BIO311: Population Ecology
Prac 8: Life tables & Population Matrices

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Contents

This is 1 out of 3 methods (so far) for extracting transition rates from the raw data.

1 Preparing the data

```
rot<-read.csv("rdata.csv",header=T,sep=",")
```

Since we aim for transitions, rearrange the data, for the transition from timestep 1 to 2:

```
rot1<-subset(rot,Day==1)
rot2<-subset(rot,Day==2)
rot12<-merge(rot1,rot2,by=c("Population","Copper","Replicate"))
```

And for the transition from 2 to 3:

```
rot3<-subset(rot,Day==3)
rot23<-merge(rot2,rot3,by=c("Population","Copper","Replicate"))
```

And we create one super object that contains all transitions:

```
rot123<-rbind(rot12,rot23)
```

2 Finding transition rates based on linear fits (`lm`)

First we focus only on the transition from timestep 2 to 3

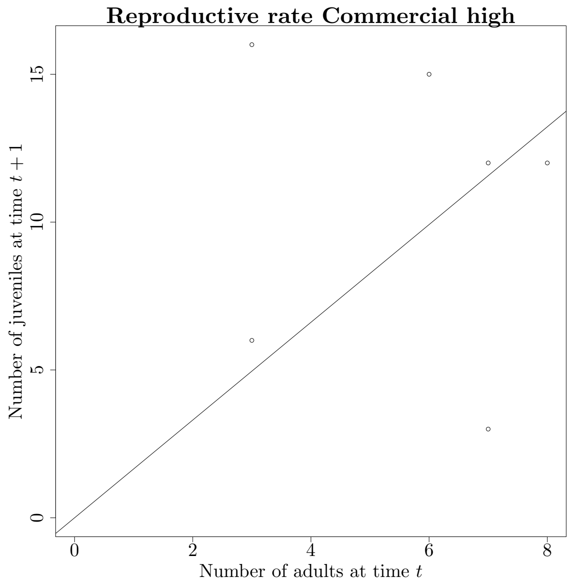
```
library('xtable')
store<-data.frame(Population=c(NA),Copper=c(NA),R=c(NA),SA=c(NA),SJ=c(NA))
for(i in levels(rot123$Population)){
  temp<-subset(rot23,Population==i)
  for(j in levels(rot123$Copper)){
        # Selecting the correct part of the dataset:
    temp2<-subset(temp,Copper==j)

    cat("\\subsection{",i,j,"}\n")
    cat("\\subsubsection{Determining reproduction}\n\n")
    cat("First we fit a value for the reproductive rate using \\texttt{lm} where we force th

    par(mar=c(6,6,2,2))
    plot(temp2$Alive_Adult.x,temp2$Alive_Juv.y,xlab="Number of adults at time $t$",ylab="Nun
```

```
    reg1<-lm(temp2$Alive_Juv.y~temp2$Alive_Adult.x+0)
    abline(reg1)
    cat("\n From this regression we found that R=",reg1$coef[[1]],"\n\n")

    cat("\\subsubsection{Determining survival}\n\n")
    cat("Now we perform a second regression. We fit a plane in which the number of adults ne
    reg2<-lm(temp2$Alive_Adult.y~temp2$Alive_Adult.x+temp2$Alive_Juv.x+0)
    cat("\\\\From this we find:\\\\ \n$S_A=$",reg2$coef[[1]],"\n$S_J=$",reg2$coef[[2]],"\n")

    storet<-data.frame(Population=c(i),Copper=c(j),R=c(reg1$coef[[1]]),SA=c(reg2$coef[[1]]),
    store<-rbind(store,storet)
  }

}
```

2.1 Commercial high

2.1.1 Determining reproduction

First we fit a value for the reproductive rate using `lm` where we force the line to go through 0.



