# Three Sessions density estimation with JAGS for Clouded Leopards (CL) in NEPL

# The data combined into one survey sessions of 50 days period

#The data are from 3 survey blocks over 3 years 2013 - 2017

#This model is based on the assumption that sigma and g0 don't change while density varies across the three seasons

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# Load the 'secr' package

library(jagsUI)

library(wiqid) # for plotting functions

library(secr)

###########################################################

#### Define state space or study area ###################

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# Trap locations for all seasons:

#Co-ordinates are in km.

all.traps <- read.traps("TDF\_all seasons.txt") #TDF is trap data file

# If not using the mask in the analysis, define the extent this way

(xl <- min(all.traps$x) - 15) # 15km (should be adjusted based on the species of interest

(xu <- max(all.traps$x) + 15)

(yl <- min(all.traps$y) - 15)

(yu <- max(all.traps$y) + 15)

# Area:

( A <- (xu - xl) \* (yu - yl) ) # 4649.671 km2 with buffer = 15km

#########################

#### Read in the data and create capture history for each survey session

#### Produce 3D arrays consisting of: Individuals, occassions, and trap locations

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## For Season One - 2013

cl.ch1 <- read.capthist("CL\_EDF\_sess1.txt", "TDF\_sess1\_km.txt", detector = "proximity", fmt= "trapID", noccasions = 55)

## For Season Two - 2015

cl.ch2 <- read.capthist("CL\_EDF\_sess2.txt", "TDF\_sess2\_km.txt", detector = "proximity", fmt= "trapID", noccasions = 53)

## For Season Three - 2017

cl.ch3 <- read.capthist("CL\_EDF\_sess3.txt", "TDF\_sess3\_km.txt", detector = "proximity", fmt= "trapID", noccasions = 53)

#####################################################################

# Convert to a y[animal, trap] matrix with number of captures:

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## Season One

yObs1 <- apply(cl.ch1, c(1, 3), sum) # "1" is the animal ID information and "3" is the detector IDs

head(yObs1)

dim(yObs1) # checking 18 individuals, 240 traps

# data = maximum number of captures per trap per animal, summed over all occasions.

max(yObs1)

# number of locations where each individual was captured

(cl.obs1 <- rowSums(yObs1))

J1 <- ncol(yObs1) # number of trap deploy in season 1

## Season two

yObs2 <- apply(cl.ch2, c(1,3), sum)

head(yObs2)

dim(yObs2)

max(yObs2)

(cl.obs2 <- rowSums(yObs2))

J2 <- ncol(yObs2) # number of trap deploy in season 2

## Season three

yObs3 <- apply(cl.ch3, c(1,3), sum)

head(yObs3)

dim(yObs3)

max(yObs3)

(cl.obs3 <- rowSums(yObs3))

J3 <- ncol(yObs3) # number of trap deploy in season 3

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# Extract the traps information

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traps1 <- as.matrix(traps(cl.ch1)) #traps information for season 1

traps2 <- as.matrix(traps(cl.ch2)) # traps information for season 2

traps3 <- as.matrix(traps(cl.ch3)) # traps information for season 3

########################################################

###### JAGS model ####################################

cat("model{

# Priors distributions for the session-invariant parameters

sigma~dunif(0, 15) #adjust to your species

sigma2<-2\*sigma\*sigma

#Expected encounter rate at distance zero to Activity Centre

lam0 ~ dgamma(0.1,0.1)

 # session 1

 psi1 ~ dunif(0, 1) # Data augmentation parameter

 # Likelihood

 for (i in 1:M){ # loop through the population for session 1

 z1[i] ~ dbern(psi1)

 SX1[i] ~ dunif(xl,xu) # priors for the activity centers

 SY1[i] ~ dunif(yl,yu) # for each individual i

 for(j in 1:J1) { #loop through the J1 trap locations

dist21[i,j] <- pow(SX1[i]-trapmat1[j,1], 2) + pow(SY1[i]-trapmat1[j,2],2) # Distance^2

 # A decreasing function between AC of i to trap j

g1[i,j] <- exp(-dist21[i,j]/sigma2)

