Figures

Henry Traynor

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```
set.seed(1)

att.param <- list(n1 = 500,
                  n2 = 0,
                  b1 = 0.65,
                  b2 = 0.65,
                  k1 = 500,
                  k2 = 500,
                  a12 = 1,
                  a21 = 1,
                  a11 = 1,
                  a22 = 1,
                  del1 = 0,
                  del2 = 2)

singleWindow.time.param <- list(tau = 1/52,
                                time.invade = 0,
                                time.window = 52,
                                time.index = 520)

source("parameter/modelParam.R")
source("simulations/alphaSim.R")
source("statistics/singleWindowStat.R")
```

```
## This is GoeVeg 0.7.2 - build: 2024-02-06
```

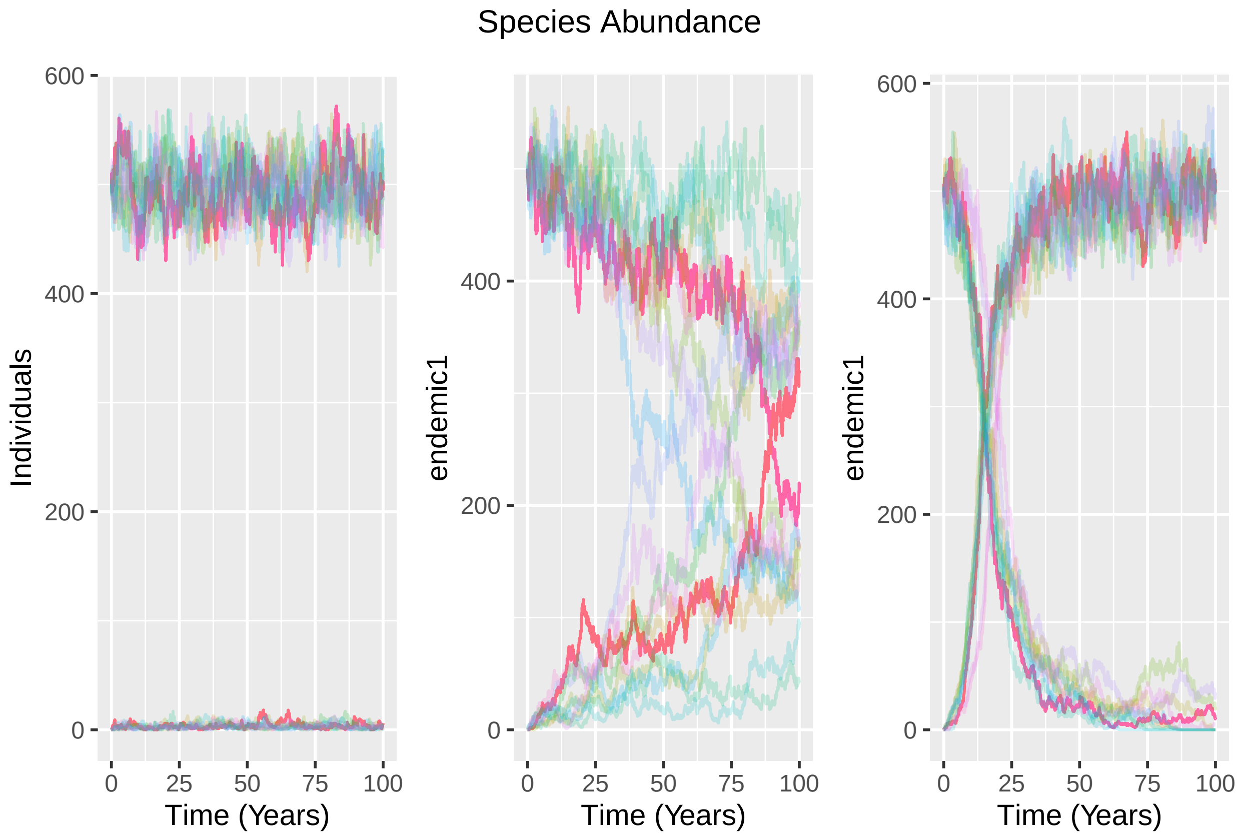
```
source("simulations/halfAndHalf.R")
source("statistics/ROCcurveData.R")
```

1. Outcomes of Model

These plots display the three outcomes of the Lotka-Volterra Competition model: endemic survival, coexistence, and invader success.

