Supplementary File 4. Parametrisation of population models of unmanaged references

$$SB(t+1) = SB(t)\,\sigma(1-\rho) + SB(t)\,\sigma\;\rho\;\varphi(x)\int_{min}^{max} s(x)\,g(y,x)\,nx(x)dx\int_{min}^{max} fl(y)\,fec(y)\,\Sigma(sr(y)\,sv(sr))\,ny(y)\,dy \quad [1]$$

Equation 1 was parameterised with data from the demographic survey (6 reference data sets, Supplementary File 2) and the seed burial experiment (3 seed survival scenarios, Supplementary File 3). We parameterised 18 models, one for each combination of reference dataset and seed survival scenario.

Since highest mortality of seeds in the soil seed bank occurs over winter (M. Vitalos et al. unpublished results), we modelled mortality of seeds to occur only between October and June. Hence parameter σ represents the probability of a seed surviving the winter in the seed bank as well as the yearly probability of seed survival. Survival of seeds was parametrized by one of the three seed survival scenarios from the seed burial experiment (Supplementary File 3, Table S3).

All estimates obtained from the demographic survey are reported in Supplementary File 4, Table S4, and the modelled vital rate functions in Figs.S6-10 (on the back-transformed values of plant height), for each of the six reference data sets. The probability (ρ) of a seed to be recruited and successfully established in June was estimated from the data from plots of reference populations that had been sampled for soil, as the global fraction of seeds in the soil seed bank that successfully established in these plots. The size distribution of the new plants φ was a probability density function of log-transformed plant height in June x, which followed a normal distribution with a mean and standard deviation of the log-transformed heights of the tagged new plants in June (Fig. S6).

The first integral in equation 1 describes transitions of nx established new plants of size x (i.e. log-transformed height) in June into ny plants of size y (i.e. log-transformed height) in September. The effects of new plant size x on survival $s(x)$ (Fig. S7) and growth $g(y,x)$ (Fig. S8) were parameterized using data from tagged new plants in plots from each reference population, applying (generalized, for binary data on survival) linear mixed effect models with log-transformed plant height as fixed effect and plot as random effect. The probability density function of growth was modelled as a normal distribution with mean standard deviation approximated by the estimates and residual standard error of the growth models.

The second integral in equation 1 describes the production of viable new seeds by n adult plants of size y between September and October. Flowering $fl(y)$ was parameterized by logistic regression of flowering as a function of log-transformed height of adult plants (Fig. S9). Fecundity $fec(y)$ is the maximum potential number of individual seeds produced per plant. Using data on the sampled plants outside plots for each reference data set, a linear model regressed the log-transformed number of individual seeds on log-transformed adult plant height. Estimates were back-transformed to get numbers of new seeds produced (Fig. S10). To obtain the number of viable seeds, we multiplied this with the probability of a seed to be viable $\Sigma(sr(y)\,sv(sr))$ as a function of plant size y. Seed ripening $sr(y)$ describes the probability distribution of seeds over the three developmental stages (flower, unripe seed, ripe seed), predicted as a function of plant height y by the multinomial model of the control treatment in the mowing experiment (Fig. 5). Each seed developing stage was linked to a probability of being viable $sv(sr)$, obtained from the post-harvest experiment (flowers: 0, unripe seeds: 0.35, ripe seeds: 0.87, see main text 'Post-harvest seed quality experiment'). Since all seeds in the unmanaged reference populations were assumed to ripen before being shed, this was set to 0.87 for all developmental stages, according to the fraction of ripe seeds that was viable in the post-harvest seed quality experiment.

Table S4. Overview of vital rate parameters (μ=mean, sd=standard deviation, α=intercept, β=slope) obtained for each of the reference data sets AT14, HU14, IT14, IT15, PL14 and PL15.

vital rate	parameter	AT14	HU14	IT14	IT15	PL14	PL15
recruitment [ρ]	-	0.229	0.148	0.213	0.046	0.702	0.021
new plant size [ϕ(x)]	μ	1.708	2.308	1.619	1.592	1.584	1.190
new plant size [ϕ(x)]	sd	0.397	0.471	0.326	0.285	0.391	0.421
survival [s(x)]	α	1.100	-2.875	1.930	-4.382	5.321	2.475
survival [s(x)]	β	0.030	1.271	0.785	1.857	-1.142	-0.004
growth [g(y,x)]	α	2.118	1.175	3.703	1.085	2.767	2.176
growth [g(y,x)]	β	0.503	1.149	0.359	1.277	0.323	0.553
growth [g(y,x)]	sd	0.517	0.506	0.213	0.359	0.743	0.322
flowering [fl(y)]	α	26.566	-5.254	26.566	-0.958	-42.492	-3.209
flowering [fl(y)]	β	0.000	1.662	0.000	1.537	27.542	2.293
fecundity [fec(y)]	α	-6.122	-2.489	-8.853	-5.133	-1.436	-9.465
fecundity [fec(y)]	β	2.957	1.565	3.433	2.782	1.791	3.805

