

**Supporting Information.** Keller, J.A., and K. Shea. 2020. Warming and shifting phenology accelerate an invasive plant life cycle. Ecology.

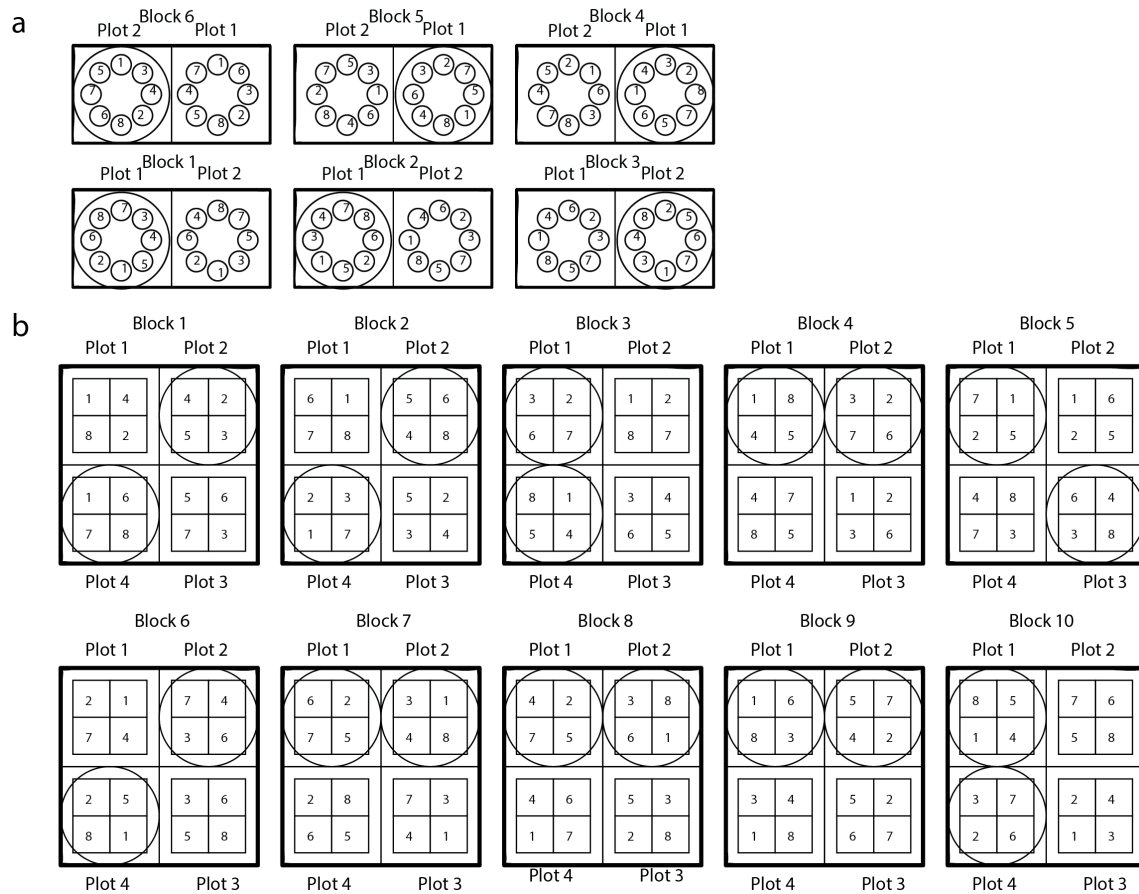
**Appendix S1.** Details on the timing of seed release treatments, fitted integral projection model parameters, field experiment layout, and seedling sizes at the end of their first growing season for the different seed release timing treatments.

**Table S1:** Planting dates for cohorts 1 and 2.

<b>Planting Date</b>	<b>Cohort 1</b>	<b>Cohort 2</b>
1	8/2/2012	8/3/2013
2	8/8/2012	8/12/2013
3	8/21/2012	8/26/2013
4	9/5/2012	9/9/2013
5	9/19/2012	9/24/2013
6	10/3/2012	10/8/2013
7	10/19/2012	10/22/2013