```
library(ggplot2)
library(cowplot)
library(gridExtra)
library(grid)
library(reshape2)
```

```
setOfAlphaSimPlot <- function(numRealizations, att.param, singleWindow.time.param, do.prob, ratio.max, t
  time.max = ttb*2
  tau = singleWindow.time.param$tau
  df.data <- data.frame(time=seq(0,time.max, by=tau))
  i=0
  while(i<numRealizations) {
    df.subData = alphaSim(att.param, singleWindow.time.param, do.prob, ratio.max, ttb, do.win)
    colnames(df.subData) = c("time", paste("endemic",i+1,sep=""), paste("invader",i+1,sep=""), "ratio")
    df.data = cbind(df.data, df.subData[2:3])
    i=i+1
  }
  plot = ggplot(data=df.data, aes(x=time)) + xlab("Time (Years)")
  plot = plot + geom_line(aes(y=endemic1, color="Endemic")) + geom_line(aes(y=invader1, color="Invader"
  df.data = melt(df.data, id.vars="time")
  plot = plot + geom_line(data=df.data, aes(time,value,color=variable), alpha=0.2) + theme(legend.positi
  return(plot)
}

endemic <- setOfAlphaSimPlot(numRealizations=10, att.param, singleWindow.time.param, do.prob=TRUE, rati
coexistence <- setOfAlphaSimPlot(numRealizations=10, att.param, singleWindow.time.param, do.prob=TRUE, r
invader <- setOfAlphaSimPlot(numRealizations=10, att.param, singleWindow.time.param, do.prob=TRUE, rati

grid.arrange(textGrob("Species Abundance", gp=gpar(size=32)), endemic+ylab("Individuals"), coexistence+
             ncol=3, nrow = 2,
             layout_matrix = rbind(c(1,1,1), c(2,3,4)),
             widths = c(13,13,13), heights = c(0.25, 2.5))
```



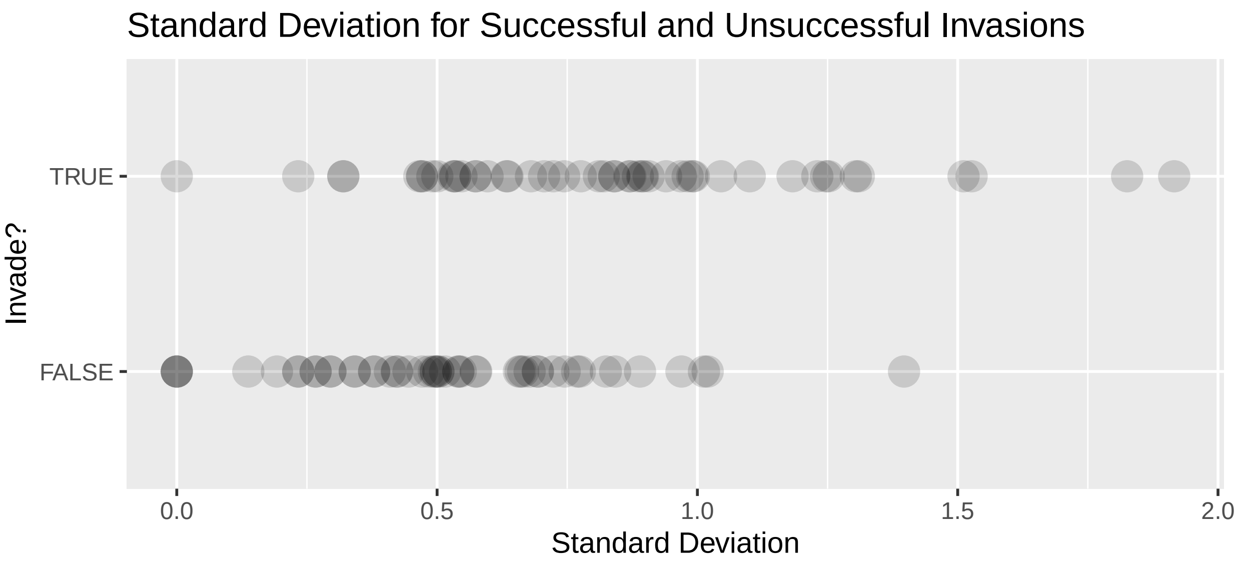
2. Two Types of Realizations

