SEGUIMIENTO DE LA DIVERSIDAD BIOLÓGICA

Modelos de población integrados con PVA

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Repetid primero los análisis que se ejecutan aquí.

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 0.986
 $ sigma.sjuv: num 0.1
 $ tau.sjuv  : num 0.1
 $ mean.sad  : num 0.869
 $ 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] 0.625 0.18 0.185 0.408 0.804 ...
 $ eps.sad   : num [1:30, 1:2] 0.837 0.749 0.01 0.106 0.731 ...
 $ eps.f     : num [1:15, 1:2] 0.975 0.798 0.868 0.742 0.54 ...
 $ mean.p    : num 0.476
 $ mean.f    : num 2.28
 $ sigma.y   : num 0.88
 $ n1        : int 5
 $ n2        : int 27
 $ 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: f, mean.f, mean.p, mean.sad, mean.sjuv, N, Ntot, sad, sjuv
===== Samplers =====
slice sampler (18)
  - N[]  (18 elements)
RW sampler (37)
  - sigma.y
  - mean.sjuv
  - mean.sad
  - sigma.sjuv
  - sigma.sad
  - mean.f
  - sigma.f
  - mean.p
  - n1
  - n2
  - eps.sjuv[]  (9 elements)
  - eps.sad[]  (9 elements)
  - eps.f[]  (9 elements)
posterior_predictive sampler (26)
  - eps.sjuv[]  (5 elements)
  - eps.sad[]  (10 elements)
  - eps.f[]  (11 elements)
===== Comments =====

> # 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 1.006956 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]    3.5023 3.507e+00 9.055e-03      8.979e-02
N[2, 1, 1]   28.2734 5.786e+00 1.494e-02      1.569e-01
N[1, 2, 1]    1.2516 1.265e+00 3.266e-03      9.839e-03
N[2, 2, 1]   29.2421 4.058e+00 1.048e-02      8.726e-02
N[1, 3, 1]    5.0753 2.411e+00 6.225e-03      2.202e-02
N[2, 3, 1]   27.3798 3.657e+00 9.443e-03      7.287e-02
N[1, 4, 1]    6.5157 2.751e+00 7.104e-03      2.793e-02
N[2, 4, 1]   30.1028 3.640e+00 9.400e-03      6.798e-02
N[1, 5, 1]    3.3647 1.983e+00 5.120e-03      1.435e-02
N[2, 5, 1]   34.0914 3.761e+00 9.711e-03      6.704e-02
```

```
N[1, 6, 1]     3.9584 2.221e+00 5.734e-03       1.679e-02
N[2, 6, 1]    34.6161 3.707e+00 9.572e-03       6.293e-02
N[1, 7, 1]     6.3771 2.802e+00 7.236e-03       2.578e-02
N[2, 7, 1]    35.3181 3.752e+00 9.687e-03       5.899e-02
N[1, 8, 1]     5.7109 2.962e+00 7.647e-03       3.224e-02
N[2, 8, 1]    38.4197 4.032e+00 1.041e-02       6.354e-02
N[1, 9, 1]     3.4397 2.150e+00 5.550e-03       1.634e-02
N[2, 9, 1]    41.2532 4.300e+00 1.110e-02       6.564e-02
N[1, 10, 1]    7.0159 3.198e+00 8.256e-03       1.619e-02
N[2, 10, 1]   41.6296 4.667e+00 1.205e-02       6.698e-02
N[1, 11, 1]    9.4762 2.126e+01 5.489e-02       1.212e-01
N[2, 11, 1]   45.1052 5.940e+00 1.534e-02       6.880e-02
N[1, 12, 1]   11.2987 5.344e+01 1.380e-01       2.559e-01
N[2, 12, 1]   50.6254 2.115e+01 5.461e-02       1.396e-01
N[1, 13, 1]   15.9021 7.960e+02 2.055e+00       2.112e+00
N[2, 13, 1]   57.4410 5.768e+01 1.489e-01       3.398e-01
N[1, 14, 1]   22.2021 9.404e+02 2.428e+00       2.976e+00
N[2, 14, 1]   68.1556 7.843e+02 2.025e+00       2.108e+00
N[1, 15, 1] 708.0531 2.634e+05 6.800e+02       6.800e+02
N[2, 15, 1]   83.9853 1.416e+03 3.656e+00       4.450e+00
N[1, 1, 2]     3.5023 3.507e+00 9.055e-03       8.979e-02
N[2, 1, 2]    28.2734 5.786e+00 1.494e-02       1.569e-01
