Universidad de
Castilla-La Mancha

SEGUIMIENTO DE LA DIVERSIDAD BIOLÓGICA

Modelos de población integrados con PVA

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Repetid primero los análisis que se ejecutan aquí. Pegad los resultados en un procesador de texto (resultados numéricos y gráficos) e incluid también vuestros propios comentarios. Enviadme vuestros trabajos por e-mail a: Jose.Jimenez@csic.es.

Información sobre códigos

El presente PVA ha sido desarrollado por Schaub (2020). Se trata de un análisis de viabilidad poblacional que se basa en un IPM, en el que incorpora diferentes posibilidades de gestión y evalua la respuesta de la población en una proyección a futuro. Para el presente curso se ha simulado una población de *Strix occidentalis caurina*, utilizando valores previamente publicados de supervivencia juvenil (*sjuv*), supervivencia adulta (*sad*) y fecundidad, y que están disponibles en la unidad de repaso de los métodos matriciales.

Discusión sobre la validez de los PVA

En ocasiones los PVA tradicionales son objeto de discusión por el uso indebido de programas informáticos genéricos y la dependencia de la opinión de los expertos para parametrizar modelos complejos no respaldados por datos (Taylor 1995, Beissinger y Westphal 1998, Hernández- Camacho y otros 2015) y donde la incertidumbre de los procesos ecológicos se incopora añadiendo variabilidad, pero no se considera la detectabilidad en los procesos de detección. Sin embargo, está surgiendo un nuevo marco de PVA en el que las previsiones se hacen utilizando modelos estadísticos ajustados a datos empíricos (Sæther y Engen 2002, Nadeem y Lele 2012, Howell et al 2020). En este marco, se elimina la distinción entre la estimación de parámetros y la modelización de la población, lo que permite tener en cuenta adecuadamente la incertidumbre de los parámetros. Si se utiliza la inferencia bayesiana, la opinión de los expertos puede incorporarse formalmente a través de los antecedentes o priors (Wade 2002, Jamieson y Brooks 2004).

1. Preparación de datos

El conjunto de datos del IPM que vamos a ver se ha simulado con 10 años de datos, con una población inicial de 400 jóvenes y 200 adultos, con una supervivencia anual de 0.36 y 0.93, y una productividad de 0.24 hembras/hembra reproductora a partir del segundo año de vida. Se ha usado una probabilidad de captura del 0.95 para jóvenes y 0.8 para adultos, y una proabilidad de encontrar una pareja reproductora, y registrar el éxito reproductor, del 0.8. Para simular los datos se ha usado el código de Abadi et al. (2010) adaptado por Schaub.

```
> library(nimble)
> library(popbio)
> library(lattice)
> library(coda)
```

```
> # Simulamos la supervivencia juvenil, pero añadiendo un ruido gaussiano
> # estocástico alrededor de la media de la supervivencia juvenil
> mean.sjuv<-0.36
> mean.logit.sjuv <- logit(mean.sjuv)
> eps.sjuv<-rnorm(9,0,0.5)
> sjuv <- expit(mean.logit.sjuv + eps.sjuv)
> sjuv<-c(0.6050644,0.5740094,0.5180878,0.3774764,0.4163225,0.4685812,0.2780022,
+         0.2332290,0.5274793)
> # Hacemos lo mismo con la supervivencia adulta
> mean.sad<-0.93
> mean.logit.sad <- logit(mean.sad)
> eps.sad<-rnorm(9,0,0.5)
> sad <- expit(mean.logit.sad + eps.sad)
> sad<-c(0.9585836,0.9092798,0.9734925,0.9504287,0.9341231,0.9641143,0.9360352,
+        0.9417192,0.9077353)
> f11<-0
> f12<-0.24
> vr<-list(mean.sjuv=0.36, mean.sad=0.93, f12=0.48)
> stages <- c("juvenil","adulto")
> post <- expression( matrix2(c(
+               0,      mean.sad*f12/2, # Aqui se usan hembras (50%)
+           mean.sjuv,  mean.sad), stages ))
> (A <- eval(post, vr))
```

```
        juvenil adulto
```

```
juvenil     0.00 0.2232
adulto      0.36 0.9300
```

```
> lambda(A)
```

```
[1] 1.009589
```

Conteos de machos adultos (desde el año 1 al 10)

```
> y <- c(28,32,25,38,40,43,36,40,44,49)
```

Datos de productividad (desde el año 1 al 9)

```
> J <- c(2,22,16,16,20,24,36,16,18,32)    # Pollos volados
> R <- c(42,42,39,44,50,48,48,51,52,55)   # Nidos localizados
```

Datos de captura-recaptura (en formato m-array, desde el año 1 a 10)

```
> m<-matrix(c(3,  1,  0,  0,  0,  0,  0,  0,  0,  5,
+              0,  7,  3,  0,  0,  0,  0,  0,  0,  9,
+              0,  0,  8,  2,  1,  1,  0,  0,  0,  5,
+              0,  0,  0,  6,  0,  2,  0,  0,  0, 22,
+              0,  0,  0,  0,  4,  0,  1,  0,  0, 12,
+              0,  0,  0,  0,  0, 10,  0,  0,  0, 11,
+              0,  0,  0,  0,  0,  0,  1,  2,  0, 17,
+              0,  0,  0,  0,  0,  0,  0,  5,  0, 22,
+              0,  0,  0,  0,  0,  0,  0,  0, 12, 20,
+             44, 10,  1,  0,  0,  0,  0,  0,  0,  3,
+              0, 39, 11,  2,  0,  0,  0,  0,  0,  8,
+              0,  0, 49,  4,  1,  1,  0,  0,  0,  4,
+              0,  0,  0, 57, 11,  2,  0,  0,  0,  4,
+              0,  0,  0,  0, 55, 10,  1,  0,  0,  6,
+              0,  0,  0,  0,  0, 44, 15,  5,  1,  7,
+              0,  0,  0,  0,  0,  0, 52,  8,  2,  8,
+              0,  0,  0,  0,  0,  0,  0, 50, 13,  7,
+              0,  0,  0,  0,  0,  0,  0,  0, 50, 20),
+              ncol = 10, byrow = TRUE)
```

