# Results

## Sensitivities and elasticities of waterhemp population growth rate to projection matrices elements

The sensitivity and elasticity patterns were consistent between weed management regimes, but graphs are separated by weed management regimes for ease of view. Darker colors represent more intense influence.

In scenario one, using the 2018 fecundity rates, the probability that a seed in the soil successfully establish had the greatest effects on waterhemp population growth (Figures 1 and 2). The absolute change in waterhemp’s population growth rates influenced by successful establishment in the cool-season crops were at a smaller magnitude than that of the warm-season crops. The number of seeds contributed to the soil seedbank intermediately affected the absolute change in waterhemp’s population growth in the cool-season crops but minimally so in the warm-season crops.

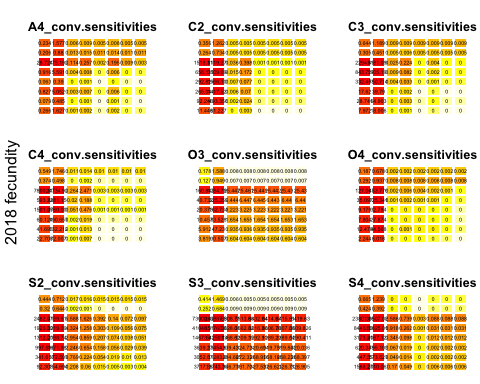


Figure 1: Sensitivities of eigen values to changes in each element of the population projection matrix, using 2018 fecundity rate. Each panel presents the sensitivities in each crop phase under or follow conventional weed management.

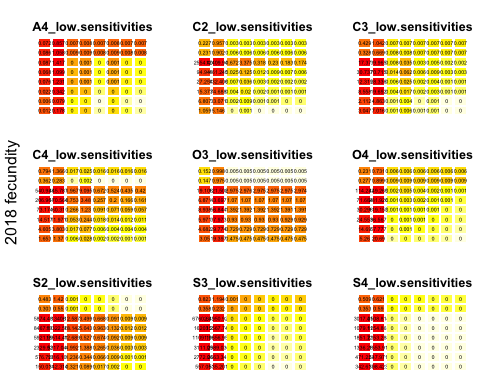


Figure 2: Sensitivities of eigen values to changes in each element of the population projection matrix, using 2018 fecundity rate. Each panel presents the sensitivities in each crop phase under or follow low herbicide weed management.

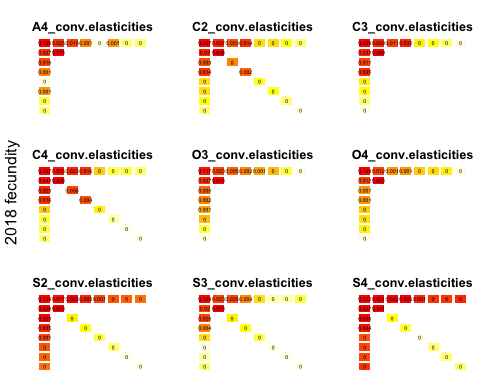


Figure 3: Elasticities of eigen values to changes in each element of the population projection matrix, using 2018 fecundity rate. Each panel presents the elasticities in each crop phase under or follow conventional weed management.

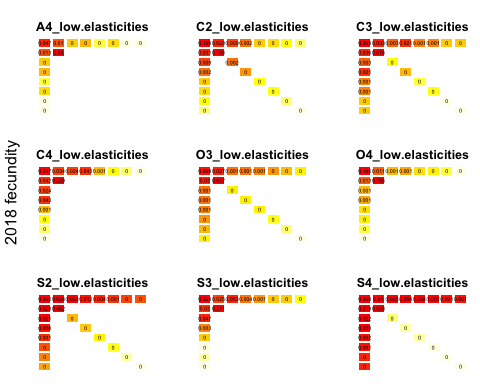


Figure 4: Elasticities of eigen values to changes in each element of the population projection matrix, using 2018 fecundity rate. Each panel presents the elasticities in each crop phase under or follow low herbicide weed management.

In scenario two, using the 2019 fecundity rates, the patterns in sensitivities and elasticities of waterhemp proportional population changes to proportional changes in projection matrices’ elements were consistent with those in scenarios one ((Figures 7 and 8). Noticeably, the success rate of plant cohort one to deposit seeds into the top soil stratum was less influential to that in the scenario one.

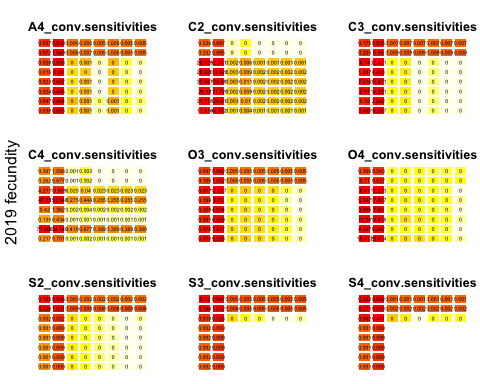


Figure 5: Sensitivities of eigen values to changes in each element of the population projection matrix. Each panel presents the sensitivities in each crop phase under or follow conventional weed management.

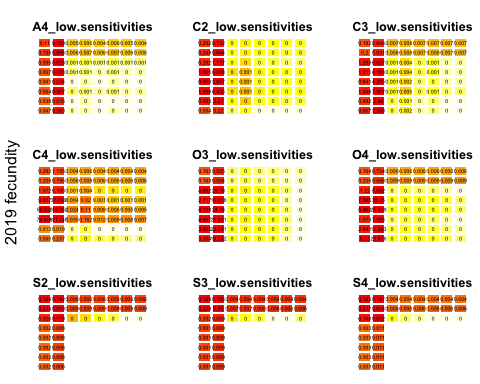


Figure 6: Sensitivities of eigen values to changes in each element of the population projection matrix. Each panel presents the sensitivities in each crop phase under or follow low herbicide weed management.

Also using the 2019 fecundity rates, the seedbank had the greatest proportional effects on waterhemp population growth in all crop phases. The influence of seedbank states on waterhemp population growth was consistent between weed management regimes (Figures 7 and 8). In general, the probability that a plant successfully contribute seeds to the soil surface was more influential to waterhemp population proportional change in warm-season crops than in cool-season crops.

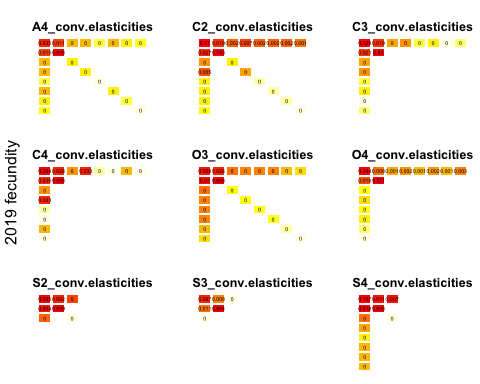


Figure 7: Elasticities of eigen values to changes in each element of the population projection matrix, using 2019 fecundity rate. Each panel presents the elasticities in each crop phase under or follow conventional weed management.

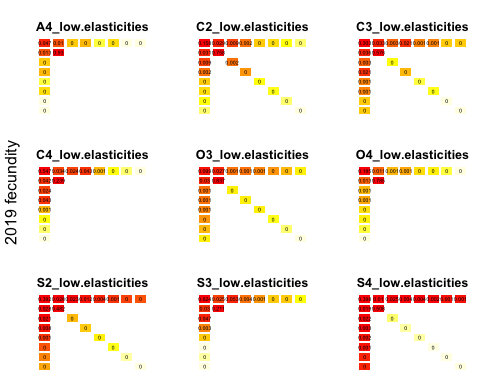
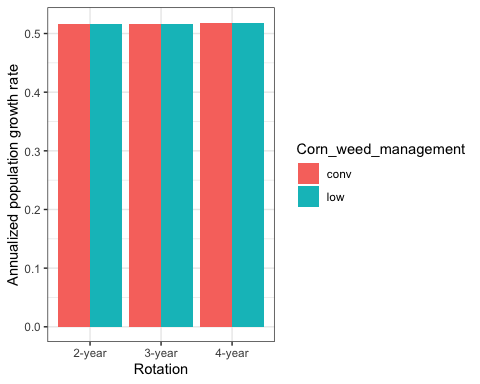


Figure 8: Elasticities of eigen values to changes in each element of the population projection matrix, using 2019 fecundity rate. Each panel presents the elasticities in each crop phase under or follow low herbicide weed management.

## Waterhemp population growth rate in three different rotation systems

Using 2018 fecundity rates, waterhemp populations in all crop identity halved annually (Figures 9 and 10). 

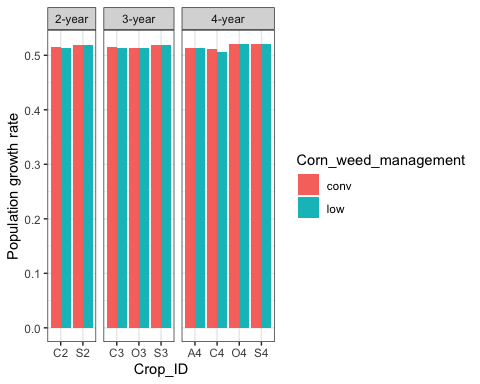


Figure 10: Waterhemp population growth rate in each crop phase using 2018 fecundity rate.