N[1, 2, 2]     1.2516 1.265e+00 3.266e-03       9.839e-03
N[2, 2, 2]    29.2421 4.058e+00 1.048e-02       8.726e-02
N[1, 3, 2]     5.0753 2.411e+00 6.225e-03       2.202e-02
N[2, 3, 2]    27.3798 3.657e+00 9.443e-03       7.287e-02
N[1, 4, 2]     6.5157 2.751e+00 7.104e-03       2.793e-02
N[2, 4, 2]    30.1028 3.640e+00 9.400e-03       6.798e-02
N[1, 5, 2]     3.3647 1.983e+00 5.120e-03       1.435e-02
N[2, 5, 2]    34.0914 3.761e+00 9.711e-03       6.704e-02
N[1, 6, 2]     3.9584 2.221e+00 5.734e-03       1.679e-02
N[2, 6, 2]    34.6161 3.707e+00 9.572e-03       6.293e-02
N[1, 7, 2]     6.3771 2.802e+00 7.236e-03       2.578e-02
N[2, 7, 2]    35.3181 3.752e+00 9.687e-03       5.899e-02
N[1, 8, 2]     5.7109 2.962e+00 7.647e-03       3.224e-02
N[2, 8, 2]    38.4197 4.032e+00 1.041e-02       6.354e-02
N[1, 9, 2]     3.4397 2.150e+00 5.550e-03       1.634e-02
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N[2, 9, 2]   41.2532 4.300e+00 1.110e-02      6.564e-02
N[1, 10, 2]   7.0159 3.198e+00 8.256e-03      1.619e-02
N[2, 10, 2]  41.6296 4.667e+00 1.205e-02      6.698e-02
N[1, 11, 2]   9.4740 2.127e+01 5.493e-02      1.219e-01
N[2, 11, 2]  45.1050 5.944e+00 1.535e-02      6.788e-02
N[1, 12, 2]  16.3941 7.672e+02 1.981e+00      2.020e+00
N[2, 12, 2]  50.6091 2.117e+01 5.467e-02      1.361e-01
N[1, 13, 2]  18.3127 1.355e+02 3.499e-01      7.491e-01
N[2, 13, 2]  62.1788 7.208e+02 1.861e+00      1.992e+00
N[1, 14, 2]  29.0784 1.310e+03 3.382e+00      3.978e+00
N[2, 14, 2]  74.6987 7.001e+02 1.808e+00      2.362e+00
N[1, 15, 2] 101.4642 1.566e+04 4.042e+01      5.185e+01
N[2, 15, 2]  96.1242 1.532e+03 3.955e+00      5.142e+00
N[1, 1, 3]    3.5023 3.507e+00 9.055e-03      8.979e-02
N[2, 1, 3]   28.2734 5.786e+00 1.494e-02      1.569e-01
N[1, 2, 3]    1.2516 1.265e+00 3.266e-03      9.839e-03
N[2, 2, 3]   29.2421 4.058e+00 1.048e-02      8.726e-02
N[1, 3, 3]    5.0753 2.411e+00 6.225e-03      2.202e-02
N[2, 3, 3]   27.3798 3.657e+00 9.443e-03      7.287e-02
N[1, 4, 3]    6.5157 2.751e+00 7.104e-03      2.793e-02
N[2, 4, 3]   30.1028 3.640e+00 9.400e-03      6.798e-02
N[1, 5, 3]    3.3647 1.983e+00 5.120e-03      1.435e-02
N[2, 5, 3]   34.0914 3.761e+00 9.711e-03      6.704e-02
N[1, 6, 3]    3.9584 2.221e+00 5.734e-03      1.679e-02
N[2, 6, 3]   34.6161 3.707e+00 9.572e-03      6.293e-02
N[1, 7, 3]    6.3771 2.802e+00 7.236e-03      2.578e-02
N[2, 7, 3]   35.3181 3.752e+00 9.687e-03      5.899e-02
N[1, 8, 3]    5.7109 2.962e+00 7.647e-03      3.224e-02
N[2, 8, 3]   38.4197 4.032e+00 1.041e-02      6.354e-02
N[1, 9, 3]    3.4397 2.150e+00 5.550e-03      1.634e-02
N[2, 9, 3]   41.2532 4.300e+00 1.110e-02      6.564e-02
N[1, 10, 3]   7.0159 3.198e+00 8.256e-03      1.619e-02
N[2, 10, 3]  41.6296 4.667e+00 1.205e-02      6.698e-02
N[1, 11, 3]   9.4640 2.135e+01 5.513e-02      1.209e-01
N[2, 11, 3]  45.2161 5.814e+00 1.501e-02      6.740e-02
N[1, 12, 3]  11.3211 5.385e+01 1.390e-01      2.510e-01
N[2, 12, 3]  50.8440 2.109e+01 5.444e-02      1.363e-01
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N[1, 13, 3]   15.9075 7.649e+02 1.975e+00      2.034e+00