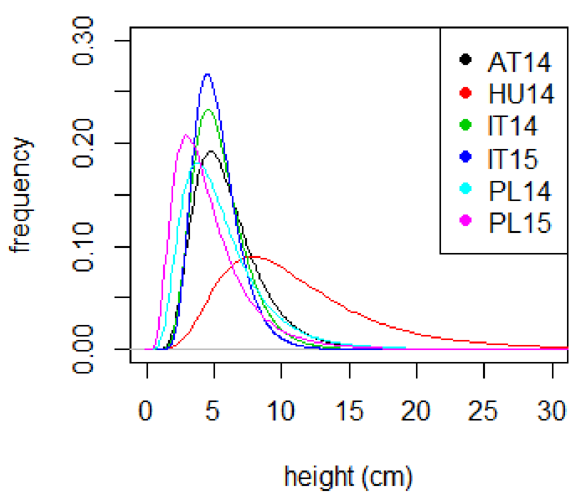

Fig. S6. Modelled distribution of heights (cm) of new plants in June. Colours represent different reference data sets.

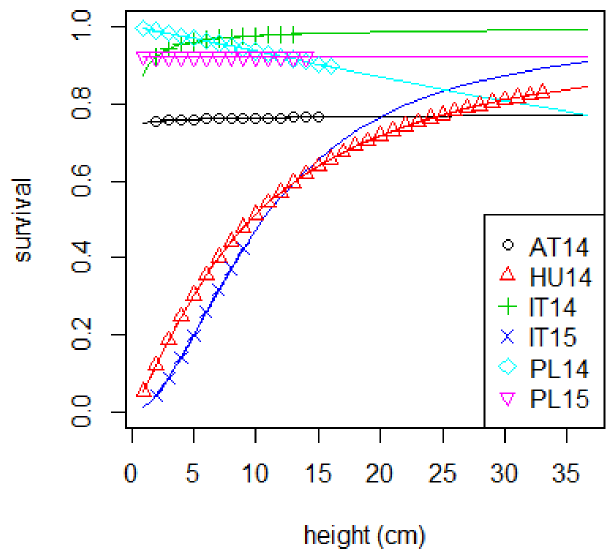

Fig. S7. Modelled survival of new plants as a function of plant height in June. Colours/symbols represent different reference data sets, symbols are only plotted for the observed range of heights.

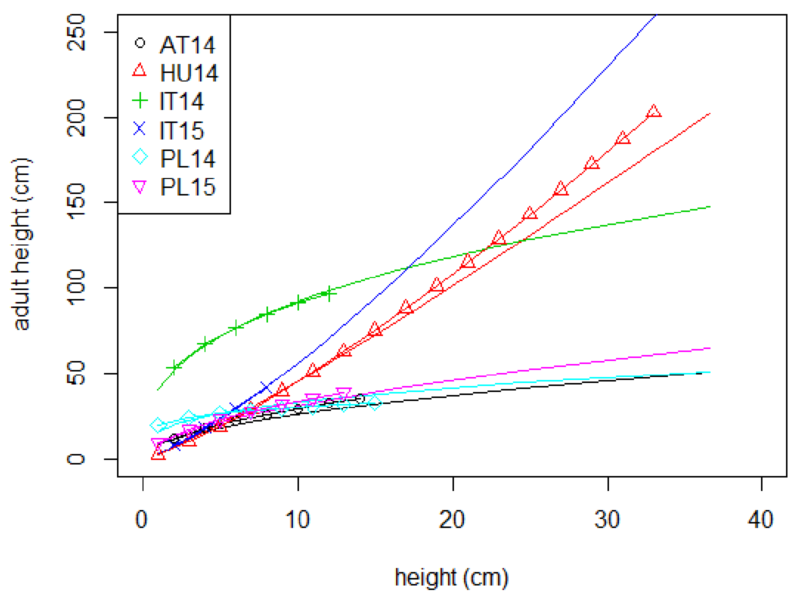

Fig. S8. Modelled plant growth, shown as height of plants in September regressed on their height as new plants in June. Colours/symbols represent different reference data sets, symbols are only plotted for the observed range of heights.

