Final Project: Statistical Analysis

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Examining the relationship between manatee (Trichechus manatus) anatomy and environment and manatee death by watercraft collision.

INIT DATA FRAMES

```
mortDat <- read.csv("https://www.dropbox.com/s/jsfh8rq2ez0wsj8/ReformattedManateeMortalityDa
cReg <- read.csv("https://www.dropbox.com/s/mpxmf4qn7aelr9v/CountyRegions.csv?dl=1") #Loads

b <- mortDat$County[mortDat$County == c(cReg$North.West.Central[1])]

southCentralWest <- vector(length = length(mortDat$County)) #Holds booleans for region
northWestCentral <- vector(length = length(mortDat$County)) #Holds booleans for region
northEastCentral <- vector(length = length(mortDat$County)) #Holds booleans for region
southCentralEast <- vector(length = length(mortDat$County)) #Holds booleans for region
```

```
for(i in 1:length(cReg$South.Central.West)){
  southCentralWest <- (southCentralWest | (mortDat$County == as.character(cReg$South.Central
}
```

Places a True if County is a member of the region

```
for(i in 1:length(cReg$North.West.Central)){
  northWestCentral <- (northWestCentral | (mortDat$County == as.character(cReg$North.West.Ce
}
```

Places a True if County is a member of the region

```
for(i in 1:length(cReg$North.East.Central)){
  northEastCentral <- (northEastCentral | (mortDat$County == as.character(cReg$North.East.Ce
}
```

Places a True if County is a member of the region

```
for(i in 1:length(cReg$South.Central.East)){
  southCentralEast <- (southCentralEast | (mortDat$County == as.character(cReg$South.Central
}
```

Places a True if County is a member of the region

```
checker = southCentralWest | northWestCentral | northEastCentral | southCentralEast
```

Make sure that all the data gets assigned regions.

```
mortDat[, "Region"] = ifelse(southCentralWest == T,F,F)
mortDat[, "Region"][southCentralWest] = "SouthCentralWest"
mortDat[, "Region"][northWestCentral] = "NorthWestCentral"
mortDat[, "Region"][northEastCentral] = "NorthEastCentral"
mortDat[, "Region"][southCentralEast] = "SouthCentralEast"


winter <- vector(length = length(mortDat$Date))
spring <- vector(length = length(mortDat$Date))
summer <- vector(length = length(mortDat$Date))
fall <- vector(length = length(mortDat$Date))

mortDat[, "Season"] = ifelse(1==1, F,F) #Initialize a empty vector for season.

for(i in 1:length(mortDat$Date)){
  if((as.Date(mortDat$Date[i], "%m/%d") >= "2016-03-20")
     &&
     (as.Date(mortDat$Date[i], "%m/%d") < "2016-06-21")) {
    mortDat$Season[i] <- "Spring"
  }
  else{
    if((as.Date(mortDat$Date[i], "%m/%d") >= "2016-06-21")
       &&
       (as.Date(mortDat$Date[i], "%m/%d") < "2016-09-22")) {
      mortDat$Season[i] <- "Summer"
    }
    else{
      if((as.Date(mortDat$Date[i], "%m/%d") >= "2016-09-22")
         &&
         (as.Date(mortDat$Date[i], "%m/%d") < "2016-12-21")){
        mortDat$Season[i] <- "Fall"
      }else{
        mortDat$Season[i] <- "Winter"
      }
    }
```

```
  }
}
```

```
naLOGI <- !is.na(mortDat$Size..cm.)
```

Locations that are not NA.

```
mortDat <- mortDat[naLOGI, ]
```

Removes the NAs from the data. Removes NAs from dataframe.

```
mortDat <- mortDat[mortDat$Size..cm. > 0, ]
```

Removes non positive values.

```
names(mortDat)[names(mortDat)=="Size..cm."] <- "Sizecm"
```

Changes the name of the column to Sizecm.
Create Collision Boolean

```
mortDat["Collision"] <- ifelse(mortDat$Probable.Cause == "Human Related: Watercraft Collisio
```

Adds a value to the datafram for the occurence of death by collision

AGGREGATION ON DATA

```
aggregate(Collision ~ Sex, mortDat, length) #Counting Sex Information
```

```
##   Sex Collision
## 1   F      4572
## 2   M      4935
## 3   U       376
```

```
aggregate(Collision ~ Region, mortDat, length) #Counting the region frequency
```

```
##             Region Collision
## 1 NorthEastCentral       898
## 2 NorthWestCentral       189
## 3 SouthCentralEast      4495
## 4 SouthCentralWest      4301
```

```
max(aggregate(Collision ~ Waterway, mortDat, length)["Collision"])
```

```
## [1] 1162
```

```r
aggregate(Collision ~ County, mortDat, length) # Much more meaningful
```

```
##          County Collision
## 1           Bay         9
## 2       Brevard      2067
## 3       Broward       283
## 4     Charlotte       360
## 5        Citrus       296
## 6          Clay        86
## 7       Collier       669
## 8        DeSoto        16
## 9         Dixie        25
## 10        Duval       430
## 11     Escambia         5
## 12      Flagler        93
## 13     Franklin        16
## 14    Gilchrist         3
## 15       Glades       139
## 16         Gulf         7
## 17       Hendry        18
## 18     Hernando        22
## 19    Highlands         1
## 20 Hillsborough       297
## 21 Indian River       270
## 22         Lake        26
## 23          Lee      1746
## 24         Levy        84
## 25      Manatee       188
## 26       Marion         3
## 27       Martin       249
## 28   Miami-Dade       329
## 29       Monroe       349
## 30       Nassau        34
## 31     Okaloosa         4
## 32   Okeechobee        35
## 33   Palm Beach       246
## 34        Pasco        46
## 35     Pinellas       219
## 36       Putnam       106
## 37   Santa Rosa         2
## 38     Sarasota       285
## 39     Seminole        12
## 40    St. Johns       107
## 41    St. Lucie       159
## 42       Taylor        11
## 43      Volusia       508
```

```
## 44      Wakulla        17
## 45       Walton         6
```

```
aggregate(Collision ~ Sex, mortDat, sum) # Males have a higher incidence of collisions but
```

```
##   Sex Collision
## 1   F      1055
## 2   M      1078
## 3   U        14
```

