Resident Canada Geese Vital Rates in the SE United States

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Population Ecology Modeling Project

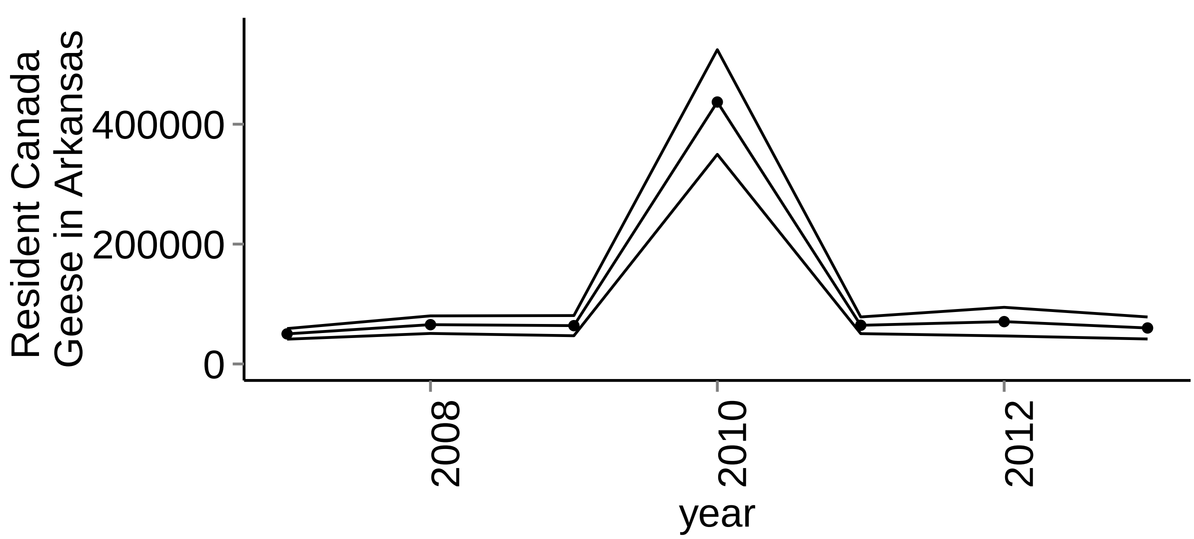
Background

Canada Geese (*Branta canadensis*) have made a large comeback across much of the southern U.S in recent years (Balkcom 2010). Some of these individuals have become resident birds, and no longer regularly migrate along with the rest of the Canada Goose population every year. Resident birds create a special management concern for southern states because they often live in urban/suburban areas and cause human/wildlife conflicts. The Arkansas Game and Fish Commission had been banding Canada Geese in Arkansas during the summer (when only resident geese are present) for ~20 years, and wants to determine if the liberalized hunting regulations of early season (September) Canada geese have had an impact on the populations of resident Canada Geese in Arkansas.