N[2, 13, 3]   57.8146 5.816e+01 1.502e-01      3.379e-01
N[1, 14, 3]   22.1810 9.106e+02 2.351e+00      2.915e+00
N[2, 14, 3]   68.5868 7.379e+02 1.905e+00      1.990e+00
N[1, 15, 3]  728.0788 2.711e+05 6.999e+02      6.999e+02
N[2, 15, 3]   84.4089 1.326e+03 3.423e+00      4.218e+00
N[1, 1, 4]     3.5023 3.507e+00 9.055e-03      8.979e-02
N[2, 1, 4]    28.2734 5.786e+00 1.494e-02      1.569e-01
N[1, 2, 4]     1.2516 1.265e+00 3.266e-03      9.839e-03
N[2, 2, 4]    29.2421 4.058e+00 1.048e-02      8.726e-02
N[1, 3, 4]     5.0753 2.411e+00 6.225e-03      2.202e-02
N[2, 3, 4]    27.3798 3.657e+00 9.443e-03      7.287e-02
N[1, 4, 4]     6.5157 2.751e+00 7.104e-03      2.793e-02
N[2, 4, 4]    30.1028 3.640e+00 9.400e-03      6.798e-02
N[1, 5, 4]     3.3647 1.983e+00 5.120e-03      1.435e-02
N[2, 5, 4]    34.0914 3.761e+00 9.711e-03      6.704e-02
N[1, 6, 4]     3.9584 2.221e+00 5.734e-03      1.679e-02
N[2, 6, 4]    34.6161 3.707e+00 9.572e-03      6.293e-02
N[1, 7, 4]     6.3771 2.802e+00 7.236e-03      2.578e-02
N[2, 7, 4]    35.3181 3.752e+00 9.687e-03      5.899e-02
N[1, 8, 4]     5.7109 2.962e+00 7.647e-03      3.224e-02
N[2, 8, 4]    38.4197 4.032e+00 1.041e-02      6.354e-02
N[1, 9, 4]     3.4397 2.150e+00 5.550e-03      1.634e-02
N[2, 9, 4]    41.2532 4.300e+00 1.110e-02      6.564e-02
N[1, 10, 4]    7.0159 3.198e+00 8.256e-03      1.619e-02
N[2, 10, 4]   41.6296 4.667e+00 1.205e-02      6.698e-02
N[1, 11, 4]   10.4360 2.308e+01 5.959e-02      1.341e-01
N[2, 11, 4]   49.7394 6.038e+00 1.559e-02      6.896e-02
N[1, 12, 4]   13.4379 6.107e+01 1.577e-01      2.931e-01
N[2, 12, 4]   60.4247 2.283e+01 5.894e-02      1.507e-01
N[1, 13, 4]   19.5825 8.531e+02 2.203e+00      2.274e+00
N[2, 13, 4]   73.1482 6.523e+01 1.684e-01      3.845e-01
N[1, 14, 4]   28.1605 1.062e+03 2.742e+00      3.364e+00
N[2, 14, 4]   90.7936 8.411e+02 2.172e+00      2.277e+00
N[1, 15, 4]  799.9753 2.957e+05 7.636e+02      7.636e+02
N[2, 15, 4]  115.1624 1.554e+03 4.011e+00      4.946e+00
Ntot[1, 1]    31.7756 4.547e+00 1.174e-02      9.806e-02
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Ntot[2, 1]    30.4936 4.105e+00 1.060e-02      8.883e-02
Ntot[3, 1]    32.4551 3.895e+00 1.006e-02      7.559e-02
Ntot[4, 1]    36.6186 4.046e+00 1.045e-02      7.108e-02
Ntot[5, 1]    37.4561 3.956e+00 1.022e-02      6.839e-02
Ntot[6, 1]    38.5745 3.956e+00 1.021e-02      6.320e-02
Ntot[7, 1]    41.6952 4.246e+00 1.096e-02      6.608e-02
Ntot[8, 1]    44.1306 4.491e+00 1.159e-02      6.864e-02
Ntot[9, 1]    44.6929 4.721e+00 1.219e-02      7.009e-02
Ntot[10, 1]   48.6454 5.703e+00 1.473e-02      7.002e-02
Ntot[11, 1]   54.5814 2.237e+01 5.776e-02      1.469e-01
Ntot[12, 1]   61.9241 6.166e+01 1.592e-01      3.651e-01
Ntot[13, 1]   73.3431 8.108e+02 2.093e+00      2.181e+00
Ntot[14, 1]   90.3577 1.496e+03 3.862e+00      4.722e+00
Ntot[15, 1] 792.0383 2.634e+05 6.802e+02      6.802e+02
Ntot[1, 2]    31.7756 4.547e+00 1.174e-02      9.806e-02
Ntot[2, 2]    30.4936 4.105e+00 1.060e-02      8.883e-02
Ntot[3, 2]    32.4551 3.895e+00 1.006e-02      7.559e-02
Ntot[4, 2]    36.6186 4.046e+00 1.045e-02      7.108e-02
