Using 2019 fecundity rates, waterhemp populations in all crop identity is decreasing in all rotation, fastest in the 3-year rotation (Figures ??).

### conventional   
  
# pick all phases in the 2yr conventional treatment and arrange in backward order, i.e., first subannual matrix in the first crop phase at the right-most (or bottom) position of the list  
all\_periods\_2yr\_conv <- scenario1\_projection\_by\_matrix\_id\_transpose[c("S2\_conv", "C2\_conv")]  
#View(all\_periods\_2yr\_conv)  
  
# remove the phase bounded structure in a chain, making a chain of 12 subannual matrices for the 2-year rotation  
all\_periods\_2yr\_conv\_chain <- unlist(all\_periods\_2yr\_conv, recursive = FALSE)  
  
# make a reference grid, based on a chain starting at the spring\_tillage matrix  
ref\_2yr\_conv <- names(all\_periods\_2yr\_conv\_chain)  
  
# create circular rotation of the first subannual matrix in each chain  
circ\_2yr\_conv <- circ(ref\_2yr\_conv)

## Warning in matrix(1:n, n + 1, n + 1, byrow = T): data length [12] is not a sub-  
## multiple or multiple of the number of rows [13]

full\_circ\_2yr\_conv <- purrr::map(1:12,~all\_periods\_2yr\_conv\_chain[circ\_2yr\_conv[.x,]])  
# name the nested list by the last element in each nested list  
# the last element in each nested list appear in the same order as circ\_2yr\_conv[,12]  
  
names(full\_circ\_2yr\_conv) <- paste0(circ\_2yr\_conv[,12],"\_contribution")   
  
# check if nested lists names matches their last elements' names: YES  
# View( full\_circ\_2yr\_conv) check  
  
# remove the last subannual matrix from the chain in full\_circ\_2yr\_conv  
until\_circ\_2yr\_conv <- full\_circ\_2yr\_conv %>%  
 map(., ~{head(.,11)})  
# until\_circ\_2yr\_conv contains 12 chains of 11 matrices each. In term of contribution to changes in lambda, each chain starts at the subannual matrix following the matrix of interest. The `until` and `though` designation is detailed in Caswell and Trevisan 1994.   
### low  
  
# pick all phases in the 2yr conventional treatment  
all\_periods\_2yr\_low <- scenario1\_projection\_by\_matrix\_id\_transpose[c("S2\_low", "C2\_low")]  
#View(all\_periods\_2yr\_conv)  
  
# rearrange the phases in a chain  
all\_periods\_2yr\_low\_chain <- unlist(all\_periods\_2yr\_low, recursive = FALSE)  
  
# make a reference grid   
ref\_2yr\_low <- names(all\_periods\_2yr\_low\_chain)  
  
circ\_2yr\_low <- circ(ref\_2yr\_low)

## Warning in matrix(1:n, n + 1, n + 1, byrow = T): data length [12] is not a sub-  
## multiple or multiple of the number of rows [13]

full\_circ\_2yr\_low <- purrr::map(1:12,~all\_periods\_2yr\_low\_chain[circ\_2yr\_low[.x,]])  
# name the nested list by the last element in each nested list  
# the last element in each nested list appear in the same order as circ\_2yr\_low[,12]  
  
names(full\_circ\_2yr\_low) <- paste0(circ\_2yr\_low[,12],"\_contribution")   
  
# check if nested lists names matches their last elements' names: YES  
# View( full\_circ\_2yr\_low): each chain's product is identified by the right-most matrix   
  
# remove the last subannual matrix from the chain in full\_circ\_2yr\_low  
until\_circ\_2yr\_low <- full\_circ\_2yr\_low %>%  
 map(., ~{head(.,11)})

In all LTRE procedures presented here, the conventional corn weed management treatment is the reference treatment and low herbicide the treatment of interest. Following @caswellSensitivityAnalysisPeriodic1994’s notions:

The sensitivity of to each element of each sub-annual periodic matrix is calculated with

where,  
 is the periodic projection matrix for sub-annual period h; h = {1,…,6},  
 is the transpose of the matrix product of all the , and  
 is the sensitivity of to each element of (the average annual projection matrix between the reference treatment and the treatment of interest)

The elasticities of to each element of a sub-annual projection matrix is calculated with

where,

is the entry at row i column j of matrix , and other elements as defined in Equation (1).

## In all LTRE procedures, the conventional treatment is the reference matrix and low the treatment of interest  
  
# left matrix multiplication of all chains (as defined by starting point, aka the right-most matrix of the chain) THROUGH the right-most matrix --> matrix A's  
  
# The product of each list in the full\_circ\_2yr\_xx is A(hk),  
# A(hk) is the product of all sub-annual period starting at phase k, period h  
A2\_conv\_contribution <- full\_circ\_2yr\_conv %>%   
 map(., ~{Reduce( "%\*%", .)})   
  
A2\_low\_contribution <- full\_circ\_2yr\_low %>%   
 map(., ~{Reduce( "%\*%", .)})   
  
A2\_contribution <- lst(A2\_conv\_contribution, A2\_low\_contribution)  
  
# calculate the A\* matrix, average of the two products representing conventional and low corn weed management treatments   
  
A2\_avg\_contribution <- lapply(Reduce(\(...)Map('+', ...), A2\_contribution), '/', length(A2\_contribution))  
  
# Matrix S\_A(h)'s: sensitivity of lambda to each element of A(h), i.e. a(ijh), using matrix A\*  
A2\_avg\_sens <- A2\_avg\_contribution %>%  
 map(., ~{sensitivity(.)})  
  
# Matrix D: the product of all sub-annual matrices in backward order, until the B(h) matrix appear.   
# other words: left matrix multiplication of all chains (as defined by starting point, B(h), UNTIL the B(h) appear, the chain that makes up D is one matrix fewer than one that makes S  
  
D2\_conv\_contribution <- until\_circ\_2yr\_conv %>%   
 map(., ~{Reduce( "%\*%", .)})   
  
D2\_low\_contribution <- until\_circ\_2yr\_low %>%   
 map(., ~{Reduce( "%\*%", .)})   
  
D2\_contribution <- lst(D2\_conv\_contribution, D2\_low\_contribution)  
  
### Do I really need D\_avg? ### Yes  
  
D2\_avg\_contribution <- lapply(Reduce(\(...)Map('+', ...), D2\_contribution), '/', length(D2\_contribution))  
  
D2\_avg\_contribution\_transposed <- D2\_avg\_contribution %>%  
 map(., ~{t(.)})  
  
# Matrix S\_B(h): sensitivity of lambda to changes in each element of the subannual matrix B(h)   
S\_B\_contribution\_2yr <- purrr::map2(D2\_avg\_contribution\_transposed, A2\_avg\_sens, `%\*%`)  
  
# remove "conv" in all names, conv was picked up from D2\_conv\_contribution because it was listed first in D2\_contribution.   
  
## pick out the names  
contribution\_2yr\_raw\_names <- names( S\_B\_contribution\_2yr)  
  
## remove "conv" in all names  
contribution\_2yr\_names <- gsub('conv.', '', contribution\_2yr\_raw\_names)  
## put the names back  
names(S\_B\_contribution\_2yr) <- contribution\_2yr\_names

In the corn phase of the 2-year rotation, the mobility of seeds at the bottom stratum to seedling cohort 2 was the highest contributor to changes in the population growth (); to the seedling cohorts 1, 3 and 4 were immediate contributors to changes in the population growth. The same pattern was observed for the top-stratum seeds in the corn phase of the 2-year rotation, but their contribution to changes in were lower than those of the bottom-stratum seeds.

In the soybean phase of the 2-year rotation, emergence minimally contributed to changes in population growth.

*need a table, as graphs will be too many*

In 2019, as ’s were under 1 for all treatments, fecundity did not contribute substantially to changes.

# lambda atscenario1\_annualized\_lambda\_df\_long$annualized\_lambd  
lambda\_2yr\_conv <-scenario1\_annualized\_lambda\_df\_long$annualized\_lambda[1]  
  
lambda\_2yr\_low <-scenario1\_annualized\_lambda\_df\_long$annualized\_lambda[2]  
# Elasticity contribution left: check if all\_periods\_2yr\_conv\_chain is the appropriate element   
# The right-most matrix of all\_periods\_2yr\_conv\_chain is C2\_spring\_tillage  
# why is the order of "all\_periods\_2yr\_conv\_chain" and "sens\_contribution\_2yr" opposite?  
  