## Appendix

The periodic matrices here are listed by chronological order, from spring tillage to overwinter every year. Each list contains eighteen matrices, corresponding to nine crop identities crossed with two corn weed management regimes. Crop identities in each list are ordered alphabetically.

#### Pre-planting tillage

Field cultivator before planting all the crops, except alfalfa sole crop (A4).

## $A4\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 1 0 0 0 0 0 0 0  
## [2,] 0 1 0 0 0 0 0 0  
## [3,] 0 0 0 0 0 0 0 0  
## [4,] 0 0 0 0 0 0 0 0  
## [5,] 0 0 0 0 0 0 0 0  
## [6,] 0 0 0 0 0 0 0 0  
## [7,] 0 0 0 0 0 0 0 0  
## [8,] 0 0 0 0 0 0 0 0  
##   
## $A4\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 1 0 0 0 0 0 0 0  
## [2,] 0 1 0 0 0 0 0 0  
## [3,] 0 0 0 0 0 0 0 0  
## [4,] 0 0 0 0 0 0 0 0  
## [5,] 0 0 0 0 0 0 0 0  
## [6,] 0 0 0 0 0 0 0 0  
## [7,] 0 0 0 0 0 0 0 0  
## [8,] 0 0 0 0 0 0 0 0  
##   
## $C2\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.5970833 0.1010417 0 0 0 0 0 0  
## [2,] 0.4000000 0.8916667 0 0 0 0 0 0  
## [3,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [4,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [5,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [6,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [7,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [8,] 0.0000000 0.0000000 0 0 0 0 0 0  
##   
## $C2\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.5970833 0.1010417 0 0 0 0 0 0  
## [2,] 0.4000000 0.8916667 0 0 0 0 0 0  
## [3,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [4,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [5,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [6,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [7,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [8,] 0.0000000 0.0000000 0 0 0 0 0 0  
##   
## $C3\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.5970833 0.1010417 0 0 0 0 0 0  
## [2,] 0.4000000 0.8916667 0 0 0 0 0 0  
## [3,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [4,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [5,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [6,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [7,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [8,] 0.0000000 0.0000000 0 0 0 0 0 0  
##   
## $C3\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.5970833 0.1010417 0 0 0 0 0 0  
## [2,] 0.4000000 0.8916667 0 0 0 0 0 0  
## [3,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [4,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [5,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [6,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [7,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [8,] 0.0000000 0.0000000 0 0 0 0 0 0  
##   
## $C4\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.5970833 0.1010417 0 0 0 0 0 0  
## [2,] 0.4000000 0.8916667 0 0 0 0 0 0  
## [3,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [4,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [5,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [6,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [7,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [8,] 0.0000000 0.0000000 0 0 0 0 0 0  
##   
## $C4\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.5970833 0.1010417 0 0 0 0 0 0  
## [2,] 0.4000000 0.8916667 0 0 0 0 0 0  
## [3,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [4,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [5,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [6,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [7,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [8,] 0.0000000 0.0000000 0 0 0 0 0 0  
##   
## $O3\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.5970833 0.1010417 0 0 0 0 0 0  
## [2,] 0.4000000 0.8916667 0 0 0 0 0 0  
## [3,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [4,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [5,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [6,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [7,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [8,] 0.0000000 0.0000000 0 0 0 0 0 0  
##   
## $O3\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.5970833 0.1010417 0 0 0 0 0 0  
## [2,] 0.4000000 0.8916667 0 0 0 0 0 0  
## [3,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [4,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [5,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [6,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [7,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [8,] 0.0000000 0.0000000 0 0 0 0 0 0  
##   
## $O4\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.5970833 0.1010417 0 0 0 0 0 0  
## [2,] 0.4000000 0.8916667 0 0 0 0 0 0  
## [3,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [4,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [5,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [6,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [7,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [8,] 0.0000000 0.0000000 0 0 0 0 0 0  
##   
## $O4\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.5970833 0.1010417 0 0 0 0 0 0  
## [2,] 0.4000000 0.8916667 0 0 0 0 0 0  
## [3,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [4,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [5,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [6,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [7,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [8,] 0.0000000 0.0000000 0 0 0 0 0 0  
##   
## $S2\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.5970833 0.1010417 0 0 0 0 0 0  
## [2,] 0.4000000 0.8916667 0 0 0 0 0 0  
## [3,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [4,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [5,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [6,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [7,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [8,] 0.0000000 0.0000000 0 0 0 0 0 0  
##   
## $S2\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.5970833 0.1010417 0 0 0 0 0 0  
## [2,] 0.4000000 0.8916667 0 0 0 0 0 0  
## [3,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [4,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [5,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [6,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [7,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [8,] 0.0000000 0.0000000 0 0 0 0 0 0  
##   
## $S3\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.5970833 0.1010417 0 0 0 0 0 0  
## [2,] 0.4000000 0.8916667 0 0 0 0 0 0  
## [3,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [4,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [5,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [6,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [7,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [8,] 0.0000000 0.0000000 0 0 0 0 0 0  
##   
## $S3\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.5970833 0.1010417 0 0 0 0 0 0  
## [2,] 0.4000000 0.8916667 0 0 0 0 0 0  
## [3,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [4,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [5,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [6,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [7,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [8,] 0.0000000 0.0000000 0 0 0 0 0 0  
##   
## $S4\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.5970833 0.1010417 0 0 0 0 0 0  
## [2,] 0.4000000 0.8916667 0 0 0 0 0 0  
## [3,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [4,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [5,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [6,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [7,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [8,] 0.0000000 0.0000000 0 0 0 0 0 0  
##   
## $S4\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.5970833 0.1010417 0 0 0 0 0 0  
## [2,] 0.4000000 0.8916667 0 0 0 0 0 0  
## [3,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [4,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [5,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [6,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [7,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [8,] 0.0000000 0.0000000 0 0 0 0 0 0

#### Recruitment rate

Numbers were calculated from the stand count densities in 2020 with regards to 2019’s seedbank densities. The 2019 seedbank densities were stratified into top (0-2cm) and bottom (2-20cm) sections. The recruitment proportion was calculated under the assumption that seeds only germinate from the top stratum.