Ntot[5, 2]    37.4561 3.956e+00 1.022e-02      6.839e-02
Ntot[6, 2]    38.5745 3.956e+00 1.021e-02      6.320e-02
Ntot[7, 2]    41.6952 4.246e+00 1.096e-02      6.608e-02
Ntot[8, 2]    44.1306 4.491e+00 1.159e-02      6.864e-02
Ntot[9, 2]    44.6929 4.721e+00 1.219e-02      7.009e-02
Ntot[10, 2]   48.6454 5.703e+00 1.473e-02      7.002e-02
Ntot[11, 2]   54.5791 2.238e+01 5.779e-02      1.476e-01
Ntot[12, 2]   67.0032 7.685e+02 1.984e+00      2.125e+00
Ntot[13, 2]   80.4916 7.619e+02 1.967e+00      2.558e+00
Ntot[14, 2] 103.7771 1.672e+03 4.316e+00      5.586e+00
Ntot[15, 2] 197.5884 1.689e+04 4.362e+01      5.552e+01
Ntot[1, 3]    31.7756 4.547e+00 1.174e-02      9.806e-02
Ntot[2, 3]    30.4936 4.105e+00 1.060e-02      8.883e-02
Ntot[3, 3]    32.4551 3.895e+00 1.006e-02      7.559e-02
Ntot[4, 3]    36.6186 4.046e+00 1.045e-02      7.108e-02
Ntot[5, 3]    37.4561 3.956e+00 1.022e-02      6.839e-02
Ntot[6, 3]    38.5745 3.956e+00 1.021e-02      6.320e-02
Ntot[7, 3]    41.6952 4.246e+00 1.096e-02      6.608e-02
Ntot[8, 3]    44.1306 4.491e+00 1.159e-02      6.864e-02
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Ntot[9, 3]    44.6929 4.721e+00 1.219e-02      7.009e-02
Ntot[10, 3]   48.6454 5.703e+00 1.473e-02      7.002e-02
Ntot[11, 3]   54.6801 2.242e+01 5.790e-02      1.434e-01
Ntot[12, 3]   62.1650 6.193e+01 1.599e-01      3.617e-01
Ntot[13, 3]   73.7222 7.804e+02 2.015e+00      2.105e+00
Ntot[14, 3]   90.7678 1.430e+03 3.691e+00      4.538e+00
Ntot[15, 3]  812.4877 2.712e+05 7.001e+02      7.001e+02
Ntot[1, 4]    31.7756 4.547e+00 1.174e-02      9.806e-02
Ntot[2, 4]    30.4936 4.105e+00 1.060e-02      8.883e-02
Ntot[3, 4]    32.4551 3.895e+00 1.006e-02      7.559e-02
Ntot[4, 4]    36.6186 4.046e+00 1.045e-02      7.108e-02
Ntot[5, 4]    37.4561 3.956e+00 1.022e-02      6.839e-02
Ntot[6, 4]    38.5745 3.956e+00 1.021e-02      6.320e-02
Ntot[7, 4]    41.6952 4.246e+00 1.096e-02      6.608e-02
Ntot[8, 4]    44.1306 4.491e+00 1.159e-02      6.864e-02
Ntot[9, 4]    44.6929 4.721e+00 1.219e-02      7.009e-02
Ntot[10, 4]   48.6454 5.703e+00 1.473e-02      7.002e-02
Ntot[11, 4]   60.1754 2.413e+01 6.230e-02      1.582e-01
Ntot[12, 4]   73.8626 6.956e+01 1.796e-01      4.148e-01
Ntot[13, 4]   92.7307 8.698e+02 2.246e+00      2.358e+00
Ntot[14, 4]  118.9541 1.641e+03 4.238e+00      5.249e+00
Ntot[15, 4]  915.1377 2.958e+05 7.639e+02      7.639e+02
f[1, 1]        0.1289 5.993e-02 1.547e-04      7.612e-04
f[2, 1]        0.4719 9.608e-02 2.481e-04      6.549e-04
f[3, 1]        0.3888 8.836e-02 2.282e-04      6.520e-04
f[4, 1]        0.3582 8.115e-02 2.095e-04      5.019e-04
f[5, 1]        0.3876 7.994e-02 2.064e-04      4.854e-04
f[6, 1]        0.4610 9.016e-02 2.328e-04      5.945e-04
f[7, 1]        0.6899 1.189e-01 3.071e-04      8.355e-04
f[8, 1]        0.3235 7.264e-02 1.876e-04      4.484e-04
f[9, 1]        0.3509 7.509e-02 1.939e-04      4.632e-04
f[10, 1]       0.5041 1.115e+00 2.880e-03      6.292e-03
f[11, 1]       0.5044 1.247e+00 3.219e-03      6.457e-03
f[12, 1]       0.5038 1.150e+00 2.970e-03      6.305e-03
