# 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. In scenario one, using the 2019 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.

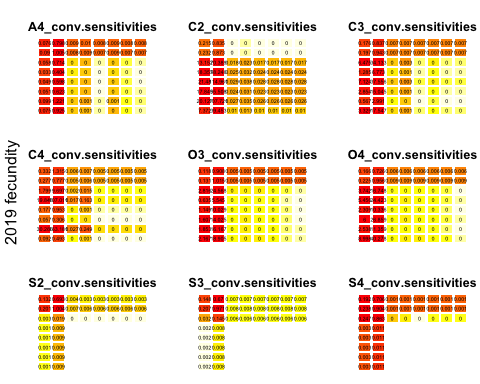


Figure 1: Sensitivities of eigen values to changes in each element of the population projection matrix. Each panel presents the sensitivities in each crop phase under or follow conventional weed management.

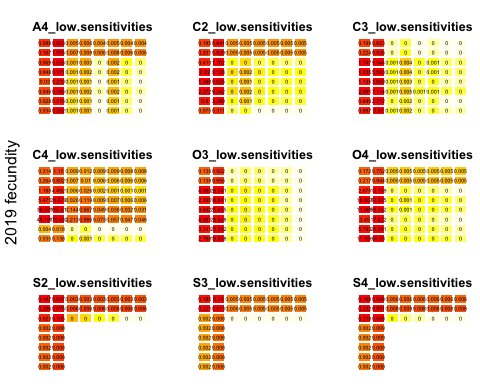


Figure 2: Sensitivities of eigen values to changes in each element of the population projection matrix. Each panel presents the sensitivities in each crop phase under or follow low herbicide weed management.

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 3 and 4). 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. Noticeably, waterhemp population proportional changes in the 2-year rotation (C2 and S2) were only influenced by the seedbank dynamics.

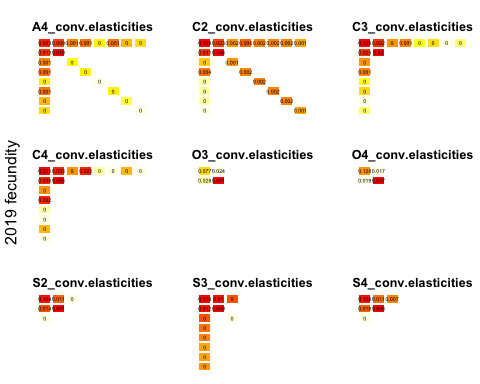


Figure 3: Elasticities of eigen values to changes in each element of the population projection matrix, using 2019 fecundity rate. Each panel presents the elasticities in each crop phase under or follow conventional weed management.

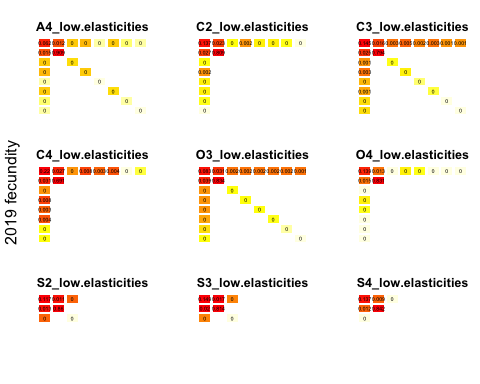
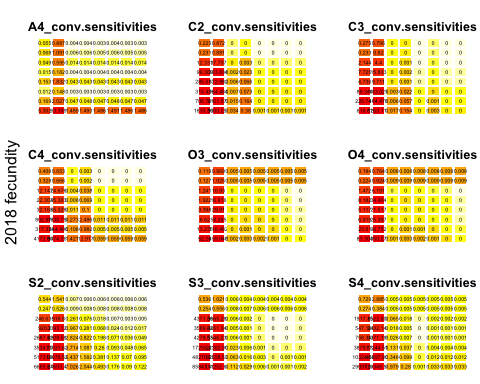


Figure 4: Elasticities of eigen values to changes in each element of the population projection matrix, using 2019 fecundity rate. Each panel presents the elasticities in each crop phase under or follow low herbicide weed management.