```r
library(ggplot2)

setOfIncAlphaSimPlot <- function(numRealizations, att.param, singleWindow.time.param, do.prob, ttb) {
  time.max = ttb*2
  tau = singleWindow.time.param$tau
  df.data <- data.frame(time=seq(0,time.max, by=tau))
  i=0
  while(i<numRealizations) {
    df.subData1 = alphaSim(att.param, singleWindow.time.param, do.prob=TRUE, ratio.max=2, ttb=50, do.wi
    colnames(df.subData1) = c("time", paste("endemic",i+1,sep=""), paste("invaderInc",i+1,sep=""), "rat
    df.subData2 = alphaSim(att.param, singleWindow.time.param, do.prob=TRUE, ratio.max=0.5, ttb=50, do.w
    colnames(df.subData2) = c("time", paste("endemic",i+1,sep=""), paste("invaderConstant",i+1,sep=""),
    df.data = cbind(df.data, df.subData1[3], df.subData2[3])
    i=i+1
  }
  plot = ggplot(data=df.data, aes(x=time)) + xlab("Time(Years)")
  plot = plot + geom_line(aes(y=invaderInc1, color="Increasing")) + geom_line(aes(y=invaderConstant1, c
  df.data = melt(df.data, id.vars="time")
  plot = plot + geom_line(data=df.data, aes(time,value,color=variable), alpha=0.2) + theme(legend.posit
  return(plot)
}

typesPlot <- setOfIncAlphaSimPlot(10, att.param, singleWindow.time.param, do.prob=TRUE, ttb=50)
```

3. Single Window Statistics

```r
library(gridExtra)
library(ggplot2)
df.test <- halfAndHalf(att.param,
                       singleWindow.time.param,
                       ttb=25,
                       halfSimulations=50,
                       win.ratio=2,
                       fail.ratio=0.1)

df.SD <- singleWindowStat(df.data=df.test,
                          time.window=52,
                          time.index=520,
                          func="sd")

endemic.data = data.frame(endemic=c(att.param[1],att.param[3],att.param[5],att.param[7],att.param[9],att
colnames(endemic.data) = c('Initial N', 'Birth Rate', 'Carrying Cap.', 'Initial Inter.', 'Intra.', 'Imm
invader.data = data.frame(invader=c(att.param[2],att.param[4],att.param[6],att.param[8],att.param[10],at
colnames(invader.data) = c('Initial N', 'Birth Rate', 'Carrying Cap.', 'Initial Inter.', 'Intra.', 'Imm
parameters = rbind(endemic.data, invader.data)
rownames(parameters) = c("endemic", 'invader')

time.parameters = as.data.frame(t(c('1 Week', '10 Years', '1 Year', '50 each')))
colnames(time.parameters) = c('Tau', 'Window Start', 'Window Length', 'Realizations')
```