2. Código en BUGS usando NIMBLE

Código:

```
> code <- nimbleCode({
+
+   #-------------------------------------------------------------
+   # MODELO DE POBLACIÓN INTEGRADO
+   #   - Modelo estructurado por edades con 2 clases:
+   #     joven (hasta 1 año) y adulto (al menos 2 años)
+   #   - Edad de primera reproducción: 1 año
+   #   - Conteos pre-reproductores (machos territoriales)
+   #   - Todos los ratios vitales se asumen constantes
+   #-------------------------------------------------------------
+
+   #############################################################
+   #          1. INFORMACIÓN A PRIORI O ANTECENDENTES
+   #############################################################
+   # Error de observación
+   tauy <- pow(sigma.y, -2)
+   sigma.y ~ dunif(0, 50)
+   sigma2.y <- pow(sigma.y, 2)
+
+   # Tamaños iniciales de población
+   n1 ~ T(dnorm(5, tauy),0,1000)      # 1-año
+   n2 ~ T(dnorm(50, tauy),0,1000)     # Adultos
+   N[1,1,1] <- round(n1)
+   N[2,1,1] <- round(n2)
+
+   # Supervivencia, productividad y probabilidad de recaptura
+   # Priors
+   mean.logit.sjuv <- logit(mean.sjuv)
+   mean.sjuv ~ dunif(0, 1)
+   mean.logit.sad <- logit(mean.sad)
+   mean.sad ~ dunif(0, 1)
+
+   sigma.sjuv ~ dunif(0, 10)
+   tau.sjuv <- pow(sigma.sjuv, -2)
```

```
+   sigma.sad ~ dunif(0, 10)
+   tau.sad <- pow(sigma.sad, -2)
+
+   mean.log.f <- log(mean.f)
+   mean.f ~ dunif(0, 10)
+   sigma.f ~ dunif(0, 10)
+   tau.f <- pow(sigma.f, -2)
+
+   mean.p ~ dunif(0, 1)
+
+   for (t in 1:(nyears-1)){
+     p[t] <- mean.p
+   }
+
+   ## OPCIÓN 1. CONTROL: SIN GESTIÓN (OPCION NULA)
+   #============================================================
+   for (t in 1:(nyears-1+K)){
+     # Supervivencia juvenil
+     logit.sjuv[t] <- mean.logit.sjuv + eps.sjuv[t]
+     eps.sjuv[t] ~ dnorm(0, tau.sjuv)
+     sjuv[t] <- expit(logit.sjuv[t])
+     # Supervivencia adlta
+     logit.sad[t,1] <- mean.logit.sad + eps.sad[t,1]
+     eps.sad[t,1] ~ dnorm(0, tau.sad)
+     sad[t,1] <- expit(logit.sad[t,1])
+   }
+   for (t in 1:(nyears+K)){
+     log.f[t,1] <- mean.log.f + eps.f[t,1]
+     eps.f[t,1] ~ dnorm(0, tau.f)
+     f[t,1] <- exp(log.f[t,1])
+   }
+
+   # OPCIÓN 2: INCREMENTAR LA PRODUCTIVIDAD EN UN 25%
+   #============================================================
+   # Hasta inicio de la gestión
+   for (t in 1:nyears){
+     log.f[t,2] <- log.f[t,1]
```

```
+      eps.f[t,2] <- eps.f[t,1]
+      f[t,2] <- f[t,1]
+    }
+
+    # Futuro: incremento de un 25%
+    for (t in (nyears+1):(nyears+K)){
+      log.f[t,2] <- mean.log.f + log(1.25) + eps.f[t,2]
+      eps.f[t,2] ~ dnorm(0, tau.f)
+      f[t,2] <- exp(log.f[t,2])
+    }
+
+    # OPCIÓN 3. REDUCCION VARIABILIDAD SUPERVIVENCIA ADULTA
+    #=============================================================
+    # Hasta inicio de la gestión
+    for (t in 1:(nyears-1)){
+      logit.sad[t,2] <- logit.sad[t,1]
+      eps.sad[t,2] <- eps.sad[t,1]
+      sad[t,2] <- sad[t,1]
+    }
+
+    # Proyección a futuro
+    for (t in nyears:(nyears-1+K)){
+      logit.sad[t,2] <- mean.logit.sad + eps.sad[t,2]
+      eps.sad[t,2] ~ dnorm(0, tau.sad*2)   # reducimos variabilidad
+      sad[t,2] <- ilogit(logit.sad[t,2])
+    }
+
+    # OPCIÓN 4. SUELTA DE 5 HEMBRAS CADA AÑO DE GESTIÓN
+    #=============================================================
+    # No afectamos a la supervivencia ni a la fecundidad, sino al
+    # tamaño poblacional (ver debajo)
+
+
+
+    ##############################################################
+    #                     2. PROBABILIDAD
+    ##############################################################
```

```
+
+   # 2.1. Probabilidad de los datos de conteos
+   # 2.1.1 Proceso de sistema (realidad biológica)
+
+   # OPCIÓN 1. CONTROL (SIN GESTIÓN)
+   #============================================================
+   for (t in 1:nyears-1+K){
+     N[1,t+1,1] ~ dpois(f[t,1] * sjuv[t] * (N[1,t,1] + N[2,t,1]))
+     N[2,t+1,1] ~ dbin(sad[t,1], (N[1,t,1] + N[2,t,1]))
+   }
+
+   # OPCIÓN 2. CON INCREMENTO DE PRODUCTIVIDAD
+   #============================================================
+   # Hasta inicio de la gestión
+   for (t in 1:nyears){
+     N[1,t,2] <- N[1,t,1]
+     N[2,t,2] <- N[2,t,1]
+   }
+   # Proyección a futuro
+   for (t in nyears:(nyears-1+K)){
+     N[1,t+1,2] ~ dpois(f[t,2] * sjuv[t] * (N[1,t,2] + N[2,t,2]))
+     N[2,t+1,2] ~ dbin(sad[t,1], (N[1,t,2] + N[2,t,2]))
+   }
+
+   # OPCIÓN 3. REDUCCION VARIABILIDAD SUPERVIVENCIA ADULTA
+   #============================================================
+   # Hasta inicio de la gestión
+   for (t in 1:nyears){
+     N[1,t,3] <- N[1,t,1]
+     N[2,t,3] <- N[2,t,1]
+   }
+   # Proyección a futuro
+   for (t in nyears:(nyears-1+K)){
+     N[1,t+1,3] ~ dpois(f[t,1] * sjuv[t] * (N[1,t,3] + N[2,t,3]))
+     N[2,t+1,3] ~ dbin(sad[t,2], (N[1,t,3] + N[2,t,3]))
+   }
+
```

```
+   # OPCIÓN 4. SUELTA DE 5 HEMBRAS CADA AÑO DE GESTIÓN
+   #============================================================
+   # Hasta inicio de la gestión
+   for (t in 1:nyears){
+     N[1,t,4] <- N[1,t,1]
+     N[2,t,4] <- N[2,t,1]
+   }
+   # Proyección a futuro
+   for (t in nyears:(nyears-1+K)){
+     N[1,t+1,4] ~ dpois(f[t,1] * sjuv[t] * (N[1,t,4] + N[2,t,4] + 5))
+     N[2,t+1,4] ~ dbin(sad[t,1], (N[1,t,4] + N[2,t,4] + 5))
+   }
+
+   # 3.1.2 Proceso de observación
+   for (t in 1:nyears){
+     y[t] ~ dnorm(N[1,t,1] + N[2,t,1], tauy)
+   }
+
+   # 2.2 Probabilidad de los datos de captura-recaptura:
+   # modelo CJS con dos clases de edad
+
+   # Probabilidad multinomial
+   for (t in 1:2*(nyears-1)){
+     m[t,1:nyears] ~ dmulti(pr[t,1:nyears], r[t])
+   }
+
+   # Probabilidades del m-array para juveniles
+   for (t in 1:(nyears-1)){
+     # Diagonal principal
+     q[t] <- 1-p[t]
+     pr[t,t] <- sjuv[t] * p[t]
+     # Por encima de la diagonal principal
+     for (j in (t+1):(nyears-1)){
+       pr[t,j] <- sjuv[t]*prod(sad[(t+1):j,1])*prod(q[t:(j-1)])*p[j]
+     } #j
+     # Bajo la diagonal principal
+     for (j in 1:(t-1)){
```

```
+       pr[t,j] <- 0
+     } #j
+     # Última columna: probabilidad de no-recaptura
+     pr[t,nyears] <- 1-sum(pr[t,1:(nyears-1)])
+   } #t
+
+   # Probabilidades del m-array para adultos
+   for (t in 1:(nyears-1)){
+     # Diagonal principal
+     pr[t+nyears-1,t] <- sad[t,1] * p[t]
+     # Por encima de la diagonal principal
+     for (j in (t+1):(nyears-1)){
+       pr[t+nyears-1,j] <- prod(sad[t:j,1])*prod(q[t:(j-1)])*p[j]
+     } #j
+     # Bajo la diagonal principal
+     for (j in 1:(t-1)){
+       pr[t+nyears-1,j] <- 0
+     } #j
+     # Última columna: probabilidad de no-recaptura
+     pr[t+nyears-1,nyears] <- 1 - sum(pr[t+nyears-1,1:(nyears-1)])
+   } #t
+
+   # 2.3. Probabilidad para datos de productividad: regresión de Poisson
+   for (t in 1:(nyears-1)){
+     J[t] ~ dpois(rho[t])
+     rho[t] <- R[t]*f[t,1]
+   }
+
+   # Derived parameters
+   for (t in 1:(nyears+K)){
+     Ntot[t,1] <- N[1,t,1] + N[2,t,1] # Sin gestión
+     Ntot[t,2] <- N[1,t,2] + N[2,t,2] # Gestión de productividad
+     Ntot[t,3] <- N[1,t,3] + N[2,t,3] # Disminuir variabilidad sad
+     Ntot[t,4] <- N[1,t,4] + N[2,t,4] # Suelta de 5 hembras anuales
+   }
+
+ })
```

Preparamos datos

```
> str (data  <-  list(m = m,
+                     y = y,
+                     J = J))
```

```
List of 3
 $ m: num [1:18, 1:10] 3 0 0 0 0 0 0 0 0 44 ...
 $ y: num [1:10] 28 32 25 38 40 43 36 40 44 49
 $ J: num [1:10] 2 22 16 16 20 24 36 16 18 32
```

Preparamos constantes

```
> str(constants<-list(R = R,
+                     nyears = dim(m)[2],
+                     r = rowSums(m),
+                     K = 5))
```

```
List of 4
 $ R     : num [1:10] 42 42 39 44 50 48 48 51 52 55
 $ nyears: int 10
 $ r     : num [1:18] 9 19 17 30 17 21 20 27 32 58 ...
 $ K     : num 5
```