# Elasticity contribution left component: b\_hij\_2/lambda, or \_3, \_4 in the later chunks   
b\_hij\_2\_over\_lambda\_conv <- all\_periods\_2yr\_conv\_chain %>%  
 map(., ~{./lambda\_2yr\_conv})  
  
b\_hij\_2\_over\_lambda\_low <- all\_periods\_2yr\_low\_chain %>%  
 map(., ~{./lambda\_2yr\_low})  
  
# Elasticity contribution right component: S\_B's   
  
# Multiply the left and right components   
E\_B\_contribution\_2yr\_conv <- Map(\(x, y) Reduce(`%\*%`, list(x, y)), b\_hij\_2\_over\_lambda\_conv, S\_B\_contribution\_2yr)  
  
## pick out the names  
E\_B\_contribution\_2yr\_conv\_raw\_names <- names(E\_B\_contribution\_2yr\_conv )  
  
## rename "means" with "E\_B" in list names, for identification  
  
E\_B\_contribution\_2yr\_conv\_names <- gsub('mean', 'E\_B', E\_B\_contribution\_2yr\_conv\_raw\_names )  
## put the names back  
names(E\_B\_contribution\_2yr\_conv ) <- E\_B\_contribution\_2yr\_conv\_names   
  
E\_B\_contribution\_2yr\_low <- Map(\(x, y) Reduce(`%\*%`, list(x, y)), b\_hij\_2\_over\_lambda\_low, S\_B\_contribution\_2yr)  
  
## pick out the names  
E\_B\_contribution\_2yr\_low\_raw\_names <- names(E\_B\_contribution\_2yr\_low)  
  
## rename "means" with "E\_B" in list names, for identification  
  
E\_B\_contribution\_2yr\_low\_names <- gsub('mean', 'E\_B', E\_B\_contribution\_2yr\_low\_raw\_names )  
## put the names back  
names(E\_B\_contribution\_2yr\_low ) <- E\_B\_contribution\_2yr\_low\_names

### conventional   
  
# pick all phases in the 3yr conventional treatment  
all\_periods\_3yr\_conv <- scenario1\_projection\_by\_matrix\_id\_transpose[c("O3\_conv", "S3\_conv", "C3\_conv")]  
#View(all\_periods\_3yr\_conv)  
  
# rearrange the phases in a chain  
all\_periods\_3yr\_conv\_chain <- unlist(all\_periods\_3yr\_conv, recursive = FALSE)  
  
# make a reference grid   
ref\_3yr\_conv <- names(all\_periods\_3yr\_conv\_chain)  
  
circ\_3yr\_conv <- circ(ref\_3yr\_conv)

## Warning in matrix(1:n, n + 1, n + 1, byrow = T): data length [18] is not a sub-  
## multiple or multiple of the number of rows [19]

full\_circ\_3yr\_conv <- purrr::map(1:18,~all\_periods\_3yr\_conv\_chain[circ\_3yr\_conv[.x,]])  
# name the nested list by the last element in each nested list  
# the last element in each nested list appear in the same order as circ\_3yr\_conv[,12]  
  
names(full\_circ\_3yr\_conv) <- paste0(circ\_3yr\_conv[,18],"\_contribution")   
  
# check if nested lists names matches their last elements' names: YES  
# View( full\_circ\_2yr\_conv) check  
  
# remove the last subannual matrix from the chain in full\_circ\_3yr\_conv  
until\_circ\_3yr\_conv <- full\_circ\_3yr\_conv %>%  
 map(., ~{head(.,11)})  
  
### low  
  
# pick all phases in the 3yr low treatment  
all\_periods\_3yr\_low <- scenario1\_projection\_by\_matrix\_id\_transpose[c("O3\_low", "S3\_low", "C3\_low")]  
#View(all\_periods\_2yr\_conv)  
  
# rearrange the phases in a chain  
all\_periods\_3yr\_low\_chain <- unlist(all\_periods\_3yr\_low, recursive = FALSE)  
  
# make a reference grid   
ref\_3yr\_low <- names(all\_periods\_3yr\_low\_chain)  
  
circ\_3yr\_low <- circ(ref\_3yr\_low)

## Warning in matrix(1:n, n + 1, n + 1, byrow = T): data length [18] is not a sub-  
## multiple or multiple of the number of rows [19]

full\_circ\_3yr\_low <- purrr::map(1:18,~all\_periods\_3yr\_low\_chain[circ\_3yr\_low[.x,]])  
# name the nested list by the last element in each nested list  
# the last element in each nested list appear in the same order as circ\_3yr\_low[,12]  
  
names(full\_circ\_3yr\_low) <- paste0(circ\_3yr\_low[,18],"\_contribution")   
  
# check if nested lists names matches their last elements' names: YES  
# View( full\_circ\_3yr\_low)   
  
# remove the last subannual matrix from the chain in full\_circ\_3yr\_low  
until\_circ\_3yr\_low <- full\_circ\_3yr\_low %>%  
 map(., ~{head(.,11)})

## In all LTRE procedures, the conventional treatment is the reference matrix and low the  
  
# left matrix multiplication of all chains (as defined by starting point, aka the right-most matrix of the chain) THROUGH the right-most matrix --> matrix A's  
A3\_conv\_contribution <- full\_circ\_3yr\_conv %>%   
 map(., ~{Reduce( "%\*%", .)})   
  
A3\_low\_contribution <- full\_circ\_3yr\_low %>%   
 map(., ~{Reduce( "%\*%", .)})   
  
A3\_contribution <- lst(A3\_conv\_contribution, A3\_low\_contribution)  
  
A3\_avg\_contribution <- lapply(Reduce(\(...)Map('+', ...), A3\_contribution), '/', length(A3\_contribution))  
  
# Sensitivities with regards to the right-most matrix --> matrix S\_a's  
A3\_avg\_sens <- A3\_avg\_contribution %>%  
 map(., ~{sensitivity(.)})  
  
# left matrix multiplication of all chains (as defined by starting point, aka the right-most matrix of the chain) UNTIL the right-most matrix appear --> matrix D's  
  
D3\_conv\_contribution <- until\_circ\_3yr\_conv %>%   
 map(., ~{Reduce( "%\*%", .)})   
  
D3\_low\_contribution <- until\_circ\_3yr\_low %>%   
 map(., ~{Reduce( "%\*%", .)})   
  
D3\_contribution <- lst(D3\_conv\_contribution, D3\_low\_contribution)  
  
D3\_avg\_contribution <- lapply(Reduce(\(...)Map('+', ...), D3\_contribution), '/', length(D3\_contribution))  
  
S\_B\_contribution\_3yr <- purrr::map2(D3\_avg\_contribution, A3\_avg\_sens, `%\*%`)  
  
# remove "conv" in all names  
contribution\_3yr\_raw\_names <- names(S\_B\_contribution\_3yr )  
  
contribution\_3yr\_names <- gsub('conv.', '', contribution\_3yr\_raw\_names)  
  
names(S\_B\_contribution\_3yr) <- contribution\_3yr\_names

# lambda at scenario1\_rotation\_wise\_lambda   
lambda\_3yr\_conv <- scenario1\_annualized\_lambda\_df\_long$annualized\_lambda[3]  
  
lambda\_3yr\_low <- scenario1\_annualized\_lambda\_df\_long$annualized\_lambda[4]  
  
  
# Elasticity contribution left component: b\_hij\_3/lambda,  
b\_hij\_3yr\_over\_lambda\_conv <- all\_periods\_3yr\_conv\_chain %>%  
 map(., ~{./lambda\_3yr\_conv})  
  
b\_hij\_3yr\_over\_lambda\_low <- all\_periods\_3yr\_low\_chain %>%  
 map(., ~{./lambda\_3yr\_low})  
  
# Elasticity contribution right component: S\_B's   
  
# ## Calculate E\_Bs: Multiply the left and right components   
E\_B\_contribution\_3yr\_conv <- Map(\(x, y) Reduce(`%\*%`, list(x, y)), b\_hij\_3yr\_over\_lambda\_conv, S\_B\_contribution\_3yr)  
## pick out the names  
E\_B\_contribution\_3yr\_conv\_raw\_names <- names(E\_B\_contribution\_3yr\_conv )  
  
## rename "means" with "E\_B" in list names, for identification  
  
E\_B\_contribution\_3yr\_conv\_names <- gsub('mean', 'E\_B', E\_B\_contribution\_3yr\_conv\_raw\_names )  
## put the names back  
names(E\_B\_contribution\_3yr\_conv ) <- E\_B\_contribution\_3yr\_conv\_names   
  
  
## Calculate E\_Bs  
E\_B\_contribution\_3yr\_low <- Map(\(x, y) Reduce(`%\*%`, list(x, y)), b\_hij\_3yr\_over\_lambda\_low, S\_B\_contribution\_3yr)  
  
## pick out the names  
E\_B\_contribution\_3yr\_low\_raw\_names <- names(E\_B\_contribution\_3yr\_low)  
  
## rename "means" with "E\_B" in list names, for identification  
  
E\_B\_contribution\_3yr\_low\_names <- gsub('mean', 'E\_B', E\_B\_contribution\_3yr\_low\_raw\_names )  
## put the names back  
names(E\_B\_contribution\_3yr\_low ) <- E\_B\_contribution\_3yr\_low\_names

### conventional   
  
# pick all phases in the 4yr conventional treatment  
all\_periods\_4yr\_conv <- scenario1\_projection\_by\_matrix\_id\_transpose[c("A4\_conv", "O4\_conv", "S4\_conv", "C4\_conv")]  
# View(all\_periods\_4yr\_conv)  
  
# rearrange the phases in a chain  
all\_periods\_4yr\_conv\_chain <- unlist(all\_periods\_4yr\_conv, recursive = FALSE)  
  
# make a reference grid   
ref\_4yr\_conv <- names(all\_periods\_4yr\_conv\_chain)  
  
circ\_4yr\_conv <- circ(ref\_4yr\_conv)