```r
rownames(time.parameters) = c('value')

plot <-ggplot(data=df.SD,
       aes(x=stat, y=do.win)) +
       geom_point(alpha=0.15, size=5) +
       labs(x='Standard Deviation', y="Invade?") +
       ggtitle("Standard Deviation for Successful and Unsuccessful Invasions")

grid.arrange(
  arrangeGrob(plot),
  tableGrob(parameters),
  tableGrob(time.parameters),
  layout_matrix = cbind(c(1,1,1,1,2,3),
                        c(1,1,1,1,2,3),
                        c(1,1,1,1,2,3),
                        c(1,1,1,1,2,3))
)
```



	Initial N	Birth Rate	Carrying Cap.	Initial Inter.	Intra.	Immigration
endemic	500	0.65	500	1	1	0
invader	0	0.65	500	1	1	2

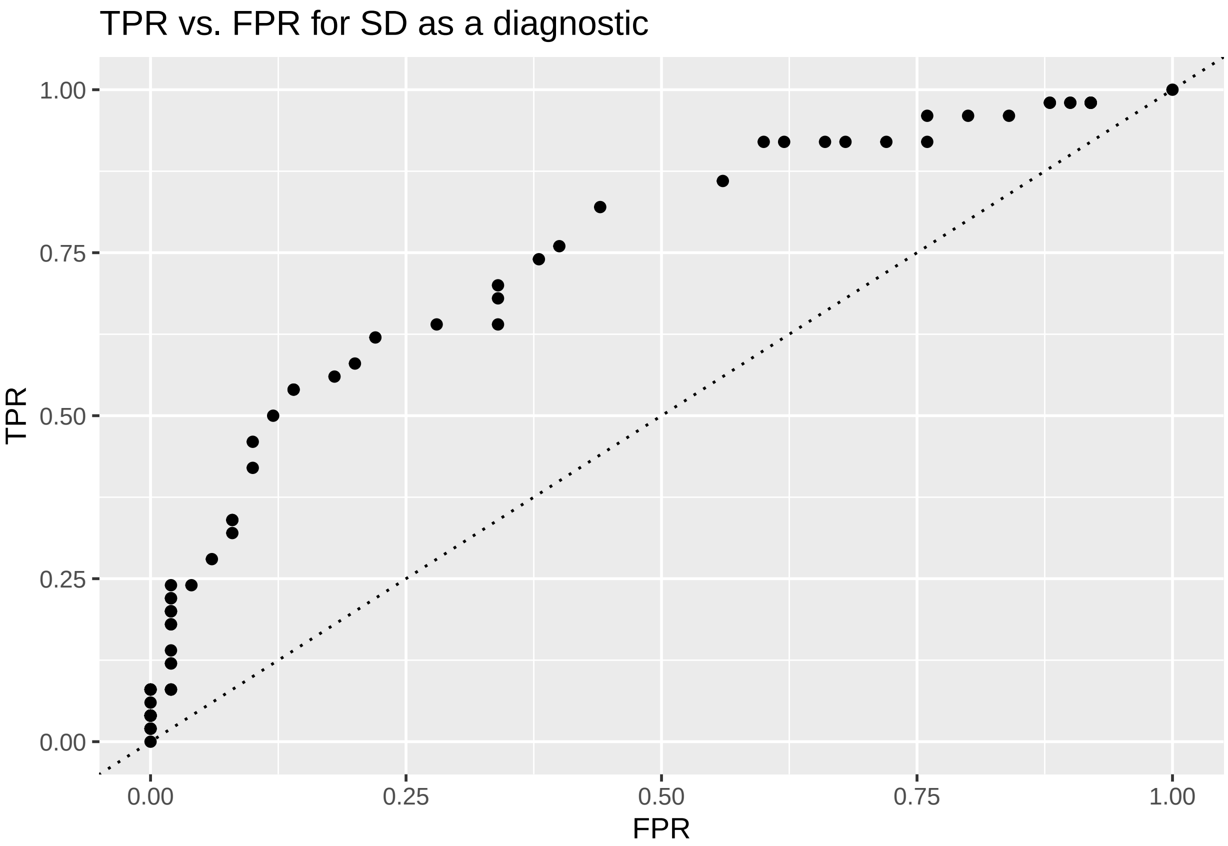
	Tau	Window Start	Window Length	Realizations
value	1 Week	10 Years	1 Year	50 each

## ROC Curve for Single Stat