f[13, 1]       0.5138 2.163e+00 5.585e-03      8.406e-03
f[14, 1]       0.5498 1.767e+01 4.562e-02      4.622e-02
f[15, 1]       0.5159 2.540e+00 6.557e-03      8.550e-03
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f[1, 2]       0.1289 5.993e-02 1.547e-04      7.612e-04
f[2, 2]       0.4719 9.608e-02 2.481e-04      6.549e-04
f[3, 2]       0.3888 8.836e-02 2.282e-04      6.520e-04
f[4, 2]       0.3582 8.115e-02 2.095e-04      5.019e-04
f[5, 2]       0.3876 7.994e-02 2.064e-04      4.854e-04
f[6, 2]       0.4610 9.016e-02 2.328e-04      5.945e-04
f[7, 2]       0.6899 1.189e-01 3.071e-04      8.355e-04
f[8, 2]       0.3235 7.264e-02 1.876e-04      4.484e-04
f[9, 2]       0.3509 7.509e-02 1.939e-04      4.632e-04
f[10, 2]      0.5041 1.115e+00 2.880e-03      6.292e-03
f[11, 2]      0.6729 1.220e+01 3.149e-02      3.261e-02
f[12, 2]      0.6357 1.833e+00 4.732e-03      1.034e-02
f[13, 2]      0.6343 2.251e+00 5.812e-03      8.962e-03
f[14, 2]      0.6338 1.703e+00 4.396e-03      8.136e-03
f[15, 2]      0.6862 2.004e+01 5.175e-02      5.211e-02
mean.f        0.3812 9.358e-02 2.416e-04      2.593e-03
mean.p        0.7757 1.644e-02 4.245e-05      9.064e-05
mean.sad      0.9317 1.376e-02 3.552e-05      2.045e-04
mean.sjuv     0.3733 7.309e-02 1.887e-04      1.286e-03
sad[1, 1]     0.9368 1.981e-02 5.115e-05      2.387e-04
sad[2, 1]     0.9172 2.660e-02 6.869e-05      3.665e-04
sad[3, 1]     0.9335 1.903e-02 4.913e-05      1.647e-04
sad[4, 1]     0.9370 1.815e-02 4.685e-05      1.957e-04
sad[5, 1]     0.9319 1.859e-02 4.799e-05      1.418e-04
sad[6, 1]     0.9268 2.072e-02 5.351e-05      1.750e-04
sad[7, 1]     0.9261 2.044e-02 5.278e-05      1.595e-04
sad[8, 1]     0.9353 1.960e-02 5.062e-05      1.987e-04
sad[9, 1]     0.9309 2.323e-02 5.998e-05      2.032e-04
sad[10, 1]    0.9270 3.773e-02 9.741e-05      3.488e-04
sad[11, 1]    0.9269 3.852e-02 9.946e-05      3.649e-04
sad[12, 1]    0.9270 3.855e-02 9.954e-05      3.138e-04
sad[13, 1]    0.9271 3.782e-02 9.765e-05      3.171e-04
sad[14, 1]    0.9270 3.837e-02 9.907e-05      3.602e-04
sad[1, 2]     0.9368 1.981e-02 5.115e-05      2.387e-04
sad[2, 2]     0.9172 2.660e-02 6.869e-05      3.665e-04
sad[3, 2]     0.9335 1.903e-02 4.913e-05      1.647e-04
sad[4, 2]     0.9370 1.815e-02 4.685e-05      1.957e-04
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sad[5, 2]      0.9319 1.859e-02 4.799e-05      1.418e-04
sad[6, 2]      0.9268 2.072e-02 5.351e-05      1.750e-04
sad[7, 2]      0.9261 2.044e-02 5.278e-05      1.595e-04
sad[8, 2]      0.9353 1.960e-02 5.062e-05      1.987e-04
sad[9, 2]      0.9309 2.323e-02 5.998e-05      2.032e-04
sad[10, 2]     0.9293 2.694e-02 6.957e-05      2.673e-04
sad[11, 2]     0.9294 2.721e-02 7.026e-05      2.657e-04
sad[12, 2]     0.9293 2.686e-02 6.935e-05      2.530e-04
sad[13, 2]     0.9293 2.759e-02 7.124e-05      2.836e-04
sad[14, 2]     0.9294 2.675e-02 6.908e-05      2.676e-04
sjuv[1]        0.4040 1.195e-01 3.085e-04      7.789e-04
sjuv[2]        0.4544 9.886e-02 2.553e-04      8.265e-04
sjuv[3]        0.5848 1.168e-01 3.016e-04      1.563e-03
sjuv[4]        0.2921 7.355e-02 1.899e-04      5.526e-04