## Warning in matrix(1:n, n + 1, n + 1, byrow = T): data length [24] is not a sub-  
## multiple or multiple of the number of rows [25]

full\_circ\_4yr\_conv <- purrr::map(1:24,~all\_periods\_4yr\_conv\_chain[circ\_4yr\_conv[.x,]])  
# name the nested list by the last element in each nested list  
# the last element in each nested list appear in the same order as circ\_4yr\_conv[,12]  
  
names(full\_circ\_4yr\_conv) <- paste0(circ\_4yr\_conv[,24],"\_contribution")   
  
# check if nested lists names matches their last elements' names: YES  
# View( full\_circ\_4yr\_conv) check  
  
# remove the last subannual matrix from the chain in full\_circ\_3yr\_conv  
until\_circ\_4yr\_conv <- full\_circ\_4yr\_conv %>%  
 map(., ~{head(.,11)})  
  
### low  
  
# pick all phases in the 3yr low treatment  
all\_periods\_4yr\_low <- scenario1\_projection\_by\_matrix\_id\_transpose[c("A4\_low", "O4\_low", "S4\_low", "C4\_low")]  
#View(all\_periods\_4yr\_conv)  
  
# rearrange the phases in a chain  
all\_periods\_4yr\_low\_chain <- unlist(all\_periods\_4yr\_low, recursive = FALSE)  
  
# make a reference grid   
ref\_4yr\_low <- names(all\_periods\_4yr\_low\_chain)  
  
circ\_4yr\_low <- circ(ref\_4yr\_low)

## Warning in matrix(1:n, n + 1, n + 1, byrow = T): data length [24] is not a sub-  
## multiple or multiple of the number of rows [25]

full\_circ\_4yr\_low <- purrr::map(1:24,~all\_periods\_4yr\_low\_chain[circ\_4yr\_low[.x,]])  
# name the nested list by the last element in each nested list  
# the last element in each nested list appear in the same order as circ\_4yr\_low[,12]  
  
names(full\_circ\_4yr\_low) <- paste0(circ\_4yr\_low[,24],"\_contribution")   
  
# check if nested lists names matches their last elements' names: YES  
# View( full\_circ\_4yr\_low)   
  
# remove the last subannual matrix from the chain in full\_circ\_4yr\_low  
until\_circ\_4yr\_low <- full\_circ\_4yr\_low %>%  
 map(., ~{head(.,11)})

## In all LTRE procedures, the conventional treatment is the reference matrix and low the  
  
# left matrix multiplication of all chains (as defined by starting point, aka the right-most matrix of the chain) THROUGH the right-most matrix --> matrix A's  
A4\_conv\_contribution <- full\_circ\_4yr\_conv %>%   
 map(., ~{Reduce( "%\*%", .)})   
  
A4\_low\_contribution <- full\_circ\_4yr\_low %>%   
 map(., ~{Reduce( "%\*%", .)})   
  
A4\_contribution <- lst(A4\_conv\_contribution, A4\_low\_contribution)  
  
A4\_avg\_contribution <- lapply(Reduce(\(...)Map('+', ...), A4\_contribution), '/', length(A4\_contribution))  
  
# Sensitivities with regards to the right-most matrix --> matrix S\_A's  
A4\_avg\_sens <- A4\_avg\_contribution %>%  
 map(., ~{sensitivity(.)})  
  
# left matrix multiplication of all chains (as defined by starting point, aka the right-most matrix of the chain) UNTIL the right-most matrix appear --> matrix D's  
  
D4\_conv\_contribution <- until\_circ\_4yr\_conv %>%   
 map(., ~{Reduce( "%\*%", .)})   
  
D4\_low\_contribution <- until\_circ\_4yr\_low %>%   
 map(., ~{Reduce( "%\*%", .)})   
  
D4\_contribution <- lst(D4\_conv\_contribution, D4\_low\_contribution)  
  
D4\_avg\_contribution <- lapply(Reduce(\(...)Map('+', ...), D4\_contribution), '/', length(D4\_contribution))  
  
D4\_avg\_contribution\_transposed <- D4\_avg\_contribution %>% map(.,~{t(.)})  
  
## contribution of each sub-annual matrix to lambda's sensitivities, matrix S\_B's   
S\_B\_contribution\_4yr <- purrr::map2(D4\_avg\_contribution\_transposed, A4\_avg\_sens, `%\*%`)  
# remove "conv" in all names  
S\_B\_contribution\_4yr\_raw\_names <- names( S\_B\_contribution\_4yr )  
  
S\_B\_contribution\_4yr\_names <- gsub('conv.', '', S\_B\_contribution\_4yr\_raw\_names)  
  
names(S\_B\_contribution\_4yr) <- S\_B\_contribution\_4yr\_names

## calculate elasticity, see p. 121  
  
## NEED NEW NAMES FOR ALL THE LIST  
# lambda at scenario1\_rotation\_wise\_lambda   
lambda\_4yr\_conv <-scenario1\_annualized\_lambda\_df\_long$annualized\_lambda[5]  
  
lambda\_4yr\_low <-scenario1\_annualized\_lambda\_df\_long$annualized\_lambda[6]  
# Elasticity contribution left: check if all\_periods\_4yr\_conv\_chain is the appropriate element   
# The right-most matrix of all\_periods\_4yr\_conv\_chain is C4\_spring\_tillage  
# why is the order of "all\_periods\_4yr\_conv\_chain" and "sens\_contribution\_4yr" opposite?  
  
  
b\_hij\_4yr\_over\_lambda\_conv\_left <- all\_periods\_4yr\_conv\_chain %>%  
 map(., ~{./lambda\_4yr\_conv})  
  
b\_hij\_4yr\_over\_lambda\_low\_left <- all\_periods\_4yr\_low\_chain %>%  
 map(., ~{./lambda\_4yr\_low})  
  
# Elasticity contribution right component: S\_B's sens\_contribution\_4yr  
  
# Elasticity  
E\_B\_contribution\_4yr\_conv <- Map(\(x, y) Reduce(`%\*%`, list(x, y)),  
 b\_hij\_4yr\_over\_lambda\_conv\_left ,  
 S\_B\_contribution\_4yr)  
## pick out the names  
E\_B\_contribution\_4yr\_conv\_raw\_names <- names(E\_B\_contribution\_4yr\_conv )  
  
## rename "means" with "E\_B" in list names, for identification  
  
E\_B\_contribution\_4yr\_conv\_names <- gsub('mean', 'E\_B', E\_B\_contribution\_4yr\_conv\_raw\_names )  
## put the names back  
names(E\_B\_contribution\_4yr\_conv ) <- E\_B\_contribution\_4yr\_conv\_names   
  
  
E\_B\_contribution\_4yr\_low <- Map(\(x, y) Reduce(`%\*%`, list(x, y)),  
 b\_hij\_4yr\_over\_lambda\_low\_left,  
 S\_B\_contribution\_4yr)  
  
## pick out the names  
E\_B\_contribution\_4yr\_low\_raw\_names <- names(E\_B\_contribution\_4yr\_low)  
  
## rename "means" with "E\_B" in list names, for identification  
  
E\_B\_contribution\_4yr\_low\_names <- gsub('mean', 'E\_B', E\_B\_contribution\_4yr\_low\_raw\_names )  
## put the names back  
names(E\_B\_contribution\_4yr\_low ) <- E\_B\_contribution\_4yr\_low\_names

In all cropping systems, the two largest component of rotational variance were from summer survival and fecundity. *Detailed contribution of variance in each sub-annual matrices to the variance of are provided in the Appendix.* This observation is expected because populations were declining in all cropping systems in this scenario.

# combine all variance into a data frame and calculate annualized lambda's var  
  
scenario1\_annualized\_lambda\_df\_long$Rotation\_var\_lambda <- c(var\_lambda\_conv\_2yr,  
 var\_lambda\_low\_2yr,  
 var\_lambda\_conv\_3yr,  
 var\_lambda\_low\_3yr,  
 var\_lambda\_conv\_4yr,  
 var\_lambda\_low\_4yr)  
  
# add multiplier to the var table  
scenario1\_annualized\_lambda\_df\_long$multiplier <- c(1/4, 1/4, 1/9, 1/9, 1/16, 1/16)  
  
  
  
# how to explain negative variance components?  
  
  
# combine lambda, var(lambda), and \*variance contribution\* and rename the data frame  
scenario1\_annualized\_lambda\_and\_var <- scenario1\_annualized\_lambda\_df\_long %>%  
 mutate(squared\_annualized\_lambda = annualized\_lambda^2,  
 var\_annualized\_lambda = multiplier \* Rotation\_var\_lambda/squared\_annualized\_lambda) %>%  
 select(.id, Corn\_weed\_management, annualized\_lambda, var\_annualized\_lambda)  
  
  
## subset all the lists  
#View( scenario1\_annualized\_lambda\_and\_var)  
#https://community.rstudio.com/t/subset-a-nested-list-to-get-all-the-lower-level-lists-with-the-same-characters-in-their-names/138320  
  
var\_lambda\_conv\_top\_element <- var\_lambda\_conv\_elements[str\_detect(names(var\_lambda\_conv\_elements), "summer")]  
  
var\_lambda\_conv\_second\_elements <- var\_lambda\_conv\_elements[str\_detect(names(var\_lambda\_conv\_elements), "fecund")]  
  
var\_lambda\_low\_top\_element <- var\_lambda\_low\_elements[str\_detect(names(var\_lambda\_low\_elements), "summer")]  
  
var\_lambda\_low\_second\_element <- var\_lambda\_low\_elements[str\_detect(names(var\_lambda\_low\_elements), "fecund")]

The demographic parameters to which ’s were the most elastic to are shown below. The full set of elasticity values are provided in the Appendix.