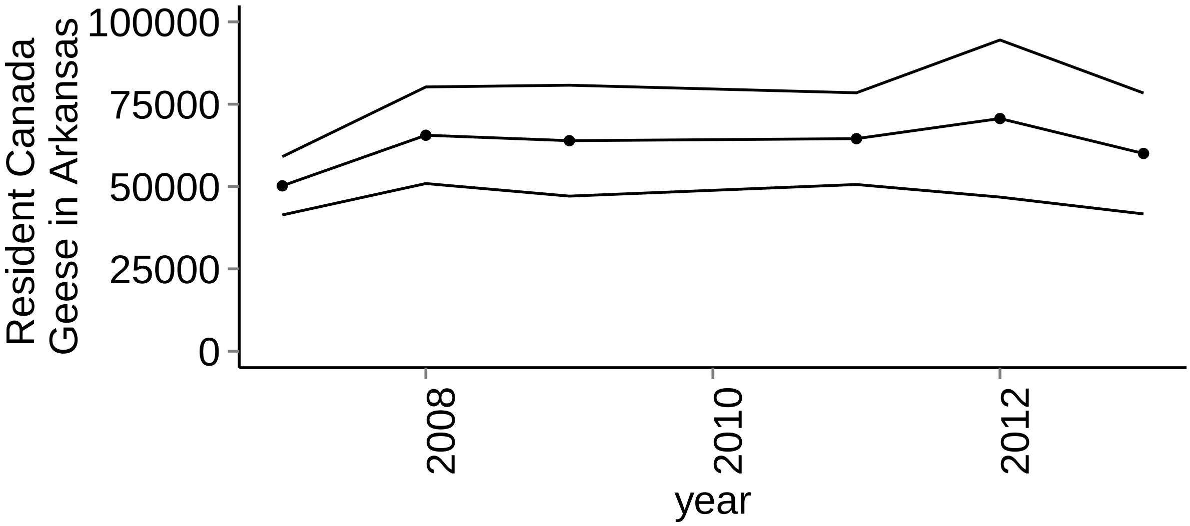
Model Description

My original plan, and still longer term plan, is to analyze these results in a live-dead recapture model in RMark/Program Mark (Laake 2013; White and Burnham 1999). That part of the analysis has been put on hold for the moment by the other members of the project, so instead I here present the Lincoln-Peterson results from the capture/recapture data from 2006-2011 and will examine vital rates from other southern resident goose populations to determine what might be driving the population dynamics of the Arkansas population.

Results and Figures



2010 has a MUCH higher estimate then the other years because Canada Goose harvest was much higher in 2010 then the other years. When we remove 2010 we see that we have a fairly stable population.



The estimates seem logical (Missouri has ~40,000 resident Canada Geese, and we would expect to have similar numbers, Andy Raedeke, MDC, personal communication). The large question is whether or not liberalized harvest in 2007 caused a decline in resident Canada Goose populations. Based on this graph the population is not declining, which is in line with other studies who have found that most suburban and urban resident Canada Goose populations are not impacted by hunting seasons (Arbaugh and Dixie 2010, Dunn and Jacobs (2000)).

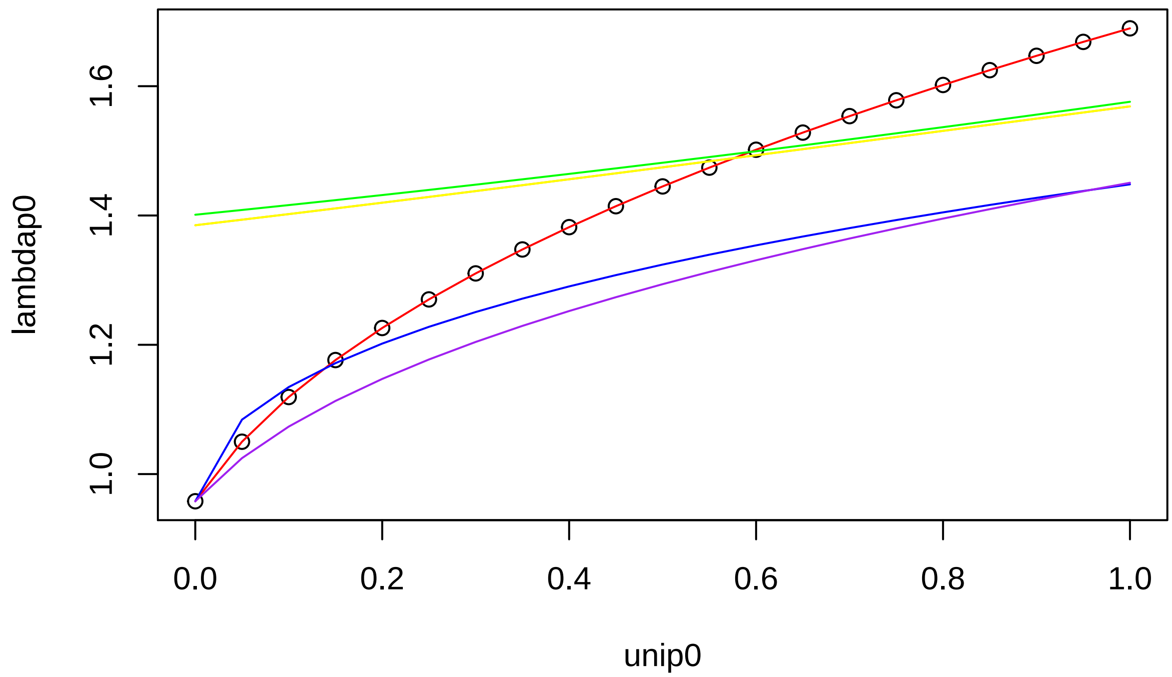
So for the moment, due to other collaborators on this project wanting to wait to take this forward, we are going to stop the analysis of Arkansas Canada Goose data here and instead throw out a wider net to resident canada goose rates across the U.S.