## $A4\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.7878687696 0 0 0 0 0 0 0  
## [2,] 0.0000000000 1 0 0 0 0 0 0  
## [3,] 0.0417808370 0 0 0 0 0 0 0  
## [4,] 0.0939593243 0 0 0 0 0 0 0  
## [5,] 0.0007980290 0 0 0 0 0 0 0  
## [6,] 0.0712078708 0 0 0 0 0 0 0  
## [7,] 0.0034391177 0 0 0 0 0 0 0  
## [8,] 0.0009460516 0 0 0 0 0 0 0  
##   
## $A4\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.809321177 0 0 0 0 0 0 0  
## [2,] 0.000000000 1 0 0 0 0 0 0  
## [3,] 0.037458667 0 0 0 0 0 0 0  
## [4,] 0.083573116 0 0 0 0 0 0 0  
## [5,] 0.001238766 0 0 0 0 0 0 0  
## [6,] 0.063465773 0 0 0 0 0 0 0  
## [7,] 0.003572915 0 0 0 0 0 0 0  
## [8,] 0.001369586 0 0 0 0 0 0 0  
##   
## $C2\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.9986356820 0 0 0 0 0 0 0  
## [2,] 0.0000000000 1 0 0 0 0 0 0  
## [3,] 0.0001117661 0 0 0 0 0 0 0  
## [4,] 0.0012451043 0 0 0 0 0 0 0  
## [5,] 0.0000018619 0 0 0 0 0 0 0  
## [6,] 0.0000018619 0 0 0 0 0 0 0  
## [7,] 0.0000018619 0 0 0 0 0 0 0  
## [8,] 0.0000018619 0 0 0 0 0 0 0  
##   
## $C2\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.9937546246 0 0 0 0 0 0 0  
## [2,] 0.0000000000 1 0 0 0 0 0 0  
## [3,] 0.0008479558 0 0 0 0 0 0 0  
## [4,] 0.0042567203 0 0 0 0 0 0 0  
## [5,] 0.0004004111 0 0 0 0 0 0 0  
## [6,] 0.0002894963 0 0 0 0 0 0 0  
## [7,] 0.0002309047 0 0 0 0 0 0 0  
## [8,] 0.0002198872 0 0 0 0 0 0 0  
##   
## $C3\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 9.953642e-01 0 0 0 0 0 0 0  
## [2,] 0.000000e+00 1 0 0 0 0 0 0  
## [3,] 4.600011e-04 0 0 0 0 0 0 0  
## [4,] 4.086206e-03 0 0 0 0 0 0 0  
## [5,] 4.538728e-06 0 0 0 0 0 0 0  
## [6,] 7.602237e-05 0 0 0 0 0 0 0  
## [7,] 4.538728e-06 0 0 0 0 0 0 0  
## [8,] 4.538728e-06 0 0 0 0 0 0 0  
##   
## $C3\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.9805858603 0 0 0 0 0 0 0  
## [2,] 0.0000000000 1 0 0 0 0 0 0  
## [3,] 0.0028416132 0 0 0 0 0 0 0  
## [4,] 0.0123674219 0 0 0 0 0 0 0  
## [5,] 0.0011714408 0 0 0 0 0 0 0  
## [6,] 0.0018329256 0 0 0 0 0 0 0  
## [7,] 0.0006004827 0 0 0 0 0 0 0  
## [8,] 0.0006002555 0 0 0 0 0 0 0  
##   
## $C4\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 9.598623e-01 0 0 0 0 0 0 0  
## [2,] 0.000000e+00 1 0 0 0 0 0 0  
## [3,] 3.859162e-03 0 0 0 0 0 0 0  
## [4,] 3.611908e-02 0 0 0 0 0 0 0  
## [5,] 3.986229e-05 0 0 0 0 0 0 0  
## [6,] 3.986229e-05 0 0 0 0 0 0 0  
## [7,] 3.986229e-05 0 0 0 0 0 0 0  
## [8,] 3.986229e-05 0 0 0 0 0 0 0  
##   
## $C4\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.861567654 0 0 0 0 0 0 0  
## [2,] 0.000000000 1 0 0 0 0 0 0  
## [3,] 0.020764644 0 0 0 0 0 0 0  
## [4,] 0.096015382 0 0 0 0 0 0 0  
## [5,] 0.007092284 0 0 0 0 0 0 0  
## [6,] 0.005531207 0 0 0 0 0 0 0  
## [7,] 0.004589409 0 0 0 0 0 0 0  
## [8,] 0.004439419 0 0 0 0 0 0 0  
##   
## $O3\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 9.978319e-01 0 0 0 0 0 0 0  
## [2,] 0.000000e+00 1 0 0 0 0 0 0  
## [3,] 4.509381e-04 0 0 0 0 0 0 0  
## [4,] 8.257658e-04 0 0 0 0 0 0 0  
## [5,] 5.284277e-04 0 0 0 0 0 0 0  
## [6,] 3.362763e-04 0 0 0 0 0 0 0  
## [7,] 2.207320e-05 0 0 0 0 0 0 0  
## [8,] 4.648702e-06 0 0 0 0 0 0 0  
##   
## $O3\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 9.976168e-01 0 0 0 0 0 0 0  
## [2,] 0.000000e+00 1 0 0 0 0 0 0  
## [3,] 4.898196e-04 0 0 0 0 0 0 0  
## [4,] 8.572739e-04 0 0 0 0 0 0 0  
## [5,] 5.657848e-04 0 0 0 0 0 0 0  
## [6,] 3.774133e-04 0 0 0 0 0 0 0  
## [7,] 6.939092e-05 0 0 0 0 0 0 0  
## [8,] 2.355477e-05 0 0 0 0 0 0 0  
##   
## $O4\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 9.995119e-01 0 0 0 0 0 0 0  
## [2,] 0.000000e+00 1 0 0 0 0 0 0  
## [3,] 6.735345e-05 0 0 0 0 0 0 0  
## [4,] 1.903155e-04 0 0 0 0 0 0 0  
## [5,] 1.287491e-04 0 0 0 0 0 0 0  
## [6,] 7.381002e-05 0 0 0 0 0 0 0  
## [7,] 2.543258e-05 0 0 0 0 0 0 0  
## [8,] 2.452158e-06 0 0 0 0 0 0 0  
##   
## $O4\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 9.995059e-01 0 0 0 0 0 0 0  
## [2,] 0.000000e+00 1 0 0 0 0 0 0  
## [3,] 7.075696e-05 0 0 0 0 0 0 0  
## [4,] 1.725836e-04 0 0 0 0 0 0 0  
## [5,] 1.215996e-04 0 0 0 0 0 0 0  
## [6,] 7.610374e-05 0 0 0 0 0 0 0  
## [7,] 3.604169e-05 0 0 0 0 0 0 0  
## [8,] 1.701127e-05 0 0 0 0 0 0 0  
##   
## $S2\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.9636892958 0 0 0 0 0 0 0  
## [2,] 0.0000000000 1 0 0 0 0 0 0  
## [3,] 0.0256346500 0 0 0 0 0 0 0  
## [4,] 0.0074585120 0 0 0 0 0 0 0  
## [5,] 0.0017978639 0 0 0 0 0 0 0  
## [6,] 0.0006437593 0 0 0 0 0 0 0  
## [7,] 0.0003290198 0 0 0 0 0 0 0  
## [8,] 0.0004468993 0 0 0 0 0 0 0  
##   
## $S2\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 9.858491e-01 0 0 0 0 0 0 0  
## [2,] 0.000000e+00 1 0 0 0 0 0 0  
## [3,] 1.056267e-02 0 0 0 0 0 0 0  
## [4,] 2.936093e-03 0 0 0 0 0 0 0  
## [5,] 5.609254e-04 0 0 0 0 0 0 0  
## [6,] 7.667130e-05 0 0 0 0 0 0 0  
## [7,] 7.246669e-06 0 0 0 0 0 0 0  
## [8,] 7.246669e-06 0 0 0 0 0 0 0  
##   
## $S3\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.9727215691 0 0 0 0 0 0 0  
## [2,] 0.0000000000 1 0 0 0 0 0 0  
## [3,] 0.0203403364 0 0 0 0 0 0 0  
## [4,] 0.0052228133 0 0 0 0 0 0 0  
## [5,] 0.0010262873 0 0 0 0 0 0 0  
## [6,] 0.0001048918 0 0 0 0 0 0 0  
## [7,] 0.0001942491 0 0 0 0 0 0 0  
## [8,] 0.0003898529 0 0 0 0 0 0 0  
##   
## $S3\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 9.847348e-01 0 0 0 0 0 0 0  
## [2,] 0.000000e+00 1 0 0 0 0 0 0  
## [3,] 1.160090e-02 0 0 0 0 0 0 0  
## [4,] 2.927560e-03 0 0 0 0 0 0 0  
## [5,] 5.198975e-04 0 0 0 0 0 0 0  
## [6,] 1.956019e-05 0 0 0 0 0 0 0  
## [7,] 4.253419e-05 0 0 0 0 0 0 0  
## [8,] 1.547575e-04 0 0 0 0 0 0 0  
##   
## $S4\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 9.992737e-01 0 0 0 0 0 0 0  
## [2,] 0.000000e+00 1 0 0 0 0 0 0  
## [3,] 5.229028e-04 0 0 0 0 0 0 0  
## [4,] 1.493401e-04 0 0 0 0 0 0 0  
## [5,] 6.874469e-07 0 0 0 0 0 0 0  
## [6,] 1.777808e-05 0 0 0 0 0 0 0  
## [7,] 1.777808e-05 0 0 0 0 0 0 0  
## [8,] 1.777808e-05 0 0 0 0 0 0 0  
##   
## $S4\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 9.992550e-01 0 0 0 0 0 0 0  
## [2,] 0.000000e+00 1 0 0 0 0 0 0  
## [3,] 4.178959e-04 0 0 0 0 0 0 0  
## [4,] 1.637767e-04 0 0 0 0 0 0 0  
## [5,] 6.265453e-05 0 0 0 0 0 0 0  
## [6,] 3.089097e-05 0 0 0 0 0 0 0  
## [7,] 3.089097e-05 0 0 0 0 0 0 0  
## [8,] 3.884417e-05 0 0 0 0 0 0 0

#### In-season survival

The first two elements of the diagonal was adopted from a study that tracked waterhemp seed survival over time at different depths [sosnoskieGlyphosateResistanceDoes2013], and the last six elements calculated from 2019 census survey at our experiment site for cohort survivals. To account for the emergence-delaying effects offered by the cool-season crops, shorter in-season periods were assigned to populations grown in the presence of oat (5.5 months) and alfalfa (4.5 months); populations grown in the presence of corn and soybean were assigned 6 months of in-season.