## $E\_B\_contribution\_2yr\_conv  
## $E\_B\_contribution\_2yr\_conv$S2\_conv.E\_B\_overwinter\_scenario1  
## seed\_top seed\_bottom  
## seed\_top 0.097 0.341  
## seed\_bottom 0.081 0.284  
##   
## $E\_B\_contribution\_2yr\_conv$S2\_conv.E\_B\_post\_harvest\_tillage  
## seed\_top seed\_bottom  
## seed\_top 0.103 0.311  
## seed\_bottom 0.123 0.372  
##   
## $E\_B\_contribution\_2yr\_conv$S2\_conv.E\_B\_fecundity\_2019  
## seed\_top seed\_bottom plant\_cohort\_1 plant\_cohort\_2 plant\_cohort\_3  
## seed\_top 350.530 1021.654 0.122 0.745 0.048  
## seed\_bottom 0.175 0.509 0.000 0.000 0.000  
## plant\_cohort\_4 plant\_cohort\_5 plant\_cohort\_6  
## seed\_top 0.035 0.028 0.027  
## seed\_bottom 0.000 0.000 0.000  
##   
## $E\_B\_contribution\_2yr\_conv$S2\_conv.E\_B\_summer\_survival\_scenario1  
## seed\_top seed\_bottom plant\_cohort\_1 plant\_cohort\_2 plant\_cohort\_3  
## seed\_top 0.074 0.242 0 0 0  
## seed\_bottom 0.085 0.277 0 0 0  
## plant\_cohort\_4 plant\_cohort\_5 plant\_cohort\_6  
## seed\_top 0 0 0  
## seed\_bottom 0 0 0  
##   
## $E\_B\_contribution\_2yr\_conv$S2\_conv.E\_B\_emergence\_scenario1  
## seed\_top seed\_bottom  
## seed\_top 0.151 0.318  
## seed\_bottom 0.179 0.377  
## plant\_cohort\_1 0.004 0.008  
## plant\_cohort\_2 0.001 0.002  
## plant\_cohort\_3 0.000 0.001  
## plant\_cohort\_4 0.000 0.000  
## plant\_cohort\_5 0.000 0.000  
## plant\_cohort\_6 0.000 0.000  
##   
## $E\_B\_contribution\_2yr\_conv$S2\_conv.E\_B\_spring\_tillage  
## seed\_top seed\_bottom  
## seed\_top 0.143 0.408  
## seed\_bottom 0.244 0.695  
##   
## $E\_B\_contribution\_2yr\_conv$C2\_conv.E\_B\_overwinter\_scenario1  
## seed\_top seed\_bottom  
## seed\_top 0.081 0.259  
## seed\_bottom 0.096 0.305  
##   
## $E\_B\_contribution\_2yr\_conv$C2\_conv.E\_B\_post\_harvest\_tillage  
## seed\_top seed\_bottom  
## seed\_top 0.089 0.260  
## seed\_bottom 0.177 0.515  
##   
## $E\_B\_contribution\_2yr\_conv$C2\_conv.E\_B\_fecundity\_2019  
## seed\_top seed\_bottom plant\_cohort\_1 plant\_cohort\_2 plant\_cohort\_3  
## seed\_top 2507.525 7442.511 43.130 10.713 2.865  
## seed\_bottom 0.185 0.549 0.003 0.001 0.000  
## plant\_cohort\_4 plant\_cohort\_5 plant\_cohort\_6  
## seed\_top 0.915 0.478 0.624  
## seed\_bottom 0.000 0.000 0.000  
##   
## $E\_B\_contribution\_2yr\_conv$C2\_conv.E\_B\_summer\_survival\_scenario1  
## seed\_top seed\_bottom plant\_cohort\_1 plant\_cohort\_2 plant\_cohort\_3  
## seed\_top 0.082 0.273 0.002 0 0  
## seed\_bottom 0.090 0.298 0.002 0 0  
##   
## $E\_B\_contribution\_2yr\_conv$C2\_conv.E\_B\_emergence\_scenario1  
## seed\_top seed\_bottom  
## seed\_top 0.132 0.414  
## seed\_bottom 0.129 0.405  
## plant\_cohort\_1 0.000 0.000  
## plant\_cohort\_2 0.000 0.000  
## plant\_cohort\_3 0.000 0.000  
## plant\_cohort\_4 0.000 0.000  
## plant\_cohort\_5 0.000 0.000  
## plant\_cohort\_6 0.000 0.000  
##   
## $E\_B\_contribution\_2yr\_conv$C2\_conv.E\_B\_spring\_tillage  
## seed\_top seed\_bottom  
## seed\_top 0.146 0.457  
## seed\_bottom 0.231 0.722  
##   
##   
## $E\_B\_contribution\_2yr\_low  
## $E\_B\_contribution\_2yr\_low$S2\_low.E\_B\_overwinter\_scenario1  
## seed\_top seed\_bottom  
## seed\_top 0.103 0.360  
## seed\_bottom 0.085 0.299  
##   
## $E\_B\_contribution\_2yr\_low$S2\_low.E\_B\_post\_harvest\_tillage  
## seed\_top seed\_bottom  
## seed\_top 0.109 0.328  
## seed\_bottom 0.130 0.392  
##   
## $E\_B\_contribution\_2yr\_low$S2\_low.E\_B\_fecundity\_2019  
## seed\_top seed\_bottom plant\_cohort\_1 plant\_cohort\_2 plant\_cohort\_3  
## seed\_top 1965.089 5727.453 0.686 4.178 0.269  
## seed\_bottom 0.184 0.538 0.000 0.000 0.000  
## plant\_cohort\_4 plant\_cohort\_5 plant\_cohort\_6  
## seed\_top 0.195 0.156 0.149  
## seed\_bottom 0.000 0.000 0.000  
##   
## $E\_B\_contribution\_2yr\_low$S2\_low.E\_B\_summer\_survival\_scenario1  
## seed\_top seed\_bottom plant\_cohort\_1 plant\_cohort\_2 plant\_cohort\_3  
## seed\_top 0.078 0.255 0 0 0  
## seed\_bottom 0.089 0.292 0 0 0  
## plant\_cohort\_4 plant\_cohort\_5 plant\_cohort\_6  
## seed\_top 0 0 0  
## seed\_bottom 0 0 0  
##   
## $E\_B\_contribution\_2yr\_low$S2\_low.E\_B\_emergence\_scenario1  
## seed\_top seed\_bottom  
## seed\_top 0.163 0.342  
## seed\_bottom 0.189 0.397  
## plant\_cohort\_1 0.002 0.003  
## plant\_cohort\_2 0.000 0.001  
## plant\_cohort\_3 0.000 0.000  
## plant\_cohort\_4 0.000 0.000  
## plant\_cohort\_5 0.000 0.000  
## plant\_cohort\_6 0.000 0.000  
##   
## $E\_B\_contribution\_2yr\_low$S2\_low.E\_B\_spring\_tillage  
## seed\_top seed\_bottom  
## seed\_top 0.151 0.431  
## seed\_bottom 0.258 0.734  
##   
## $E\_B\_contribution\_2yr\_low$C2\_low.E\_B\_overwinter\_scenario1  
## seed\_top seed\_bottom  
## seed\_top 0.086 0.273  
## seed\_bottom 0.101 0.322  
##   
## $E\_B\_contribution\_2yr\_low$C2\_low.E\_B\_post\_harvest\_tillage  
## seed\_top seed\_bottom  
## seed\_top 0.094 0.274  
## seed\_bottom 0.187 0.544  
##   
## $E\_B\_contribution\_2yr\_low$C2\_low.E\_B\_fecundity\_2019  
## seed\_top seed\_bottom plant\_cohort\_1 plant\_cohort\_2 plant\_cohort\_3  
## seed\_top 182.936 542.967 3.147 0.782 0.209  
## seed\_bottom 0.195 0.579 0.003 0.001 0.000  
## plant\_cohort\_4 plant\_cohort\_5 plant\_cohort\_6  
## seed\_top 0.067 0.035 0.046  
## seed\_bottom 0.000 0.000 0.000  
##   
## $E\_B\_contribution\_2yr\_low$C2\_low.E\_B\_summer\_survival\_scenario1  
## seed\_top seed\_bottom plant\_cohort\_1 plant\_cohort\_2 plant\_cohort\_3  
## seed\_top 0.087 0.288 0.002 0 0  
## seed\_bottom 0.095 0.315 0.002 0 0  
##   
## $E\_B\_contribution\_2yr\_low$C2\_low.E\_B\_emergence\_scenario1  
## seed\_top seed\_bottom  
## seed\_top 0.139 0.435  
## seed\_bottom 0.137 0.427  
## plant\_cohort\_1 0.000 0.000  
## plant\_cohort\_2 0.001 0.002  
## plant\_cohort\_3 0.000 0.000  
## plant\_cohort\_4 0.000 0.000  
## plant\_cohort\_5 0.000 0.000  
## plant\_cohort\_6 0.000 0.000  
##   