Preparamos inicios

```
> nyears<-10; K<-5
> Ns<- array(NA,c(2,15,4))
> for(i in 1:4){
+   Ns[,,i]<-matrix(rbind(rep(5,15),rep(30,15)))
+ }
> eps.ads<-matrix(runif(15*2*2,0,1),ncol=2)
> eps.sjuvs<-c(runif(15*1*2,0,1))
> eps.fs<-cbind(runif((nyears+K),0.3,1),runif((nyears+K),0.3,1))
> str(inits  <-  list(mean.sjuv = runif(1, 0.5, 1),
+                     sigma.sjuv=0.1,
+                     tau.sjuv=0.1,
+                     mean.sad = runif(1, 0.5, 1),
+                     sigma.sad=0.1,
+                     tau.sad=0.1,
+                     sigma.f=0.1,
```

```
+                          tau.f=0.1,
+                          eps.sjuv=eps.sjuvs,
+                          eps.sad=eps.ads,
+                          eps.f=eps.fs,
+                          mean.p = runif(1, 0.3, 1),
+                          mean.f = runif(1, 0.3, 5),
+                          sigma.y = runif(1, 0.2, 1),
+                          n1 = rpois(1, 5),
+                          n2 = rpois(1, 30),
+                          N=round(Ns,0),
+                          Ntot=apply(Ns,c(2,3),sum)))
```

```
List of 18
 $ mean.sjuv : num 0.809
 $ sigma.sjuv: num 0.1
 $ tau.sjuv  : num 0.1
 $ mean.sad  : num 0.568
 $ sigma.sad : num 0.1
 $ tau.sad   : num 0.1
 $ sigma.f   : num 0.1
 $ tau.f     : num 0.1
 $ eps.sjuv  : num [1:30] 0.2192 0.2023 0.0365 0.379 0.9288 ...
 $ eps.sad   : num [1:30, 1:2] 0.711 0.663 0.328 0.525 0.778 ...
 $ eps.f     : num [1:15, 1:2] 0.782 0.902 0.53 0.608 0.806 ...
 $ mean.p    : num 0.731
 $ mean.f    : num 2.87
 $ sigma.y   : num 0.999
 $ n1        : int 5
 $ n2        : int 33
 $ N         : num [1:2, 1:15, 1:4] 5 30 5 30 5 30 5 30 5 30 ...
 $ Ntot      : num [1:15, 1:4] 35 35 35 35 35 35 35 35 35 35 ...
```

Especificamos los parámetros a monitorizar

```
> params <- c('mean.sjuv','sjuv','mean.sad','sad','mean.p','mean.f', 'f',
+              'N','Ntot')
```