From this regression we found that R= 1.653

2.1.2 Determining survival

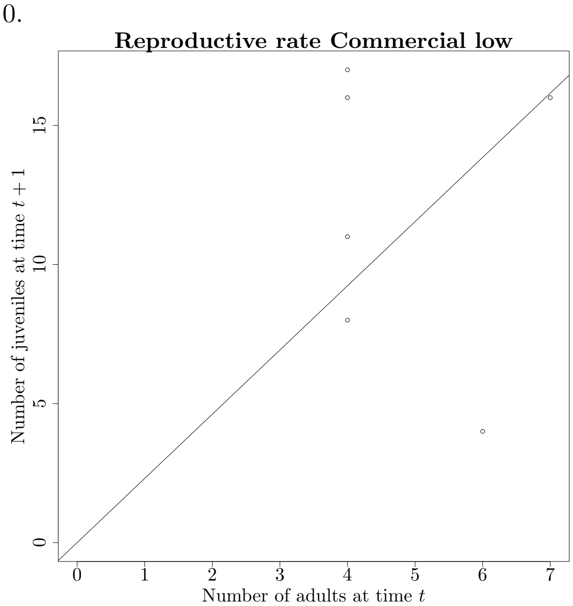
Now we perform a second regression. We fit a plane in which the number of adults next year depends on both the number of juveniles this year and the

number of adults this year
From this we find:
$S_A = 1.698$ $S_J = 0.5537$

2.2 Commercial low

2.2.1 Determining reproduction

First we fit a value for the reproductive rate using `lm` where we force the line to go through 0.



From this regression we found that R= 2.309

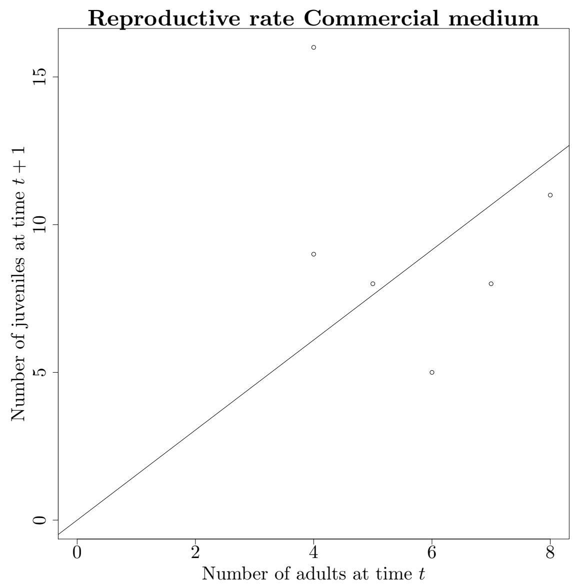
2.2.2 Determining survival

Now we perform a second regression. We fit a plane in which the number of adults next year depends on both the number of juveniles this year and the number of adults this year
From this we find:
$S_A = 0.893$ $S_J = 1.039$

2.3 Commercial medium

2.3.1 Determining reproduction

First we fit a value for the reproductive rate using `lm` where we force the line to go through 0.



From this regression we found that R= 1.524

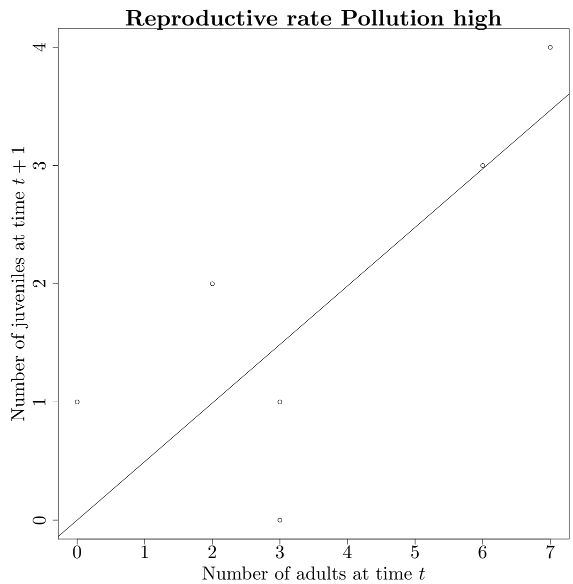
2.3.2 Determining survival

Now we perform a second regression. We fit a plane in which the number of adults next year depends on both the number of juveniles this year and the number of adults this year
From this we find:
$S_A = 1.669$ $S_J = 0.3427$

2.4 Pollution high

2.4.1 Determining reproduction

First we fit a value for the reproductive rate using `lm` where we force the line to go through 0.