## $E\_B\_contribution\_2yr\_low$C2\_low.E\_B\_spring\_tillage  
## seed\_top seed\_bottom  
## seed\_top 0.154 0.483  
## seed\_bottom 0.244 0.762  
##   
##   
## $E\_B\_contribution\_3yr\_conv  
## $E\_B\_contribution\_3yr\_conv$O3\_conv.E\_B\_overwinter\_scenario1  
## seed\_top seed\_bottom  
## seed\_top 0.002 0.030  
## seed\_bottom 0.038 0.674  
##   
## $E\_B\_contribution\_3yr\_conv$O3\_conv.E\_B\_post\_harvest\_tillage  
## seed\_top seed\_bottom  
## seed\_top 0.011 0.054  
## seed\_bottom 0.168 0.801  
##   
## $E\_B\_contribution\_3yr\_conv$O3\_conv.E\_B\_fecundity\_2019  
## seed\_top seed\_bottom plant\_cohort\_1 plant\_cohort\_2 plant\_cohort\_3  
## seed\_top 41.463 199.200 0.050 0.254 0.017  
## seed\_bottom 138.361 664.719 0.167 0.849 0.058  
## plant\_cohort\_4 plant\_cohort\_5 plant\_cohort\_6  
## seed\_top 0.028 0.009 0.009  
## seed\_bottom 0.094 0.030 0.030  
##   
## $E\_B\_contribution\_3yr\_conv$O3\_conv.E\_B\_summer\_survival\_scenario1  
## seed\_top seed\_bottom plant\_cohort\_1 plant\_cohort\_2  
## seed\_top 0.014 0.075 0 0  
## seed\_bottom 0.084 0.455 0 0  
## plant\_cohort\_1 0.000 0.000 0 0  
## plant\_cohort\_2 0.000 0.000 0 0  
## plant\_cohort\_3 0.000 0.000 0 0  
## plant\_cohort\_4 0.000 0.000 0 0  
## plant\_cohort\_5 0.000 0.000 0 0  
## plant\_cohort\_6 0.000 0.000 0 0  
## plant\_cohort\_3 plant\_cohort\_4 plant\_cohort\_5 plant\_cohort\_6  
## seed\_top 0 0 0 0  
## seed\_bottom 0 0 0 0  
## plant\_cohort\_1 0 0 0 0  
## plant\_cohort\_2 0 0 0 0  
## plant\_cohort\_3 0 0 0 0  
## plant\_cohort\_4 0 0 0 0  
## plant\_cohort\_5 0 0 0 0  
## plant\_cohort\_6 0 0 0 0  
##   
## $E\_B\_contribution\_3yr\_conv$O3\_conv.E\_B\_emergence\_scenario1  
## seed\_top seed\_bottom  
## seed\_top 0.057 0.187  
## seed\_bottom 0.190 0.628  
## plant\_cohort\_1 0.000 0.000  
## plant\_cohort\_2 0.000 0.000  
## plant\_cohort\_3 0.000 0.000  
## plant\_cohort\_4 0.000 0.000  
## plant\_cohort\_5 0.000 0.000  
## plant\_cohort\_6 0.000 0.000  
##   
## $E\_B\_contribution\_3yr\_conv$O3\_conv.E\_B\_spring\_tillage  
## seed\_top seed\_bottom  
## seed\_top 0.078 0.284  
## seed\_bottom 0.241 0.873  
##   
## $E\_B\_contribution\_3yr\_conv$S3\_conv.E\_B\_overwinter\_scenario1  
## seed\_top seed\_bottom  
## seed\_top 0.028 0.112  
## seed\_bottom 0.128 0.520  
##   
## $E\_B\_contribution\_3yr\_conv$S3\_conv.E\_B\_post\_harvest\_tillage  
## seed\_top seed\_bottom  
## seed\_top 0.058 0.186  
## seed\_bottom 0.188 0.601  
##   
## $E\_B\_contribution\_3yr\_conv$S3\_conv.E\_B\_fecundity\_2019  
## seed\_top seed\_bottom plant\_cohort\_1 plant\_cohort\_2 plant\_cohort\_3  
## seed\_top 75.233 244.866 0.912 0.181 0.044  
## seed\_bottom 227.050 738.995 2.752 0.546 0.132  
## plant\_cohort\_4 plant\_cohort\_5 plant\_cohort\_6  
## seed\_top 0.002 0.006 0.016  
## seed\_bottom 0.007 0.019 0.048  
##   
## $E\_B\_contribution\_3yr\_conv$S3\_conv.E\_B\_summer\_survival\_scenario1  
## seed\_top seed\_bottom plant\_cohort\_1 plant\_cohort\_2  
## seed\_top 0.031 0.113 0.001 0  
## seed\_bottom 0.127 0.464 0.002 0  
## plant\_cohort\_1 0.001 0.003 0.000 0  
## plant\_cohort\_2 0.000 0.000 0.000 0  
## plant\_cohort\_3 0.000 0.000 0.000 0  
## plant\_cohort\_3  
## seed\_top 0  
## seed\_bottom 0  
## plant\_cohort\_1 0  
## plant\_cohort\_2 0  
## plant\_cohort\_3 0  
##   
## $E\_B\_contribution\_3yr\_conv$S3\_conv.E\_B\_emergence\_scenario1  
## seed\_top seed\_bottom  
## seed\_top 0.064 0.216  
## seed\_bottom 0.178 0.599  
## plant\_cohort\_1 0.001 0.003  
## plant\_cohort\_2 0.000 0.001  
## plant\_cohort\_3 0.000 0.000  
## plant\_cohort\_4 0.000 0.000  
## plant\_cohort\_5 0.000 0.000  
## plant\_cohort\_6 0.000 0.000  
##   
## $E\_B\_contribution\_3yr\_conv$S3\_conv.E\_B\_spring\_tillage  
## seed\_top seed\_bottom  
## seed\_top 0.098 0.328  
## seed\_bottom 0.262 0.882  
##   
## $E\_B\_contribution\_3yr\_conv$C3\_conv.E\_B\_overwinter\_scenario1  
## seed\_top seed\_bottom  
## seed\_top 0.046 0.174  
## seed\_bottom 0.135 0.507  
##   
## $E\_B\_contribution\_3yr\_conv$C3\_conv.E\_B\_post\_harvest\_tillage  
## seed\_top seed\_bottom  
## seed\_top 0.053 0.164  
## seed\_bottom 0.176 0.548  
##   
## $E\_B\_contribution\_3yr\_conv$C3\_conv.E\_B\_fecundity\_2019  
## seed\_top seed\_bottom plant\_cohort\_1 plant\_cohort\_2 plant\_cohort\_3  
## seed\_top 1672.591 5212.371 0.560 1.002 0.651  
## seed\_bottom 2767.792 8625.395 0.926 1.658 1.078  
## plant\_cohort\_4 plant\_cohort\_5 plant\_cohort\_6  
## seed\_top 0.424 0.054 0.016  
## seed\_bottom 0.702 0.089 0.027  
##   
## $E\_B\_contribution\_3yr\_conv$C3\_conv.E\_B\_summer\_survival\_scenario1  
## seed\_top seed\_bottom plant\_cohort\_1 plant\_cohort\_2  
## seed\_top 0.035 0.123 0 0  
## seed\_bottom 0.122 0.423 0 0  
## plant\_cohort\_1 0.000 0.000 0 0  
## plant\_cohort\_2 0.000 0.000 0 0  
## plant\_cohort\_3 0.000 0.000 0 0  
## plant\_cohort\_4 0.000 0.000 0 0  
## plant\_cohort\_5 0.000 0.000 0 0  
## plant\_cohort\_6 0.000 0.000 0 0  
## plant\_cohort\_3 plant\_cohort\_4 plant\_cohort\_5 plant\_cohort\_6  
## seed\_top 0 0 0 0  
## seed\_bottom 0 0 0 0  
## plant\_cohort\_1 0 0 0 0  
## plant\_cohort\_2 0 0 0 0  
## plant\_cohort\_3 0 0 0 0  
## plant\_cohort\_4 0 0 0 0  
## plant\_cohort\_5 0 0 0 0  
## plant\_cohort\_6 0 0 0 0  
##   
## $E\_B\_contribution\_3yr\_conv$C3\_conv.E\_B\_emergence\_scenario1  
## seed\_top seed\_bottom  
## seed\_top 0.067 0.215  
## seed\_bottom 0.167 0.536  
## plant\_cohort\_1 0.000 0.000  
## plant\_cohort\_2 0.000 0.001  
## plant\_cohort\_3 0.000 0.000  
## plant\_cohort\_4 0.000 0.000  
## plant\_cohort\_5 0.000 0.000  
## plant\_cohort\_6 0.000 0.000  
##   
## $E\_B\_contribution\_3yr\_conv$C3\_conv.E\_B\_spring\_tillage  
## seed\_top seed\_bottom  
## seed\_top 0.015 0.233  
## seed\_bottom 0.070 1.096  
##   
##   
## $E\_B\_contribution\_3yr\_low  
## $E\_B\_contribution\_3yr\_low$O3\_low.E\_B\_overwinter\_scenario1  
## seed\_top