I am going to examine the vital rates of resident Canada Geese in Georgia and compare these rates between rural and urban geese (data from (Balkcom 2010)). I would expect that geese in urban situations will have higher survival because they are not exposed to hunting mortality. There could be other sources of mortality in urban situations though that are not present in rural environments (Balkcom 2010). When trying to control urban and suburban goose populations new challenges arrive becuase non-hunter removal fo animals is very expensive, outside of cities hunters are the most cost effective method of animal removal as they pay to remove then, instead of having to pay others to do it (Conover 2001).

Urban goose survival = .958 +/- .020 Rural goose survival = .682 +/- .682

In other states (GA, PA, others) additional hunting seasons have not been found to control the resident Canada Goose problem because urban geese, which make up most of resident goose populations, are not exposed to hunting pressure. (Arbaugh and Dixie 2010, Dunn and Jacobs (2000)) 'Hunting oppurtunity may be at or near the maximum sustainable rate for rural geese, yet sport hunting appears to have a small impact on urban geese' (Balkcom 2010). One factor not taken into account in the following matrix model is differences in survival because of banding type. When game bird are banded with visual bands (such as neck bands) their survival declines because they are specifically targeted by hunters (survival dropped from 82 to 67% in (Castelli and Trost 1996)).

Survival of gooslings varies with age, with older birds fledging more gooslings then younger individuals (25% of 2-year-olds raise 2.3, 31% of 3-year-olds raised 2.9 and 58% of 4+ year-olds raised 3.7 gooslings (Raveling 1981)). After fledgling a juvenile Canda Goose has a 49.1% chance of surviving to their next year (Eberhardt, Anthony, and Rickard 1989).



The only variable which when varied from 0-1 that has lambda below 1 is when you vary the survival of juvenile Canada Geese, and that survival has to be below 10% before lambda is below 1.

Conclusions

Based on these results a massive effort to reduce the survival of Canada Geese juveniles may be the only effective way to reduce Canada Goose populations. Killing young geese is not likely to be a publically accepted option, and oiling goose eggs is very time consuming. Sterilizing male canada geese surgically has been shown to be effective, sterile males still pair up and females lay infertile eggs (except where extra pair copulations take place) (Converse and Kennelly 1994). While this method would also be very time consuming if it was done intensively for several years in a small area it could lower the population, though just like in areas with Trap,Neuter,Release feral cats, eventually the neutered cats die and new, fertile individuals take their place.