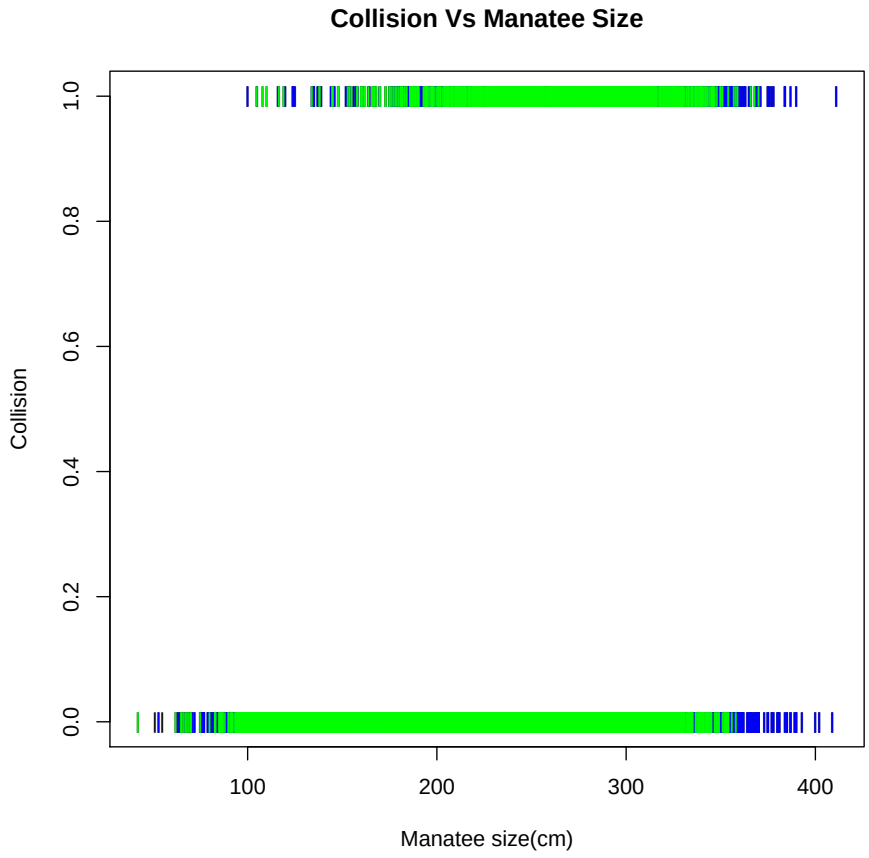
```
aggregate(Sizecm ~ Collision, mortDat, mean)
```

```
##   Collision   Sizecm
## 1     FALSE 218.0519
## 2      TRUE 271.0433
```

Size is considerably higher in average with Collision. 271.0433 average in collision vs 218.0519 without.

Visualizations

```
plot(Collision ~ Sizecm, mortDat, pch = "|",  xlab = "Manatee size(cm)",
     ylab = "Collision", main="Collision Vs Manatee Size")
mdm <- mortDat[mortDat$Sex == "M",]
mdf <- mortDat[mortDat$Sex == "F",]
mdc <- mortDat[(mortDat$Sex == "M") | (mortDat$Sex == "F")  ,]
points(mdf$Sizecm, mdf$Collision, pch = "|", col = "blue") # Mort Dat Female
points(mdm$Sizecm, mdm$Collision, pch = "|", col = "green")  # Mort Dat Male
```



