**Sensitivity analysis**

**Method**

For the sensitivity analysis, we increased each parameter (Table 1) in turn by 5% and calculated the log-transformed growth rate when rare (GRWR) for the annual and the perennial. To calculate the sensitivity of log(GRWR) to the parameter, we used the equation

where *p* is the parameter value and the asterisk indicates that the value was calculated after the perturbation to *p*. We also decreased each parameter by 5% and found qualitatively similar results, so we only report quantitative results from the sensitivity analysis with increased parameter values.

Table 1: Descriptions of model parameters. Subscript meanings as follows: *p* = perennial adult, *s* = perennial seedling, *a* = annual, *i* = can be any of the preceding three

|  |  |  |  |
| --- | --- | --- | --- |
| Parameter | Meaning | Units | Source |
| *mp* | Proportion of perennial adults that survive for a year |  | Literature |
| *si* | Proportion of dormant seeds of species i that survive for a year |  | Literature |
| 𝛾*i* | Germination rate in the absence of competition for species i | seedlings/  seed | Greenhouse experiment |
| 𝛼*iL* | Competitive effect of litter on germination rate | g-1 | Greenhouse experiment |
| *b* | Proportion of litter biomass remaining after one year | g | Literature |
| *ca* | Conversion factor: annual seed production to biomass | g/seed | Literature |
| *hi* | Proportion of seedlings of species i that survive through the growing season |  | Field experiment |
| 𝜆*i* | Seeds produced by species i in the absence of competition | seeds/  individual | Field experiment (currently literature) |
| 𝛼*ij* | Competitive effect of species j on seed production of species i | individuals-1 | Field experiment (currently greenhouse experiment and literature) |
| *toli* | The proportion of seed production maintained by species i while infected (i.e. tolerance) |  | Literature and estimate |

**Results**

When infection was included in the model, the annual’s GRWR was highly sensitive to perennial adult survival (*mp*, sensitivity = -51.8, Fig. 1). The seven next most influential parameters had the same magnitudes of sensitivity (Fig. 1): annual establishment (*ha*, sensitivity = 2.5), annual fecundity in the absence of competition (λ*a*, sensitivity = 2.5), annual tolerance of infection (*tola*, sensitivity = 2.5), intraspecific competition among perennial adults (α*pp*, sensitivity = 2.5), perennial fecundity in the absence of competition (λ*p*, sensitivity = -2.5), perennial tolerance of infection (*tolp*, sensitivity = -2.5), and the competitive effects of the perennial seedling on the annual (α*as*, sensitivity = -2.5). The perennial’s GRWR was also most sensitive to perennial adult survival (*mp*, sensitivity = 2.6), with perennial seed survival a close second (*ss*, sensitivity = 2.5, Fig. 1). The most influential annual parameter on perennial GRWR was the annual seed survival (*sa*, sensitivity = -1.5, Fig. 1).

When disease tolerance for both species was maximized, such that there was no impact of infection on seed production, the results were qualitatively similar to when disease tolerance was lower (Fig. 2). The magnitude of parameter sensitivity decreased for the annual GRWR and increased for the perennial GRWR. In addition, perennial seed survival became a more influential parameter (*ss*, sensitivity = 3.5) than perennial adult survival (*mp*, sensitivity = 3.2) for the perennial GRWR (Fig. 2).



Figure 1: Sensitivity analysis of fully parameterized model



Figure 2: Sensitivity analysis of model without infection (*tola* = 1, *tolp* = 1)

**Recommendations for field experiment year 2**

Collecting data on perennial survival (first-year and older) in spring 2019 should be a priority. We will assess survival as green tissue appearing by May 2019. At this time, the first-year perennials will be replaced with seedlings grown in the greenhouse. Seed survival studies that we start in October 2019 and carry out until spring 2020 will improve model predictions. Seed production data that we have collected in 2018 and will collect in 2019 will address the remaining sensitive parameters.