From this regression we found that R= 0.4953

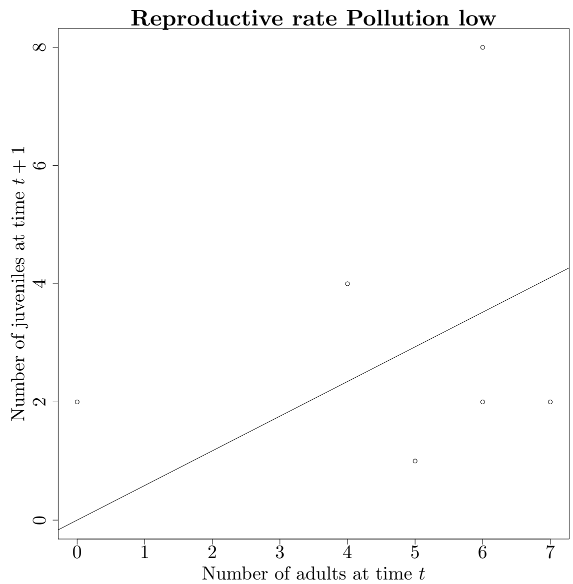
2.4.2 Determining survival

Now we perform a second regression. We fit a plane in which the number of adults next year depends on both the number of juveniles this year and the number of adults this year
From this we find:
S_A = 1.295 S_J = -0.07418

2.5 Pollution low

2.5.1 Determining reproduction

First we fit a value for the reproductive rate using `lm` where we force the line to go through 0.



From this regression we found that R= 0.5864

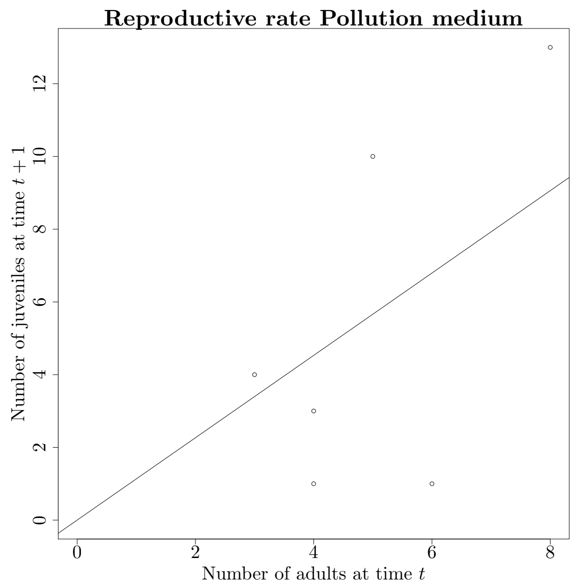
2.5.2 Determining survival

Now we perform a second regression. We fit a plane in which the number of adults next year depends on both the number of juveniles this year and the number of adults this year
From this we find:
$S_A = 1.373$ $S_J = 0.424$

2.6 Pollution medium

2.6.1 Determining reproduction

First we fit a value for the reproductive rate using `lm` where we force the line to go through 0.



From this regression we found that R= 1.133

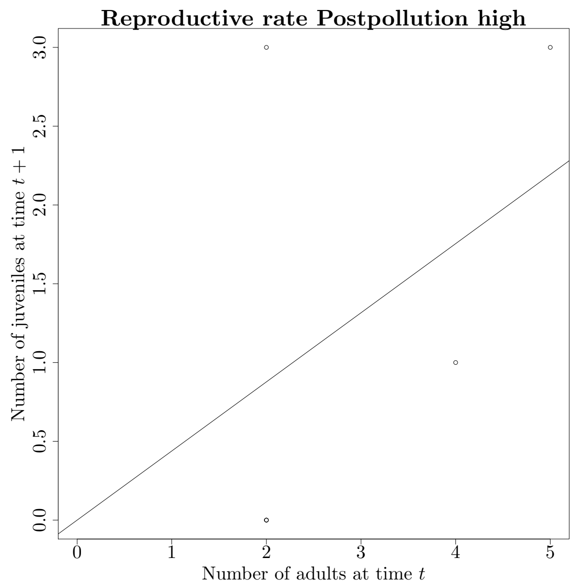
2.6.2 Determining survival

Now we perform a second regression. We fit a plane in which the number of adults next year depends on both the number of juveniles this year and the number of adults this year
From this we find:
S_A = 1.086 S_J = -0.08364

2.7 Postpollution high

2.7.1 Determining reproduction

First we fit a value for the reproductive rate using `lm` where we force the line to go through 0.