sjuv[5]        0.3152 9.023e-02 2.330e-04      6.797e-04
sjuv[6]        0.4294 9.227e-02 2.382e-04      7.149e-04
sjuv[7]        0.2209 8.115e-02 2.095e-04      1.052e-03
sjuv[8]        0.2495 7.687e-02 1.985e-04      7.880e-04
sjuv[9]        0.4523 9.460e-02 2.443e-04      7.658e-04
sjuv[10]       0.3868 1.799e-01 4.646e-04      1.167e-03
sjuv[11]       0.3872 1.803e-01 4.655e-04      1.149e-03
sjuv[12]       0.3869 1.796e-01 4.638e-04      1.141e-03
sjuv[13]       0.3866 1.801e-01 4.651e-04      1.142e-03
sjuv[14]       0.3869 1.802e-01 4.654e-04      1.155e-03

2. Quantiles for each variable:

                   2.5%       25%       50%       75%     97.5%
N[1, 1, 1]      0.00000   1.00000    2.0000    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   5.00000    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]  27.00000 32.00000  34.0000  37.0000  41.0000
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  13.0000
N[2, 7, 1]  28.00000 33.00000  35.0000  38.0000  43.0000
N[1, 8, 1]   1.00000  4.00000   5.0000   8.0000  12.0000
N[2, 8, 1]  31.00000 36.00000  38.0000  41.0000  47.0000
N[1, 9, 1]   0.00000  2.00000   3.0000   5.0000   8.0000
N[2, 9, 1]  33.00000 38.00000  41.0000  44.0000  50.0000
N[1, 10, 1]  2.00000  5.00000   7.0000   9.0000  14.0000
N[2, 10, 1] 33.00000 39.00000  42.0000  45.0000  51.0000
N[1, 11, 1]  0.00000  3.00000   6.0000  11.0000  36.0000
N[2, 11, 1] 34.00000 41.00000  45.0000  49.0000  57.0000
N[1, 12, 1]  0.00000  3.00000   7.0000  12.0000  43.0000
N[2, 12, 1] 33.00000 43.00000  48.0000  55.0000  79.0000
N[1, 13, 1]  0.00000  4.00000   7.0000  14.0000  51.0000
N[2, 13, 1] 33.00000 45.00000  52.0000  62.0000 105.0000
N[1, 14, 1]  0.00000  4.00000   8.0000  15.0000  62.0000
N[2, 14, 1] 33.00000 47.00000  57.0000  70.0000 135.0000
N[1, 15, 1]  0.00000  4.00000   9.0000  17.0000  76.0000
N[2, 15, 1] 33.00000 50.00000  62.0000  79.0000 173.0000
N[1, 1, 2]   0.00000  1.00000   2.0000   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  5.00000   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]  27.00000 32.00000  34.0000  37.0000  41.0000
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  13.0000
N[2, 7, 2]  28.00000 33.00000  35.0000  38.0000  43.0000
N[1, 8, 2]   1.00000  4.00000   5.0000   8.0000  12.0000
N[2, 8, 2]  31.00000 36.00000  38.0000  41.0000  47.0000
```

```
N[1, 9, 2]   0.00000  2.00000   3.0000   5.0000   8.0000
N[2, 9, 2]  33.00000 38.00000  41.0000  44.0000  50.0000
N[1, 10, 2]  2.00000  5.00000   7.0000   9.0000  14.0000
N[2, 10, 2] 33.00000 39.00000  42.0000  45.0000  51.0000
N[1, 11, 2]  0.00000  3.00000   6.0000  11.0000  36.0000
N[2, 11, 2] 34.00000 41.00000  45.0000  49.0000  57.0000
N[1, 12, 2]  0.00000  4.00000   9.0000  15.0000  53.0000
N[2, 12, 2] 33.00000 43.00000  48.0000  55.0000  79.0000
N[1, 13, 2]  0.00000  5.00000  10.0000  18.0000  68.0000
N[2, 13, 2] 34.00000 46.00000  54.0000  65.0000 113.0000
N[1, 14, 2]  1.00000  5.00000  11.0000  20.0000  86.0000
N[2, 14, 2] 35.00000 50.00000  61.0000  76.0000 156.0000
N[1, 15, 2]  1.00000  6.00000  12.0000  24.0000 111.0000
