**Supplementary Material**

Population decline and range contraction of the Egyptian Vulture *Neophron percnopterus* in the Balkan Peninsula

METODIJA VELEVSKI, STOYAN C. NIKOLOV, BEN HALLMANN, VLADIMIR DOBREV, LAVRENTIS SIDIROPOULOS, VICTORIA SARAVIA, RIGAS TSIAKIRIS, VOLEN ARKUMAREV, ANTONIA GALANAKI, THEODOROS KOMINOS, KALLIOPI STARA, ELZBIETA KRET, BRATISLAV GRUBAČ, EMANUEL LISIČANEC, THANOS KASTRITIS, DIMITRIS VAVYLIS, MIRJAN TOPI, BLEDI HOXHA and STEFFEN OPPEL

**Contents**

Trend estimation for Egyptian Vultures in the Balkans

**# TREND ESTIMATION FOR EGYPTIAN VULTURES IN THE BALKANS**

**# R code written by Steffen Oppel on 20 May 2014 (steffen.oppel@rspb.org.uk)**

**# based on Chapter 5 in Kéry and Schaub (2012)**

**# requires JAGS 3.3 to be installed on computer**

# LOAD DATA FROM DATABASE

library(R2jags)

library(Hmisc)

EGVU<-read.table("Balkan\_EV.csv", header=T, sep=",")

year<-seq(1980,2013,1)

n.years=length(year)

# SPECIFY STATE-SPACE MODEL IN BUGS LANGUAGE

sink("EGVU\_Balkantrend.txt")

cat("

model{

##### Priors and constraints

for (s in 1:countries){ ### start loop over every country

N.est[1,s] ~ dunif(0,500) # prior for initial population size

mean.lambda[s] ~ dunif(0,10) # Prior for mean growth rate

sigma.proc[s] ~ dunif(0,10) # Prior for annual variation in pop size

sigma2.proc[s]<-pow(sigma.proc[s],2)

tau.proc[s]<-pow(sigma.proc[s],-2)

sigma.obs[s] ~ dunif(0,100) # Prior for variation in detectability

sigma2.obs[s]<-pow(sigma.obs[s],2)

tau.obs[s]<-pow(sigma.obs[s],-2)

}

##### Likelihood function

for (s in 1:countries){ ### start loop over every country

## State process for entire time series

for (t in 1:(T-1)){

lambda[t,s] ~ dnorm(mean.lambda[s], tau.proc[s])

N.est[t+1,s]<-N.est[t,s]\*lambda[t,s]

}

## Observation process

for (t in 1:T){

y[t,s] ~ dnorm(N.est[t,s], tau.obs[s])

}

} ### end country loop

##### Derived parameters

for (t in 1:T){

pop.size[t]<-sum(N.est[t,]) ### Balkan population size for each year

}

Balkan.lam<-mean(mean.lambda[]) ### pop growth rate for Balkans

for (s in 1:countries){

mlam10country[s] <- mean(lambda[(T-10):(T-1),s]) ### pop growth rate 2003-2013

}

} ### close the model loop

", fill=TRUE)

sink()

# PREPARE INPUT DATA AND INITIAL VALUES

## Bundle data

bugs.data<-list(y=as.matrix(EV), T=n.years, countries=3)

## Initial values

inits<- function() {list(sigma.proc=runif(countries,0,5),

mean.lambda=runif(countries,0.1,2),

sigma.obs=runif(countries,0,10),

N.est=matrix(data=(c(runif(countries,150,300),rep(NA,(n.years-1)\*countries))), nrow=n.years,byrow=T))}

## Parameters to be estimated

params<-c("N.est","pop.size", "mean.lambda", "Balkan.lam","mlam10country")

## MCMC settings

ni<-5000000 ## number of iterations

nt<-25 ## thinning rate

nb<-2500000 ## length of burn-in

nc<-3 ## number of chains

# RUN THE MODEL IN JAGS AND SAVE OUTPUT

Balkan<- jags(data=bugs.data, inits=inits, parameters.to.save=params, model.file="EGVU\_Balkantrend.txt", n.chains=nc, n.thin=nt, n.iter=ni, n.burnin=nb)

sink("EGVU\_trend\_summaries.txt")

print(Balkan,dig = 3)

sink()

# COMPILE ESTIMATES TO PRODUCE TREND PLOT

EV.ssm<-Balkan$BUGSoutput

fitted<-lower<-upper<-Greece<-FYROM<-Bulgaria<-as.numeric()

for (i in 1:(n.years)){

fitted[i]<-quantile(EV.ssm$sims.list$pop.size[,i], 0.5)

lower[i]<-quantile(EV.ssm$sims.list$pop.size[,i], 0.025)

upper[i]<-quantile(EV.ssm$sims.list$pop.size[,i], 0.975)

Greece[i]<-quantile(EV.ssm$sims.list$N.est[,i,3], 0.5)

FYROM[i]<-quantile(EV.ssm$sims.list$N.est[,i,2], 0.5)

Bulgaria[i]<-quantile(EV.ssm$sims.list$N.est[,i,1], 0.5)

}

top<-max(upper)+7

# PLOT POPULATION TREND (Figure 1)

par(oma=c(0,0,0,0),mar=c(4,4,0,0), cex=1.2)

errbar(c(1980:2013),fitted, lower,upper,ylim=c(0,700), xlim=c(1980, 2013), ylab="Egyptian Vulture breeding pairs", xlab="Year", las=1, type='p', pch=16, main="",frame=FALSE, axes=FALSE, cex.axis=1.3, cex=1, cex.lab=1.3)

axis(2, at=seq(0,700,100),labels=T, las=1, mgp=c(3,0.5,0), cex.axis=1.3)

axis(1, at=c(1980:2013),labels=T, , cex.axis=1.3)

points(x=c(1980:2013),fitted, type='l', col='black', lwd=2, lty=1)

points(x=c(1980:2013),Greece, type='l', col='grey38', lwd=2, lty=2)

points(x=c(1980:2013),FYROM, type='l', col='grey38', lwd=2, lty=3)

points(x=c(1980:2013),Bulgaria, type='l', col='grey38', lwd=1, lty=1)

legend(2013,700,lty=c(2,3,1), col="grey38", legend=c("Greece", "FYR of Macedonia", "Bulgaria"), lwd=c(2,2,1), bty='n',cex=1.2, xjust=1)