From this regression we found that R= 0.4386

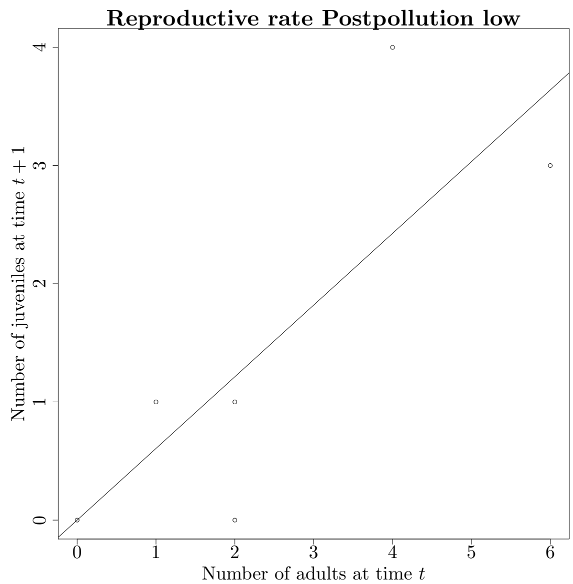
2.7.2 Determining survival

Now we perform a second regression. We fit a plane in which the number of adults next year depends on both the number of juveniles this year and the number of adults this year
From this we find:
$S_A = 1.024$ $S_J = 0.4491$

2.8 Postpollution low

2.8.1 Determining reproduction

First we fit a value for the reproductive rate using `lm` where we force the line to go through 0.



From this regression we found that R= 0.6066

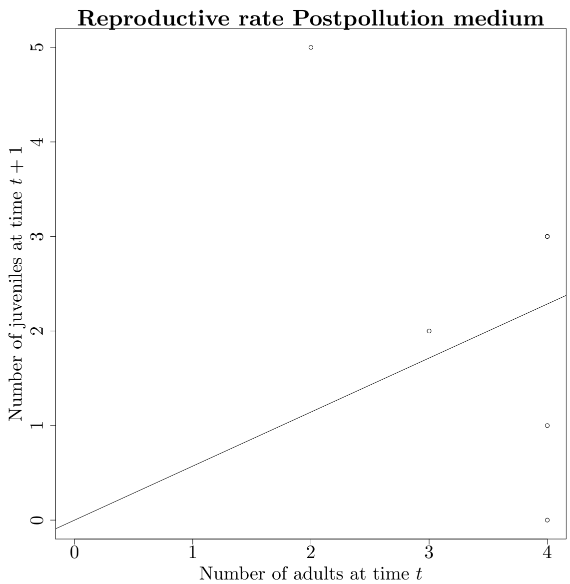
2.8.2 Determining survival

Now we perform a second regression. We fit a plane in which the number of adults next year depends on both the number of juveniles this year and the number of adults this year
From this we find:
$S_A = 0.07692$ $S_J = 4.692$

2.9 Postpollution medium

2.9.1 Determining reproduction

First we fit a value for the reproductive rate using `lm` where we force the line to go through 0.



From this regression we found that R= 0.5714

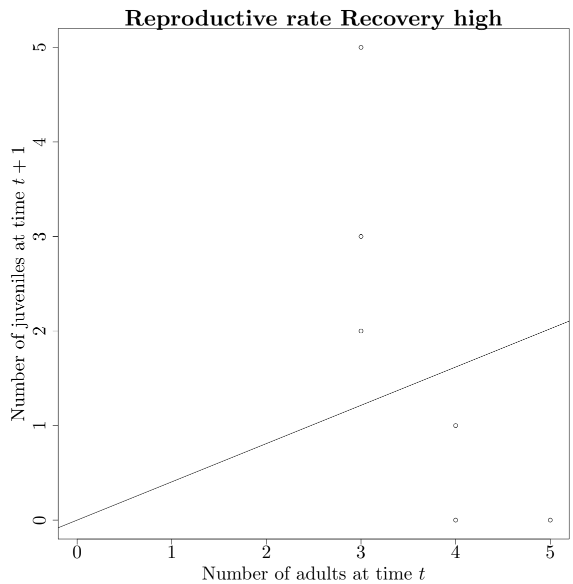
2.9.2 Determining survival

Now we perform a second regression. We fit a plane in which the number of adults next year depends on both the number of juveniles this year and the number of adults this year
From this we find:
S_A = 0.8715 S_J = -0.257

2.10 Recovery high

2.10.1 Determining reproduction

First we fit a value for the reproductive rate using `lm` where we force the line to go through 0.



