SUPPLEMENTARY ELECTRONIC MATERIAL (Appendix 2)

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TWO SURVEYS PER SPRING ARE ENOUGH TO OBTAIN ROBUST POPULATION TRENDS OF COMMON AND WIDESPREAD BIRDS IN YEARLY MONITORING PROGRAMMES

DOS CENSOS POR PRIMAVERA SON SUFICIENTES PARA OBTENER TENDENCIAS POBLACIONALES ROBUSTAS EN PROGRAMAS DE SEGUIMIENTO DE AVES COMUNES

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Appendix 2. R script for estimating the power of ascertaining true population changes in virtual species between two consecutive years.

[Códigos de R utilizados para estimar la potencia de los tests al estimar tasas de cambio entre dos años consecutivos (en porcentaje) para especies virtuales.]

```
## Two surveys per spring are enough to obtain robust population trends
##   of common and widespread birds in yearly monitoring programmes
## Luis M. Carrascal, Juan Carlos del Moral

## run under R version 3.2.5 (2016-04-14) -- "Very, Very Secure Dishes"
##  to make use of SDMTools package
library(SDMTools)
library(psych)

## DATA FOR THE VIRTUAL SPECIES
## parameters for the negative binomial distribution to generate random
numbers
##   in 750 virtual UTM squares, using different combinations of the parameters
##   mu (mean) and size-k (variance = mu2 + [mu^2]/k).
mi.mu <- 12       ## mu of the negative binomial distribution
mi.size <- 1      ## size of the negative binomial distribution

## yearly inter-annual change
mi.tasa <- 1.05    ## inter-annual change (1.05 is x1.05 or a 5% increase)
n.simuls <- 300    ## number of simulations

set.seed(699)
tiempo.inicio <- Sys.time()

## seed values for the pattern of distribution of the species in time zero
##   considering 750 UTM sampled (change that number in n=750)
semilla.utm.t1 <- rnbinom(n=750, mu=mi.mu, size=mi.size)

## calculations
utms.uno <- rep(999999, times=n.simuls)
utms.dos <- rep(999999, times=n.simuls)
utms.diez <- rep(999999, times=n.simuls)
max.uno <- rep(999999, times=n.simuls)
max.dos <- rep(999999, times=n.simuls)
max.diez <- rep(999999, times=n.simuls)
maximo <- rep(999999, times=n.simuls)
abund20.uno <- rep(999999, times=n.simuls)
abund20.dos <- rep(999999, times=n.simuls)
abund20.diez <- rep(999999, times=n.simuls)
power.uno <- rep(999999, times=n.simuls)
power.dos <- rep(999999, times=n.simuls)
power.diez <- rep(999999, times=n.simuls)
cor.ns.uno.t1 <- rep(999999, times=n.simuls)
cor.ns.dos.t1 <- rep(999999, times=n.simuls)
```

```
cor.ns.diez.t1 <- rep(999999, times=n.simuls)
cor.ns.uno.t2 <- rep(999999, times=n.simuls)
cor.ns.dos.t2 <- rep(999999, times=n.simuls)
cor.ns.diez.t2 <- rep(999999, times=n.simuls)
ratio.uno <- rep(999999, times=n.simuls)
ratio.dos <- rep(999999, times=n.simuls)
ratio.diez <- rep(999999, times=n.simuls)
##
for (i in 1:n.simuls) {
  matrix.t1 <- data.frame(matrix(data=999999, nrow=1000, ncol=750))
  un.censo.t1 <- rep(999999, times=750)
  dos.censo.t1 <- rep(999999, times=750)
  diez.censo.t1 <- rep(999999, times=750)
  conteos.censo.t1 <- rep(999999, times=750)
  for (j in 1:750) {
    matrix.t1[,j] <- rnbinom(n=1000, mu=semilla.utm.t1[j]/20, size=mi.size)
  }
  for (j in 1:750) {
    un.censo.t1[j] <- sum(matrix.t1[c(1:20),j])
    dos.censo.t1[j] <- sum(matrix.t1[c(1:40),j])/2
    diez.censo.t1[j] <- sum(matrix.t1[c(1:200),j])/10
    conteos.censo.t1[j] <- sum(matrix.t1[c(1:1000),j])/50
  }
  ##
  matrix.t2 <- data.frame(matrix(data=999999, nrow=1000, ncol=750))
  un.censo.t2 <- rep(999999, times=750)
  dos.censo.t2 <- rep(999999, times=750)
  diez.censo.t2 <- rep(999999, times=750)