seed\_bottom  
## seed\_top 0.002 0.030  
## seed\_bottom 0.038 0.677  
##   
## $E\_B\_contribution\_3yr\_low$O3\_low.E\_B\_post\_harvest\_tillage  
## seed\_top seed\_bottom  
## seed\_top 0.011 0.055  
## seed\_bottom 0.169 0.804  
##   
## $E\_B\_contribution\_3yr\_low$O3\_low.E\_B\_fecundity\_2019  
## seed\_top seed\_bottom plant\_cohort\_1 plant\_cohort\_2 plant\_cohort\_3  
## seed\_top 49.626 238.416 0.060 0.305 0.021  
## seed\_bottom 138.950 667.549 0.167 0.853 0.058  
## plant\_cohort\_4 plant\_cohort\_5 plant\_cohort\_6  
## seed\_top 0.034 0.011 0.011  
## seed\_bottom 0.095 0.030 0.030  
##   
## $E\_B\_contribution\_3yr\_low$O3\_low.E\_B\_summer\_survival\_scenario1  
## seed\_top seed\_bottom plant\_cohort\_1 plant\_cohort\_2  
## seed\_top 0.014 0.075 0 0  
## seed\_bottom 0.085 0.457 0 0  
## plant\_cohort\_1 0.000 0.000 0 0  
## plant\_cohort\_2 0.000 0.000 0 0  
## plant\_cohort\_3 0.000 0.000 0 0  
## plant\_cohort\_4 0.000 0.000 0 0  
## plant\_cohort\_5 0.000 0.000 0 0  
## plant\_cohort\_6 0.000 0.000 0 0  
## plant\_cohort\_3 plant\_cohort\_4 plant\_cohort\_5 plant\_cohort\_6  
## seed\_top 0 0 0 0  
## seed\_bottom 0 0 0 0  
## plant\_cohort\_1 0 0 0 0  
## plant\_cohort\_2 0 0 0 0  
## plant\_cohort\_3 0 0 0 0  
## plant\_cohort\_4 0 0 0 0  
## plant\_cohort\_5 0 0 0 0  
## plant\_cohort\_6 0 0 0 0  
##   
## $E\_B\_contribution\_3yr\_low$O3\_low.E\_B\_emergence\_scenario1  
## seed\_top seed\_bottom  
## seed\_top 0.057 0.188  
## seed\_bottom 0.191 0.631  
## plant\_cohort\_1 0.000 0.000  
## plant\_cohort\_2 0.000 0.000  
## plant\_cohort\_3 0.000 0.000  
## plant\_cohort\_4 0.000 0.000  
## plant\_cohort\_5 0.000 0.000  
## plant\_cohort\_6 0.000 0.000  
##   
## $E\_B\_contribution\_3yr\_low$O3\_low.E\_B\_spring\_tillage  
## seed\_top seed\_bottom  
## seed\_top 0.079 0.285  
## seed\_bottom 0.242 0.877  
##   
## $E\_B\_contribution\_3yr\_low$S3\_low.E\_B\_overwinter\_scenario1  
## seed\_top seed\_bottom  
## seed\_top 0.028 0.113  
## seed\_bottom 0.128 0.522  
##   
## $E\_B\_contribution\_3yr\_low$S3\_low.E\_B\_post\_harvest\_tillage  
## seed\_top seed\_bottom  
## seed\_top 0.058 0.187  
## seed\_bottom 0.188 0.604  
##   
## $E\_B\_contribution\_3yr\_low$S3\_low.E\_B\_fecundity\_2019  
## seed\_top seed\_bottom plant\_cohort\_1 plant\_cohort\_2 plant\_cohort\_3  
## seed\_top 68.453 222.798 0.830 0.164 0.040  
## seed\_bottom 228.016 742.141 2.763 0.548 0.133  
## plant\_cohort\_4 plant\_cohort\_5 plant\_cohort\_6  
## seed\_top 0.002 0.006 0.014  
## seed\_bottom 0.007 0.020 0.048  
##   
## $E\_B\_contribution\_3yr\_low$S3\_low.E\_B\_summer\_survival\_scenario1  
## seed\_top seed\_bottom plant\_cohort\_1 plant\_cohort\_2  
## seed\_top 0.031 0.113 0.001 0  
## seed\_bottom 0.128 0.466 0.002 0  
## plant\_cohort\_1 0.001 0.003 0.000 0  
## plant\_cohort\_2 0.000 0.000 0.000 0  
## plant\_cohort\_3 0.000 0.000 0.000 0  
## plant\_cohort\_3  
## seed\_top 0  
## seed\_bottom 0  
## plant\_cohort\_1 0  
## plant\_cohort\_2 0  
## plant\_cohort\_3 0  
##   
## $E\_B\_contribution\_3yr\_low$S3\_low.E\_B\_emergence\_scenario1  
## seed\_top seed\_bottom  
## seed\_top 0.065 0.219  
## seed\_bottom 0.179 0.602  
## plant\_cohort\_1 0.001 0.002  
## plant\_cohort\_2 0.000 0.000  
## plant\_cohort\_3 0.000 0.000  
## plant\_cohort\_4 0.000 0.000  
## plant\_cohort\_5 0.000 0.000  
## plant\_cohort\_6 0.000 0.000  
##   
## $E\_B\_contribution\_3yr\_low$S3\_low.E\_B\_spring\_tillage  
## seed\_top seed\_bottom  
## seed\_top 0.098 0.329  
## seed\_bottom 0.264 0.886  
##   
## $E\_B\_contribution\_3yr\_low$C3\_low.E\_B\_overwinter\_scenario1  
## seed\_top seed\_bottom  
## seed\_top 0.046 0.174  
## seed\_bottom 0.135 0.509  
##   
## $E\_B\_contribution\_3yr\_low$C3\_low.E\_B\_post\_harvest\_tillage  
## seed\_top seed\_bottom  
## seed\_top 0.053 0.165  
## seed\_bottom 0.177 0.550  
##   
## $E\_B\_contribution\_3yr\_low$C3\_low.E\_B\_fecundity\_2019  
## seed\_top seed\_bottom plant\_cohort\_1 plant\_cohort\_2 plant\_cohort\_3  
## seed\_top 1381.798 4306.159 0.462 0.828 0.538  
## seed\_bottom 2779.574 8662.114 0.930 1.665 1.082  
## plant\_cohort\_4 plant\_cohort\_5 plant\_cohort\_6  
## seed\_top 0.351 0.044 0.014  
## seed\_bottom 0.705 0.089 0.027  
##   
## $E\_B\_contribution\_3yr\_low$C3\_low.E\_B\_summer\_survival\_scenario1  
## seed\_top seed\_bottom plant\_cohort\_1 plant\_cohort\_2  
## seed\_top 0.036 0.123 0 0  
## seed\_bottom 0.123 0.424 0 0  
## plant\_cohort\_1 0.000 0.000 0 0  
## plant\_cohort\_2 0.000 0.000 0 0  
## plant\_cohort\_3 0.000 0.000 0 0  
## plant\_cohort\_4 0.000 0.000 0 0  
## plant\_cohort\_5 0.000 0.000 0 0  
## plant\_cohort\_6 0.000 0.000 0 0  
## plant\_cohort\_3 plant\_cohort\_4 plant\_cohort\_5 plant\_cohort\_6  
## seed\_top 0 0 0 0  
## seed\_bottom 0 0 0 0  
## plant\_cohort\_1 0 0 0 0  
## plant\_cohort\_2 0 0 0 0  
## plant\_cohort\_3 0 0 0 0  
## plant\_cohort\_4 0 0 0 0  
## plant\_cohort\_5 0 0 0 0  
## plant\_cohort\_6 0 0 0 0  
##   
## $E\_B\_contribution\_3yr\_low$C3\_low.E\_B\_emergence\_scenario1  
## seed\_top seed\_bottom  
## seed\_top 0.067 0.214  
## seed\_bottom 0.168 0.538  
## plant\_cohort\_1 0.000 0.000  
## plant\_cohort\_2 0.001 0.002  
## plant\_cohort\_3 0.000 0.000  
## plant\_cohort\_4 0.000 0.000  
## plant\_cohort\_5 0.000 0.000  
## plant\_cohort\_6 0.000 0.000  
##   
## $E\_B\_contribution\_3yr\_low$C3\_low.E\_B\_spring\_tillage  
## seed\_top seed\_bottom  
## seed\_top 0.015 0.234  
## seed\_bottom 0.070 1.101  
##   
##   
## $E\_B\_contribution\_4yr\_conv  
## $E\_B\_contribution\_4yr\_conv$A4\_conv.E\_B\_overwinter\_scenario1  
## seed\_top seed\_bottom  
## seed\_top 0.008 0.149  
## seed\_bottom 0.016 0.276  
##   
## $E\_B\_contribution\_4yr\_conv$A4\_conv.E\_B\_post\_harvest\_tillage  
## seed\_top seed\_bottom  
## seed\_top 0.006 0.030  
## seed\_bottom 0.113 0.537  
##   
## $E\_B\_contribution\_4yr\_conv$A4\_conv.E\_B\_fecundity\_2019  
## seed\_top