From this regression we found that R= 0.4048

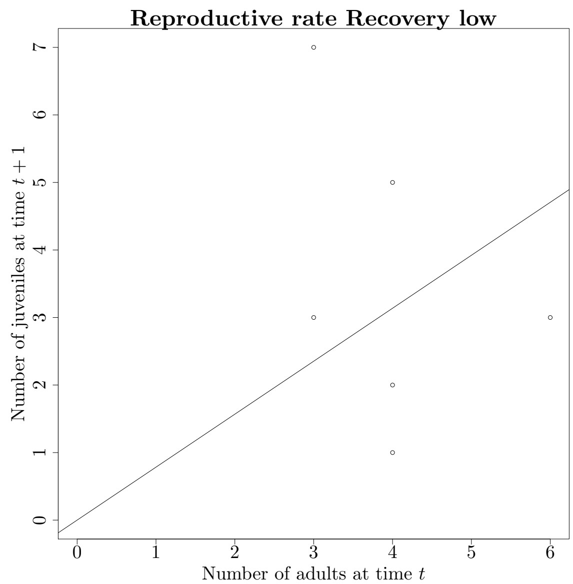
2.10.2 Determining survival

Now we perform a second regression. We fit a plane in which the number of adults next year depends on both the number of juveniles this year and the number of adults this year
From this we find:
$S_A = 1.097$ $S_J = 0.4803$

2.11 Recovery low

2.11.1 Determining reproduction

First we fit a value for the reproductive rate using `lm` where we force the line to go through 0.



From this regression we found that R= 0.7843

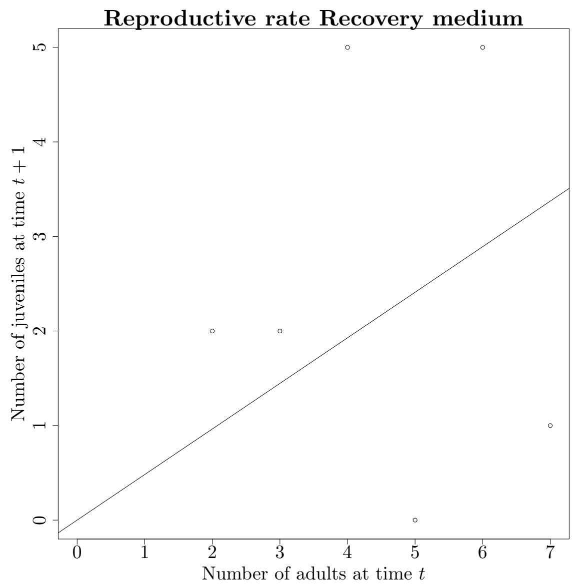
2.11.2 Determining survival

Now we perform a second regression. We fit a plane in which the number of adults next year depends on both the number of juveniles this year and the number of adults this year
From this we find:
$S_A = 0.8964$ $S_J = 0.5193$

2.12 Recovery medium

2.12.1 Determining reproduction

First we fit a value for the reproductive rate using `lm` where we force the line to go through 0.