Compilamos y ejecutamos el modelo

```
> # Preparamos el modelo para ejecución en Nimble
```

```
> Rmodel <- nimbleModel(code=code, constants=constants, data=data,
+                        inits=inits, check=FALSE)
> Rmodel$initializeInfo()
> Cmodel <- compileNimble(Rmodel)
> # Establecemos los parámetros a monitorizar
> mcmcspec<-configureMCMC(Rmodel, monitors=params, nthin=10)
```

```
===== Monitors =====
thin = 1: mean.sjuv, sjuv, mean.sad, sad, mean.p, mean.f, f, N, Ntot
===== Samplers =====
slice sampler (50)
  - N[]  (50 elements)
RW sampler (61)
  - sigma.y
  - mean.sjuv
  - mean.sad
  - sigma.sjuv
  - sigma.sad
  - mean.f
  - sigma.f
  - mean.p
  - n1
  - n2
  - eps.sjuv[]  (14 elements)
  - eps.sad[]  (19 elements)
  - eps.f[]  (18 elements)
posterior_predictive sampler (10)
  - eps.f[]  (2 elements)
  - N[]  (8 elements)
```

```
> # Contruimos el modelo
> IPM_MCMC <- buildMCMC(mcmcspec)
> # Compilamos
> CIPM_MCMC <- compileNimble(IPM_MCMC, project = Rmodel)
> # Ejecutamos el modelo
> nb=5000       # Iteraciones a desechar
> ni=50000 +nb  # Iteraciones
> nc=3          # Cadenas
```

```
> start.time2<-Sys.time()
> outNim <- runMCMC(CIPM_MCMC, niter = ni , nburnin = nb , nchains = nc,
+                     inits=inits, setSeed = TRUE, progressBar = TRUE,
+                     samplesAsCodaMCMC = TRUE)
|-------------|-------------|-------------|-------------|
|-------------------------------------------------------|
|-------------|-------------|-------------|-------------|
|-------------------------------------------------------|
|-------------|-------------|-------------|-------------|
|-------------------------------------------------------|

> end.time<-Sys.time()
> end.time-start.time2 # tiempo de ejecución

Time difference of 1.658394 mins

> summary(outNim)

Iterations = 1:50000
Thinning interval = 1
Number of chains = 3
Sample size per chain = 50000

1. Empirical mean and standard deviation for each variable,
   plus standard error of the mean:

                Mean      SD  Naive SE Time-series SE
N[1, 1, 1]    3.6504 3.53153 9.118e-03      8.468e-02
N[2, 1, 1]   28.0597 5.73392 1.480e-02      1.566e-01
N[1, 2, 1]    1.2731 1.28289 3.312e-03      1.216e-02
N[2, 2, 1]   29.1919 4.05594 1.047e-02      8.478e-02
N[1, 3, 1]    5.0776 2.40112 6.200e-03      2.138e-02
N[2, 3, 1]   27.3221 3.66654 9.467e-03      7.347e-02
N[1, 4, 1]    6.4736 2.75742 7.120e-03      2.949e-02
N[2, 4, 1]   30.0392 3.67622 9.492e-03      7.273e-02
N[1, 5, 1]    3.3463 2.00073 5.166e-03      1.477e-02
N[2, 5, 1]   33.9815 3.89739 1.006e-02      7.558e-02
N[1, 6, 1]    3.8519 2.19480 5.667e-03      1.662e-02
N[2, 6, 1]   34.4785 3.85849 9.963e-03      7.816e-02
```

```
N[1, 7, 1]    6.2537  2.81454 7.267e-03       3.131e-02
N[2, 7, 1]   35.0595  3.87368 1.000e-02       8.062e-02
N[1, 8, 1]    5.5334  2.92308 7.547e-03       4.127e-02
N[2, 8, 1]   37.9804  4.20619 1.086e-02       9.869e-02
N[1, 9, 1]    3.3459  2.12156 5.478e-03       2.397e-02
N[2, 9, 1]   40.6294  4.45207 1.150e-02       1.301e-01
N[1, 10, 1]   6.6779  3.15476 8.146e-03       6.061e-02
N[2, 10, 1]  40.8384  4.76976 1.232e-02       1.632e-01
N[1, 11, 1]   7.7772  8.33009 2.151e-02       5.425e-01
N[2, 11, 1]  43.8565  6.26052 1.616e-02       2.535e-01
N[1, 12, 1]   8.1619  9.61304 2.482e-02       6.365e-01
N[2, 12, 1]  47.7924 10.87405 2.808e-02       7.337e-01
N[1, 13, 1]   8.6525  8.44353 2.180e-02       3.972e-01
N[2, 13, 1]  51.7919 15.38355 3.972e-02       1.187e+00
N[1, 14, 1]  16.5580 39.53734 1.021e-01       7.170e+00
N[2, 14, 1]  55.9946 18.12116 4.679e-02       1.336e+00
N[1, 15, 1]  13.3839 18.00711 4.649e-02       8.967e-01
N[2, 15, 1]  67.1833 43.55039 1.124e-01       6.138e+00
N[1, 1, 2]    3.6504  3.53153 9.118e-03       8.468e-02
N[2, 1, 2]   28.0597  5.73392 1.480e-02       1.566e-01
N[1, 2, 2]    1.2731  1.28289 3.312e-03       1.216e-02
N[2, 2, 2]   29.1919  4.05594 1.047e-02       8.478e-02
N[1, 3, 2]    5.0776  2.40112 6.200e-03       2.138e-02
N[2, 3, 2]   27.3221  3.66654 9.467e-03       7.347e-02
N[1, 4, 2]    6.4736  2.75742 7.120e-03       2.949e-02
N[2, 4, 2]   30.0392  3.67622 9.492e-03       7.273e-02
N[1, 5, 2]    3.3463  2.00073 5.166e-03       1.477e-02
N[2, 5, 2]   33.9815  3.89739 1.006e-02       7.558e-02
N[1, 6, 2]    3.8519  2.19480 5.667e-03       1.662e-02
N[2, 6, 2]   34.4785  3.85849 9.963e-03       7.816e-02
N[1, 7, 2]    6.2537  2.81454 7.267e-03       3.131e-02
N[2, 7, 2]   35.0595  3.87368 1.000e-02       8.062e-02
N[1, 8, 2]    5.5334  2.92308 7.547e-03       4.127e-02
N[2, 8, 2]   37.9804  4.20619 1.086e-02       9.869e-02
N[1, 9, 2]    3.3459  2.12156 5.478e-03       2.397e-02
N[2, 9, 2]   40.6294  4.45207 1.150e-02       1.301e-01
N[1, 10, 2]   6.6779  3.15476 8.146e-03       6.061e-02
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N[2, 10, 2]  40.8384  4.76976 1.232e-02       1.632e-01
N[1, 11, 2]   7.8760  8.57410 2.214e-02       5.702e-01
N[2, 11, 2]  43.8606  6.18874 1.598e-02       2.425e-01
N[1, 12, 2]  12.0198 16.56956 4.278e-02       1.420e+00
N[2, 12, 2]  47.8948 11.00928 2.843e-02       7.593e-01
N[1, 13, 2]  11.5065 10.99430 2.839e-02       4.001e-01
N[2, 13, 2]  55.4567 20.54998 5.306e-02       1.820e+00
N[1, 14, 2]  14.7819 16.96255 4.380e-02       7.998e-01
N[2, 14, 2]  62.0293 24.86949 6.421e-02       2.029e+00
N[1, 15, 2]  20.6493 38.76377 1.001e-01       2.384e+00
N[2, 15, 2]  71.0780 33.39979 8.624e-02       2.511e+00
N[1, 1, 3]    3.6504  3.53153 9.118e-03       8.468e-02
N[2, 1, 3]   28.0597  5.73392 1.480e-02       1.566e-01
N[1, 2, 3]    1.2731  1.28289 3.312e-03       1.216e-02
N[2, 2, 3]   29.1919  4.05594 1.047e-02       8.478e-02
N[1, 3, 3]    5.0776  2.40112 6.200e-03       2.138e-02
N[2, 3, 3]   27.3221  3.66654 9.467e-03       7.347e-02
N[1, 4, 3]    6.4736  2.75742 7.120e-03       2.949e-02
N[2, 4, 3]   30.0392  3.67622 9.492e-03       7.273e-02
N[1, 5, 3]    3.3463  2.00073 5.166e-03       1.477e-02
N[2, 5, 3]   33.9815  3.89739 1.006e-02       7.558e-02
N[1, 6, 3]    3.8519  2.19480 5.667e-03       1.662e-02
N[2, 6, 3]   34.4785  3.85849 9.963e-03       7.816e-02
N[1, 7, 3]    6.2537  2.81454 7.267e-03       3.131e-02
N[2, 7, 3]   35.0595  3.87368 1.000e-02       8.062e-02
N[1, 8, 3]    5.5334  2.92308 7.547e-03       4.127e-02
N[2, 8, 3]   37.9804  4.20619 1.086e-02       9.869e-02
N[1, 9, 3]    3.3459  2.12156 5.478e-03       2.397e-02
N[2, 9, 3]   40.6294  4.45207 1.150e-02       1.301e-01
N[1, 10, 3]   6.6779  3.15476 8.146e-03       6.061e-02
N[2, 10, 3]  40.8384  4.76976 1.232e-02       1.632e-01
N[1, 11, 3]   7.7768  8.37063 2.161e-02       5.665e-01
N[2, 11, 3]  44.1029  5.94483 1.535e-02       2.236e-01
N[1, 12, 3]   8.0933  9.02801 2.331e-02       5.772e-01
N[2, 12, 3]  48.1683 10.55932 2.726e-02       6.954e-01
N[1, 13, 3]   8.6701  8.33078 2.151e-02       3.568e-01
N[2, 13, 3]  52.2361 14.54240 3.755e-02       1.057e+00
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N[1, 14, 3]  16.7472 39.98372 1.032e-01      6.767e+00
N[2, 14, 3]  56.5322 17.38969 4.490e-02      1.189e+00
N[1, 15, 3]  13.4522 17.62642 4.551e-02      8.444e-01
N[2, 15, 3]  68.0679 43.87773 1.133e-01      6.118e+00
N[1, 1, 4]    3.6504  3.53153 9.118e-03      8.468e-02
N[2, 1, 4]   28.0597  5.73392 1.480e-02      1.566e-01
N[1, 2, 4]    1.2731  1.28289 3.312e-03      1.216e-02
N[2, 2, 4]   29.1919  4.05594 1.047e-02      8.478e-02
N[1, 3, 4]    5.0776  2.40112 6.200e-03      2.138e-02
N[2, 3, 4]   27.3221  3.66654 9.467e-03      7.347e-02
N[1, 4, 4]    6.4736  2.75742 7.120e-03      2.949e-02
N[2, 4, 4]   30.0392  3.67622 9.492e-03      7.273e-02
N[1, 5, 4]    3.3463  2.00073 5.166e-03      1.477e-02
N[2, 5, 4]   33.9815  3.89739 1.006e-02      7.558e-02
N[1, 6, 4]    3.8519  2.19480 5.667e-03      1.662e-02
N[2, 6, 4]   34.4785  3.85849 9.963e-03      7.816e-02
N[1, 7, 4]    6.2537  2.81454 7.267e-03      3.131e-02
N[2, 7, 4]   35.0595  3.87368 1.000e-02      8.062e-02
N[1, 8, 4]    5.5334  2.92308 7.547e-03      4.127e-02
N[2, 8, 4]   37.9804  4.20619 1.086e-02      9.869e-02
N[1, 9, 4]    3.3459  2.12156 5.478e-03      2.397e-02
N[2, 9, 4]   40.6294  4.45207 1.150e-02      1.301e-01
N[1, 10, 4]   6.6779  3.15476 8.146e-03      6.061e-02
N[2, 10, 4]  40.8384  4.76976 1.232e-02      1.632e-01
N[1, 11, 4]   8.6058  9.27567 2.395e-02      6.038e-01
N[2, 11, 4]  48.4703  6.32189 1.632e-02      2.509e-01
N[1, 12, 4]   9.7387 10.91192 2.817e-02      6.808e-01
N[2, 12, 4]  57.4388 11.70651 3.023e-02      7.615e-01
N[1, 13, 4]  11.0615 10.35519 2.674e-02      4.473e-01