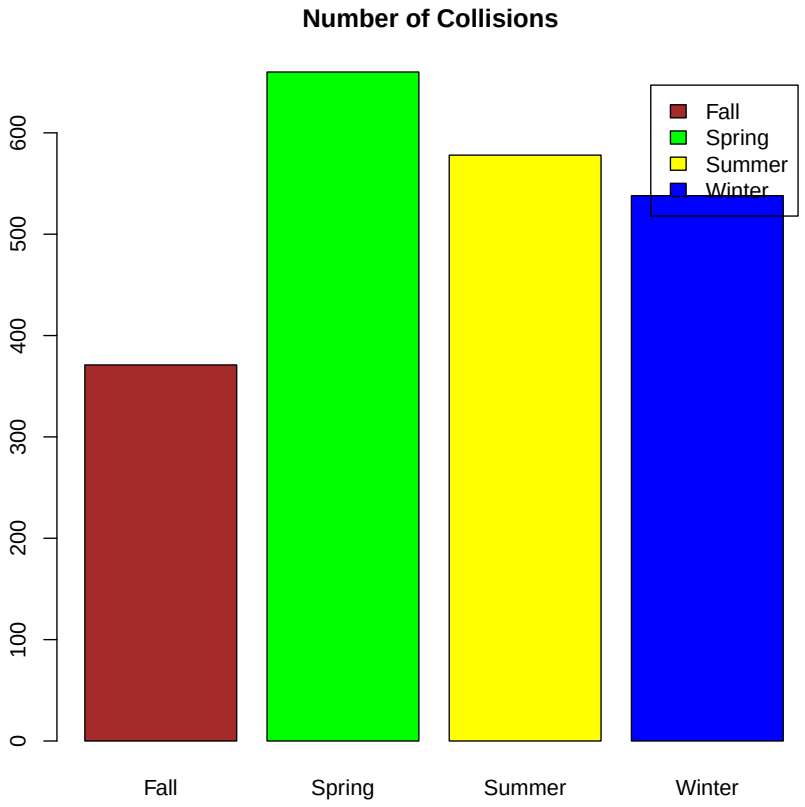

```
wc <- mortDat[mortDat['Collision'] == TRUE, ]  #Population with collision
nc <- mortDat[mortDat['Collision'] == FALSE, ] #Population without collision

aggregate(Collision ~ Season, wc, length) #Some Evidence of a difference by Season.
```

```
##   Season Collision
## 1   Fall       371
## 2 Spring       660
## 3 Summer       578
## 4 Winter       538
```

Season Visulization

```
season = wc["Season"]
season.freq = table(season)
colors = c("brown", "green", "yellow", "blue")
```

```
barplot(season.freq, col=colors,        legend = rownames(season.freq), main="Number of Coll
```



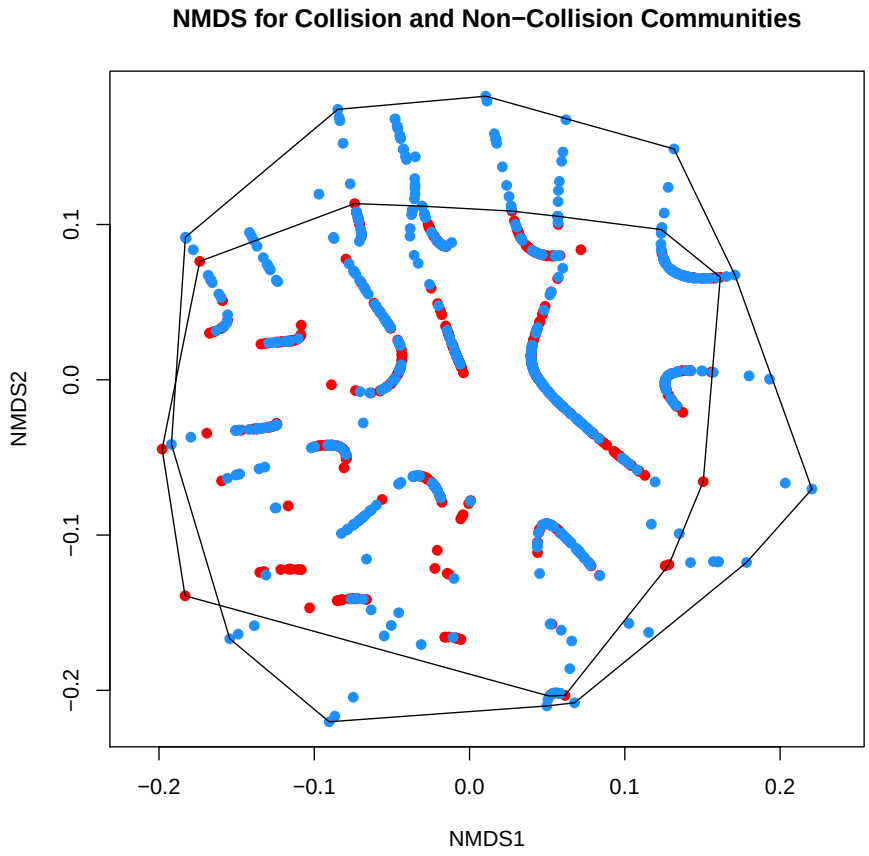
Random sampling based Nonmetric Multidimensional Scaling Code

```
library(vegan)

## Loading required package:  permute
## Loading required package:  lattice
## This is vegan 2.3-4

alt <- mortDat[!(mortDat["Sex"] == "U"),]
alt <- alt[,c("Region", "Sex", "Sizecm", "Season", "Collision")]
altP <- alt[alt$Collision == TRUE, c("Region", "Sex", "Sizecm", "Season", "Collision")] #Co
```