From this regression we found that R= 0.482

2.12.2 Determining survival

Now we perform a second regression. We fit a plane in which the number of adults next year depends on both the number of juveniles this year and the number of adults this year
From this we find:
S_A = 1.09 S_J = -0.1955

```
cat("\\subsection{Summary of the data for the 2--3 transition}")
```

2.13 Summary of the data for the 2–3 transition

```
store<-store[-1,]
print(xtable(store, digits=2),
      size="footnotesize", #Change size; useful for bigger tables
      include.rownames=FALSE, #Don't print rownames
      include.colnames=FALSE, #We create them ourselves
      floating=FALSE,
      hline.after=NULL, #We don't need hline; we use booktabs
      add.to.row = list(pos = list(-1,
                             nrow(store)),
                   command = c(paste("\\toprule \n",
                                "$Population$ & $Copper$ & $R$ & $S_A$ & $S_J$ \\
                                "\\midrule \n"),
```

```
                                          "\\bottomrule \n")
                         ))
```

Population	*Copper*	*R*	S_A	S_J
Commercial	high	1.65	1.70	0.55
Commercial	low	2.31	0.89	1.04
Commercial	medium	1.52	1.67	0.34
Pollution	high	0.50	1.30	-0.07
Pollution	low	0.59	1.37	0.42
Pollution	medium	1.13	1.09	-0.08
Postpollution	high	0.44	1.02	0.45
Postpollution	low	0.61	0.08	4.69
Postpollution	medium	0.57	0.87	-0.26
Recovery	high	0.40	1.10	0.48
Recovery	low	0.78	0.90	0.52
Recovery	medium	0.48	1.09	-0.20

```
cat("\\subsection{Summary of the data for both transitions}")
```

2.14 Summary of the data for both transitions

```
store<-data.frame(Population=c(NA),Copper=c(NA),R=c(NA),SA=c(NA),SJ=c(NA))
for(i in levels(rot123$Population)){
  temp<-subset(rot123,Population==i)
  for(j in levels(rot123$Copper)){
        # Selecting the correct part of the dataset:
    temp2<-subset(temp,Copper==j)
    reg1<-lm(temp2$Alive_Juv.y~temp2$Alive_Adult.x+0)
    reg2<-lm(temp2$Alive_Adult.y~temp2$Alive_Adult.x+temp2$Alive_Juv.x+0)

    storet<-data.frame(Population=c(i),Copper=c(j),R=c(reg1$coef[[1]]),SA=c(reg2$coef[[1]]),
    store<-rbind(store,storet)
  }

}
store<-store[-1,]
print(xtable(store, digits=2),
      size="footnotesize", #Change size; useful for bigger tables
      include.rownames=FALSE, #Don't print rownames
      include.colnames=FALSE, #We create them ourselves
      floating=FALSE,
      hline.after=NULL, #We don't need hline; we use booktabs
      add.to.row = list(pos = list(-1,
                                   nrow(store)),
                        command = c(paste("\\toprule \n",
                                          "$Population$ & $Copper$ & $R$ & $S_A$ & $S_J$ \\
                                          "\\midrule \n"),
```

```
                                     "\\bottomrule \n")
                        ))
```

Population	*Copper*	R	S_A	S_J
Commercial	high	1.59	1.72	0.42
Commercial	low	2.26	0.75	1.09
Commercial	medium	1.55	1.66	0.32
Pollution	high	0.48	1.31	-0.13
Pollution	low	0.59	1.40	0.24
Pollution	medium	1.09	0.79	0.61
Postpollution	high	0.40	1.15	-0.10
Postpollution	low	0.40	0.95	-0.04
Postpollution	medium	0.69	0.76	0.09
Recovery	high	0.62	1.14	0.29
Recovery	low	0.78	0.94	0.42
Recovery	medium	0.36	1.05	0.30