N[2, 13, 4]  66.7964 16.83799 4.348e-02      1.271e+00
N[1, 14, 4]  22.2879 51.52541 1.330e-01      1.058e+01
N[2, 14, 4]  76.7514 20.53521 5.302e-02      1.417e+00
N[1, 15, 4]  18.8679 23.22910 5.998e-02      1.108e+00
N[2, 15, 4]  96.3074 55.10127 1.423e-01      8.402e+00
Ntot[1, 1]   31.7100  4.53707 1.171e-02      9.748e-02
Ntot[2, 1]   30.4650  4.12058 1.064e-02      8.617e-02
Ntot[3, 1]   32.3997  3.94258 1.018e-02      7.621e-02
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Ntot[4, 1]    36.5127  4.18359 1.080e-02      8.281e-02
Ntot[5, 1]    37.3279  4.10878 1.061e-02      8.008e-02
Ntot[6, 1]    38.3304  4.12259 1.064e-02      8.385e-02
Ntot[7, 1]    41.3131  4.43037 1.144e-02      9.929e-02
Ntot[8, 1]    43.5138  4.62958 1.195e-02      1.225e-01
Ntot[9, 1]    43.9753  4.83969 1.250e-02      1.551e-01
Ntot[10, 1]   47.5163  5.91439 1.527e-02      2.301e-01
Ntot[11, 1]   51.6337 11.27935 2.912e-02      7.810e-01
Ntot[12, 1]   55.9544 16.21938 4.188e-02      1.292e+00
Ntot[13, 1]   60.4444 19.32812 4.990e-02      1.470e+00
Ntot[14, 1]   72.5525 46.65413 1.205e-01      6.656e+00
Ntot[15, 1]   80.5673 54.53671 1.408e-01      6.178e+00
Ntot[1, 2]    31.7100  4.53707 1.171e-02      9.748e-02
Ntot[2, 2]    30.4650  4.12058 1.064e-02      8.617e-02
Ntot[3, 2]    32.3997  3.94258 1.018e-02      7.621e-02
Ntot[4, 2]    36.5127  4.18359 1.080e-02      8.281e-02
Ntot[5, 2]    37.3279  4.10878 1.061e-02      8.008e-02
Ntot[6, 2]    38.3304  4.12259 1.064e-02      8.385e-02
Ntot[7, 2]    41.3131  4.43037 1.144e-02      9.929e-02
Ntot[8, 2]    43.5138  4.62958 1.195e-02      1.225e-01
Ntot[9, 2]    43.9753  4.83969 1.250e-02      1.551e-01
Ntot[10, 2]   47.5163  5.91439 1.527e-02      2.301e-01
Ntot[11, 2]   51.7365 11.41660 2.948e-02      8.154e-01
Ntot[12, 2]   59.9145 21.89079 5.652e-02      1.957e+00
Ntot[13, 2]   66.9632 26.75703 6.909e-02      2.093e+00
Ntot[14, 2]   76.8112 35.74558 9.229e-02      2.699e+00
Ntot[15, 2]   91.7273 62.97425 1.626e-01      4.751e+00
Ntot[1, 3]    31.7100  4.53707 1.171e-02      9.748e-02
Ntot[2, 3]    30.4650  4.12058 1.064e-02      8.617e-02
Ntot[3, 3]    32.3997  3.94258 1.018e-02      7.621e-02
Ntot[4, 3]    36.5127  4.18359 1.080e-02      8.281e-02
Ntot[5, 3]    37.3279  4.10878 1.061e-02      8.008e-02
Ntot[6, 3]    38.3304  4.12259 1.064e-02      8.385e-02
Ntot[7, 3]    41.3131  4.43037 1.144e-02      9.929e-02
Ntot[8, 3]    43.5138  4.62958 1.195e-02      1.225e-01
Ntot[9, 3]    43.9753  4.83969 1.250e-02      1.551e-01
Ntot[10, 3]   47.5163  5.91439 1.527e-02      2.301e-01
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Ntot[11, 3]   51.8797 11.06098 2.856e-02       7.588e-01
Ntot[12, 3]   56.2616 15.36909 3.968e-02       1.163e+00
Ntot[13, 3]   60.9062 18.51573 4.781e-02       1.307e+00
Ntot[14, 3]   73.2794 47.04664 1.215e-01       6.704e+00
Ntot[15, 3]   81.5201 54.31628 1.402e-01       6.298e+00
Ntot[1, 4]    31.7100  4.53707 1.171e-02       9.748e-02
Ntot[2, 4]    30.4650  4.12058 1.064e-02       8.617e-02
Ntot[3, 4]    32.3997  3.94258 1.018e-02       7.621e-02
Ntot[4, 4]    36.5127  4.18359 1.080e-02       8.281e-02
Ntot[5, 4]    37.3279  4.10878 1.061e-02       8.008e-02
Ntot[6, 4]    38.3304  4.12259 1.064e-02       8.385e-02
Ntot[7, 4]    41.3131  4.43037 1.144e-02       9.929e-02
Ntot[8, 4]    43.5138  4.62958 1.195e-02       1.225e-01
Ntot[9, 4]    43.9753  4.83969 1.250e-02       1.551e-01
Ntot[10, 4]   47.5163  5.91439 1.527e-02       2.301e-01
Ntot[11, 4]   57.0761 12.05360 3.112e-02       8.480e-01
Ntot[12, 4]   67.1774 17.65095 4.557e-02       1.347e+00
Ntot[13, 4]   77.8579 21.77898 5.623e-02       1.548e+00
Ntot[14, 4]   99.0393 59.00927 1.524e-01       9.869e+00
Ntot[15, 4] 115.1753 68.34003 1.765e-01       8.125e+00
f[1, 1]        0.1316  0.06063 1.565e-04       1.203e-03
f[2, 1]        0.4713  0.09624 2.485e-04       7.087e-04
f[3, 1]        0.3874  0.08717 2.251e-04       6.484e-04
f[4, 1]        0.3578  0.08113 2.095e-04       5.066e-04
f[5, 1]        0.3859  0.07903 2.041e-04       4.789e-04
f[6, 1]        0.4582  0.08904 2.299e-04       5.973e-04
f[7, 1]        0.6876  0.11843 3.058e-04       1.027e-03
f[8, 1]        0.3230  0.07244 1.870e-04       4.905e-04
f[9, 1]        0.3484  0.07401 1.911e-04       6.656e-04
f[10, 1]       0.4399  0.34783 8.981e-04       1.447e-02
f[11, 1]       0.4265  0.39340 1.016e-03       2.126e-02
f[12, 1]       0.4297  0.31430 8.115e-04       1.013e-02
f[13, 1]       0.5986  1.02263 2.640e-03       1.397e-01
f[14, 1]       0.4485  0.34499 8.908e-04       1.127e-02
f[15, 1]       0.4987  2.57115 6.639e-03       1.256e-02
f[1, 2]        0.1316  0.06063 1.565e-04       1.203e-03
f[2, 2]        0.4713  0.09624 2.485e-04       7.087e-04
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f[3, 2]       0.3874  0.08717 2.251e-04       6.484e-04
f[4, 2]       0.3578  0.08113 2.095e-04       5.066e-04
f[5, 2]       0.3859  0.07903 2.041e-04       4.789e-04
f[6, 2]       0.4582  0.08904 2.299e-04       5.973e-04
f[7, 2]       0.6876  0.11843 3.058e-04       1.027e-03
f[8, 2]       0.3230  0.07244 1.870e-04       4.905e-04
f[9, 2]       0.3484  0.07401 1.911e-04       6.656e-04
f[10, 2]      0.4399  0.34783 8.981e-04       1.447e-02
f[11, 2]      0.6197  0.75587 1.952e-03       4.948e-02
f[12, 2]      0.5365  0.37875 9.779e-04       8.360e-03
f[13, 2]      0.5718  0.47891 1.237e-03       1.650e-02
f[14, 2]      0.6024  0.59352 1.532e-03       2.599e-02
f[15, 2]      0.6094  1.35145 3.489e-03       1.034e-02
mean.f        0.3757  0.08834 2.281e-04       3.271e-03
mean.p        0.7760  0.01650 4.259e-05       9.254e-05
mean.sad      0.9306  0.01346 3.476e-05       2.741e-04
mean.sjuv     0.3668  0.07538 1.946e-04       2.058e-03
sad[1, 1]     0.9364  0.02029 5.238e-05       2.999e-04
sad[2, 1]     0.9157  0.02735 7.062e-05       4.676e-04
sad[3, 1]     0.9329  0.01958 5.056e-05       2.011e-04
sad[4, 1]     0.9366  0.01860 4.804e-05       2.427e-04
sad[5, 1]     0.9314  0.01933 4.991e-05       1.807e-04
sad[6, 1]     0.9264  0.02084 5.380e-05       1.964e-04
sad[7, 1]     0.9248  0.02133 5.507e-05       2.174e-04
sad[8, 1]     0.9349  0.02003 5.172e-05       2.623e-04
sad[9, 1]     0.9296  0.02386 6.162e-05       2.728e-04
sad[10, 1]    0.9236  0.04678 1.208e-04       2.122e-03
sad[11, 1]    0.9255  0.03685 9.514e-05       8.311e-04
sad[12, 1]    0.9254  0.03679 9.499e-05       1.107e-03
sad[13, 1]    0.9261  0.03409 8.801e-05       7.015e-04
sad[14, 1]    0.9247  0.03966 1.024e-04       9.030e-04
sad[1, 2]     0.9364  0.02029 5.238e-05       2.999e-04
sad[2, 2]     0.9157  0.02735 7.062e-05       4.676e-04
sad[3, 2]     0.9329  0.01958 5.056e-05       2.011e-04
sad[4, 2]     0.9366  0.01860 4.804e-05       2.427e-04
sad[5, 2]     0.9314  0.01933 4.991e-05       1.807e-04
sad[6, 2]     0.9264  0.02084 5.380e-05       1.964e-04
```

```
sad[7, 2]      0.9248  0.02133 5.507e-05      2.174e-04
sad[8, 2]      0.9349  0.02003 5.172e-05      2.623e-04
sad[9, 2]      0.9296  0.02386 6.162e-05      2.728e-04
sad[10, 2]     0.9282  0.02644 6.826e-05      4.181e-04
sad[11, 2]     0.9282  0.02577 6.653e-05      3.801e-04
sad[12, 2]     0.9282  0.02735 7.061e-05      4.643e-04
sad[13, 2]     0.9280  0.02674 6.905e-05      5.128e-04
sad[14, 2]     0.9282  0.02638 6.812e-05      4.156e-04
sjuv[1]        0.4015  0.12016 3.103e-04      9.204e-04
sjuv[2]        0.4549  0.09956 2.571e-04      1.028e-03
sjuv[3]        0.5827  0.11731 3.029e-04      1.930e-03
sjuv[4]        0.2903  0.07286 1.881e-04      6.158e-04
sjuv[5]        0.3113  0.08997 2.323e-04      6.966e-04
sjuv[6]        0.4276  0.09251 2.389e-04      8.078e-04
sjuv[7]        0.2176  0.08124 2.098e-04      1.264e-03
sjuv[8]        0.2480  0.07637 1.972e-04      9.092e-04
sjuv[9]        0.4487  0.09566 2.470e-04      1.101e-03
sjuv[10]       0.3731  0.17806 4.597e-04      3.769e-03
sjuv[11]       0.3712  0.17878 4.616e-04      4.482e-03
sjuv[12]       0.3669  0.17647 4.556e-04      4.237e-03
sjuv[13]       0.3806  0.18523 4.783e-04      5.616e-03
sjuv[14]       0.3882  0.18325 4.731e-04      4.202e-03

2. Quantiles for each variable:

                 2.5%      25%     50%     75%   97.5%
N[1, 1, 1]   0.00000  1.00000  3.0000  5.0000 13.0000
N[2, 1, 1]  15.00000 25.00000 29.0000 32.0000 38.0000
N[1, 2, 1]   0.00000  0.00000  1.0000  2.0000  4.0000
N[2, 2, 1]  21.00000 27.00000 29.0000 32.0000 37.0000
N[1, 3, 1]   1.00000  3.00000  5.0000  7.0000 10.0000
N[2, 3, 1]  20.00000 25.00000 27.0000 30.0000 34.0000
N[1, 4, 1]   2.00000  4.00000  6.0000  8.0000 12.0000