seed\_bottom plant\_cohort\_1 plant\_cohort\_2 plant\_cohort\_3  
## seed\_top 665.008 3407.876 7.094 36.784 2.145  
## seed\_bottom 0.085 0.434 0.001 0.005 0.000  
## plant\_cohort\_4 plant\_cohort\_5 plant\_cohort\_6  
## seed\_top 1.674 1.391 1.346  
## seed\_bottom 0.000 0.000 0.000  
##   
## $E\_B\_contribution\_4yr\_conv$A4\_conv.E\_B\_summer\_survival\_scenario1  
## seed\_top seed\_bottom plant\_cohort\_1 plant\_cohort\_2 plant\_cohort\_3  
## seed\_top 0.027 0.155 0.000 0.001 0  
## seed\_bottom 0.044 0.254 0.001 0.002 0  
## plant\_cohort\_4 plant\_cohort\_5 plant\_cohort\_6  
## seed\_top 0 0 0  
## seed\_bottom 0 0 0  
##   
## $E\_B\_contribution\_4yr\_conv$A4\_conv.E\_B\_emergence\_scenario1  
## seed\_top seed\_bottom  
## seed\_top 1.588 0.179  
## seed\_bottom 3.063 0.345  
## plant\_cohort\_1 0.087 0.010  
## plant\_cohort\_2 0.195 0.022  
## plant\_cohort\_3 0.002 0.000  
## plant\_cohort\_4 0.148 0.017  
## plant\_cohort\_5 0.007 0.001  
## plant\_cohort\_6 0.002 0.000  
##   
## $E\_B\_contribution\_4yr\_conv$A4\_conv.E\_B\_spring\_tillage  
## seed\_top seed\_bottom  
## seed\_top 1.918 1.635  
## seed\_bottom 2.559 2.181  
##   
## $E\_B\_contribution\_4yr\_conv$O4\_conv.E\_B\_overwinter\_scenario1  
## seed\_top seed\_bottom  
## seed\_top 0.802 0.766  
## seed\_bottom 1.210 1.156  
##   
## $E\_B\_contribution\_4yr\_conv$O4\_conv.E\_B\_post\_harvest\_tillage  
## seed\_top seed\_bottom  
## seed\_top 1.027 1.694  
## seed\_bottom 1.242 2.049  
##   
## $E\_B\_contribution\_4yr\_conv$O4\_conv.E\_B\_fecundity\_2019  
## seed\_top seed\_bottom plant\_cohort\_1 plant\_cohort\_2 plant\_cohort\_3  
## seed\_top 7668.732 12653.698 2.551 0.739 0.291  
## seed\_bottom 1.563 2.578 0.001 0.000 0.000  
## plant\_cohort\_4 plant\_cohort\_5 plant\_cohort\_6  
## seed\_top 0.159 0.159 0.196  
## seed\_bottom 0.000 0.000 0.000  
##   
## $E\_B\_contribution\_4yr\_conv$O4\_conv.E\_B\_summer\_survival\_scenario1  
## seed\_top seed\_bottom plant\_cohort\_1 plant\_cohort\_2 plant\_cohort\_3  
## seed\_top 0.631 1.166 0 0 0  
## seed\_bottom 0.777 1.436 0 0 0  
##   
## $E\_B\_contribution\_4yr\_conv$O4\_conv.E\_B\_emergence\_scenario1  
## seed\_top seed\_bottom  
## seed\_top 2.761 5.033  
## seed\_bottom 0.907 1.654  
## plant\_cohort\_1 0.000 0.000  
## plant\_cohort\_2 0.001 0.001  
## plant\_cohort\_3 0.000 0.001  
## plant\_cohort\_4 0.000 0.000  
## plant\_cohort\_5 0.000 0.000  
## plant\_cohort\_6 0.000 0.000  
##   
## $E\_B\_contribution\_4yr\_conv$O4\_conv.E\_B\_spring\_tillage  
## seed\_top seed\_bottom  
## seed\_top 2.966 5.406  
## seed\_bottom 3.012 5.491  
##   
## $E\_B\_contribution\_4yr\_conv$S4\_conv.E\_B\_overwinter\_scenario1  
## seed\_top seed\_bottom  
## seed\_top 3.321 6.785  
## seed\_bottom 0.100 0.205  
##   
## $E\_B\_contribution\_4yr\_conv$S4\_conv.E\_B\_post\_harvest\_tillage  
## seed\_top seed\_bottom  
## seed\_top 0.096 0.228  
## seed\_bottom 0.123 0.291  
##   
## $E\_B\_contribution\_4yr\_conv$S4\_conv.E\_B\_fecundity\_2019  
## seed\_top seed\_bottom plant\_cohort\_1 plant\_cohort\_2 plant\_cohort\_3  
## seed\_top 6223.320 14800.211 0.424 1.067 0.745  
## seed\_bottom 0.166 0.395 0.000 0.000 0.000  
## plant\_cohort\_4 plant\_cohort\_5 plant\_cohort\_6  
## seed\_top 0.458 0.205 0.085  
## seed\_bottom 0.000 0.000 0.000  
##   
## $E\_B\_contribution\_4yr\_conv$S4\_conv.E\_B\_summer\_survival\_scenario1  
## seed\_top seed\_bottom plant\_cohort\_1 plant\_cohort\_2 plant\_cohort\_3  
## seed\_top 0.065 0.172 0 0 0  
## seed\_bottom 0.083 0.220 0 0 0  
## plant\_cohort\_4 plant\_cohort\_5 plant\_cohort\_6  
## seed\_top 0 0 0  
## seed\_bottom 0 0 0  
##   
## $E\_B\_contribution\_4yr\_conv$S4\_conv.E\_B\_emergence\_scenario1  
## seed\_top seed\_bottom  
## seed\_top 0.090 0.230  
## seed\_bottom 0.119 0.307  
## plant\_cohort\_1 0.000 0.000  
## plant\_cohort\_2 0.000 0.000  
## plant\_cohort\_3 0.000 0.000  
## plant\_cohort\_4 0.000 0.000  
## plant\_cohort\_5 0.000 0.000  
## plant\_cohort\_6 0.000 0.000  
##   
## $E\_B\_contribution\_4yr\_conv$S4\_conv.E\_B\_spring\_tillage  
## seed\_top seed\_bottom  
## seed\_top 0.105 0.270  
## seed\_bottom 0.193 0.495  
##   
## $E\_B\_contribution\_4yr\_conv$C4\_conv.E\_B\_overwinter\_scenario1  
## seed\_top seed\_bottom  
## seed\_top 0.047 0.137  
## seed\_bottom 0.080 0.232  
##   
## $E\_B\_contribution\_4yr\_conv$C4\_conv.E\_B\_post\_harvest\_tillage  
## seed\_top seed\_bottom  
## seed\_top 0.053 0.153  
## seed\_bottom 0.126 0.367  
##   
## $E\_B\_contribution\_4yr\_conv$C4\_conv.E\_B\_fecundity\_2019  
## seed\_top seed\_bottom plant\_cohort\_1 plant\_cohort\_2 plant\_cohort\_3  
## seed\_top 2789.914 10116.636 136.570 305.243 4.088  
## seed\_bottom 0.118 0.427 0.006 0.013 0.000  
## plant\_cohort\_4 plant\_cohort\_5 plant\_cohort\_6  
## seed\_top 231.696 12.626 4.566  
## seed\_bottom 0.010 0.001 0.000  
##   
## $E\_B\_contribution\_4yr\_conv$C4\_conv.E\_B\_summer\_survival\_scenario1  
## seed\_top seed\_bottom plant\_cohort\_1 plant\_cohort\_2 plant\_cohort\_3  
## seed\_top 0.041 0.162 0 0.001 0  
## seed\_bottom 0.063 0.250 0 0.001 0  
## plant\_cohort\_4 plant\_cohort\_5 plant\_cohort\_6  
## seed\_top 0.000 0 0  
## seed\_bottom 0.001 0 0  
##   
## $E\_B\_contribution\_4yr\_conv$C4\_conv.E\_B\_emergence\_scenario1  
## seed\_top seed\_bottom  
## seed\_top 0.069 0.242  
## seed\_bottom 0.097 0.340  
## plant\_cohort\_1 0.000 0.001  
## plant\_cohort\_2 0.002 0.007  
## plant\_cohort\_3 0.000 0.000  
## plant\_cohort\_4 0.000 0.000  
## plant\_cohort\_5 0.000 0.000  
## plant\_cohort\_6 0.000 0.000  
##   
## $E\_B\_contribution\_4yr\_conv$C4\_conv.E\_B\_spring\_tillage  
## seed\_top seed\_bottom  
## seed\_top 0.023 0.356  
## seed\_bottom 0.043 0.659  
##   
##   
## $E\_B\_contribution\_4yr\_low  
## $E\_B\_contribution\_4yr\_low$A4\_low.E\_B\_overwinter\_scenario1  
## seed\_top seed\_bottom  
## seed\_top 0.006 0.108  
## seed\_bottom 