```r
library(DescTools)
df.rates <- ROCcurveData(df.SD, numThresholds = 75, inequality = ">", statistic="sd")
auc <- AUC(x=df.rates$FPR, y=df.rates$TPR, method='trapezoid')
```

```
## Warning in regularize.values(x, y, ties, missing(ties), na.rm = na.rm):
## collapsing to unique 'x' values
```

```
ggplot(data=df.rates, aes(x=FPR, y=TPR)) + geom_point() + geom_abline(slope=1, intercept=0, linetype=3)
```



## 4. Several Statistics and Realization Types

```
library(goeveg)
library(moments)
# increasing ratio
df.increasing <- halfAndHalf(att.param, singleWindow.time.param, ttb=25, halfSimulations=100, win.ratio
# constant ratio: a12 > a21
df.constant <- halfAndHalf(att.param, singleWindow.time.param, ttb=25, halfSimulations=100, win.ratio=2

#statistics
stats <- c("mean", "sd", "cv", "kurtosis", "skewness")
inequalities <- c(">", ">", "<", "<", "<")
windows <- c(52,104,156)
time.index=520

singleStatWindows <- function(df.data, windows, time.index, statsNum) {
  df1 <- singleWindowStat(df.data, time.window=windows[1], time.index, func=stats[statsNum])
  df2 <- singleWindowStat(df.data, time.window=windows[2], time.index, func=stats[statsNum])
  df3 <- singleWindowStat(df.data, time.window=windows[3], time.index, func=stats[statsNum])
  df.stat.type <- cbind(df1,df2,df3)
  colnames(df.stat.type) = c("do.win", "stat1","do.win2", "stat2","do.win3", "stat3")
  return(df.stat.type)
}

dfListing <- function(df.increasing, df.constant, stats) {
  statsList = list()
  for(i in 1:length(stats)) {
    df.stat.increasing = singleStatWindows(df.increasing, windows, time.index, i)
    df.stat.increasing = subset(df.stat.increasing, select = -c(do.win2, do.win3))
    df.stat.constant = singleStatWindows(df.constant, windows,time.index, i)
    df.stat.constant = subset(df.stat.constant, select = -c(do.win2, do.win3))
    statsList[[i]] = df.stat.increasing
    statsList[[length(stats)+i]] = df.stat.constant
  }
  return(statsList)
}