N[2, 4, 1]  23.00000 28.00000 30.0000 32.0000 37.0000
N[1, 5, 1]   0.00000  2.00000  3.0000  5.0000  8.0000
N[2, 5, 1]  26.00000 32.00000 34.0000 37.0000 42.0000
N[1, 6, 1]   0.00000  2.00000  4.0000  5.0000  9.0000
```

```
N[2, 6, 1]  27.00000 32.00000 35.0000  37.0000  42.0000
N[1, 7, 1]   2.00000  4.00000  6.0000   8.0000  12.0000
N[2, 7, 1]  27.00000 33.00000 35.0000  38.0000  43.0000
N[1, 8, 1]   1.00000  3.00000  5.0000   7.0000  12.0000
N[2, 8, 1]  30.00000 35.00000 38.0000  41.0000  47.0000
N[1, 9, 1]   0.00000  2.00000  3.0000   5.0000   8.0000
N[2, 9, 1]  32.00000 38.00000 40.0000  43.0000  50.0000
N[1, 10, 1]  2.00000  4.00000  6.0000   9.0000  14.0000
N[2, 10, 1] 32.00000 38.00000 41.0000  44.0000  51.0000
N[1, 11, 1]  0.00000  3.00000  6.0000  10.0000  32.0000
N[2, 11, 1] 32.00000 40.00000 44.0000  48.0000  57.0000
N[1, 12, 1]  0.00000  3.00000  6.0000  10.0000  34.0000
N[2, 12, 1] 31.00000 41.00000 46.0000  52.0000  76.0000
N[1, 13, 1]  0.00000  3.00000  6.0000  11.0000  33.0000
N[2, 13, 1] 31.00000 42.00000 49.0000  57.0000  90.0000
N[1, 14, 1]  0.00000  3.00000  7.0000  14.0000 121.0000
N[2, 14, 1] 31.00000 44.00000 53.0000  63.0000 100.0000
N[1, 15, 1]  0.00000  4.00000  8.0000  15.0000  69.0000
N[2, 15, 1] 30.00000 46.00000 57.0000  72.0000 187.0000
N[1, 1, 2]   0.00000  1.00000  3.0000   5.0000  13.0000
N[2, 1, 2]  15.00000 25.00000 29.0000  32.0000  38.0000
N[1, 2, 2]   0.00000  0.00000  1.0000   2.0000   4.0000
N[2, 2, 2]  21.00000 27.00000 29.0000  32.0000  37.0000
N[1, 3, 2]   1.00000  3.00000  5.0000   7.0000  10.0000
N[2, 3, 2]  20.00000 25.00000 27.0000  30.0000  34.0000
N[1, 4, 2]   2.00000  4.00000  6.0000   8.0000  12.0000
N[2, 4, 2]  23.00000 28.00000 30.0000  32.0000  37.0000
N[1, 5, 2]   0.00000  2.00000  3.0000   5.0000   8.0000
N[2, 5, 2]  26.00000 32.00000 34.0000  37.0000  42.0000
N[1, 6, 2]   0.00000  2.00000  4.0000   5.0000   9.0000
N[2, 6, 2]  27.00000 32.00000 35.0000  37.0000  42.0000
N[1, 7, 2]   2.00000  4.00000  6.0000   8.0000  12.0000
N[2, 7, 2]  27.00000 33.00000 35.0000  38.0000  43.0000
N[1, 8, 2]   1.00000  3.00000  5.0000   7.0000  12.0000
N[2, 8, 2]  30.00000 35.00000 38.0000  41.0000  47.0000
N[1, 9, 2]   0.00000  2.00000  3.0000   5.0000   8.0000
N[2, 9, 2]  32.00000 38.00000 40.0000  43.0000  50.0000
```

```
N[1, 10, 2]  2.00000  4.00000  6.0000   9.0000  14.0000
N[2, 10, 2] 32.00000 38.00000 41.0000  44.0000  51.0000
N[1, 11, 2]  0.00000  3.00000  6.0000  10.0000  33.0000
N[2, 11, 2] 32.00000 40.00000 44.0000  48.0000  56.0000
N[1, 12, 2]  0.00000  4.00000  8.0000  14.0000  54.0000
N[2, 12, 2] 31.00000 41.00000 46.0000  52.0000  77.0000
N[1, 13, 2]  0.00000  4.00000  8.0000  15.0000  41.0000
N[2, 13, 2] 32.00000 44.00000 51.0000  61.0000 106.0000
N[1, 14, 2]  0.00000  5.00000 10.0000  18.0000  61.0000
N[2, 14, 2] 33.00000 47.00000 57.0000  71.0000 121.0000
N[1, 15, 2]  1.00000  5.00000 11.0000  21.0000 103.0000
N[2, 15, 2] 33.00000 50.00000 64.0000  83.0000 149.0000
N[1, 1, 3]   0.00000  1.00000  3.0000   5.0000  13.0000
N[2, 1, 3]  15.00000 25.00000 29.0000  32.0000  38.0000
N[1, 2, 3]   0.00000  0.00000  1.0000   2.0000   4.0000
N[2, 2, 3]  21.00000 27.00000 29.0000  32.0000  37.0000
N[1, 3, 3]   1.00000  3.00000  5.0000   7.0000  10.0000
N[2, 3, 3]  20.00000 25.00000 27.0000  30.0000  34.0000
N[1, 4, 3]   2.00000  4.00000  6.0000   8.0000  12.0000
N[2, 4, 3]  23.00000 28.00000 30.0000  32.0000  37.0000
N[1, 5, 3]   0.00000  2.00000  3.0000   5.0000   8.0000
N[2, 5, 3]  26.00000 32.00000 34.0000  37.0000  42.0000
N[1, 6, 3]   0.00000  2.00000  4.0000   5.0000   9.0000
N[2, 6, 3]  27.00000 32.00000 35.0000  37.0000  42.0000
N[1, 7, 3]   2.00000  4.00000  6.0000   8.0000  12.0000
N[2, 7, 3]  27.00000 33.00000 35.0000  38.0000  43.0000
N[1, 8, 3]   1.00000  3.00000  5.0000   7.0000  12.0000
N[2, 8, 3]  30.00000 35.00000 38.0000  41.0000  47.0000
N[1, 9, 3]   0.00000  2.00000  3.0000   5.0000   8.0000
N[2, 9, 3]  32.00000 38.00000 40.0000  43.0000  50.0000
N[1, 10, 3]  2.00000  4.00000  6.0000   9.0000  14.0000
N[2, 10, 3] 32.00000 38.00000 41.0000  44.0000  51.0000
N[1, 11, 3]  0.00000  3.00000  6.0000  10.0000  31.0000
N[2, 11, 3] 33.00000 40.00000 44.0000  48.0000  56.0000
N[1, 12, 3]  0.00000  3.00000  6.0000  10.0000  32.0000
N[2, 12, 3] 33.00000 41.00000 47.0000  53.0000  76.0000
N[1, 13, 3]  0.00000  3.00000  6.0000  11.0000  32.0000
```

```
N[2, 13, 3] 32.00000 43.00000 50.0000  58.0000  87.0000
N[1, 14, 3]  0.00000  3.00000  7.0000  14.0000 121.0000
N[2, 14, 3] 32.00000 45.00000 53.0000  64.0000  99.0000
N[1, 15, 3]  0.00000  4.00000  8.0000  16.0000  69.0000
N[2, 15, 3] 32.00000 47.00000 58.0000  73.0000 190.0000
N[1, 1, 4]   0.00000  1.00000  3.0000   5.0000  13.0000
N[2, 1, 4]  15.00000 25.00000 29.0000  32.0000  38.0000
N[1, 2, 4]   0.00000  0.00000  1.0000   2.0000   4.0000
N[2, 2, 4]  21.00000 27.00000 29.0000  32.0000  37.0000
N[1, 3, 4]   1.00000  3.00000  5.0000   7.0000  10.0000
N[2, 3, 4]  20.00000 25.00000 27.0000  30.0000  34.0000
N[1, 4, 4]   2.00000  4.00000  6.0000   8.0000  12.0000
N[2, 4, 4]  23.00000 28.00000 30.0000  32.0000  37.0000
N[1, 5, 4]   0.00000  2.00000  3.0000   5.0000   8.0000
N[2, 5, 4]  26.00000 32.00000 34.0000  37.0000  42.0000
N[1, 6, 4]   0.00000  2.00000  4.0000   5.0000   9.0000
N[2, 6, 4]  27.00000 32.00000 35.0000  37.0000  42.0000
N[1, 7, 4]   2.00000  4.00000  6.0000   8.0000  12.0000
N[2, 7, 4]  27.00000 33.00000 35.0000  38.0000  43.0000
N[1, 8, 4]   1.00000  3.00000  5.0000   7.0000  12.0000
N[2, 8, 4]  30.00000 35.00000 38.0000  41.0000  47.0000
N[1, 9, 4]   0.00000  2.00000  3.0000   5.0000   8.0000
N[2, 9, 4]  32.00000 38.00000 40.0000  43.0000  50.0000
N[1, 10, 4]  2.00000  4.00000  6.0000   9.0000  14.0000
N[2, 10, 4] 32.00000 38.00000 41.0000  44.0000  51.0000
N[1, 11, 4]  0.00000  3.00000  6.0000  11.0000  34.0250
N[2, 11, 4] 36.00000 44.00000 48.0000  52.0000  61.0000
N[1, 12, 4]  0.00000  3.00000  7.0000  12.0000  40.0000
N[2, 12, 4] 40.00000 50.00000 56.0000  62.0000  87.0000
N[1, 13, 4]  0.00000  4.00000  8.0000  15.0000  40.0000
N[2, 13, 4] 44.00000 56.00000 64.0000  73.0000 109.0000
N[1, 14, 4]  0.00000  5.00000 10.0000  19.0000 157.0000
N[2, 14, 4] 48.00000 63.00000 73.0000  85.0000 128.0000
N[1, 15, 4]  1.00000  6.00000 12.0000  22.0000  91.0000
N[2, 15, 4] 52.00000 71.00000 83.0000 102.0000 251.0000
Ntot[1, 1]  22.00000 29.00000 32.0000  35.0000  40.0000
Ntot[2, 1]  22.00000 28.00000 31.0000  33.0000  38.0000
```

```
Ntot[3, 1]   24.00000 30.00000 32.0000  35.0000  40.0000
Ntot[4, 1]   28.00000 34.00000 37.0000  39.0000  45.0000
Ntot[5, 1]   29.00000 35.00000 37.0000  40.0000  45.0000
Ntot[6, 1]   30.00000 36.00000 38.0000  41.0000  46.0000
Ntot[7, 1]   33.00000 38.00000 41.0000  44.0000  51.0000
Ntot[8, 1]   35.00000 40.00000 43.0000  46.0000  53.0000
Ntot[9, 1]   35.00000 41.00000 44.0000  47.0000  54.0000
Ntot[10, 1]  36.00000 44.00000 47.0000  51.0000  60.0000
Ntot[11, 1]  35.00000 45.00000 50.0000  56.0000  81.0000
Ntot[12, 1]  35.00000 46.00000 53.0000  62.0000  96.0000
Ntot[13, 1]  34.00000 48.00000 57.0000  68.0000 107.0000
Ntot[14, 1]  34.00000 50.00000 61.0000  78.0000 201.0000
Ntot[15, 1]  34.00000 53.00000 66.0000  86.0000 255.0000
Ntot[1, 2]   22.00000 29.00000 32.0000  35.0000  40.0000
Ntot[2, 2]   22.00000 28.00000 31.0000  33.0000  38.0000
Ntot[3, 2]   24.00000 30.00000 32.0000  35.0000  40.0000
Ntot[4, 2]   28.00000 34.00000 37.0000  39.0000  45.0000
Ntot[5, 2]   29.00000 35.00000 37.0000  40.0000  45.0000
Ntot[6, 2]   30.00000 36.00000 38.0000  41.0000  46.0000
Ntot[7, 2]   33.00000 38.00000 41.0000  44.0000  51.0000
Ntot[8, 2]   35.00000 40.00000 43.0000  46.0000  53.0000
Ntot[9, 2]   35.00000 41.00000 44.0000  47.0000  54.0000
Ntot[10, 2]  36.00000 44.00000 47.0000  51.0000  60.0000
Ntot[11, 2]  35.00000 45.00000 50.0000  56.0000  82.0000
Ntot[12, 2]  35.00000 47.00000 55.0000  65.0000 114.0000
Ntot[13, 2]  36.00000 51.00000 61.0000  76.0000 130.0000
Ntot[14, 2]  36.00000 55.00000 69.0000  89.0000 160.0000
Ntot[15, 2]  37.00000 59.00000 77.0000 103.0000 238.0000
Ntot[1, 3]   22.00000 29.00000 32.0000  35.0000  40.0000
Ntot[2, 3]   22.00000 28.00000 31.0000  33.0000  38.0000
Ntot[3, 3]   24.00000 30.00000 32.0000  35.0000  40.0000
Ntot[4, 3]   28.00000 34.00000 37.0000  39.0000  45.0000
Ntot[5, 3]   29.00000 35.00000 37.0000  40.0000  45.0000
Ntot[6, 3]   30.00000 36.00000 38.0000  41.0000  46.0000
Ntot[7, 3]   33.00000 38.00000 41.0000  44.0000  51.0000
Ntot[8, 3]   35.00000 40.00000 43.0000  46.0000  53.0000
Ntot[9, 3]   35.00000 41.00000 44.0000  47.0000  54.0000
```