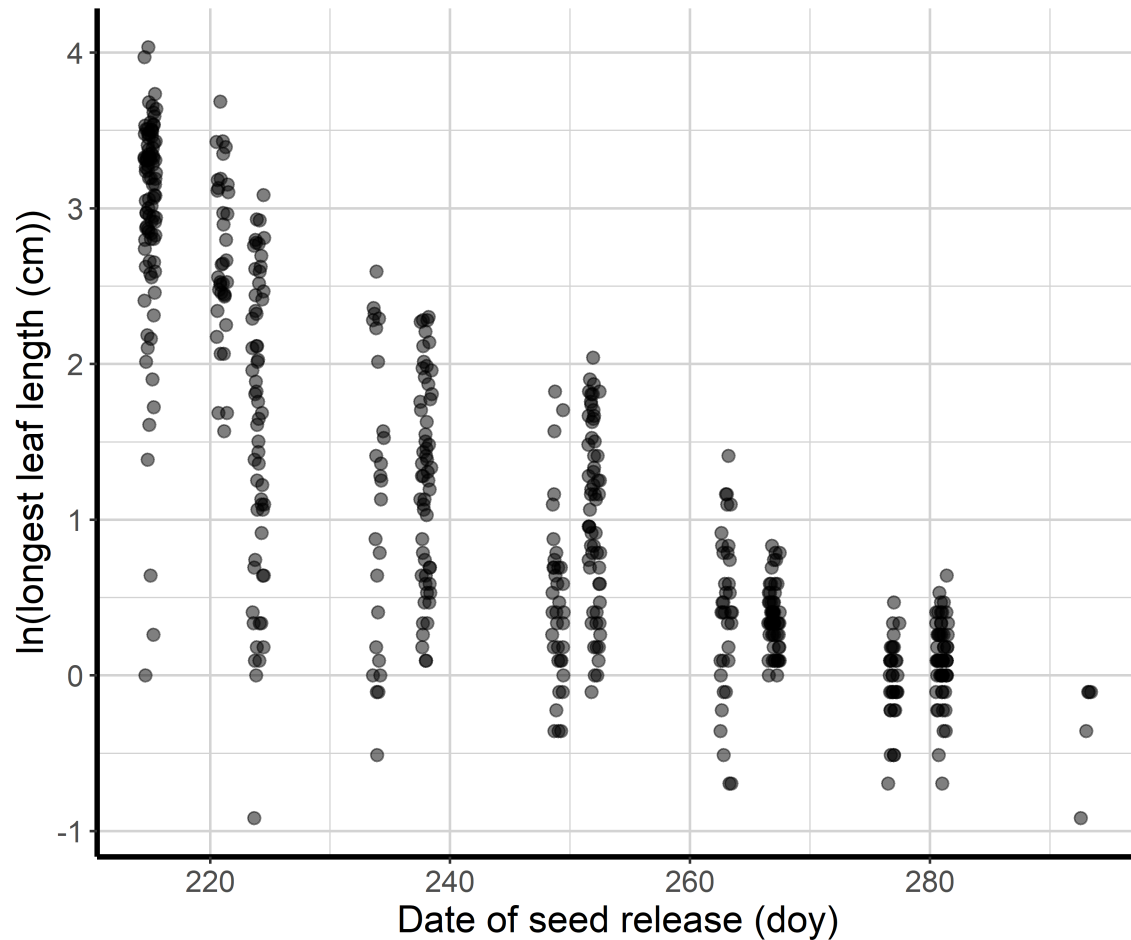
**Table S2:** Parameter estimates used in the IPM.

<b>Parameter</b>	<b>Description</b>	<b>Estimate</b>	<b>SE</b>	<b>Notes</b>
<b>(a) Survival <math>s(z, w)</math> (logit)</b>	Probability of surviving			
Intercept		0.3175	0.2829	
Size		0.4652	0.1542	
OTC		1.0123	0.3232	
<b>(b) Growth <math>G(z, z', w)</math> (identity)</b>	Probability of growing from size $z$ to $z'$			
Intercept		1.159677	0.11992	
Size		0.20324	0.07685	
OTC		0.53902	0.11396	
<b>(c) Probability of reproducing <math>p_r(z)</math> (logit)</b>	Probability of bolting/flowering at size $z$			
Intercept		-8.3683	1.2022	
Size		4.5298	0.6247	
<b>(d) Fecundity <math>b(z, w)</math> (log)</b>	Number of seeds produced by flowering individuals of size $z$			Seed production estimated based on flower head diameters.
Intercept		-1.6561	0.6329	
Size		2.7907	0.2337	
<b>(e) Probability of establishment <math>p_r</math></b>	Average probability of a seed germinating and establishing as a rosette	0.03	NA	Value from Lee & Hamrick (1983)
<b>(f) Size of recruits <math>c_0(z', d_j)</math></b>	Size distribution of newly established rosettes	NA	NA	See section "Estimating new recruit size distribution"



**Figure S1:** Experimental layout for the first cohort (a) and second cohort (b) of the field experiment conducted at the Russell E.

Larson Agricultural Center in Rock Springs, PA. Within each block, plots were randomly allocated to warming treatments: warming via open top chamber (indicated by a large circle within the plot) or ambient (no circle). Within each plot, seven seed release timing treatments (1-7, see Table S2) and an unplanted control (here marked 8) were randomly allocated to areas within plots. Note that the layout here does not reflect actual size of planting areas: all areas were 10 x 15 cm.



**Figure S2:** End-of-season *Carduus nutans* rosette sizes, as measured by the natural log of the longest leaf length, for rosettes planted in each of our seven seed release timing treatments, which span early August to late October (n=558), noted by Julian day of the year (doy). Rosettes were grown with competition suppressed at the Russell E. Larson Agricultural Center in Rock Springs, PA. Data for two cohorts are included here.

**Literature cited:**

Lee, J. M., & Hamrick, J. L. (1983). Demography of two natural populations of musk thistle (*Carduus nutans*). *The Journal of Ecology* 71(3), 923-936.