R Code

```
library(ggplot2)
library(grid)

options(scipen=999)
m <- as.data.frame(matrix(c(2006,2007,2008,2009,2010,2011,2012,2013,980,807,741,938,1172,1498,1123,814,
colnames(m) <- c("year","banded","recovered")
m$recov_rate <- m$recovered/m$banded
m$recov_var <- ((m$recov_rate*(1-m$recov_rate))/(m$banded-1))
```

```
m$recov_se <- sqrt(m$recov_var)
m$report_rate <- 0.736
m$report_var <- .002
m$report_se <- .046
m$harvest_rate <- m$recov_rate/m$report_rate
m$harvest_var <- (m$recov_var/(m$report_rate^2))+(((m$recov_rate^2)*m$report_var)/(m$report_rate^4))
m$num_harvested <- c(0,4851,4139,2277,22425,2207,1261,1807)
m$adjust_harvested <- m$num_harvested*.61
m$N_Cago <- m$adjust_harvest/m$harvest_rate
m$N_var <- (0.1/(m$harvest_rate^2))+((m$adjust_harvested^2)*((m$harvest_var)/(m$harvest_rate^4)))
m$N_se <- sqrt(m$N_var)
m$N_ci_u <- m$N_Cago+m$N_se
m$N_ci_l <- m$N_Cago-m$N_se

options(scipen=999)
ggplot()+
  geom_point(data=m[m$year!=2006,], aes(x=year, y=N_Cago))+
  geom_line(data=m[m$year!=2006,], aes(x=year, y=N_Cago))+
  geom_line(data=m[m$year!=2006,], aes(x=year, y=N_ci_u))+
  geom_line(data=m[m$year!=2006,], aes(x=year, y=N_ci_l))+
  ylim(0,550000)+
  xlab("year")+
  ylab("Resident Canada \nGeese in Arkansas")+
  theme(plot.title = element_text(colour="black",size=15), #plot title
        axis.text.x = element_text(ang=90, colour="black", size=15), #x axis labels
        axis.text.y = element_text(colour="black",size=15), #y axis labels
        axis.title.x = element_text(colour="black",size=15),
        axis.title.y = element_text(colour="black",size=15), #y ,axis title
        legend.text = element_text(colour="black", size=15), #legend text
        legend.title = element_blank(),#legend title
        legend.background = element_rect(fill="white"), #legend background color
        legend.position = "top",
        legend.direction= "horizontal",
        legend.key = element_rect(colour="black", fill="white"),
        legend.key.width=unit(3,"cm"),
        plot.background = element_rect(fill = "white" ), #plot background color
        panel.grid.major= element_line(colour=NA),
        panel.grid.minor=element_line(colour=NA),
        panel.background = element_rect(fill = "white"),
        axis.line=element_line(colour="black"))

options(scipen=999)
ggplot()+
  geom_point(data=m[m$year!=2010&m$year!=2006,], aes(x=year, y=N_Cago))+
  geom_line(data=m[m$year!=2010&m$year!=2006,], aes(x=year, y=N_Cago))+
  geom_line(data=m[m$year!=2010&m$year!=2006,], aes(x=year, y=N_ci_u))+
  geom_line(data=m[m$year!=2010&m$year!=2006,], aes(x=year, y=N_ci_l))+
  ylim(0,100000)+
  xlab("year")+
  ylab("Resident Canada \nGeese in Arkansas")+
  theme(plot.title = element_text(colour="black",size=15), #plot title
        axis.text.x = element_text(ang=90, colour="black", size=15), #x axis labels
        axis.text.y = element_text(colour="black",size=15), #y axis labels
```

```
        axis.title.x = element_text(colour="black",size=15),
        axis.title.y = element_text(colour="black",size=15), #y ,axis title
        legend.text = element_text(colour="black", size=15), #legend text
        legend.title = element_blank(),#legend title
        legend.background = element_rect(fill="white"), #legend background color
        legend.position = "top",
        legend.direction= "horizontal",
        legend.key = element_rect(colour="black", fill="white"),
        legend.key.width=unit(3,"cm"),
        plot.background = element_rect(fill = "white" ), #plot background color
        panel.grid.major= element_line(colour=NA),
        panel.grid.minor=element_line(colour=NA),
        panel.background = element_rect(fill = "white"),
        axis.line=element_line(colour="black"))

mat <- matrix(c(0,.491,0,0,.25*2.3,0,0.958,0,.31*3.9, 0,0,0.958,.58*3.7,0,0,.958),ncol=4)

v <- matrix(nrow=4, ncol=100)

v[,1]<- c(20000*.25,20000*.25,20000*.24,20000*.26)

for(i in 1:99){

  v[,i+1] <- mat %*% v[,i]

}

col <- colSums(v)

eigens=eigen(mat)

lambda=eigens$values[1]
c=eigens$vectors[,1]/sum(eigens$vectors[,1])




##
lambdap0 <- matrix(nrow=1, ncol=21)
unip0 <- seq(0, 1,by=.05)
for(i in 1:21){
  mat <- matrix(c(0,unip0[i],0,0,.25*2.3,0,0.958,0,.31*3.9, 0,0,0.958,.58*3.7,0,0,.958),ncol=4)
eigenp0 <- eigen(mat)
lambdap0[i] <- eigenp0$values[1]
}
plot(unip0, lambdap0)

lambdap1 <- matrix(nrow=1, ncol=21)
unip1 <- seq(0, 1,by=.05)
for(i in 1:21){
  mat <- matrix(c(0,.491,0,0,.25*2.3,0,unip1[i],0,.31*3.9, 0,0,0.958,.58*3.7,0,0,.958),ncol=4)
eigenp1 <- eigen(mat)
lambdap1[i] <- eigenp1$values[1]
```

```r
}
#plot(unip1, lambdap1)


lambdap2 <- matrix(nrow=1, ncol=21)
unip2 <- seq(0, 1,by=.05)
for(i in 1:21){
  mat <- matrix(c(0,.491,0,0,.25*2.3,0,.958,0,.31*3.9, 0,0,unip2[i],.58*3.7,0,0,.958),ncol=4)
eigenp2 <- eigen(mat)
lambdap2[i] <- eigenp2$values[1]
}
#plot(unip2, lambdap2)

# matrix(c(0,.491,0,0,.25*2.3,0,0.958,0,.31*3.9, 0,0,0.958,.58*3.7,0,0,.958),ncol=4)
lambdap3 <- matrix(nrow=1, ncol=21)
unip3 <- seq(0, 1,by=.05)
for(i in 1:21){
  mat <- matrix(c(0,.491,0,0,unip3[i]*2.3,0,.958,0,.31*3.9, 0,0,.958,.58*3.7,0,0,.958),ncol=4)
eigenp3 <- eigen(mat)
lambdap3[i] <- eigenp3$values[1]
}
#plot(unip3, lambdap3)



lambdap4 <- matrix(nrow=1, ncol=21)
unip4 <- seq(0, 1,by=.05)
for(i in 1:21){
  mat <- matrix(c(0,.491,0,0,.25*2.3,0,.958,0,unip4[i]*3.9, 0,0,.958,.58*3.7,0,0,.958),ncol=4)
eigenp4 <- eigen(mat)
lambdap4[i] <- eigenp4$values[1]
}
#plot(unip4, lambdap4)



lambdap5 <- matrix(nrow=1, ncol=21)
unip5 <- seq(0, 1,by=.05)
for(i in 1:21){
  mat <- matrix(c(0,.491,0,0,.25*2.3,0,.958,0,unip5[i]*3.9, 0,0,.958,.58*3.7,0,0,.958),ncol=4)
eigenp5 <- eigen(mat)
lambdap5[i] <- eigenp5$values[1]
}
#plot(unip5, lambdap5)
```