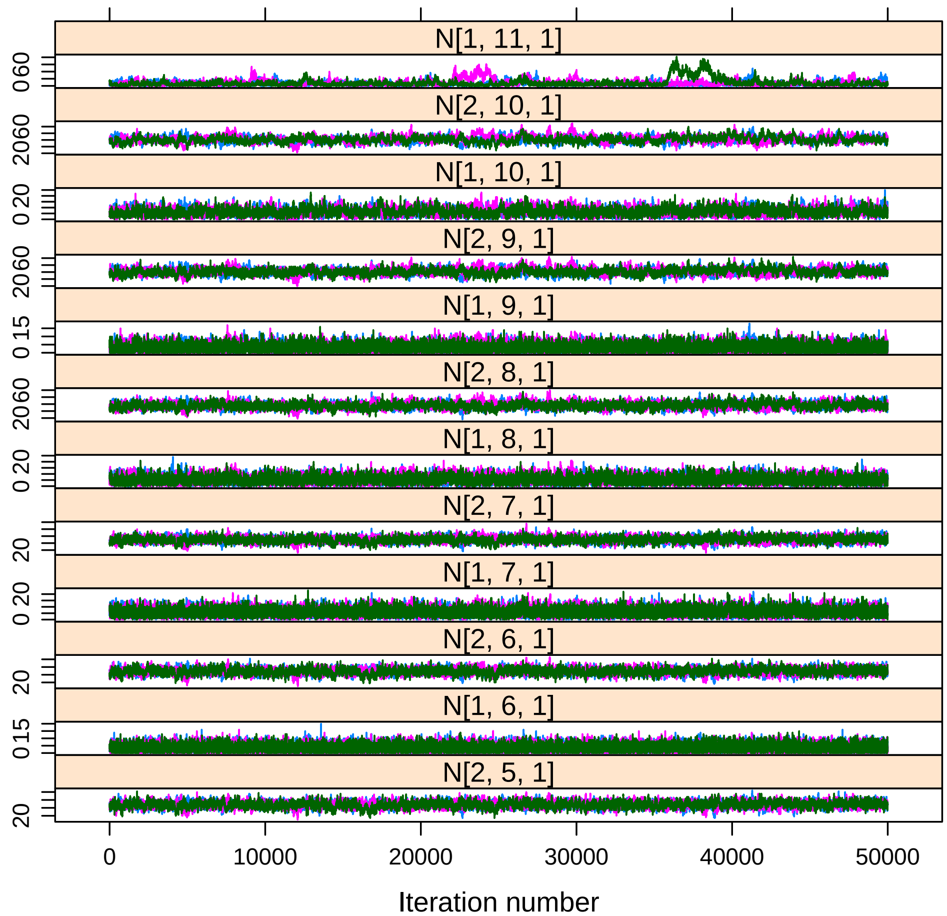
```
Ntot[10, 3] 36.00000 44.00000 47.0000  51.0000  60.0000
Ntot[11, 3] 36.00000 45.00000 50.0000  56.0000  81.0000
Ntot[12, 3] 36.00000 46.00000 53.0000  62.0000  94.0000
Ntot[13, 3] 36.00000 49.00000 57.0000  69.0000 107.0000
Ntot[14, 3] 36.00000 51.00000 62.0000  78.0000 205.0000
Ntot[15, 3] 36.00000 54.00000 67.0000  87.0000 255.0000
Ntot[1, 4]  22.00000 29.00000 32.0000  35.0000  40.0000
Ntot[2, 4]  22.00000 28.00000 31.0000  33.0000  38.0000
Ntot[3, 4]  24.00000 30.00000 32.0000  35.0000  40.0000
Ntot[4, 4]  28.00000 34.00000 37.0000  39.0000  45.0000
Ntot[5, 4]  29.00000 35.00000 37.0000  40.0000  45.0000
Ntot[6, 4]  30.00000 36.00000 38.0000  41.0000  46.0000
Ntot[7, 4]  33.00000 38.00000 41.0000  44.0000  51.0000
Ntot[8, 4]  35.00000 40.00000 43.0000  46.0000  53.0000
Ntot[9, 4]  35.00000 41.00000 44.0000  47.0000  54.0000
Ntot[10, 4] 36.00000 44.00000 47.0000  51.0000  60.0000
Ntot[11, 4] 40.00000 50.00000 55.0000  62.0000  88.0000
Ntot[12, 4] 44.00000 56.00000 64.0000  73.0000 112.0000
Ntot[13, 4] 48.00000 64.00000 74.0000  87.0000 132.0000
Ntot[14, 4] 52.00000 72.00000 85.0000 105.0000 266.0000
Ntot[15, 4] 57.00000 80.00000 97.0000 123.0000 335.0000
f[1, 1]      0.03776  0.08702  0.1238   0.1674   0.2724
f[2, 1]      0.30470  0.40309  0.4639   0.5308   0.6813
f[3, 1]      0.23631  0.32614  0.3804   0.4416   0.5779
f[4, 1]      0.21764  0.30043  0.3511   0.4077   0.5349
f[5, 1]      0.24698  0.32988  0.3803   0.4357   0.5568
f[6, 1]      0.30146  0.39550  0.4520   0.5143   0.6494
f[7, 1]      0.47540  0.60439  0.6805   0.7638   0.9369
f[8, 1]      0.19592  0.27167  0.3179   0.3684   0.4790
f[9, 1]      0.21739  0.29623  0.3436   0.3947   0.5085
f[10, 1]     0.08075  0.24001  0.3561   0.5184   1.4432
f[11, 1]     0.07770  0.23293  0.3481   0.5038   1.2700
f[12, 1]     0.08587  0.24101  0.3577   0.5175   1.2677
f[13, 1]     0.08446  0.25251  0.3729   0.5541   3.0345
f[14, 1]     0.07860  0.24390  0.3658   0.5424   1.3883
f[15, 1]     0.08403  0.24774  0.3676   0.5392   1.5420
f[1, 2]      0.03776  0.08702  0.1238   0.1674   0.2724
```

```
f[2, 2]      0.30470  0.40309  0.4639   0.5308   0.6813
f[3, 2]      0.23631  0.32614  0.3804   0.4416   0.5779
f[4, 2]      0.21764  0.30043  0.3511   0.4077   0.5349
f[5, 2]      0.24698  0.32988  0.3803   0.4357   0.5568
f[6, 2]      0.30146  0.39550  0.4520   0.5143   0.6494
f[7, 2]      0.47540  0.60439  0.6805   0.7638   0.9369
f[8, 2]      0.19592  0.27167  0.3179   0.3684   0.4790
f[9, 2]      0.21739  0.29623  0.3436   0.3947   0.5085
f[10, 2]     0.08075  0.24001  0.3561   0.5184   1.4432
f[11, 2]     0.10738  0.30935  0.4579   0.6715   2.0722
f[12, 2]     0.09902  0.30527  0.4514   0.6574   1.5233
f[13, 2]     0.10552  0.31056  0.4624   0.6762   1.7781
f[14, 2]     0.10489  0.31154  0.4619   0.6776   2.1124
f[15, 2]     0.10694  0.31150  0.4613   0.6760   1.9286
mean.f       0.22847  0.32025  0.3671   0.4192   0.5857
mean.p       0.74301  0.76510  0.7763   0.7873   0.8074
mean.sad     0.90194  0.92257  0.9311   0.9393   0.9559
mean.sjuv    0.23231  0.31864  0.3623   0.4084   0.5347
sad[1, 1]    0.89529  0.92425  0.9358   0.9485   0.9785
sad[2, 1]    0.84378  0.90433  0.9217   0.9338   0.9526
sad[3, 1]    0.89085  0.92197  0.9333   0.9449   0.9708
sad[4, 1]    0.89954  0.92503  0.9363   0.9481   0.9746
sad[5, 1]    0.88874  0.92078  0.9323   0.9432   0.9681
sad[6, 1]    0.87675  0.91609  0.9287   0.9394   0.9617
sad[7, 1]    0.87288  0.91457  0.9277   0.9384   0.9597
sad[8, 1]    0.89347  0.92318  0.9347   0.9469   0.9756
sad[9, 1]    0.87351  0.91817  0.9314   0.9436   0.9734
sad[10, 1]   0.82739  0.91571  0.9305   0.9435   0.9747
sad[11, 1]   0.83732  0.91613  0.9308   0.9435   0.9748
sad[12, 1]   0.84044  0.91572  0.9306   0.9434   0.9749
sad[13, 1]   0.83702  0.91627  0.9309   0.9437   0.9756
sad[14, 1]   0.82903  0.91618  0.9307   0.9435   0.9745
sad[1, 2]    0.89529  0.92425  0.9358   0.9485   0.9785
sad[2, 2]    0.84378  0.90433  0.9217   0.9338   0.9526
sad[3, 2]    0.89085  0.92197  0.9333   0.9449   0.9708
sad[4, 2]    0.89954  0.92503  0.9363   0.9481   0.9746
sad[5, 2]    0.88874  0.92078  0.9323   0.9432   0.9681
```

```
sad[6, 2]     0.87675  0.91609  0.9287   0.9394   0.9617
sad[7, 2]     0.87288  0.91457  0.9277   0.9384   0.9597
sad[8, 2]     0.89347  0.92318  0.9347   0.9469   0.9756
sad[9, 2]     0.87351  0.91817  0.9314   0.9436   0.9734
sad[10, 2]    0.86881  0.91887  0.9310   0.9421   0.9687
sad[11, 2]    0.86881  0.91849  0.9309   0.9420   0.9689
sad[12, 2]    0.86780  0.91906  0.9311   0.9422   0.9687
sad[13, 2]    0.86845  0.91884  0.9309   0.9418   0.9682
sad[14, 2]    0.86938  0.91869  0.9310   0.9420   0.9695
sjuv[1]       0.18884  0.31728  0.3916   0.4786   0.6592
sjuv[2]       0.27592  0.38365  0.4497   0.5218   0.6611
sjuv[3]       0.35645  0.49944  0.5836   0.6655   0.8090
sjuv[4]       0.15677  0.23917  0.2878   0.3389   0.4391
sjuv[5]       0.14646  0.24776  0.3084   0.3700   0.4990
sjuv[6]       0.26001  0.36238  0.4230   0.4885   0.6218
sjuv[7]       0.07665  0.15728  0.2126   0.2719   0.3869
sjuv[8]       0.11116  0.19279  0.2443   0.2993   0.4045
sjuv[9]       0.27952  0.38025  0.4424   0.5110   0.6503
sjuv[10]      0.06905  0.24964  0.3556   0.4767   0.7852
sjuv[11]      0.07465  0.24609  0.3510   0.4728   0.7900
sjuv[12]      0.06705  0.24275  0.3507   0.4708   0.7763
sjuv[13]      0.07447  0.24981  0.3588   0.4889   0.8104
sjuv[14]      0.08353  0.26056  0.3653   0.4935   0.8157
```