## $A4\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7]  
## [1,] 0.7282864 0.0000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000  
## [2,] 0.0000000 0.7945236 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000  
## [3,] 0.0000000 0.0000000 0.08013973 0.00000000 0.00000000 0.00000000 0.00000000  
## [4,] 0.0000000 0.0000000 0.00000000 0.08013973 0.00000000 0.00000000 0.00000000  
## [5,] 0.0000000 0.0000000 0.00000000 0.00000000 0.08013973 0.00000000 0.00000000  
## [6,] 0.0000000 0.0000000 0.00000000 0.00000000 0.00000000 0.08013973 0.00000000  
## [7,] 0.0000000 0.0000000 0.00000000 0.00000000 0.00000000 0.00000000 0.08013973  
## [8,] 0.0000000 0.0000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000  
## [,8]  
## [1,] 0.00000000  
## [2,] 0.00000000  
## [3,] 0.00000000  
## [4,] 0.00000000  
## [5,] 0.00000000  
## [6,] 0.00000000  
## [7,] 0.00000000  
## [8,] 0.08013973  
##   
## $A4\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7]  
## [1,] 0.7282864 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
## [2,] 0.0000000 0.7945236 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
## [3,] 0.0000000 0.0000000 0.1314378 0.0000000 0.0000000 0.0000000 0.0000000  
## [4,] 0.0000000 0.0000000 0.0000000 0.1314378 0.0000000 0.0000000 0.0000000  
## [5,] 0.0000000 0.0000000 0.0000000 0.0000000 0.1314378 0.0000000 0.0000000  
## [6,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.1314378 0.0000000  
## [7,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.1314378  
## [8,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
## [,8]  
## [1,] 0.0000000  
## [2,] 0.0000000  
## [3,] 0.0000000  
## [4,] 0.0000000  
## [5,] 0.0000000  
## [6,] 0.0000000  
## [7,] 0.0000000  
## [8,] 0.1314378  
##   
## $C2\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7]  
## [1,] 0.6576641 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
## [2,] 0.0000000 0.7371141 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
## [3,] 0.0000000 0.0000000 0.0771456 0.0000000 0.0000000 0.0000000 0.0000000  
## [4,] 0.0000000 0.0000000 0.0000000 0.0771456 0.0000000 0.0000000 0.0000000  
## [5,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0771456 0.0000000 0.0000000  
## [6,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0771456 0.0000000  
## [7,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0771456  
## [8,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
## [,8]  
## [1,] 0.0000000  
## [2,] 0.0000000  
## [3,] 0.0000000  
## [4,] 0.0000000  
## [5,] 0.0000000  
## [6,] 0.0000000  
## [7,] 0.0000000  
## [8,] 0.0771456  
##   
## $C2\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7]  
## [1,] 0.6576641 0.0000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000  
## [2,] 0.0000000 0.7371141 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000  
## [3,] 0.0000000 0.0000000 0.01348412 0.00000000 0.00000000 0.00000000 0.00000000  
## [4,] 0.0000000 0.0000000 0.00000000 0.01348412 0.00000000 0.00000000 0.00000000  
## [5,] 0.0000000 0.0000000 0.00000000 0.00000000 0.01348412 0.00000000 0.00000000  
## [6,] 0.0000000 0.0000000 0.00000000 0.00000000 0.00000000 0.01348412 0.00000000  
## [7,] 0.0000000 0.0000000 0.00000000 0.00000000 0.00000000 0.00000000 0.01348412  
## [8,] 0.0000000 0.0000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000  
## [,8]  
## [1,] 0.00000000  
## [2,] 0.00000000  
## [3,] 0.00000000  
## [4,] 0.00000000  
## [5,] 0.00000000  
## [6,] 0.00000000  
## [7,] 0.00000000  
## [8,] 0.01348412  
##   
## $C3\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7]  
## [1,] 0.6576641 0.0000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000  
## [2,] 0.0000000 0.7371141 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000  
## [3,] 0.0000000 0.0000000 0.08507367 0.00000000 0.00000000 0.00000000 0.00000000  
## [4,] 0.0000000 0.0000000 0.00000000 0.08507367 0.00000000 0.00000000 0.00000000  
## [5,] 0.0000000 0.0000000 0.00000000 0.00000000 0.08507367 0.00000000 0.00000000  
## [6,] 0.0000000 0.0000000 0.00000000 0.00000000 0.00000000 0.08507367 0.00000000  
## [7,] 0.0000000 0.0000000 0.00000000 0.00000000 0.00000000 0.00000000 0.08507367  
## [8,] 0.0000000 0.0000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000  
## [,8]  
## [1,] 0.00000000  
## [2,] 0.00000000  
## [3,] 0.00000000  
## [4,] 0.00000000  
## [5,] 0.00000000  
## [6,] 0.00000000  
## [7,] 0.00000000  
## [8,] 0.08507367  
##   
## $C3\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7]  
## [1,] 0.6576641 0.0000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000  
## [2,] 0.0000000 0.7371141 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000  
## [3,] 0.0000000 0.0000000 0.02245207 0.00000000 0.00000000 0.00000000 0.00000000  
## [4,] 0.0000000 0.0000000 0.00000000 0.02245207 0.00000000 0.00000000 0.00000000  
## [5,] 0.0000000 0.0000000 0.00000000 0.00000000 0.02245207 0.00000000 0.00000000  
## [6,] 0.0000000 0.0000000 0.00000000 0.00000000 0.00000000 0.02245207 0.00000000  
## [7,] 0.0000000 0.0000000 0.00000000 0.00000000 0.00000000 0.00000000 0.02245207  
## [8,] 0.0000000 0.0000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000  
## [,8]  
## [1,] 0.00000000  
## [2,] 0.00000000  
## [3,] 0.00000000  
## [4,] 0.00000000  
## [5,] 0.00000000  
## [6,] 0.00000000  
## [7,] 0.00000000  
## [8,] 0.02245207  
##   
## $C4\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7]  
## [1,] 0.6576641 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
## [2,] 0.0000000 0.7371141 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
## [3,] 0.0000000 0.0000000 0.2079896 0.0000000 0.0000000 0.0000000 0.0000000  
## [4,] 0.0000000 0.0000000 0.0000000 0.2079896 0.0000000 0.0000000 0.0000000  
## [5,] 0.0000000 0.0000000 0.0000000 0.0000000 0.2079896 0.0000000 0.0000000  
## [6,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.2079896 0.0000000  
## [7,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.2079896  
## [8,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
## [,8]  
## [1,] 0.0000000  
## [2,] 0.0000000  
## [3,] 0.0000000  
## [4,] 0.0000000  
## [5,] 0.0000000  
## [6,] 0.0000000  
## [7,] 0.0000000  
## [8,] 0.2079896  
##   
## $C4\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7]  
## [1,] 0.6576641 0.0000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000  
## [2,] 0.0000000 0.7371141 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000  
## [3,] 0.0000000 0.0000000 0.03608227 0.00000000 0.00000000 0.00000000 0.00000000  
## [4,] 0.0000000 0.0000000 0.00000000 0.03608227 0.00000000 0.00000000 0.00000000  
## [5,] 0.0000000 0.0000000 0.00000000 0.00000000 0.03608227 0.00000000 0.00000000  
## [6,] 0.0000000 0.0000000 0.00000000 0.00000000 0.00000000 0.03608227 0.00000000  
## [7,] 0.0000000 0.0000000 0.00000000 0.00000000 0.00000000 0.00000000 0.03608227  
## [8,] 0.0000000 0.0000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000  
## [,8]  
## [1,] 0.00000000  
## [2,] 0.00000000  
## [3,] 0.00000000  
## [4,] 0.00000000  
## [5,] 0.00000000  
## [6,] 0.00000000  
## [7,] 0.00000000  
## [8,] 0.03608227  
##   
## $O3\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7]  
## [1,] 0.6804092 0.0000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000  
## [2,] 0.0000000 0.7557743 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000  
## [3,] 0.0000000 0.0000000 0.03484358 0.00000000 0.00000000 0.00000000 0.00000000  
## [4,] 0.0000000 0.0000000 0.00000000 0.03484358 0.00000000 0.00000000 0.00000000  
## [5,] 0.0000000 0.0000000 0.00000000 0.00000000 0.03484358 0.00000000 0.00000000  
## [6,] 0.0000000 0.0000000 0.00000000 0.00000000 0.00000000 0.03484358 0.00000000  
## [7,] 0.0000000 0.0000000 0.00000000 0.00000000 0.00000000 0.00000000 0.03484358  
## [8,] 0.0000000 0.0000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000  
## [,8]  
## [1,] 0.00000000  
## [2,] 0.00000000  
## [3,] 0.00000000  
## [4,] 0.00000000  
## [5,] 0.00000000  
## [6,] 0.00000000  
## [7,] 0.00000000  
## [8,] 0.03484358  
##   
## $O3\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7]  
## [1,] 0.6804092 0.0000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000  
## [2,] 0.0000000 0.7557743 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000  
## [3,] 0.0000000 0.0000000 0.04470131 0.00000000 0.00000000 0.00000000 0.00000000  
## [4,] 0.0000000 0.0000000 0.00000000 0.04470131 0.00000000 0.00000000 0.00000000  
