of the body mass data.

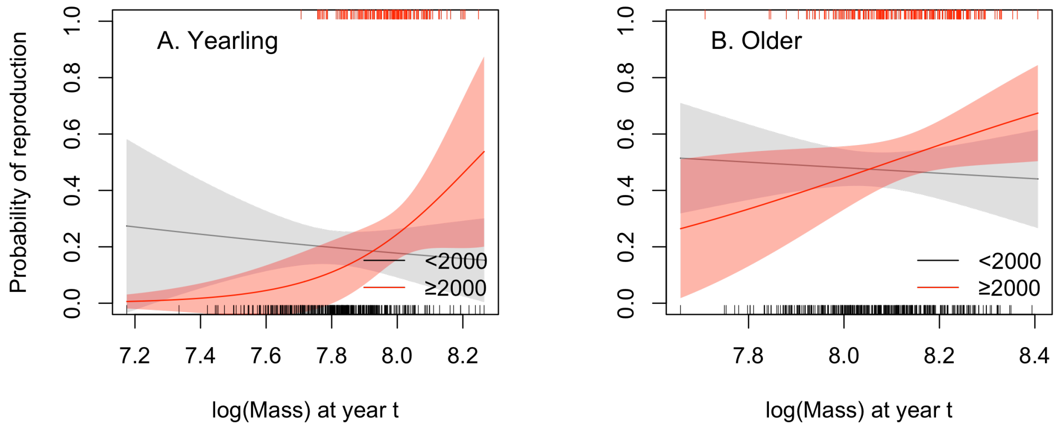

Figure S6. The relationship between body mass and age-specific probability of reproduction for <2000 and ≥2000 years. Shaded areas indicate the 95% confidence intervals, and rugs above and below the graph represent the distribution of the body mass data.

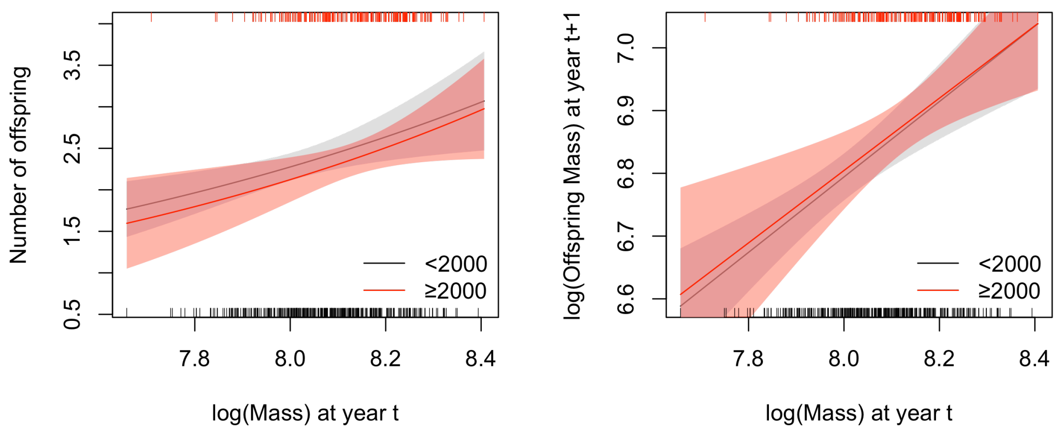

Figure S7. The relationship between body mass and (A) number of offspring produced and (B) offspring mass for <2000 and ≥2000 years. Shaded areas indicate the 95% confidence intervals, and rugs above and below the graph represent the distribution of the body mass data.

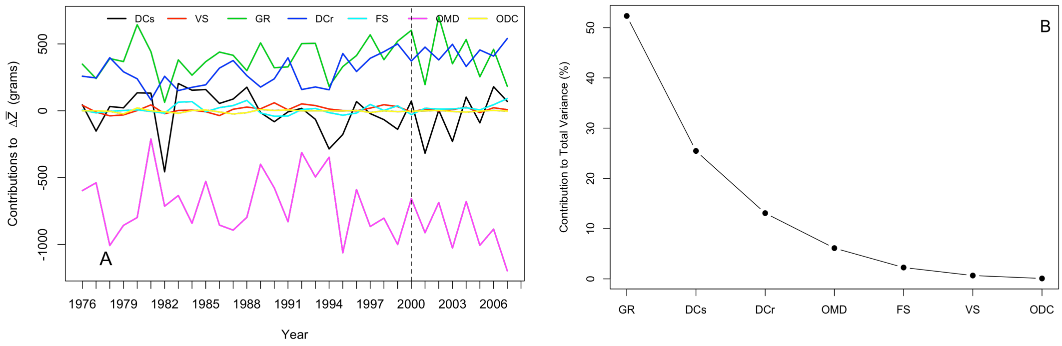

Figure S8. (A) Time-series of the contributions of different terms to $\Delta\overline{Z}$ summed across all ages, and (B) the percentage contribution of each term to the observed total variation in $\Delta\overline{Z}$ (see *Methods* for definition of abbreviations).