statsList <- dfListing(df.increasing, df.constant, stats)
```

5. ROC Data

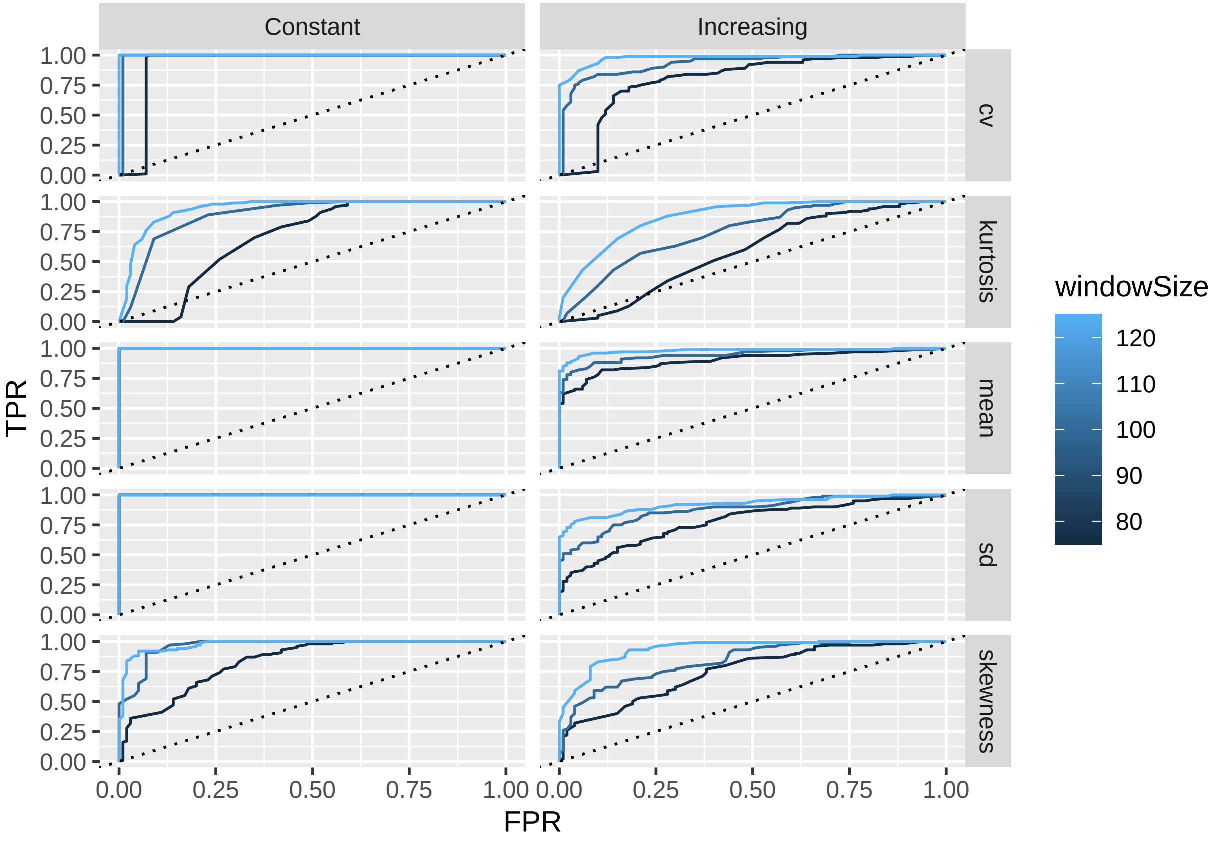
```
library(tidyverse)
```

```
## -- Attaching core tidyverse packages ------------------------ tidyverse 2.0.0 --
## v dplyr     1.1.4     v readr     2.1.5
## v forcats   1.0.0     v stringr   1.5.1
## v lubridate 1.9.3     v tibble    3.2.1
## v purrr     1.0.2     v tidyr     1.3.1
## -- Conflicts ------------------------------------------ tidyverse_conflicts() --
## x dplyr::combine()   masks gridExtra::combine()
## x dplyr::filter()    masks stats::filter()
## x dplyr::lag()       masks stats::lag()
## x lubridate::stamp() masks cowplot::stamp()
## i Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to become errors
```

```
numThresholds=200

ROCdata <- function(statsList, numThresholds, stats, windows, inequalities) {
  columns = c("threshold", "TPR", "FPR", "Statistic", "realizationType", "windowSize")
  roc.df = data.frame(matrix(nrow =0, ncol = length(columns)))
  colnames(roc.df) = columns
  ineqList = rep(1:5,2)
  for(i in 1:length(statsList)) {
    for(j in 1:length(windows)) {
      roc.df = rbind(roc.df, arrange(.data=ROCcurveData(statsList[[i]][c(1,j+1)], numThresholds, inequal
    }
  }
  roc.df$realizationType = c(matrix(replicate(15*numThresholds, "Increasing")),
                              matrix(replicate(15*numThresholds, "Constant")))
  roc.df$windowSize = c(replicate(2,replicate(5,cbind(replicate(numThresholds,ttb.times[1]),replicate(nu
  colnames(roc.df) = columns
  return(roc.df)
}

roc.df <- ROCdata(statsList, numThresholds, stats, windows, inequalities)
```

6. ROC Plots

```
library(ggplot2)
library(tidyverse)

## with facet
ggplot(data=roc.df, aes(x=FPR, y=TPR, color=windowSize)) +
  geom_line(aes(group=windowSize)) +
  facet_grid(Statistic ~ realizationType) +
  geom_abline(slope=1, intercept=0, linetype=3)
```


Constant
Increasing
cv
kurtosis
mean
sd
skewness
TPR
FPR
windowSize