# Detection probability, K is number of survey occasions

pmean1[i,j] <- K1[j] \* g1[i,j] \* lam0 \* z1[i]

 y1[i,j] ~ dpois(pmean1[i,j]) # Encounter frequency

 }

 }

 N1 <- sum(z1[1:M]) #derive number (check against M)

 D1 <- N1 / A #derive density over state space

 # session 2

 psi2 ~ dunif(0, 1)

 #Likelihood

 for (i in 1:M){ # loop through the population for session 2

 z2[i] ~ dbern(psi2)

 SX2[i] ~ dunif(xl,xu) # priors for the activity centers

 SY2[i] ~ dunif(yl,yu) # for each individual

 for(j in 1:J2) { #loop through the J2 trap locations

dist22[i,j] <- pow(SX2[i]-trapmat2[j,1], 2) + pow(SY2[i]-trapmat2[j,2],2) # Distance^2

# A decreasing function between AC of i to trap j

g2[i,j] <- exp(-dist22[i,j]/sigma2)

# Detection probability, K is number of survey occasions

pmean2[i,j] <- K2[j] \* g2[i,j] \* lam0 \* z2[i]

 y2[i,j] ~ dpois(pmean2[i,j]) # Encounter frequency

 }

 }

N2 <- sum(z2[1:M])

D2 <- N2 / A

# session 3

 psi3 ~ dunif(0, 1)

 #Likelihood

 for (i in 1:M){

 z3[i] ~ dbern(psi3)

 SX3[i] ~ dunif(xl,xu)

 SY3[i] ~ dunif(yl,yu)

 for(j in 1:J3) {

dist23[i,j] <- pow(SX3[i]-trapmat3[j,1], 2) + pow(SY3[i]-trapmat3[j,2],2) # Distance^2

 g3[i,j] <- exp(-dist23[i,j]/sigma2)

 pmean3[i,j] <- K3[j] \* g3[i,j] \* lam0 \* z3[i]

 y3[i,j] ~ dpois(pmean3[i,j])

 }

 }

 N3 <- sum(z3[1:M])

 D3 <- N3 / A

trend <- D3 / D1 - 1

D <- (D1 + D2 + D3) / 3 #Average density from three season

}

 ", file = "CL\_3sess\_SCR.txt")

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#Prepare data for JAGS

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# Create the augmented captures matrix:

M <- 180 # Number of capture histories after augmentation

# Number of survey occasions, This can be different for different seasons

K1 <- read.table("K1.txt")[,1]

K2 <- read.table("K2.txt")[,1]

K3 <- read.table("K3.txt")[,1]

# Capture matrix y is an M x traps matrix with number of captures:

#180 by 240 locations

y1 <- rbind(yObs1, matrix(0, M - nrow(yObs1), J1))

y2 <- rbind(yObs2, matrix(0, M - nrow(yObs2), J2))

y3 <- rbind(yObs3, matrix(0, M - nrow(yObs3), J3))

dim(y1)

dim(y2)

dim(y3)

# Specify the data in a list, for shipment to JAGS:

jagsdata = list(y1 = y1, y2 = y2, y3 = y3, M = M, xl = xl, xu = xu, yl = yl, yu = yu, A = A, J1 = J1, J2 = J2, J3 = J3, trapmat1 =traps1, trapmat2 =traps2, trapmat3 =traps3, K1 = as.vector(K1), K2 = as.vector(K2), K3 = as.vector(K3))

str(jagsdata)

# Initial values for z:

inits <- function() list(z1=rep(1,M), z2=rep(1,M), z3=rep(1,M))

wanted <- c("trend", "N1", "N2", "N3", "D1", "D2", "D3", "psi1", "psi2", "psi3", "lam0", "sigma", "D")

##################################################

# Run the model

cljags <- jags(jagsdata, inits=inits, wanted, model.file="CL\_3sess\_SCR.txt", n.chains=3, n.iter=100000, n.burnin=50000, n.thin=10, parallel=TRUE, DIC=FALSE)

#save the results

save(cljags, file="cljags\_3sess\_100k.Rdata")

# Check the results

load("cljags\_3sess\_100k.Rdata") #load the saved results

cljags

plot(cljags)

View(cljags)