N[2, 15, 2] 35.00000 54.00000  69.0000  90.0000 213.0000
N[1, 1, 3]   0.00000  1.00000   2.0000   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  5.00000   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]  27.00000 32.00000  34.0000  37.0000  41.0000
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  13.0000
N[2, 7, 3]  28.00000 33.00000  35.0000  38.0000  43.0000
N[1, 8, 3]   1.00000  4.00000   5.0000   8.0000  12.0000
N[2, 8, 3]  31.00000 36.00000  38.0000  41.0000  47.0000
N[1, 9, 3]   0.00000  2.00000   3.0000   5.0000   8.0000
N[2, 9, 3]  33.00000 38.00000  41.0000  44.0000  50.0000
N[1, 10, 3]  2.00000  5.00000   7.0000   9.0000  14.0000
N[2, 10, 3] 33.00000 39.00000  42.0000  45.0000  51.0000
N[1, 11, 3]  0.00000  3.00000   6.0000  11.0000  36.0000
N[2, 11, 3] 34.00000 41.00000  45.0000  49.0000  57.0000
N[1, 12, 3]  0.00000  3.00000   7.0000  13.0000  43.0000
```

```
N[2, 12, 3] 34.00000 43.00000  49.0000  55.0000  79.0000
N[1, 13, 3]  0.00000  4.00000   7.0000  14.0000  51.0000
N[2, 13, 3] 34.00000 45.00000  53.0000  62.0000 105.0000
N[1, 14, 3]  0.00000  4.00000   8.0000  15.0000  62.0000
N[2, 14, 3] 34.00000 48.00000  57.0000  71.0000 135.0000
N[1, 15, 3]  0.00000  4.00000   9.0000  17.0000  76.0000
N[2, 15, 3] 35.00000 51.00000  63.0000  80.0000 174.0000
N[1, 1, 4]   0.00000  1.00000   2.0000   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  5.00000   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]  27.00000 32.00000  34.0000  37.0000  41.0000
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  13.0000
N[2, 7, 4]  28.00000 33.00000  35.0000  38.0000  43.0000
N[1, 8, 4]   1.00000  4.00000   5.0000   8.0000  12.0000
N[2, 8, 4]  31.00000 36.00000  38.0000  41.0000  47.0000
N[1, 9, 4]   0.00000  2.00000   3.0000   5.0000   8.0000
N[2, 9, 4]  33.00000 38.00000  41.0000  44.0000  50.0000
N[1, 10, 4]  2.00000  5.00000   7.0000   9.0000  14.0000
N[2, 10, 4] 33.00000 39.00000  42.0000  45.0000  51.0000
N[1, 11, 4]  0.00000  3.00000   7.0000  12.0000  39.0000
N[2, 11, 4] 38.00000 46.00000  50.0000  54.0000  62.0000
N[1, 12, 4]  0.00000  4.00000   8.0000  15.0000  50.0000
N[2, 12, 4] 42.00000 52.00000  58.0000  65.0000  91.0000
N[1, 13, 4]  0.00000  5.00000  10.0000  18.0000  63.0000
N[2, 13, 4] 46.00000 59.00000  68.0000  78.0000 126.0000
N[1, 14, 4]  1.00000  6.00000  11.0000  21.0000  81.0000
N[2, 14, 4] 50.00000 67.00000  78.0000  93.0000 169.0000
N[1, 15, 4]  1.00000  6.00000  13.0000  24.0000 103.0000
N[2, 15, 4] 55.00000 75.00000  90.0000 110.0000 224.0000
```

```
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]  25.00000 30.00000  32.0000  35.0000  40.0000
Ntot[4, 1]  29.00000 34.00000  37.0000  39.0000  45.0000
Ntot[5, 1]  30.00000 35.00000  37.0000  40.0000  45.0000
Ntot[6, 1]  31.00000 36.00000  39.0000  41.0000  46.0000
Ntot[7, 1]  34.00000 39.00000  42.0000  44.0000  50.0000
Ntot[8, 1]  36.00000 41.00000  44.0000  47.0000  54.0000
Ntot[9, 1]  36.00000 42.00000  45.0000  48.0000  55.0000
Ntot[10, 1] 38.00000 45.00000  48.0000  52.0000  61.0000
Ntot[11, 1] 37.00000 47.00000  52.0000  59.0000  84.0000