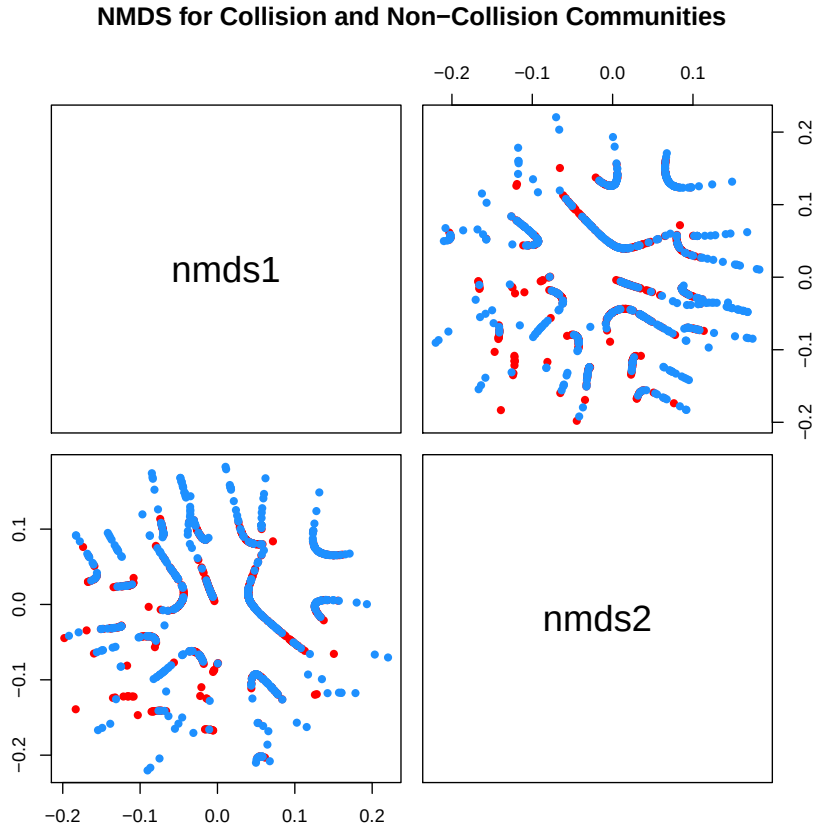
```
altNP <- alt[alt$Collision == FALSE, c("Region", "Sex", "Sizecm", "Season", "Collision")] #
altR <- rbind(altP[sample(1:length(altP$Region), 500),], altNP[sample(1:length(altNP$Region)
```

New sample set composed of 500 datapoints each from collision and non-collision.

```
#Ordinates categorical variables to be numerical factors
altR$Region <- as.numeric(factor(altR$Region , levels=unique(alt$Region)))
altR$Sex <- as.numeric(factor(altR$Sex , levels=unique(alt$Sex)))
altR$Season <- as.numeric(factor(altR$Season , levels=unique(alt$Season)))
altR$Collision <- as.numeric(factor(altR$Collision , levels=unique(alt$Collision)))

c.mds <- metaMDS(altR[,1:4], zerodist="add")

## Square root transformation
## Wisconsin double standardization
## Zero dissimilarities changed into  0.0001038296
## Run 0 stress 0.1893291
## Run 1 stress 0.1950198
## Run 2 stress 0.1955467
## Run 3 stress 0.1954207
## Run 4 stress 0.4203501
## Run 5 stress 0.192938
## Run 6 stress 0.1894116
## ... procrustes: rmse 0.002177115  max resid 0.06859807
## Run 7 stress 0.195726
## Run 8 stress 0.1912247
## Run 9 stress 0.195569
## Run 10 stress 0.1935351
## Run 11 stress 0.1909318
## Run 12 stress 0.1948448
## Run 13 stress 0.1926753
## Run 14 stress 0.1902997
## Run 15 stress 0.1928693
## Run 16 stress 0.1949402
## Run 17 stress 0.1902939
## Run 18 stress 0.1949735
## Run 19 stress 0.1949626
## Run 20 stress 0.1926543

par(mfcol = c(1,1))
fig <- ordiplot(c.mds, type = "none", main = "NMDS for Collision and Non-Collision Communiti
points(fig, "sites", pch=16, col=c("dodgerblue", "red")[altR$Collision], bg="white", cex=1.1
ordihull(c.mds, altR$Collision == "2", display = "sites", draw = "polygon")
```




```
altR$nmds1 <- c.mds$points[,1]
altR$nmds2 <- c.mds$points[,2]

pairs(altR[,6:7], col= c("dodgerblue", "red")[altR$Collision], pch = 16, main = "NMDS for Co
```



Generalized Linear Modeling Selection Process

```
library(xtable)
#Model Selection

mortD <- mortDat[!(mortDat["Sex"] == "U"),]

options(na.action = "na.fail") #Specifies NA treatment
subset <- mortD[c("Sizecm","Region", "Sex", "Season","Collision")] #Subsets data to the expl
maximal <- glm(Collision ~ Sizecm*Region*Sex*Season, data = subset, family = binomial, na.ac
```