Visualizamos la convergencia

```
> xyplot(outNim[,10:21])
```



Preparamos los resultados para consulta

```
> ipm<-as.data.frame(rbind(outNim$chain1,outNim$chain2,outNim$chain2))
> names(ipm) <- gsub('\"', "", names(ipm))
```

Probabilidad de que incrementar la productividad sea mejor que el control

```
> round(mean(ipm$'Ntot[15, 2]' >  ipm$'Ntot[15, 1]'), 3)
```

```
[1] 0.631
```

```
> round(sd(ipm$'Ntot[15, 2]' >  ipm$'Ntot[15, 1]'), 3)
```

```
[1] 0.482
```

Probabilidad de que reducir la variabilidad sea mejor que el control

```
> round(mean(ipm$'Ntot[15, 3]' >  ipm$'Ntot[15, 1]'), 3)
[1] 0.508
> round(sd(ipm$'Ntot[15, 3]' >  ipm$'Ntot[15, 1]'), 3)
[1] 0.5
```

Probabilidad de que la gestion con sueltas sea mejor que el control

```
> round(mean(ipm$'Ntot[15, 4]' >  ipm$'Ntot[15, 1]'), 3)
[1] 0.986
> round(sd(ipm$'Ntot[15, 4]' >  ipm$'Ntot[15, 1]'), 3)
[1] 0.116
```

Es evidente que la cuarta opción (sueltas) es la que va a tener un mejor resultado sobre el incremento futuro de la población, tanto considerando el valor medio como la variación en el resultado de la gestión.

3. REFERENCIAS

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