References

Arbaugh, J Ason S C, and N Dixie. 2010. "Nest-Site Selection and Nesting Ecology of Giant Canada Geese in Central Tennessee." *Human–Wildlife Interactions* 4 (2): 207–12.

Balkcom, Gregory D. 2010. "Demographic Parameters of Rural and Urban Adult Resident Canada Geese in Georgia." *Journal of Wildlife Management* 74 (1): 120–23. doi:10.2193/2009-007. http://www.bioone.org/doi/abs/10.2193/2009-007.

Castelli, Paul M., and Robert E. Trost. 1996. “Neck Bands Reduce Survival of Canada Geese in New Jersey.” *The Journal of Wildlife Management* 60 (4): 891–98.

Conover, Michael R. 2001. “Effect of Hunting Wildlife and Damage Trapping.” *The Wildlife Society Bulletin* 29 (2): 521–32.

Converse, Kathryn A., and James J. Kennelly. 1994. “Evaluation of Canada Goose Sterilization for Population Control.” *Wildlife Society Bulletin* 22 (2): 265–69.

Dunn, John P, and Kevin J Jacobs. 2000. “Special Resident Canada Goose Hunting Seasons in Pennsylvania - Management Implications for Controlling Resident Canada Geese.” *The Ninth Wildlife Damage Management Conference Proceedings*, no. 2000: 322–36.

Eberhardt, Lester E., Robert G. Anthony, and William H. Rickard. 1989. “Survival of Juvenile Canada Geese During the Rearing Period.” *The Journal of Wildlife Management* 53 (2): 372–77.

Laake, Jeff L. 2013. “RMark : An R Interface for Analysis of Capture-Recapture Data with Mark.” Alaska Fish Science Center, NOAA.

Raveling, Dennis G. 1981. “Survival, Experience and Age in Relation to Breeding Success of Canada Geese.” *The Journal of Wildlife Management* 45 (4): 817–29.

White, Gary C., and K.P. Burnham. 1999. “Program MARK: Survival Estimation from Populations of Marked Animals.” *Bird Study* 46 Supplem: 120–38.