STEP AIC Method

```r
model <- glm(Collision ~ Sizecm*Region*Sex*Season, data = mortD, family = binomial, na.actio
summary(model)
```

```
##
## Call:
## glm(formula = Collision ~ Sizecm * Region * Sex * Season, family = binomial,
##     data = mortD, na.action = na.fail)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -1.8715  -0.7261  -0.4646  -0.2902   2.5633
##
## Coefficients:
##                                                 Estimate Std. Error
## (Intercept)                                   -3.9792753  1.4904950
## Sizecm                                         0.0105109  0.0053728
## RegionNorthWestCentral                        -1.4770445  4.2154018
## RegionSouthCentralEast                        -0.2374862  1.6135738
## RegionSouthCentralWest                         0.9182840  1.5967759
## SexM                                           1.6645543  1.8710938
## SeasonSpring                                   0.9858437  1.6836772
## SeasonSummer                                   1.2378793  1.6882345
## SeasonWinter                                  -1.5663994  2.2063178
## Sizecm:RegionNorthWestCentral                  0.0091041  0.0167030
## Sizecm:RegionSouthCentralEast                  0.0004921  0.0058147
## Sizecm:RegionSouthCentralWest                 -0.0020174  0.0057789
## Sizecm:SexM                                   -0.0027896  0.0068306
## RegionNorthWestCentral:SexM                   -1.0431218  7.0328503
## RegionSouthCentralEast:SexM                   -2.0036415  2.0626063
## RegionSouthCentralWest:SexM                   -2.5748479  2.0450856
## Sizecm:SeasonSpring                           -0.0006557  0.0060754
## Sizecm:SeasonSummer                           -0.0038117  0.0060281
## Sizecm:SeasonWinter                            0.0033545  0.0081739
## RegionNorthWestCentral:SeasonSpring            1.3086386  4.5601541
## RegionSouthCentralEast:SeasonSpring           -1.0267916  1.8505785
## RegionSouthCentralWest:SeasonSpring           -0.9823429  1.8132461
## RegionNorthWestCentral:SeasonSummer            0.7322562  5.2893006
## RegionSouthCentralEast:SeasonSummer           -0.9318533  1.8636635
## RegionSouthCentralWest:SeasonSummer           -1.7804699  1.8348033
## RegionNorthWestCentral:SeasonWinter            1.5541247  6.3392272
## RegionSouthCentralEast:SeasonWinter            1.2099843  2.3350573
## RegionSouthCentralWest:SeasonWinter            0.3312152  2.3322402
## SexM:SeasonSpring                             -6.2511615  2.4824137
## SexM:SeasonSummer                             -3.6821017  2.2920365
## SexM:SeasonWinter                             -0.6042932  3.0577212
## Sizecm:RegionNorthWestCentral:SexM            -0.0035674  0.0254683
```

```
## Sizecm:RegionSouthCentralEast:SexM                0.0053262  0.0075449
## Sizecm:RegionSouthCentralWest:SexM                0.0062116  0.0075196
## Sizecm:RegionNorthWestCentral:SeasonSpring       -0.0128531  0.0179025
## Sizecm:RegionSouthCentralEast:SeasonSpring        0.0022954  0.0066838
## Sizecm:RegionSouthCentralWest:SeasonSpring        0.0011069  0.0065784
## Sizecm:RegionNorthWestCentral:SeasonSummer       -0.0107289  0.0205092
## Sizecm:RegionSouthCentralEast:SeasonSummer        0.0032662  0.0066546
## Sizecm:RegionSouthCentralWest:SeasonSummer        0.0074382  0.0065887
## Sizecm:RegionNorthWestCentral:SeasonWinter       -0.0098543  0.0266129
## Sizecm:RegionSouthCentralEast:SeasonWinter       -0.0021934  0.0086336
## Sizecm:RegionSouthCentralWest:SeasonWinter       -0.0016841  0.0086384
## Sizecm:SexM:SeasonSpring                          0.0210785  0.0089779
## Sizecm:SexM:SeasonSummer                          0.0134853  0.0083013
## Sizecm:SexM:SeasonWinter                         -0.0022245  0.0115304
## RegionNorthWestCentral:SexM:SeasonSpring          2.5499119  7.6373634
## RegionSouthCentralEast:SexM:SeasonSpring          6.2649663  2.7052993
## RegionSouthCentralWest:SexM:SeasonSpring          6.3158963  2.6766517
## RegionNorthWestCentral:SexM:SeasonSummer          2.8314487  8.2198145
## RegionSouthCentralEast:SexM:SeasonSummer          3.2718067  2.5471781
## RegionSouthCentralWest:SexM:SeasonSummer          3.1578815  2.5416806
## RegionNorthWestCentral:SexM:SeasonWinter          1.6978567  9.5858797
## RegionSouthCentralEast:SexM:SeasonWinter          0.9962753  3.2440849
## RegionSouthCentralWest:SexM:SeasonWinter          1.5897948  3.2494577
## Sizecm:RegionNorthWestCentral:SexM:SeasonSpring   0.0031795  0.0279352
## Sizecm:RegionSouthCentralEast:SexM:SeasonSpring  -0.0219140  0.0098254
## Sizecm:RegionSouthCentralWest:SexM:SeasonSpring  -0.0224944  0.0097599
## Sizecm:RegionNorthWestCentral:SexM:SeasonSummer  -0.0007464  0.0299511
## Sizecm:RegionSouthCentralEast:SexM:SeasonSummer  -0.0109615  0.0092528
## Sizecm:RegionSouthCentralWest:SexM:SeasonSummer  -0.0105737  0.0093010
## Sizecm:RegionNorthWestCentral:SexM:SeasonWinter  -0.0023414  0.0370964
## Sizecm:RegionSouthCentralEast:SexM:SeasonWinter  -0.0003113  0.0122189
## Sizecm:RegionSouthCentralWest:SexM:SeasonWinter  -0.0016075  0.0122604
##                                                 z value Pr(>|z|)
## (Intercept)                                      -2.670  0.00759 **
## Sizecm                                            1.956  0.05043 .
## RegionNorthWestCentral                           -0.350  0.72604
## RegionSouthCentralEast                           -0.147  0.88299
## RegionSouthCentralWest                            0.575  0.56523
## SexM                                              0.890  0.37367
## SeasonSpring                                      0.586  0.55819
## SeasonSummer                                      0.733  0.46341
## SeasonWinter                                     -0.710  0.47773
## Sizecm:RegionNorthWestCentral                     0.545  0.58571
## Sizecm:RegionSouthCentralEast                     0.085  0.93255
## Sizecm:RegionSouthCentralWest                    -0.349  0.72702
```