## [5,] 0.0000000 0.0000000 0.00000000 0.00000000 0.04470131 0.00000000 0.00000000  
## [6,] 0.0000000 0.0000000 0.00000000 0.00000000 0.00000000 0.04470131 0.00000000  
## [7,] 0.0000000 0.0000000 0.00000000 0.00000000 0.00000000 0.00000000 0.04470131  
## [8,] 0.0000000 0.0000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000  
## [,8]  
## [1,] 0.00000000  
## [2,] 0.00000000  
## [3,] 0.00000000  
## [4,] 0.00000000  
## [5,] 0.00000000  
## [6,] 0.00000000  
## [7,] 0.00000000  
## [8,] 0.04470131  
##   
## $O4\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7]  
## [1,] 0.6804092 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
## [2,] 0.0000000 0.7557743 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
## [3,] 0.0000000 0.0000000 0.1723087 0.0000000 0.0000000 0.0000000 0.0000000  
## [4,] 0.0000000 0.0000000 0.0000000 0.1723087 0.0000000 0.0000000 0.0000000  
## [5,] 0.0000000 0.0000000 0.0000000 0.0000000 0.1723087 0.0000000 0.0000000  
## [6,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.1723087 0.0000000  
## [7,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.1723087  
## [8,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
## [,8]  
## [1,] 0.0000000  
## [2,] 0.0000000  
## [3,] 0.0000000  
## [4,] 0.0000000  
## [5,] 0.0000000  
## [6,] 0.0000000  
## [7,] 0.0000000  
## [8,] 0.1723087  
##   
## $O4\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7]  
## [1,] 0.6804092 0.0000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000  
## [2,] 0.0000000 0.7557743 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000  
## [3,] 0.0000000 0.0000000 0.07808835 0.00000000 0.00000000 0.00000000 0.00000000  
## [4,] 0.0000000 0.0000000 0.00000000 0.07808835 0.00000000 0.00000000 0.00000000  
## [5,] 0.0000000 0.0000000 0.00000000 0.00000000 0.07808835 0.00000000 0.00000000  
## [6,] 0.0000000 0.0000000 0.00000000 0.00000000 0.00000000 0.07808835 0.00000000  
## [7,] 0.0000000 0.0000000 0.00000000 0.00000000 0.00000000 0.00000000 0.07808835  
## [8,] 0.0000000 0.0000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000  
## [,8]  
## [1,] 0.00000000  
## [2,] 0.00000000  
## [3,] 0.00000000  
## [4,] 0.00000000  
## [5,] 0.00000000  
## [6,] 0.00000000  
## [7,] 0.00000000  
## [8,] 0.07808835  
##   
## $S2\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6]  
## [1,] 0.6576641 0.0000000 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00  
## [2,] 0.0000000 0.7371141 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00  
## [3,] 0.0000000 0.0000000 4.424374e-09 0.000000e+00 0.000000e+00 0.000000e+00  
## [4,] 0.0000000 0.0000000 0.000000e+00 4.424374e-09 0.000000e+00 0.000000e+00  
## [5,] 0.0000000 0.0000000 0.000000e+00 0.000000e+00 4.424374e-09 0.000000e+00  
## [6,] 0.0000000 0.0000000 0.000000e+00 0.000000e+00 0.000000e+00 4.424374e-09  
## [7,] 0.0000000 0.0000000 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00  
## [8,] 0.0000000 0.0000000 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00  
## [,7] [,8]  
## [1,] 0.000000e+00 0.000000e+00  
## [2,] 0.000000e+00 0.000000e+00  
## [3,] 0.000000e+00 0.000000e+00  
## [4,] 0.000000e+00 0.000000e+00  
## [5,] 0.000000e+00 0.000000e+00  
## [6,] 0.000000e+00 0.000000e+00  
## [7,] 4.424374e-09 0.000000e+00  
## [8,] 0.000000e+00 4.424374e-09  
##   
## $S2\_low  
## [,1] [,2] [,3] [,4] [,5] [,6]  
## [1,] 0.6576641 0.0000000 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00  
## [2,] 0.0000000 0.7371141 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00  
## [3,] 0.0000000 0.0000000 6.363606e-09 0.000000e+00 0.000000e+00 0.000000e+00  
## [4,] 0.0000000 0.0000000 0.000000e+00 6.363606e-09 0.000000e+00 0.000000e+00  
## [5,] 0.0000000 0.0000000 0.000000e+00 0.000000e+00 6.363606e-09 0.000000e+00  
## [6,] 0.0000000 0.0000000 0.000000e+00 0.000000e+00 0.000000e+00 6.363606e-09  
## [7,] 0.0000000 0.0000000 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00  
## [8,] 0.0000000 0.0000000 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00  
## [,7] [,8]  
## [1,] 0.000000e+00 0.000000e+00  
## [2,] 0.000000e+00 0.000000e+00  
## [3,] 0.000000e+00 0.000000e+00  
## [4,] 0.000000e+00 0.000000e+00  
## [5,] 0.000000e+00 0.000000e+00  
## [6,] 0.000000e+00 0.000000e+00  
## [7,] 6.363606e-09 0.000000e+00  
## [8,] 0.000000e+00 6.363606e-09  
##   
## $S3\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6]  
## [1,] 0.6576641 0.0000000 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00  
## [2,] 0.0000000 0.7371141 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00  
## [3,] 0.0000000 0.0000000 2.306888e-08 0.000000e+00 0.000000e+00 0.000000e+00  
## [4,] 0.0000000 0.0000000 0.000000e+00 2.306888e-08 0.000000e+00 0.000000e+00  
## [5,] 0.0000000 0.0000000 0.000000e+00 0.000000e+00 2.306888e-08 0.000000e+00  
## [6,] 0.0000000 0.0000000 0.000000e+00 0.000000e+00 0.000000e+00 2.306888e-08  
## [7,] 0.0000000 0.0000000 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00  
## [8,] 0.0000000 0.0000000 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00  
## [,7] [,8]  
## [1,] 0.000000e+00 0.000000e+00  
## [2,] 0.000000e+00 0.000000e+00  
## [3,] 0.000000e+00 0.000000e+00  
## [4,] 0.000000e+00 0.000000e+00  
## [5,] 0.000000e+00 0.000000e+00  
## [6,] 0.000000e+00 0.000000e+00  
## [7,] 2.306888e-08 0.000000e+00  
## [8,] 0.000000e+00 2.306888e-08  
##   
## $S3\_low  
## [,1] [,2] [,3] [,4] [,5] [,6]  
## [1,] 0.6576641 0.0000000 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00  
## [2,] 0.0000000 0.7371141 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00  
## [3,] 0.0000000 0.0000000 1.967164e-08 0.000000e+00 0.000000e+00 0.000000e+00  
## [4,] 0.0000000 0.0000000 0.000000e+00 1.967164e-08 0.000000e+00 0.000000e+00  
## [5,] 0.0000000 0.0000000 0.000000e+00 0.000000e+00 1.967164e-08 0.000000e+00  
## [6,] 0.0000000 0.0000000 0.000000e+00 0.000000e+00 0.000000e+00 1.967164e-08  
## [7,] 0.0000000 0.0000000 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00  
## [8,] 0.0000000 0.0000000 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00  
## [,7] [,8]  
## [1,] 0.000000e+00 0.000000e+00  
## [2,] 0.000000e+00 0.000000e+00  
## [3,] 0.000000e+00 0.000000e+00  
## [4,] 0.000000e+00 0.000000e+00  
## [5,] 0.000000e+00 0.000000e+00  
## [6,] 0.000000e+00 0.000000e+00  
## [7,] 1.967164e-08 0.000000e+00  
## [8,] 0.000000e+00 1.967164e-08  
##   
## $S4\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6]  
## [1,] 0.6576641 0.0000000 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00  
## [2,] 0.0000000 0.7371141 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00  
## [3,] 0.0000000 0.0000000 2.473966e-08 0.000000e+00 0.000000e+00 0.000000e+00  
## [4,] 0.0000000 0.0000000 0.000000e+00 2.473966e-08 0.000000e+00 0.000000e+00  
## [5,] 0.0000000 0.0000000 0.000000e+00 0.000000e+00 2.473966e-08 0.000000e+00  
## [6,] 0.0000000 0.0000000 0.000000e+00 0.000000e+00 0.000000e+00 2.473966e-08  
## [7,] 0.0000000 0.0000000 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00  
## [8,] 0.0000000 0.0000000 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00  
## [,7] [,8]  
## [1,] 0.000000e+00 0.000000e+00  
## [2,] 0.000000e+00 0.000000e+00  
## [3,] 0.000000e+00 0.000000e+00  
## [4,] 0.000000e+00 0.000000e+00  
## [5,] 0.000000e+00 0.000000e+00  
## [6,] 0.000000e+00 0.000000e+00  
## [7,] 2.473966e-08 0.000000e+00  
## [8,] 0.000000e+00 2.473966e-08  
##   
## $S4\_low  
## [,1] [,2] [,3] [,4] [,5] [,6]  
## [1,] 0.6576641 0.0000000 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00  
## [2,] 0.0000000 0.7371141 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00  
## [3,] 0.0000000 0.0000000 1.528734e-08 0.000000e+00 0.000000e+00 0.000000e+00  
## [4,] 0.0000000 0.0000000 0.000000e+00 1.528734e-08 0.000000e+00 0.000000e+00  
## [5,] 0.0000000 0.0000000 0.000000e+00 0.000000e+00 1.528734e-08 0.000000e+00  
## [6,] 0.0000000 0.0000000 0.000000e+00 0.000000e+00 0.000000e+00 1.528734e-08  
## [7,] 0.0000000 0.0000000 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00  
## [8,] 0.0000000 0.0000000 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00  
## [,7] [,8]  
## [1,] 0.000000e+00 0.000000e+00  
## [2,] 0.000000e+00 0.000000e+00  
## [3,] 0.000000e+00 0.000000e+00  
## [4,] 0.000000e+00 0.000000e+00  
## [5,] 0.000000e+00 0.000000e+00  
## [6,] 0.000000e+00 0.000000e+00  
## [7,] 1.528734e-08 0.000000e+00  
## [8,] 0.000000e+00 1.528734e-08