3 Taking into account that $0 < S_J < 1$ and $0 < S_A < 1$

We now use `nls()` to ensure that both S_J and S_A stay between 0 and 1. (not sure if this is the best solution, but at least it is a solution.)

```
library('xtable')
store<-data.frame(Population=c(NA),Copper=c(NA),R=c(NA),SA=c(NA),SJ=c(NA))
for(i in levels(rot123$Population)){
  temp<-subset(rot123,Population==i)
  for(j in levels(rot123$Copper)){
        # Selecting the correct part of the dataset:
    temp2<-subset(temp,Copper==j)
    reg1<-lm(temp2$Alive_Juv.y~temp2$Alive_Adult.x+0)
    y<-temp2$Alive_Adult.y
    x1<-temp2$Alive_Adult.x
    x2<-temp2$Alive_Juv.x
    nlsfit<-nls(y~sa*x1+sj*x2,start=c(sa=0.5,sj=0.5),upper=c(sa=1,sj=1),lower=c(sa=0,sj=0),a

    storet<-data.frame(Population=c(i),Copper=c(j),R=c(reg1$coef[[1]]),SA=c(coef(nlsfit)[[1
    store<-rbind(store,storet)
  }

}
store<-store[-1,]
print(xtable(store, digits=2),
      size="footnotesize", #Change size; useful for bigger tables
      include.rownames=FALSE, #Don't print rownames
      include.colnames=FALSE, #We create them ourselves
```

```
      floating=FALSE,
      hline.after=NULL, #We don't need hline; we use booktabs
      add.to.row = list(pos = list(-1,
                                   nrow(store)),
                        command = c(paste("\\toprule \n",
                                          "$Population$ & $Copper$ & $R$ & $S_A$ & $S_J$ \\\
                                          "\\midrule \n"),
                                    "\\bottomrule \n")
                        ))
```

$Population$	$Copper$	R	S_A	S_J
Commercial	high	1.59	1.00	1.00
Commercial	low	2.26	0.85	1.00
Commercial	medium	1.55	1.00	0.96
Pollution	high	0.48	1.00	0.25
Pollution	low	0.59	1.00	0.72
Pollution	medium	1.09	0.79	0.61
Postpollution	high	0.40	1.00	0.06
Postpollution	low	0.40	0.92	0.00
Postpollution	medium	0.69	0.76	0.09
Recovery	high	0.62	1.00	0.42
Recovery	low	0.78	0.94	0.42
Recovery	medium	0.36	1.00	0.35

```
store$lambda<-NA
library('popbio')

## Loading required package:  quadprog

for(i in 1:length(store$SJ)){
A<-matrix(c(0,store$SJ[i],store$R[i],store$SA[i]),nrow=2)

  store$lambda[i]<-lambda(A)
}
print(xtable(store, digits=4),
      size="footnotesize", #Change size; useful for bigger tables
      include.rownames=FALSE, #Don't print rownames
      include.colnames=FALSE, #We create them ourselves
      floating=FALSE,
      hline.after=NULL, #We don't need hline; we use booktabs
      add.to.row = list(pos = list(-1,
                                   nrow(store)),
                        command = c(paste("\\toprule \n",
                                          "$Population$ & $Copper$ & $R$ & $S_A$ & $S_J$ & $
                                          "\\midrule \n"),
                                    "\\bottomrule \n")
                        ))
```

Population	*Copper*	R	S_A	S_J	λ
Commercial	high	1.5889	1.0000	1.0000	1.8561
Commercial	low	2.2562	0.8522	1.0000	1.9874
Commercial	medium	1.5538	1.0000	0.9565	1.8177
Pollution	high	0.4783	1.0000	0.2500	1.1079
Pollution	low	0.5926	1.0000	0.7241	1.3241
Pollution	medium	1.0900	0.7948	0.6130	1.3063
Postpollution	high	0.3962	1.0000	0.0645	1.0249
Postpollution	low	0.4000	0.9217	0.0000	0.9217
Postpollution	medium	0.6928	0.7583	0.0945	0.8366
Recovery	high	0.6165	1.0000	0.4153	1.2114
Recovery	low	0.7821	0.9356	0.4224	1.2089
Recovery	medium	0.3591	1.0000	0.3529	1.1138

4 What the students found

Population	*Copper*	R	S_A	S_J	λ
Commercial	high	2.8557	0.9523	0.8917	2.1414
Commercial	low	3.3523	0.9523	0.8555	2.2353
Commercial	medium	2.2175	0.9583	0.9207	1.9862
Pollution	high	0.5126	0.8334	0.5833	1.1042
Pollution	low	0.8452	0.6695	0.5833	1.1126
Pollution	medium	1.2013	0.8790	0.3195	1.1991
Postpollution	high	0.5750	0.5833	0.4167	0.8614
Postpollution	low	1.0000	0.5833	0.2500	0.8705
Postpollution	medium	1.1528	0.5833	0.4000	1.0307
Recovery	high	0.5973	0.9583	0.7222	1.2922
Recovery	low	0.8888	0.8888	0.5833	1.2906
Recovery	medium	0.5912	0.7112	0.2000	0.8502