```
## Sizecm:SexM                                        -0.408  0.68298
## RegionNorthWestCentral:SexM                        -0.148  0.88209
## RegionSouthCentralEast:SexM                        -0.971  0.33134
## RegionSouthCentralWest:SexM                        -1.259  0.20802
## Sizecm:SeasonSpring                                -0.108  0.91405
## Sizecm:SeasonSummer                                -0.632  0.52718
## Sizecm:SeasonWinter                                 0.410  0.68152
## RegionNorthWestCentral:SeasonSpring                 0.287  0.77413
## RegionSouthCentralEast:SeasonSpring                -0.555  0.57900
## RegionSouthCentralWest:SeasonSpring                -0.542  0.58798
## RegionNorthWestCentral:SeasonSummer                 0.138  0.88989
## RegionSouthCentralEast:SeasonSummer                -0.500  0.61707
## RegionSouthCentralWest:SeasonSummer                -0.970  0.33185
## RegionNorthWestCentral:SeasonWinter                 0.245  0.80633
## RegionSouthCentralEast:SeasonWinter                 0.518  0.60433
## RegionSouthCentralWest:SeasonWinter                 0.142  0.88707
## SexM:SeasonSpring                                  -2.518  0.01180 *
## SexM:SeasonSummer                                  -1.606  0.10817
## SexM:SeasonWinter                                  -0.198  0.84334
## Sizecm:RegionNorthWestCentral:SexM                 -0.140  0.88860
## Sizecm:RegionSouthCentralEast:SexM                  0.706  0.48023
## Sizecm:RegionSouthCentralWest:SexM                  0.826  0.40877
## Sizecm:RegionNorthWestCentral:SeasonSpring         -0.718  0.47279
## Sizecm:RegionSouthCentralEast:SeasonSpring          0.343  0.73128
## Sizecm:RegionSouthCentralWest:SeasonSpring          0.168  0.86638
## Sizecm:RegionNorthWestCentral:SeasonSummer         -0.523  0.60089
## Sizecm:RegionSouthCentralEast:SeasonSummer          0.491  0.62356
## Sizecm:RegionSouthCentralWest:SeasonSummer          1.129  0.25892
## Sizecm:RegionNorthWestCentral:SeasonWinter         -0.370  0.71117
## Sizecm:RegionSouthCentralEast:SeasonWinter         -0.254  0.79946
## Sizecm:RegionSouthCentralWest:SeasonWinter         -0.195  0.84543
## Sizecm:SexM:SeasonSpring                            2.348  0.01888 *
## Sizecm:SexM:SeasonSummer                            1.624  0.10428
## Sizecm:SexM:SeasonWinter                           -0.193  0.84702
## RegionNorthWestCentral:SexM:SeasonSpring            0.334  0.73848
## RegionSouthCentralEast:SexM:SeasonSpring            2.316  0.02057 *
## RegionSouthCentralWest:SexM:SeasonSpring            2.360  0.01829 *
## RegionNorthWestCentral:SexM:SeasonSummer            0.344  0.73050
## RegionSouthCentralEast:SexM:SeasonSummer            1.284  0.19897
## RegionSouthCentralWest:SexM:SeasonSummer            1.242  0.21407
## RegionNorthWestCentral:SexM:SeasonWinter            0.177  0.85941
## RegionSouthCentralEast:SexM:SeasonWinter            0.307  0.75876
## RegionSouthCentralWest:SexM:SeasonWinter            0.489  0.62467
## Sizecm:RegionNorthWestCentral:SexM:SeasonSpring     0.114  0.90938
## Sizecm:RegionSouthCentralEast:SexM:SeasonSpring    -2.230  0.02572 *
```

```
## Sizecm:RegionSouthCentralWest:SexM:SeasonSpring  -2.305  0.02118 *
## Sizecm:RegionNorthWestCentral:SexM:SeasonSummer  -0.025  0.98012
## Sizecm:RegionSouthCentralEast:SexM:SeasonSummer  -1.185  0.23615
## Sizecm:RegionSouthCentralWest:SexM:SeasonSummer  -1.137  0.25561
## Sizecm:RegionNorthWestCentral:SexM:SeasonWinter  -0.063  0.94967
## Sizecm:RegionSouthCentralEast:SexM:SeasonWinter  -0.025  0.97968
## Sizecm:RegionSouthCentralWest:SexM:SeasonWinter  -0.131  0.89569
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 10122.5  on 9506  degrees of freedom
## Residual deviance:  8778.3  on 9443  degrees of freedom
## AIC: 8906.3
##
## Number of Fisher Scoring iterations: 5

model2 <- step(model) #Step AIC model reduction

## Start:  AIC=8906.29
## Collision ~ Sizecm * Region * Sex * Season
##
##                             Df Deviance    AIC
## - Sizecm:Region:Sex:Season  9   8787.5 8897.5
## <none>                          8778.3 8906.3
##
## Step:  AIC=8897.54
## Collision ~ Sizecm + Region + Sex + Season + Sizecm:Region +
##     Sizecm:Sex + Region:Sex + Sizecm:Season + Region:Season +
##     Sex:Season + Sizecm:Region:Sex + Sizecm:Region:Season + Sizecm:Sex:Season +
##     Region:Sex:Season
##
##                         Df Deviance    AIC
## - Region:Sex:Season     9   8796.4 8888.4
## - Sizecm:Region:Season  9   8800.5 8892.5
## - Sizecm:Region:Sex     3   8791.7 8895.7
## <none>                      8787.5 8897.5
## - Sizecm:Sex:Season     3   8793.8 8897.8
##
## Step:  AIC=8888.39
## Collision ~ Sizecm + Region + Sex + Season + Sizecm:Region +
##     Sizecm:Sex + Region:Sex + Sizecm:Season + Region:Season +
##     Sex:Season + Sizecm:Region:Sex + Sizecm:Region:Season + Sizecm:Sex:Season
##
##                         Df Deviance    AIC
```