#### Fecundity

Individual fecundity (Nguyen and Liebman 2022) was summarized to cohort-averaged fecundity by partitioning plant size and fecundity into six size-based group.

## $A4\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 1 0 460.3333 14.66667 1 13.25 1.25 4.25  
## [2,] 0 1 0.0000 0.00000 0 0.00 0.00 0.00  
## [3,] 0 0 0.0000 0.00000 0 0.00 0.00 0.00  
## [4,] 0 0 0.0000 0.00000 0 0.00 0.00 0.00  
## [5,] 0 0 0.0000 0.00000 0 0.00 0.00 0.00  
## [6,] 0 0 0.0000 0.00000 0 0.00 0.00 0.00  
## [7,] 0 0 0.0000 0.00000 0 0.00 0.00 0.00  
## [8,] 0 0 0.0000 0.00000 0 0.00 0.00 0.00  
##   
## $A4\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 1 0 10.66667 8.25 9.25 2.5 0.5 1.25  
## [2,] 0 1 0.00000 0.00 0.00 0.0 0.0 0.00  
## [3,] 0 0 0.00000 0.00 0.00 0.0 0.0 0.00  
## [4,] 0 0 0.00000 0.00 0.00 0.0 0.0 0.00  
## [5,] 0 0 0.00000 0.00 0.00 0.0 0.0 0.00  
## [6,] 0 0 0.00000 0.00 0.00 0.0 0.0 0.00  
## [7,] 0 0 0.00000 0.00 0.00 0.0 0.0 0.00  
## [8,] 0 0 0.00000 0.00 0.00 0.0 0.0 0.00  
##   
## $C2\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 1 0 36077.33 15592.33 6958.8 6298.6 2192.133 272  
## [2,] 0 1 0.00 0.00 0.0 0.0 0.000 0  
## [3,] 0 0 0.00 0.00 0.0 0.0 0.000 0  
## [4,] 0 0 0.00 0.00 0.0 0.0 0.000 0  
## [5,] 0 0 0.00 0.00 0.0 0.0 0.000 0  
## [6,] 0 0 0.00 0.00 0.0 0.0 0.000 0  
## [7,] 0 0 0.00 0.00 0.0 0.0 0.000 0  
## [8,] 0 0 0.00 0.00 0.0 0.0 0.000 0  
##   
## $C2\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 1 0 84140.39 3127.222 897.6667 506.3333 224.1667 34.83333  
## [2,] 0 1 0.00 0.000 0.0000 0.0000 0.0000 0.00000  
## [3,] 0 0 0.00 0.000 0.0000 0.0000 0.0000 0.00000  
## [4,] 0 0 0.00 0.000 0.0000 0.0000 0.0000 0.00000  
## [5,] 0 0 0.00 0.000 0.0000 0.0000 0.0000 0.00000  
## [6,] 0 0 0.00 0.000 0.0000 0.0000 0.0000 0.00000  
## [7,] 0 0 0.00 0.000 0.0000 0.0000 0.0000 0.00000  
## [8,] 0 0 0.00 0.000 0.0000 0.0000 0.0000 0.00000  
##   
## $C3\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 1 0 21662.67 7965.778 3138.778 166.3333 271.3333 75.25  
## [2,] 0 1 0.00 0.000 0.000 0.0000 0.0000 0.00  
## [3,] 0 0 0.00 0.000 0.000 0.0000 0.0000 0.00  
## [4,] 0 0 0.00 0.000 0.000 0.0000 0.0000 0.00  
## [5,] 0 0 0.00 0.000 0.000 0.0000 0.0000 0.00  
## [6,] 0 0 0.00 0.000 0.000 0.0000 0.0000 0.00  
## [7,] 0 0 0.00 0.000 0.000 0.0000 0.0000 0.00  
## [8,] 0 0 0.00 0.000 0.000 0.0000 0.0000 0.00  
##   
## $C3\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 1 0 292.3333 517.3333 207.25 144 35.5 51.25  
## [2,] 0 1 0.0000 0.0000 0.00 0 0.0 0.00  
## [3,] 0 0 0.0000 0.0000 0.00 0 0.0 0.00  
## [4,] 0 0 0.0000 0.0000 0.00 0 0.0 0.00  
## [5,] 0 0 0.0000 0.0000 0.00 0 0.0 0.00  
## [6,] 0 0 0.0000 0.0000 0.00 0 0.0 0.00  
## [7,] 0 0 0.0000 0.0000 0.00 0 0.0 0.00  
## [8,] 0 0 0.0000 0.0000 0.00 0 0.0 0.00  
##   
## $C4\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 1 0 93672.33 7124 18026.33 722 500.6667 272.6667  
## [2,] 0 1 0.00 0 0.00 0 0.0000 0.0000  
## [3,] 0 0 0.00 0 0.00 0 0.0000 0.0000  
## [4,] 0 0 0.00 0 0.00 0 0.0000 0.0000  
## [5,] 0 0 0.00 0 0.00 0 0.0000 0.0000  
## [6,] 0 0 0.00 0 0.00 0 0.0000 0.0000  
## [7,] 0 0 0.00 0 0.00 0 0.0000 0.0000  
## [8,] 0 0 0.00 0 0.00 0 0.0000 0.0000  
##   
## $C4\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 1 0 6139.556 2349 830.5 164.75 52.25 18.75  
## [2,] 0 1 0.000 0 0.0 0.00 0.00 0.00  
## [3,] 0 0 0.000 0 0.0 0.00 0.00 0.00  
## [4,] 0 0 0.000 0 0.0 0.00 0.00 0.00  
## [5,] 0 0 0.000 0 0.0 0.00 0.00 0.00  
## [6,] 0 0 0.000 0 0.0 0.00 0.00 0.00  
## [7,] 0 0 0.000 0 0.0 0.00 0.00 0.00  
## [8,] 0 0 0.000 0 0.0 0.00 0.00 0.00  
##   
## $O3\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 1 0 3353.667 849.25 424.75 218 123.25 79.6  
## [2,] 0 1 0.000 0.00 0.00 0 0.00 0.0  
## [3,] 0 0 0.000 0.00 0.00 0 0.00 0.0  
## [4,] 0 0 0.000 0.00 0.00 0 0.00 0.0  
## [5,] 0 0 0.000 0.00 0.00 0 0.00 0.0  
## [6,] 0 0 0.000 0.00 0.00 0 0.00 0.0  
## [7,] 0 0 0.000 0.00 0.00 0 0.00 0.0  
## [8,] 0 0 0.000 0.00 0.00 0 0.00 0.0  
##   
## $O3\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 1 0 658 236.6 307.8 205.6 161.2 105  
## [2,] 0 1 0 0.0 0.0 0.0 0.0 0  
## [3,] 0 0 0 0.0 0.0 0.0 0.0 0  
## [4,] 0 0 0 0.0 0.0 0.0 0.0 0  
## [5,] 0 0 0 0.0 0.0 0.0 0.0 0  
## [6,] 0 0 0 0.0 0.0 0.0 0.0 0  
## [7,] 0 0 0 0.0 0.0 0.0 0.0 0  
## [8,] 0 0 0 0.0 0.0 0.0 0.0 0  
##   
## $O4\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 1 0 3696.556 1021 267 227 363 65.25  
## [2,] 0 1 0.000 0 0 0 0 0.00  
## [3,] 0 0 0.000 0 0 0 0 0.00  
## [4,] 0 0 0.000 0 0 0 0 0.00  
## [5,] 0 0 0.000 0 0 0 0 0.00  
## [6,] 0 0 0.000 0 0 0 0 0.00  
## [7,] 0 0 0.000 0 0 0 0 0.00  
## [8,] 0 0 0.000 0 0 0 0 0.00  
##   
## $O4\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 1 0 3361.556 2109.444 891.5 722.5 432.25 154.75  
## [2,] 0 1 0.000 0.000 0.0 0.0 0.00 0.00  
## [3,] 0 0 0.000 0.000 0.0 0.0 0.00 0.00  
## [4,] 0 0 0.000 0.000 0.0 0.0 0.00 0.00  
## [5,] 0 0 0.000 0.000 0.0 0.0 0.00 0.00  
## [6,] 0 0 0.000 0.000 0.0 0.0 0.00 0.00  
## [7,] 0 0 0.000 0.000 0.0 0.0 0.00 0.00  
## [8,] 0 0 0.000 0.000 0.0 0.0 0.00 0.00  
##   
## $S2\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 1 0 47226.33 36547 24963.5 18982.89 6499.889 1756.222  
## [2,] 0 1 0.00 0 0.0 0.00 0.000 0.000  
## [3,] 0 0 0.00 0 0.0 0.00 0.000 0.000  
## [4,] 0 0 0.00 0 0.0 0.00 0.000 0.000  
## [5,] 0 0 0.00 0 0.0 0.00 0.000 0.000  
## [6,] 0 0 0.00 0 0.0 0.00 0.000 0.000  
## [7,] 0 0 0.00 0 0.0 0.00 0.000 0.000  
## [8,] 0 0 0.00 0 0.0 0.00 0.000 0.000  
##   
## $S2\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 1 0 54736.67 78894 55179.33 21709.5 5373.667 1397.667  
## [2,] 0 1 0.00 0 0.00 0.0 0.000 0.000  
## [3,] 0 0 0.00 0 0.00 0.0 0.000 0.000  
## [4,] 0 0 0.00 0 0.00 0.0 0.000 0.000  
## [5,] 0 0 0.00 0 0.00 0.0 0.000 0.000  
## [6,] 0 0 0.00 0 0.00 0.0 0.000 0.000  
## [7,] 0 0 0.00 0 0.00 0.0 0.000 0.000  
## [8,] 0 0 0.00 0 0.00 0.0 0.000 0.000  
##   
## $S3\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 1 0 1249255 702469.2 251112.9 62278.67 52229.92 63615.4  
## [2,] 0 1 0 0.0 0.0 0.00 0.00 0.0  
## [3,] 0 0 0 0.0 0.0 0.00 0.00 0.0  
## [4,] 0 0 0 0.0 0.0 0.00 0.00 0.0  
## [5,] 0 0 0 0.0 0.0 0.00 0.00 0.0  
## [6,] 0 0 0 0.0 0.0 0.00 0.00 0.0  
## [7,] 0 0 0 0.0 0.0 0.00 0.00 0.0  
## [8,] 0 0 0 0.0 0.0 0.00 0.00 0.0  
##   
## $S3\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 1 0 682268.7 163529.3 111944.6 31397.89 27976.67 5621.889  
## [2,] 0 1 0.0 0.0 0.0 0.00 0.00 0.000  
## [3,] 0 0 0.0 0.0 0.0 0.00 0.00 0.000  
## [4,] 0 0 0.0 0.0 0.0 0.00 0.00 0.000  
## [5,] 0 0 0.0 0.0 0.0 0.00 0.00 0.000  
## [6,] 0 0 0.0 0.0 0.0 0.00 0.00 0.000  
## [7,] 0 0 0.0 0.0 0.0 0.00 0.00 0.000  
## [8,] 0 0 0.0 0.0 0.0 0.00 0.00 0.000  
##   
## $S4\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 1 0 287288.8 101940.4 38300.5 7487.5 5401.833 18928.92  
## [2,] 0 1 0.0 0.0 0.0 0.0 0.000 0.00  
## [3,] 0 0 0.0 0.0 0.0 0.0 0.000 0.00  
## [4,] 0 0 0.0 0.0 0.0 0.0 0.000 0.00  
## [5,] 0 0 0.0 0.0 0.0 0.0 0.000 0.00  
## [6,] 0 0 0.0 0.0 0.0 0.0 0.000 0.00  
## [7,] 0 0 0.0 0.0 0.0 0.0 0.000 0.00  
## [8,] 0 0 0.0 0.0 0.0 0.0 0.000 0.00  
##   
## $S4\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 1 0 41160 14720 25259 18228 6427.833 4673.556  
## [2,] 0 1 0 0 0 0 0.000 0.000  
## [3,] 0 0 0 0 0 0 0.000 0.000  
## [4,] 0 0 0 0 0 0 0.000 0.000  
## [5,] 0 0 0 0 0 0 0.000 0.000  
## [6,] 0 0 0 0 0 0 0.000 0.000  
## [7,] 0 0 0 0 0 0 0.000 0.000  
## [8,] 0 0 0 0 0 0 0.000 0.000