0.011 0.200  
##   
## $E\_B\_contribution\_4yr\_low$A4\_low.E\_B\_post\_harvest\_tillage  
## seed\_top seed\_bottom  
## seed\_top 0.004 0.021  
## seed\_bottom 0.082 0.389  
##   
## $E\_B\_contribution\_4yr\_low$A4\_low.E\_B\_fecundity\_2019  
## seed\_top seed\_bottom plant\_cohort\_1 plant\_cohort\_2 plant\_cohort\_3  
## seed\_top 261.944 1342.347 2.794 14.489 0.845  
## seed\_bottom 0.061 0.314 0.001 0.003 0.000  
## plant\_cohort\_4 plant\_cohort\_5 plant\_cohort\_6  
## seed\_top 0.66 0.548 0.53  
## seed\_bottom 0.00 0.000 0.00  
##   
## $E\_B\_contribution\_4yr\_low$A4\_low.E\_B\_summer\_survival\_scenario1  
## seed\_top seed\_bottom plant\_cohort\_1 plant\_cohort\_2 plant\_cohort\_3  
## seed\_top 0.020 0.112 0 0.001 0  
## seed\_bottom 0.032 0.184 0 0.001 0  
## plant\_cohort\_4 plant\_cohort\_5 plant\_cohort\_6  
## seed\_top 0 0 0  
## seed\_bottom 0 0 0  
##   
## $E\_B\_contribution\_4yr\_low$A4\_low.E\_B\_emergence\_scenario1  
## seed\_top seed\_bottom  
## seed\_top 1.185 0.134  
## seed\_bottom 2.220 0.250  
## plant\_cohort\_1 0.056 0.006  
## plant\_cohort\_2 0.126 0.014  
## plant\_cohort\_3 0.002 0.000  
## plant\_cohort\_4 0.095 0.011  
## plant\_cohort\_5 0.005 0.001  
## plant\_cohort\_6 0.002 0.000  
##   
## $E\_B\_contribution\_4yr\_low$A4\_low.E\_B\_spring\_tillage  
## seed\_top seed\_bottom  
## seed\_top 1.390 1.185  
## seed\_bottom 1.855 1.581  
##   
## $E\_B\_contribution\_4yr\_low$O4\_low.E\_B\_overwinter\_scenario1  
## seed\_top seed\_bottom  
## seed\_top 0.581 0.555  
## seed\_bottom 0.877 0.838  
##   
## $E\_B\_contribution\_4yr\_low$O4\_low.E\_B\_post\_harvest\_tillage  
## seed\_top seed\_bottom  
## seed\_top 0.745 1.228  
## seed\_bottom 0.901 1.485  
##   
## $E\_B\_contribution\_4yr\_low$O4\_low.E\_B\_fecundity\_2019  
## seed\_top seed\_bottom plant\_cohort\_1 plant\_cohort\_2 plant\_cohort\_3  
## seed\_top 8654.467 14280.199 2.879 0.834 0.328  
## seed\_bottom 1.133 1.869 0.000 0.000 0.000  
## plant\_cohort\_4 plant\_cohort\_5 plant\_cohort\_6  
## seed\_top 0.179 0.179 0.221  
## seed\_bottom 0.000 0.000 0.000  
##   
## $E\_B\_contribution\_4yr\_low$O4\_low.E\_B\_summer\_survival\_scenario1  
## seed\_top seed\_bottom plant\_cohort\_1 plant\_cohort\_2 plant\_cohort\_3  
## seed\_top 0.457 0.846 0 0 0  
## seed\_bottom 0.563 1.041 0 0 0  
##   
## $E\_B\_contribution\_4yr\_low$O4\_low.E\_B\_emergence\_scenario1  
## seed\_top seed\_bottom  
## seed\_top 2.001 3.648  
## seed\_bottom 0.658 1.199  
## plant\_cohort\_1 0.000 0.000  
## plant\_cohort\_2 0.000 0.001  
## plant\_cohort\_3 0.000 0.000  
## plant\_cohort\_4 0.000 0.000  
## plant\_cohort\_5 0.000 0.000  
## plant\_cohort\_6 0.000 0.000  
##   
## $E\_B\_contribution\_4yr\_low$O4\_low.E\_B\_spring\_tillage  
## seed\_top seed\_bottom  
## seed\_top 2.150 3.919  
## seed\_bottom 2.184 3.980  
##   
## $E\_B\_contribution\_4yr\_low$S4\_low.E\_B\_overwinter\_scenario1  
## seed\_top seed\_bottom  
## seed\_top 2.407 4.918  
## seed\_bottom 0.073 0.149  
##   
## $E\_B\_contribution\_4yr\_low$S4\_low.E\_B\_post\_harvest\_tillage  
## seed\_top seed\_bottom  
## seed\_top 0.069 0.165  
## seed\_bottom 0.089 0.211  
##   
## $E\_B\_contribution\_4yr\_low$S4\_low.E\_B\_fecundity\_2019  
## seed\_top seed\_bottom plant\_cohort\_1 plant\_cohort\_2 plant\_cohort\_3  
## seed\_top 3939.312 9368.415 0.269 0.675 0.472  
## seed\_bottom 0.121 0.287 0.000 0.000 0.000  
## plant\_cohort\_4 plant\_cohort\_5 plant\_cohort\_6  
## seed\_top 0.29 0.13 0.054  
## seed\_bottom 0.00 0.00 0.000  
##   
## $E\_B\_contribution\_4yr\_low$S4\_low.E\_B\_summer\_survival\_scenario1  
## seed\_top seed\_bottom plant\_cohort\_1 plant\_cohort\_2 plant\_cohort\_3  
## seed\_top 0.047 0.125 0 0 0  
## seed\_bottom 0.060 0.160 0 0 0  
## plant\_cohort\_4 plant\_cohort\_5 plant\_cohort\_6  
## seed\_top 0 0 0  
## seed\_bottom 0 0 0  
##   
## $E\_B\_contribution\_4yr\_low$S4\_low.E\_B\_emergence\_scenario1  
## seed\_top seed\_bottom  
## seed\_top 0.065 0.167  
## seed\_bottom 0.087 0.222  
## plant\_cohort\_1 0.000 0.000  
## plant\_cohort\_2 0.000 0.000  
## plant\_cohort\_3 0.000 0.000  
## plant\_cohort\_4 0.000 0.000  
## plant\_cohort\_5 0.000 0.000  
## plant\_cohort\_6 0.000 0.000  
##   
## $E\_B\_contribution\_4yr\_low$S4\_low.E\_B\_spring\_tillage  
## seed\_top seed\_bottom  
## seed\_top 0.076 0.196  
## seed\_bottom 0.140 0.359  
##   
## $E\_B\_contribution\_4yr\_low$C4\_low.E\_B\_overwinter\_scenario1  
## seed\_top seed\_bottom  
## seed\_top 0.034 0.099  
## seed\_bottom 0.058 0.168  
##   
## $E\_B\_contribution\_4yr\_low$C4\_low.E\_B\_post\_harvest\_tillage  
## seed\_top seed\_bottom  
## seed\_top 0.038 0.111  
## seed\_bottom 0.092 0.266  
##   
## $E\_B\_contribution\_4yr\_low$C4\_low.E\_B\_fecundity\_2019  
## seed\_top seed\_bottom plant\_cohort\_1 plant\_cohort\_2 plant\_cohort\_3  
## seed\_top 2952.864 10707.52 144.546 323.071 4.327  
## seed\_bottom 0.085 0.31 0.004 0.009 0.000  
## plant\_cohort\_4 plant\_cohort\_5 plant\_cohort\_6  
## seed\_top 245.229 13.363 4.833  
## seed\_bottom 0.007 0.000 0.000  
##   
## $E\_B\_contribution\_4yr\_low$C4\_low.E\_B\_summer\_survival\_scenario1  
## seed\_top seed\_bottom plant\_cohort\_1 plant\_cohort\_2 plant\_cohort\_3  
## seed\_top 0.030 0.118 0 0.000 0  
## seed\_bottom 0.046 0.181 0 0.001 0  
## plant\_cohort\_4 plant\_cohort\_5 plant\_cohort\_6  
## seed\_top 0.000 0 0  
## seed\_bottom 0.001 0 0  
##   
## $E\_B\_contribution\_4yr\_low$C4\_low.E\_B\_emergence\_scenario1  
## seed\_top seed\_bottom  
## seed\_top 0.047 0.163  
## seed\_bottom 0.071 0.247  
## plant\_cohort\_1 0.001 0.003  
## plant\_cohort\_2 0.004 0.013  
## plant\_cohort\_3 0.000 0.001  
## plant\_cohort\_4 0.000 0.001  
## plant\_cohort\_5 0.000 0.001  
## plant\_cohort\_6 0.000 0.001  
##   
## $E\_B\_contribution\_4yr\_low$C4\_low.E\_B\_spring\_tillage  
## seed\_top seed\_bottom  
## seed\_top 0.017 0.258  
## seed\_bottom 0.031 0.478