Leslie_HW5

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```
#set up matrix
teasel <- matrix(0, 6, 6)
teasel[1,] <- c(0, 0, 0, 0, 0, 322.38)
teasel[2,] <- c(0.966, 0, 0, 0, 0, 0)
teasel[3,] <- c(0.013, 0.01, 0.125, 0, 0, 3.448)
teasel[4,] <- c(0.007, 0, 0.125, 0.238, 0, 30.17)
teasel[5,] <- c(0.008, 0, 0, 0.245, 0.167, 0.862)
teasel[6,] <- c(0, 0, 0, 0.023, 0.75, 0)
teasel
```

```
##       [,1] [,2]  [,3]  [,4]  [,5]    [,6]
## [1,] 0.000 0.00 0.000 0.000 0.000 322.380
## [2,] 0.966 0.00 0.000 0.000 0.000   0.000
## [3,] 0.013 0.01 0.125 0.000 0.000   3.448
## [4,] 0.007 0.00 0.125 0.238 0.000  30.170
## [5,] 0.008 0.00 0.000 0.245 0.167   0.862
## [6,] 0.000 0.00 0.000 0.023 0.750   0.000
```

```
# population growth rate (λ)
#λ = e^r
λ <- eigen(teasel)$values[1]
λ # = 2.32188
```

```
## [1] 2.32188+0i
```

```
# stable age distribution (re-scale so that the sum = 1)
stable_age_distribution <- round(eigen(teasel)$vectors[ ,1]/sum(eigen(teasel)$vectors[ ,1]),4
)
sum(stable_age_distribution)
```

```
## [1] 1.0001+0i
```

```
stable_age_distribution
```

```
## [1] 0.6369+0i 0.2650+0i 0.0122+0i 0.0693+0i 0.0121+0i 0.0046+0i
```

```
#relative reproductive value (the first element is 1.0)
eigen(t(teasel))
```

```
## eigen() decomposition
## $values
## [1]  2.3218801+0.000000i -0.9573856+1.488566i -0.9573856-1.488566i
## [4]  0.1423853+0.198015i  0.1423853-0.198015i -0.1618797+0.000000i
##
## $vectors
##                  [,1]                        [,2]                        [,3]
## [1,] 1.299554e-03+0i -4.324298e-04+1.555749e-03i -4.324298e-04-1.555749e-03i
## [2,] 1.201025e-05+0i -1.087410e-05-1.192266e-05i -1.087410e-05+1.192266e-05i
## [3,] 2.788635e-03+0i  2.815837e-03-4.772222e-04i  2.815837e-03+4.772222e-04i
## [4,] 4.901038e-02+0i -1.869956e-02+3.766477e-02i -1.869956e-02-3.766477e-02i
## [5,] 3.283103e-01+0i -2.246296e-01-2.973855e-01i -2.246296e-01+2.973855e-01i
## [6,] 9.432926e-01+0i  9.269975e-01+0.000000e+00i  9.269975e-01+0.000000e+00i
##                          [,4]                     [,5]           [,6]
## [1,] -0.06182597+0.00287052i -0.06182597-0.00287052i  0.03929031+0i
## [2,] -0.01296093-0.01116238i -0.01296093+0.01116238i -0.01247880+0i
## [3,]  0.03648725-0.41558172i  0.03648725+0.41558172i  0.20200636+0i
## [4,]  0.66340609+0.00000000i  0.66340609+0.00000000i -0.46361216+0i
## [5,] -0.24617967+0.54395873i -0.24617967-0.54395873i  0.78917730+0i
## [6,] -0.13553648-0.08284885i -0.13553648+0.08284885i -0.34605916+0i
```

```
stable_age_distribution_t <- 1000*round(eigen(t(teasel))$vectors[ ,1]/sum(eigen(t(teasel))$ve
ctors[ ,1]),4)
stable_age_distribution_t
```