  conteos.censo.t2 <- rep(999999, times=750)
  for (j in 1:750) {
    matrix.t2[,j] <- rnbinom(n=1000, mu=(semilla.utm.t1[j]*mi.tasa)/20,
size=mi.size)
  }
  for (j in 1:750) {
    un.censo.t2[j] <- sum(matrix.t2[c(1:20),j])
    dos.censo.t2[j] <- sum(matrix.t2[c(1:40),j])/2
    diez.censo.t2[j] <- sum(matrix.t2[c(1:200),j])/10
    conteos.censo.t2[j] <- sum(matrix.t2[c(1:1000),j])/50
  }
  ##
  ## correlations between the spatial variation of abundance
  cor.ns.uno.t1[i] <- cor(un.censo.t1, conteos.censo.t1)
  cor.ns.dos.t1[i] <- cor(dos.censo.t1, conteos.censo.t1)
  cor.ns.diez.t1[i] <- cor(diez.censo.t1, conteos.censo.t1)
  cor.ns.uno.t2[i] <- cor(un.censo.t2, conteos.censo.t2)
  cor.ns.dos.t2[i] <- cor(dos.censo.t2, conteos.censo.t2)
  cor.ns.diez.t2[i] <- cor(diez.censo.t2, conteos.censo.t2)
  ##
  ## selection of UTMs with the presence of the species (with at least one bird)
  tasas.uno <- data.frame(un.censo.t1, un.censo.t2)
```

```
  tasas.dos <- data.frame(dos.censo.t1, dos.censo.t2)
  tasas.diez <- data.frame(diez.censo.t1, diez.censo.t2)
  tasas.uno <- subset(tasas.uno, tasas.uno$un.censo.t1>=1 &
tasas.uno$un.censo.t2>=1)
  tasas.dos <- subset(tasas.dos, tasas.dos$dos.censo.t1>=1 &
tasas.dos$dos.censo.t2>=1)
  tasas.diez <- subset(tasas.diez, tasas.diez$diez.censo.t1>=1 &
tasas.diez$diez.censo.t2>=1)
  tasas.uno$ratio.t2t1 <- tasas.uno[,2]/tasas.uno[,1]
  tasas.dos$ratio.t2t1 <- tasas.dos[,2]/tasas.dos[,1]
  tasas.diez$ratio.t2t1 <- tasas.diez[,2]/tasas.diez[,1]
  ##
  ## occupied UTM, average abundance in 20 census plots per UTM,
  ##   and maximum number of birds in the sample of occupied UTM
  utms.uno[i] <- dim(tasas.uno)[1]
  utms.dos[i] <- dim(tasas.dos)[1]
  utms.diez[i] <- dim(tasas.diez)[1]
  max.uno[i] <- max(tasas.uno[,1])
  max.dos[i] <- max(tasas.dos[,1])
  max.diez[i] <- max(tasas.diez[,1])
  maximo[i] <- max(conteos.censo.t1)
  abund20.uno[i] <- mean(tasas.uno[,1])
  abund20.dos[i] <- mean(tasas.dos[,1])
  abund20.diez[i] <- mean(tasas.diez[,1])
  ratio.uno[i] <- wt.mean(x=tasas.uno$ratio.t2t1, wt=tasas.uno[,1])
  ratio.dos[i] <- wt.mean(x=tasas.dos$ratio.t2t1, wt=tasas.dos[,1])
  ratio.diez[i] <- wt.mean(x=tasas.diez$ratio.t2t1, wt=tasas.diez[,1])
  ##
  ## power of the tests at alfa=0.05 in a paired t-test
  ##   (using weights of each occupied UTM according to the number of birds
per UTM)
  test.uno <- (wt.mean(x=tasas.uno$ratio.t2t1, wt=tasas.uno[,1])-
1)/(wt.sd(x=tasas.uno$ratio.t2t1, wt=tasas.uno[,1])/sqrt(dim(tasas.uno)[1]))
  power.uno[i] <- ifelse(test.uno>qt(p=0.05/2, df=dim(tasas.uno)[1]-1,
lower.tail=FALSE), 1, 0)
  test.dos <- (wt.mean(x=tasas.dos$ratio.t2t1, wt=tasas.dos[,1])-
1)/(wt.sd(x=tasas.dos$ratio.t2t1, wt=tasas.dos[,1])/sqrt(dim(tasas.dos)[1]))
  power.dos[i] <- ifelse(test.dos>qt(p=0.05/2, df=dim(tasas.dos)[1]-1,
lower.tail=FALSE), 1, 0)
  test.diez <- (wt.mean(x=tasas.diez$ratio.t2t1, wt=tasas.diez[,1])-
1)/(wt.sd(x=tasas.diez$ratio.t2t1, wt=tasas.diez[,1])/sqrt(dim(tasas.diez)[1]))
  power.diez[i] <- ifelse(test.diez>qt(p=0.05/2, df=dim(tasas.diez)[1]-1,
lower.tail=FALSE), 1, 0)
}
##
## RESULTS
matrix.results <- data.frame(utms.uno, utms.dos, utms.diez, max.uno, max.dos,
max.diez, maximo, abund20.uno, abund20.dos, abund20.diez, power.uno,
power.dos, power.diez, cor.ns.uno.t1, cor.ns.dos.t1, cor.ns.diez.t1,
cor.ns.uno.t2, cor.ns.dos.t2, cor.ns.diez.t2, ratio.uno, ratio.dos, ratio.diez)
```

```
##
print(describe(matrix.results)[, c(1:4, 9)], digits=3)
##
tiempo.fin <- Sys.time()
tiempo.fin-tiempo.inicio
```