 In scenario two, the patterns in sensitivities and elasticities of waterhemp proportional population changes to proportional changes in projection matrices’ elements using 2018 fecundity rate were consistent with those in scenarios one ((Figures 7 and 8).

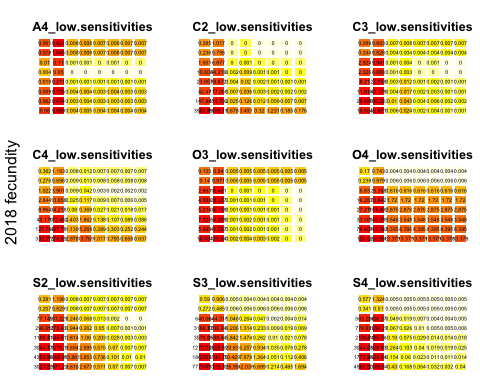


Figure 6: Sensitivities of eigen values to changes in each element of the population projection matrix, using 2018 fecundity rate. Each panel presents the sensitivities in each crop phase under or follow low herbicide weed management.

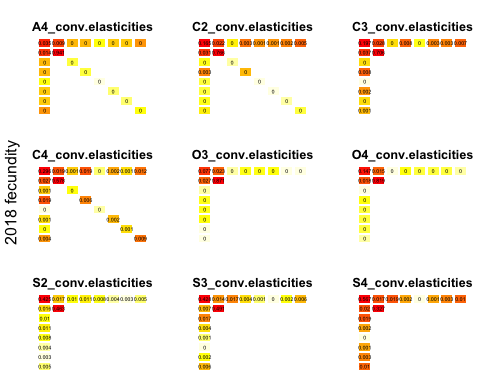


Figure 7: Elasticities of eigen values to changes in each element of the population projection matrix, using 2018 fecundity rate. Each panel presents the elasticities in each crop phase under or follow conventional weed management.

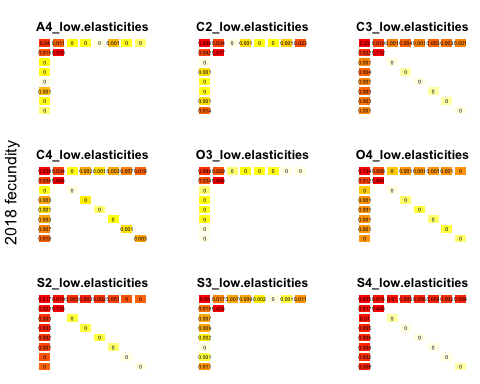
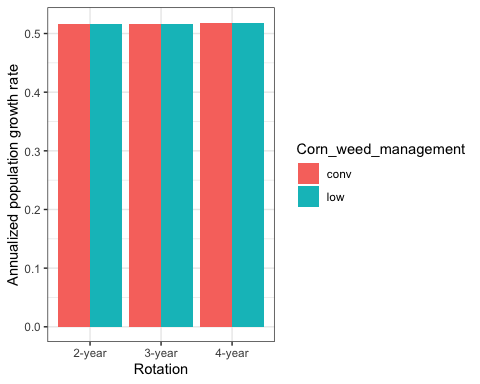


Figure 8: Elasticities of eigen values to changes in each element of the population projection matrix, using 2018 fecundity rate. Each panel presents the elasticities in each crop phase under or follow low herbicide weed management.

## 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). 

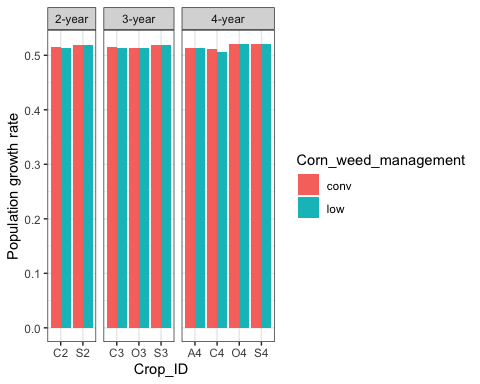


Figure 10: Waterhemp population growth rate in each crop phase using 2018 fecundity rate.

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

#### 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>.