#### Post-harvest tillage

At our experiment site, chisel tillage followed corn (C2, C3, and C4); moldboard followed oat in the 3-year rotation (O3) and alfalfa (A4); and no till followed oat in the 4-year rotation (O4) and soybean (S2, S3, and S4). The top left 2x2 section of each matrix was resized from a relevant 18x18 matrix in the Seed Chaser program (Spokas et al. 2007).

## $A4\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.016875 0.07770833 0 0 0 0 0 0  
## [2,] 0.976875 0.89250000 0 0 0 0 0 0  
## [3,] 0.000000 0.00000000 0 0 0 0 0 0  
## [4,] 0.000000 0.00000000 0 0 0 0 0 0  
## [5,] 0.000000 0.00000000 0 0 0 0 0 0  
## [6,] 0.000000 0.00000000 0 0 0 0 0 0  
## [7,] 0.000000 0.00000000 0 0 0 0 0 0  
## [8,] 0.000000 0.00000000 0 0 0 0 0 0  
##   
## $A4\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.016875 0.07770833 0 0 0 0 0 0  
## [2,] 0.976875 0.89250000 0 0 0 0 0 0  
## [3,] 0.000000 0.00000000 0 0 0 0 0 0  
## [4,] 0.000000 0.00000000 0 0 0 0 0 0  
## [5,] 0.000000 0.00000000 0 0 0 0 0 0  
## [6,] 0.000000 0.00000000 0 0 0 0 0 0  
## [7,] 0.000000 0.00000000 0 0 0 0 0 0  
## [8,] 0.000000 0.00000000 0 0 0 0 0 0  
##   
## $C2\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.5916667 0.073125 0 0 0 0 0 0  
## [2,] 0.4047917 0.913750 0 0 0 0 0 0  
## [3,] 0.0000000 0.000000 0 0 0 0 0 0  
## [4,] 0.0000000 0.000000 0 0 0 0 0 0  
## [5,] 0.0000000 0.000000 0 0 0 0 0 0  
## [6,] 0.0000000 0.000000 0 0 0 0 0 0  
## [7,] 0.0000000 0.000000 0 0 0 0 0 0  
## [8,] 0.0000000 0.000000 0 0 0 0 0 0  
##   
## $C2\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.5916667 0.073125 0 0 0 0 0 0  
## [2,] 0.4047917 0.913750 0 0 0 0 0 0  
## [3,] 0.0000000 0.000000 0 0 0 0 0 0  
## [4,] 0.0000000 0.000000 0 0 0 0 0 0  
## [5,] 0.0000000 0.000000 0 0 0 0 0 0  
## [6,] 0.0000000 0.000000 0 0 0 0 0 0  
## [7,] 0.0000000 0.000000 0 0 0 0 0 0  
## [8,] 0.0000000 0.000000 0 0 0 0 0 0  
##   
## $C3\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.5916667 0.073125 0 0 0 0 0 0  
## [2,] 0.4047917 0.913750 0 0 0 0 0 0  
## [3,] 0.0000000 0.000000 0 0 0 0 0 0  
## [4,] 0.0000000 0.000000 0 0 0 0 0 0  
## [5,] 0.0000000 0.000000 0 0 0 0 0 0  
## [6,] 0.0000000 0.000000 0 0 0 0 0 0  
## [7,] 0.0000000 0.000000 0 0 0 0 0 0  
## [8,] 0.0000000 0.000000 0 0 0 0 0 0  
##   
## $C3\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.5916667 0.073125 0 0 0 0 0 0  
## [2,] 0.4047917 0.913750 0 0 0 0 0 0  
## [3,] 0.0000000 0.000000 0 0 0 0 0 0  
## [4,] 0.0000000 0.000000 0 0 0 0 0 0  
## [5,] 0.0000000 0.000000 0 0 0 0 0 0  
## [6,] 0.0000000 0.000000 0 0 0 0 0 0  
## [7,] 0.0000000 0.000000 0 0 0 0 0 0  
## [8,] 0.0000000 0.000000 0 0 0 0 0 0  
##   
## $C4\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.5916667 0.073125 0 0 0 0 0 0  
## [2,] 0.4047917 0.913750 0 0 0 0 0 0  
## [3,] 0.0000000 0.000000 0 0 0 0 0 0  
## [4,] 0.0000000 0.000000 0 0 0 0 0 0  
## [5,] 0.0000000 0.000000 0 0 0 0 0 0  
## [6,] 0.0000000 0.000000 0 0 0 0 0 0  
## [7,] 0.0000000 0.000000 0 0 0 0 0 0  
## [8,] 0.0000000 0.000000 0 0 0 0 0 0  
##   
## $C4\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.5916667 0.073125 0 0 0 0 0 0  
## [2,] 0.4047917 0.913750 0 0 0 0 0 0  
## [3,] 0.0000000 0.000000 0 0 0 0 0 0  
## [4,] 0.0000000 0.000000 0 0 0 0 0 0  
## [5,] 0.0000000 0.000000 0 0 0 0 0 0  
## [6,] 0.0000000 0.000000 0 0 0 0 0 0  
## [7,] 0.0000000 0.000000 0 0 0 0 0 0  
## [8,] 0.0000000 0.000000 0 0 0 0 0 0  
##   
## $O3\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.016875 0.07770833 0 0 0 0 0 0  
## [2,] 0.976875 0.89250000 0 0 0 0 0 0  
## [3,] 0.000000 0.00000000 0 0 0 0 0 0  
## [4,] 0.000000 0.00000000 0 0 0 0 0 0  
## [5,] 0.000000 0.00000000 0 0 0 0 0 0  
## [6,] 0.000000 0.00000000 0 0 0 0 0 0  
## [7,] 0.000000 0.00000000 0 0 0 0 0 0  
## [8,] 0.000000 0.00000000 0 0 0 0 0 0  
##   
## $O3\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.016875 0.07770833 0 0 0 0 0 0  
## [2,] 0.976875 0.89250000 0 0 0 0 0 0  
## [3,] 0.000000 0.00000000 0 0 0 0 0 0  
## [4,] 0.000000 0.00000000 0 0 0 0 0 0  
## [5,] 0.000000 0.00000000 0 0 0 0 0 0  
## [6,] 0.000000 0.00000000 0 0 0 0 0 0  
## [7,] 0.000000 0.00000000 0 0 0 0 0 0  
## [8,] 0.000000 0.00000000 0 0 0 0 0 0  
##   
## $O4\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 1 0 0 0 0 0 0 0  
## [2,] 0 1 0 0 0 0 0 0  
## [3,] 0 0 0 0 0 0 0 0  
## [4,] 0 0 0 0 0 0 0 0  
## [5,] 0 0 0 0 0 0 0 0  
## [6,] 0 0 0 0 0 0 0 0  
## [7,] 0 0 0 0 0 0 0 0  
## [8,] 0 0 0 0 0 0 0 0  
##   
## $O4\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 1 0 0 0 0 0 0 0  
## [2,] 0 1 0 0 0 0 0 0  
## [3,] 0 0 0 0 0 0 0 0  
## [4,] 0 0 0 0 0 0 0 0  
## [5,] 0 0 0 0 0 0 0 0  
## [6,] 0 0 0 0 0 0 0 0  
## [7,] 0 0 0 0 0 0 0 0  
## [8,] 0 0 0 0 0 0 0 0  
##   
## $S2\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 1 0 0 0 0 0 0 0  
## [2,] 0 1 0 0 0 0 0 0  
## [3,] 0 0 0 0 0 0 0 0  
## [4,] 0 0 0 0 0 0 0 0  
## [5,] 0 0 0 0 0 0 0 0  
## [6,] 0 0 0 0 0 0 0 0  
## [7,] 0 0 0 0 0 0 0 0  
## [8,] 0 0 0 0 0 0 0 0  
##   
## $S2\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 1 0 0 0 0 0 0 0  
## [2,] 0 1 0 0 0 0 0 0  
## [3,] 0 0 0 0 0 0 0 0  
## [4,] 0 0 0 0 0 0 0 0  
## [5,] 0 0 0 0 0 0 0 0  
## [6,] 0 0 0 0 0 0 0 0  
## [7,] 0 0 0 0 0 0 0 0  
## [8,] 0 0 0 0 0 0 0 0  
##   
## $S3\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 1 0 0 0 0 0 0 0  
## [2,] 0 1 0 0 0 0 0 0  
## [3,] 0 0 0 0 0 0 0 0  
## [4,] 0 0 0 0 0 0 0 0  
## [5,] 0 0 0 0 0 0 0 0  
## [6,] 0 0 0 0 0 0 0 0  
## [7,] 0 0 0 0 0 0 0 0  
## [8,] 0 0 0 0 0 0 0 0  
##   
## $S3\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 1 0 0 0 0 0 0 0  
## [2,] 0 1 0 0 0 0 0 0  
## [3,] 0 0 0 0 0 0 0 0  
## [4,] 0 0 0 0 0 0 0 0  
## [5,] 0 0 0 0 0 0 0 0  
## [6,] 0 0 0 0 0 0 0 0  
## [7,] 0 0 0 0 0 0 0 0  
## [8,] 0 0 0 0 0 0 0 0  
##   
## $S4\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 1 0 0 0 0 0 0 0  
## [2,] 0 1 0 0 0 0 0 0  
## [3,] 0 0 0 0 0 0 0 0  
## [4,] 0 0 0 0 0 0 0 0  
## [5,] 0 0 0 0 0 0 0 0  
## [6,] 0 0 0 0 0 0 0 0  
## [7,] 0 0 0 0 0 0 0 0  
## [8,] 0 0 0 0 0 0 0 0  
##   
## $S4\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 1 0 0 0 0 0 0 0  
## [2,] 0 1 0 0 0 0 0 0  
## [3,] 0 0 0 0 0 0 0 0  
## [4,] 0 0 0 0 0 0 0 0  
## [5,] 0 0 0 0 0 0 0 0  
## [6,] 0 0 0 0 0 0 0 0  
## [7,] 0 0 0 0 0 0 0 0  
## [8,] 0 0 0 0 0 0 0 0