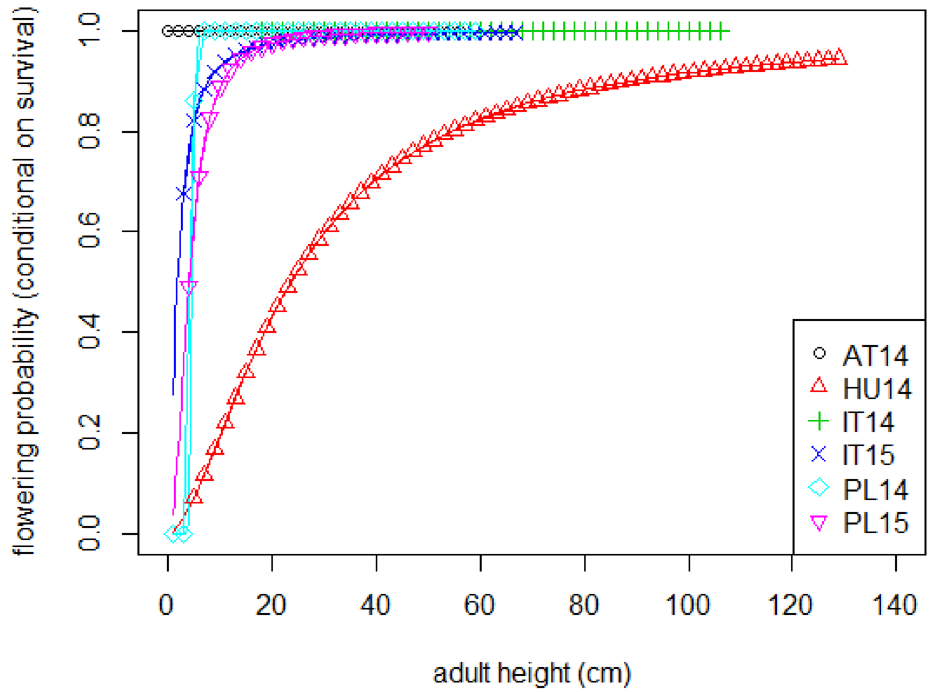

Fig. S9. Modelled probability of flowering of adult plants, as a function of adult plant height in September. Colours/symbols represent different reference data sets, symbols only plotted for the observed range of heights.

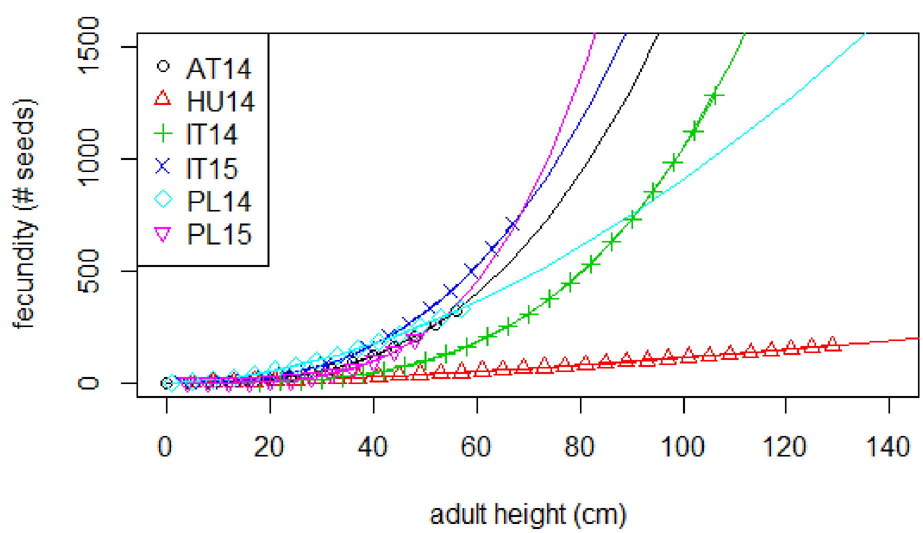

Fig. S10. Modelled fecundity of adult plants as a function of adult plant height in September. Colours/symbols represent different reference data sets, symbols are only plotted for the observed range of heights.