```
## [1]   1.0+0i   0.0+0i   2.1+0i  37.0+0i 247.8+0i 712.1+0i
```

##Sensitivity

```
growth.rate.1.1 <- matrix(nrow = 6, ncol = 6)
for (i in 1:6){
  for (j in 1:6){
    teasel.new <- teasel
    teasel.new[i,j] <- teasel.new[i,j]*1.1
    growth.rate.1.1[i,j] <- eigen(teasel.new)$values[1]
  }
}
growth.rate.1.1
```

```
##              [,1]        [,2]        [,3]        [,4]        [,5]        [,6]
## [1,] 2.321880+0i 2.321880+0i 2.321880+0i 2.321880+0i 2.321880+0i 2.337072+0i
## [2,] 2.321939+0i 2.321880+0i 2.321880+0i 2.321880+0i 2.321880+0i 2.321880+0i
## [3,] 2.322064+0i 2.321939+0i 2.321914+0i 2.321880+0i 2.321880+0i 2.322231+0i
## [4,] 2.323618+0i 2.321880+0i 2.322474+0i 2.328355+0i 2.321880+0i 2.374782+0i
## [5,] 2.335127+0i 2.321880+0i 2.321880+0i 2.365286+0i 2.327171+0i 2.332220+0i
## [6,] 2.321880+0i 2.321880+0i 2.321880+0i 2.333847+0i 2.388039+0i 2.321880+0i
```

```
#Sensitivity value
#new teasel - old teasel = 0.1*teasel
growth.rate.new <- (growth.rate.1.1-eigen(teasel)$values[1])/0.1*teasel
growth.rate.new
```

```
##                  [,1]             [,2]             [,3]            [,4]
## [1,] 0.000000e+00+0i 0.000000e+00+0i 0.000000e+00+0i 0.000000000+0i
## [2,] 5.686097e-04+0i 0.000000e+00+0i 0.000000e+00+0i 0.000000000+0i
## [3,] 2.390713e-05+0i 5.886229e-06+0i 4.250108e-05+0i 0.000000000+0i
## [4,] 1.216765e-04+0i 0.000000e+00+0i 7.422720e-04+0i 0.015409048+0i
## [5,] 1.059776e-03+0i 0.000000e+00+0i 0.000000e+00+0i 0.106344929+0i
## [6,] 0.000000e+00+0i 0.000000e+00+0i 0.000000e+00+0i 0.002752294+0i
##                 [,5]           [,6]
## [1,] 0.000000000+0i 48.97660598+0i
## [2,] 0.000000000+0i  0.00000000+0i
## [3,] 0.000000000+0i  0.01211209+0i
## [4,] 0.000000000+0i 15.96059401+0i
## [5,] 0.008835874+0i  0.08912939+0i
## [6,] 0.496191443+0i  0.00000000+0i
```

```
#the two matrix elements (in terms of life histories) that caused the
#largest increase in population growth rate
growth.rate.new.percentage <- round(growth.rate.new*teasel/eigen(teasel)$values[1],4)
growth.rate.new.percentage
```

```
##          [,1] [,2] [,3]      [,4]      [,5]         [,6]
## [1,] 0e+00+0i 0+0i 0+0i 0.0000+0i 0.0000+0i 6800.1263+0i
## [2,] 2e-04+0i 0+0i 0+0i 0.0000+0i 0.0000+0i    0.0000+0i
## [3,] 0e+00+0i 0+0i 0+0i 0.0000+0i 0.0000+0i    0.0180+0i
## [4,] 0e+00+0i 0+0i 0+0i 0.0016+0i 0.0000+0i  207.3884+0i
## [5,] 0e+00+0i 0+0i 0+0i 0.0112+0i 0.0006+0i    0.0331+0i
## [6,] 0e+00+0i 0+0i 0+0i 0.0000+0i 0.1603+0i    0.0000+0i
```

#From the result, we can know the two matrix elements is at [1,6] & [4,6]