#### Off-season survival

The first two elements of the diagonal was also adopted from a study that tracked waterhemp seed survival over time at different depths [sosnoskieGlyphosateResistanceDoes2013]. To account for the emergence-delaying effects offered by the cool-season crops, longer off-season periods were assigned to populations grown in the presence of oat (6.5 months) and alfalfa (7.5 months); populations grown in the presence of corn and soybean were assigned 6 months of off-season.

## $A4\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.5938901 0.0000000 0 0 0 0 0 0  
## [2,] 0.0000000 0.6838528 0 0 0 0 0 0  
## [3,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [4,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [5,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [6,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [7,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [8,] 0.0000000 0.0000000 0 0 0 0 0 0  
##   
## $A4\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.5938901 0.0000000 0 0 0 0 0 0  
## [2,] 0.0000000 0.6838528 0 0 0 0 0 0  
## [3,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [4,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [5,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [6,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [7,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [8,] 0.0000000 0.0000000 0 0 0 0 0 0  
##   
## $C2\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.6576641 0.0000000 0 0 0 0 0 0  
## [2,] 0.0000000 0.7371141 0 0 0 0 0 0  
## [3,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [4,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [5,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [6,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [7,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [8,] 0.0000000 0.0000000 0 0 0 0 0 0  
##   
## $C2\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.6576641 0.0000000 0 0 0 0 0 0  
## [2,] 0.0000000 0.7371141 0 0 0 0 0 0  
## [3,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [4,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [5,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [6,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [7,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [8,] 0.0000000 0.0000000 0 0 0 0 0 0  
##   
## $C3\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.6576641 0.0000000 0 0 0 0 0 0  
## [2,] 0.0000000 0.7371141 0 0 0 0 0 0  
## [3,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [4,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [5,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [6,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [7,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [8,] 0.0000000 0.0000000 0 0 0 0 0 0  
##   
## $C3\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.6576641 0.0000000 0 0 0 0 0 0  
## [2,] 0.0000000 0.7371141 0 0 0 0 0 0  
## [3,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [4,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [5,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [6,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [7,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [8,] 0.0000000 0.0000000 0 0 0 0 0 0  
##   
## $C4\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.6576641 0.0000000 0 0 0 0 0 0  
## [2,] 0.0000000 0.7371141 0 0 0 0 0 0  
## [3,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [4,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [5,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [6,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [7,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [8,] 0.0000000 0.0000000 0 0 0 0 0 0  
##   
## $C4\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.6576641 0.0000000 0 0 0 0 0 0  
## [2,] 0.0000000 0.7371141 0 0 0 0 0 0  
## [3,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [4,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [5,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [6,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [7,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [8,] 0.0000000 0.0000000 0 0 0 0 0 0  
##   
## $O3\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.6356794 0.0000000 0 0 0 0 0 0  
## [2,] 0.0000000 0.7189147 0 0 0 0 0 0  
## [3,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [4,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [5,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [6,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [7,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [8,] 0.0000000 0.0000000 0 0 0 0 0 0  
##   
## $O3\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.6356794 0.0000000 0 0 0 0 0 0  
## [2,] 0.0000000 0.7189147 0 0 0 0 0 0  
## [3,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [4,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [5,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [6,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [7,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [8,] 0.0000000 0.0000000 0 0 0 0 0 0  
##   
## $O4\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.6356794 0.0000000 0 0 0 0 0 0  
## [2,] 0.0000000 0.7189147 0 0 0 0 0 0  
## [3,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [4,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [5,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [6,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [7,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [8,] 0.0000000 0.0000000 0 0 0 0 0 0  
##   
## $O4\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.6356794 0.0000000 0 0 0 0 0 0  
## [2,] 0.0000000 0.7189147 0 0 0 0 0 0  
## [3,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [4,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [5,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [6,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [7,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [8,] 0.0000000 0.0000000 0 0 0 0 0 0  
##   
## $S2\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.6576641 0.0000000 0 0 0 0 0 0  
## [2,] 0.0000000 0.7371141 0 0 0 0 0 0  
## [3,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [4,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [5,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [6,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [7,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [8,] 0.0000000 0.0000000 0 0 0 0 0 0  
##   
## $S2\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.6576641 0.0000000 0 0 0 0 0 0  
## [2,] 0.0000000 0.7371141 0 0 0 0 0 0  
## [3,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [4,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [5,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [6,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [7,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [8,] 0.0000000 0.0000000 0 0 0 0 0 0  
##   
## $S3\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.6576641 0.0000000 0 0 0 0 0 0  
## [2,] 0.0000000 0.7371141 0 0 0 0 0 0  
## [3,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [4,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [5,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [6,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [7,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [8,] 0.0000000 0.0000000 0 0 0 0 0 0  
##   
## $S3\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.6576641 0.0000000 0 0 0 0 0 0  
## [2,] 0.0000000 0.7371141 0 0 0 0 0 0  
## [3,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [4,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [5,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [6,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [7,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [8,] 0.0000000 0.0000000 0 0 0 0 0 0  
##   
## $S4\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.6576641 0.0000000 0 0 0 0 0 0  
## [2,] 0.0000000 0.7371141 0 0 0 0 0 0  
## [3,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [4,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [5,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [6,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [7,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [8,] 0.0000000 0.0000000 0 0 0 0 0 0  
##   
## $S4\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.6576641 0.0000000 0 0 0 0 0 0  
## [2,] 0.0000000 0.7371141 0 0 0 0 0 0  
## [3,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [4,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [5,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [6,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [7,] 0.0000000 0.0000000 0 0 0 0 0 0  
## [8,] 0.0000000 0.0000000 0 0 0 0 0 0

Nguyen, Huong T. X., and Matt Liebman. 2022. “Impact of Cropping System Diversification on Vegetative and Reproductive Characteristics of Waterhemp (*A. Tuberculatus*).” *Frontiers in Agronomy* 4. <https://doi.org/10.3389/fagro.2022.811359>.

Spokas, K., F. Forcella, D. Archer, and D. Reicosky. 2007. “SeedChaser: Vertical Soil Tillage Distribution Model.” *Computers and Electronics in Agriculture* 57 (1): 62–73. <https://doi.org/dzh845>.