```
## - Sizecm:Region:Season  9   8809.3 8883.3
## - Sizecm:Region:Sex     3   8800.5 8886.5
## <none>                      8796.4 8888.4
## - Sizecm:Sex:Season     3   8802.6 8888.6
##
## Step:  AIC=8883.28
## Collision ~ Sizecm + Region + Sex + Season + Sizecm:Region +
##     Sizecm:Sex + Region:Sex + Sizecm:Season + Region:Season +
##     Sex:Season + Sizecm:Region:Sex + Sizecm:Sex:Season
##
##                     Df Deviance    AIC
## - Sizecm:Region:Sex  3   8813.7 8881.7
## - Sizecm:Sex:Season  3   8815.1 8883.1
## <none>                   8809.3 8883.3
## - Region:Season      9   8870.9 8926.9
##
## Step:  AIC=8881.75
## Collision ~ Sizecm + Region + Sex + Season + Sizecm:Region +
##     Sizecm:Sex + Region:Sex + Sizecm:Season + Region:Season +
##     Sex:Season + Sizecm:Sex:Season
##
##                     Df Deviance    AIC
## - Sizecm:Region      3   8816.7 8878.7
## <none>                   8813.7 8881.7
## - Sizecm:Sex:Season  3   8820.9 8882.9
## - Region:Sex         3   8825.6 8887.6
## - Region:Season      9   8875.5 8925.5
##
## Step:  AIC=8878.72
## Collision ~ Sizecm + Region + Sex + Season + Sizecm:Sex + Region:Sex +
##     Sizecm:Season + Region:Season + Sex:Season + Sizecm:Sex:Season
##
##                     Df Deviance    AIC
## <none>                   8816.7 8878.7
## - Sizecm:Sex:Season  3   8824.1 8880.1
## - Region:Sex         3   8827.9 8883.9
## - Region:Season      9   8878.7 8922.7
```

```
summary(model2)
```

```
##
## Call:
## glm(formula = Collision ~ Sizecm + Region + Sex + Season + Sizecm:Sex +
##     Region:Sex + Sizecm:Season + Region:Season + Sex:Season +
##     Sizecm:Sex:Season, family = binomial, data = mortD, na.action = na.fail)
##
```

```
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -1.7406  -0.7283  -0.4632  -0.2910   2.7645
##
## Coefficients:
##                                    Estimate Std. Error z value Pr(>|z|)
## (Intercept)                      -3.5588986  0.4598964  -7.738 1.01e-14
## Sizecm                            0.0098506  0.0014597   6.748 1.50e-11
## RegionNorthWestCentral           -0.6669296  0.7127040  -0.936 0.349390
## RegionSouthCentralEast           -0.3498613  0.2639951  -1.325 0.185086
## RegionSouthCentralWest            0.1258460  0.2587647   0.486 0.626731
## SexM                             -0.0807929  0.5870742  -0.138 0.890541
## SeasonSpring                      0.4529067  0.5386926   0.841 0.400487
## SeasonSummer                     -0.2445034  0.5647746  -0.433 0.665071
## SeasonWinter                     -1.6186623  0.5857172  -2.764 0.005718
## Sizecm:SexM                       0.0022902  0.0021008   1.090 0.275643
## RegionNorthWestCentral:SexM       0.1580309  0.5725747   0.276 0.782548
## RegionSouthCentralEast:SexM      -0.2081688  0.1938159  -1.074 0.282798
## RegionSouthCentralWest:SexM      -0.4996420  0.1927597  -2.592 0.009541
## Sizecm:SeasonSpring               0.0004482  0.0017497   0.256 0.797839
## Sizecm:SeasonSummer               0.0007891  0.0018095   0.436 0.662758
## Sizecm:SeasonWinter               0.0013904  0.0018874   0.737 0.461330
## RegionNorthWestCentral:SeasonSpring -0.0543141  0.6962555  -0.078 0.937821
## RegionSouthCentralEast:SeasonSpring -0.1620992  0.2923679  -0.554 0.579281
## RegionSouthCentralWest:SeasonSpring -0.4580531  0.2867128  -1.598 0.110131
## RegionNorthWestCentral:SeasonSummer -0.1862646  0.8483267  -0.220 0.826208
## RegionSouthCentralEast:SeasonSummer  0.2058133  0.2985816   0.689 0.490632
## RegionSouthCentralWest:SeasonSummer  0.4360056  0.2940571   1.483 0.138148
## RegionNorthWestCentral:SeasonWinter -0.4387200  0.8339371  -0.526 0.598831
## RegionSouthCentralEast:SeasonWinter  1.1658173  0.3178515   3.668 0.000245
## RegionSouthCentralWest:SeasonWinter  0.5518911  0.3168227   1.742 0.081516
## SexM:SeasonSpring                 -0.7388077  0.6850617  -1.078 0.280831
## SexM:SeasonSummer                 -0.7798668  0.7235299  -1.078 0.281094
## SexM:SeasonWinter                  0.4416666  0.7329603   0.603 0.546789
## Sizecm:SexM:SeasonSpring           0.0018851  0.0025771   0.731 0.464478
## Sizecm:SexM:SeasonSummer           0.0039181  0.0027047   1.449 0.147443
## Sizecm:SexM:SeasonWinter          -0.0024947  0.0027598  -0.904 0.366013
##
## (Intercept)                       ***
## Sizecm                            ***
## RegionNorthWestCentral
## RegionSouthCentralEast
## RegionSouthCentralWest
## SexM
## SeasonSpring
```

```
## SeasonSummer
## SeasonWinter                         **
## Sizecm:SexM
## RegionNorthWestCentral:SexM
## RegionSouthCentralEast:SexM
## RegionSouthCentralWest:SexM          **
## Sizecm:SeasonSpring
## Sizecm:SeasonSummer
## Sizecm:SeasonWinter
## RegionNorthWestCentral:SeasonSpring
## RegionSouthCentralEast:SeasonSpring
## RegionSouthCentralWest:SeasonSpring
## RegionNorthWestCentral:SeasonSummer
## RegionSouthCentralEast:SeasonSummer
## RegionSouthCentralWest:SeasonSummer
## RegionNorthWestCentral:SeasonWinter
## RegionSouthCentralEast:SeasonWinter ***
## RegionSouthCentralWest:SeasonWinter .
## SexM:SeasonSpring
## SexM:SeasonSummer
## SexM:SeasonWinter
## Sizecm:SexM:SeasonSpring
## Sizecm:SexM:SeasonSummer
## Sizecm:SexM:SeasonWinter
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 10122.5  on 9506  degrees of freedom
## Residual deviance:  8816.7  on 9476  degrees of freedom
## AIC: 8878.7
##
## Number of Fisher Scoring iterations: 5
```

Resulting models

```
stepAICModel <- glm(formula = Collision ~ Sizecm + Region + Sex + Season + Sizecm:Sex +
      Region:Sex + Sizecm:Season + Region:Season + Sex:Season +
      Sizecm:Sex:Season, family = binomial, data = mortD, na.action = na.fail)
```

Step AIC Reduced Model

```
oneStep  <- glm(formula = Collision ~ Sizecm + Region + Sex + Season + Sizecm:Sex +
                  Region:Sex + Region:Season + Sex:Season +
                  Sizecm:Sex:Season, family = binomial, data = mortD, na.action = na.fail)
```

Removal of Sex:Season in comparison to StepAIC model

```
oneStepAlt <- glm(formula = Collision ~ Sizecm + Region + Sex + Season + Sizecm:Sex +
                  Region:Sex + Sizecm:Season + Region:Season + Sex:Season ,
                  family = binomial, data = mortD, na.action = na.fail)
```

Removal of Sizecm:Sex:Season in comparison to StepAIC model

Dredge Model

```
library(MuMIn)
dd <- dredge(maximal)

## Fixed term is "(Intercept)"
```

Produces model selection table based on AIC ranking from low to high by recursively making all model combinations from the largest possible model.

```
dredgeModel <- glm(Collision ~ Region + Season + Sex + Sizecm + Region:Season + Region:Sex +
maximal <- glm(Collision ~ Sizecm*Region*Sex*Season, data = subset, family = binomial, na.ac
```

Anova Table Generation

```
#Anova Table Generation Code.

print(xtable(anova(maximal, stepAICModel, test="Chi"))) #Anova Table for maximal model vs D

## % latex table generated in R 3.2.3 by xtable 1.8-2 package
## % Mon Mar 14 01:46:51 2016
## \begin{table}[ht]
## \centering
## \begin{tabular}{lrrrrr}
##   \hline
##  & Resid. Df & Resid. Dev & Df & Deviance & Pr($>$Chi) \\
##   \hline
## 1 & 9443 & 8778.29 &  &  &  \\
##   2 & 9476 & 8816.72 & -33 & -38.43 & 0.2369 \\
##    \hline
## \end{tabular}
## \end{table}
```

```
print(xtable(anova(maximal, dredgeModel, test="Chi"))) #Anova Table for maximal model vs Dre

## % latex table generated in R 3.2.3 by xtable 1.8-2 package
## % Mon Mar 14 01:46:51 2016
## \begin{table}[ht]
## \centering
## \begin{tabular}{lrrrrr}
##   \hline
##  & Resid. Df & Resid. Dev & Df & Deviance & Pr($>$Chi) \\
##   \hline
## 1 & 9443 & 8778.29 &  &  &  \\
##   2 & 9482 & 8828.62 & -39 & -50.33 & 0.1056 \\
##    \hline
## \end{tabular}
## \end{table}

print(xtable(anova(maximal, oneStep, oneStepAlt, dredgeModel, test="Chi"))) #Anova Table for

## % latex table generated in R 3.2.3 by xtable 1.8-2 package
## % Mon Mar 14 01:46:51 2016
## \begin{table}[ht]
## \centering
## \begin{tabular}{lrrrrr}
##   \hline
##  & Resid. Df & Resid. Dev & Df & Deviance & Pr($>$Chi) \\
##   \hline
## 1 & 9443 & 8778.29 &  &  &  \\
##   2 & 9476 & 8816.72 & -33 & -38.43 & 0.2369 \\
##   3 & 9479 & 8824.05 & -3 & -7.33 & 0.0622 \\
##   4 & 9482 & 8828.62 & -3 & -4.57 & 0.2059 \\
##    \hline
## \end{tabular}
## \end{table}
```