Ntot[12, 1] 37.00000 49.00000  56.0000  67.0000 112.0000
Ntot[13, 1] 37.00000 51.00000  61.0000  75.0000 145.0000
Ntot[14, 1] 37.00000 54.00000  67.0000  85.0000 186.0000
Ntot[15, 1] 37.00000 57.00000  73.0000  96.0000 240.0000
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]  25.00000 30.00000  32.0000  35.0000  40.0000
Ntot[4, 2]  29.00000 34.00000  37.0000  39.0000  45.0000
Ntot[5, 2]  30.00000 35.00000  37.0000  40.0000  45.0000
Ntot[6, 2]  31.00000 36.00000  39.0000  41.0000  46.0000
Ntot[7, 2]  34.00000 39.00000  42.0000  44.0000  50.0000
Ntot[8, 2]  36.00000 41.00000  44.0000  47.0000  54.0000
Ntot[9, 2]  36.00000 42.00000  45.0000  48.0000  55.0000
Ntot[10, 2] 38.00000 45.00000  48.0000  52.0000  61.0000
Ntot[11, 2] 37.00000 47.00000  52.0000  59.0000  85.0000
Ntot[12, 2] 38.00000 50.00000  58.0000  70.0000 121.0000
Ntot[13, 2] 38.00000 54.00000  65.0000  82.0000 168.0000
Ntot[14, 2] 39.00000 59.00000  74.0000  97.0000 229.0000
Ntot[15, 2] 40.00000 64.00000  83.0000 113.0000 313.0000
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]  25.00000 30.00000  32.0000  35.0000  40.0000
Ntot[4, 3]  29.00000 34.00000  37.0000  39.0000  45.0000
Ntot[5, 3]  30.00000 35.00000  37.0000  40.0000  45.0000
Ntot[6, 3]  31.00000 36.00000  39.0000  41.0000  46.0000
Ntot[7, 3]  34.00000 39.00000  42.0000  44.0000  50.0000
```

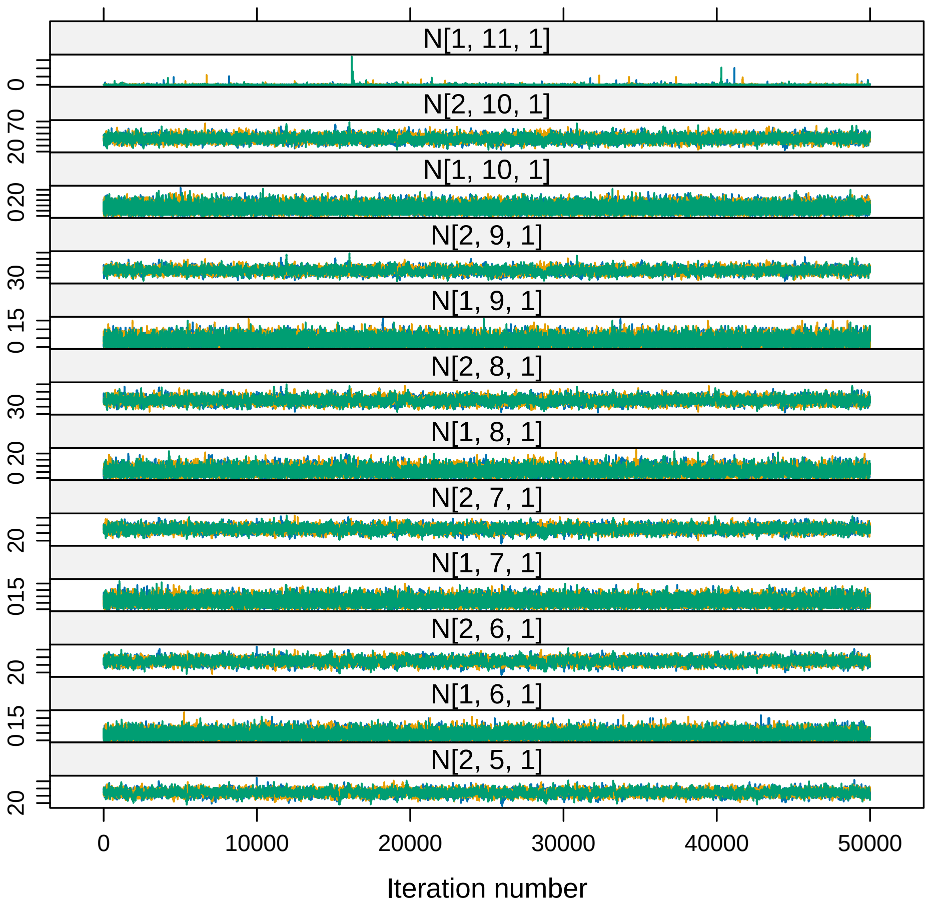
```
Ntot[8, 3]  36.00000 41.00000  44.0000  47.0000  54.0000
Ntot[9, 3]  36.00000 42.00000  45.0000  48.0000  55.0000
Ntot[10, 3] 38.00000 45.00000  48.0000  52.0000  61.0000
Ntot[11, 3] 38.00000 47.00000  52.0000  59.0000  84.0000
Ntot[12, 3] 38.00000 49.00000  57.0000  67.0000 112.0000
Ntot[13, 3] 38.00000 52.00000  62.0000  76.0000 145.0000
Ntot[14, 3] 38.00000 55.00000  67.0000  85.0000 187.0000
Ntot[15, 3] 38.00000 58.00000  73.0000  97.0000 241.0000
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]  25.00000 30.00000  32.0000  35.0000  40.0000
Ntot[4, 4]  29.00000 34.00000  37.0000  39.0000  45.0000
Ntot[5, 4]  30.00000 35.00000  37.0000  40.0000  45.0000
Ntot[6, 4]  31.00000 36.00000  39.0000  41.0000  46.0000
Ntot[7, 4]  34.00000 39.00000  42.0000  44.0000  50.0000
Ntot[8, 4]  36.00000 41.00000  44.0000  47.0000  54.0000
Ntot[9, 4]  36.00000 42.00000  45.0000  48.0000  55.0000
Ntot[10, 4] 38.00000 45.00000  48.0000  52.0000  61.0000
Ntot[11, 4] 42.00000 52.00000  57.0000  64.0000  92.0000
Ntot[12, 4] 47.00000 59.00000  68.0000  79.0000 130.0000
Ntot[13, 4] 51.00000 67.00000  79.0000  95.0000 177.0000
Ntot[14, 4] 56.00000 76.00000  91.0000 113.0000 236.0000
Ntot[15, 4] 60.00000 86.00000 105.0000 133.0000 315.0000
f[1, 1]       0.03674  0.08482   0.1206   0.1638   0.2673
f[2, 1]       0.30569  0.40366   0.4642   0.5318   0.6798
f[3, 1]       0.23596  0.32637   0.3823   0.4437   0.5820
f[4, 1]       0.21793  0.30135   0.3517   0.4081   0.5355
f[5, 1]       0.24797  0.33100   0.3822   0.4379   0.5591
f[6, 1]       0.30372  0.39774   0.4544   0.5172   0.6563
f[7, 1]       0.47861  0.60527   0.6832   0.7660   0.9435
f[8, 1]       0.19755  0.27172   0.3181   0.3692   0.4804
f[9, 1]       0.21952  0.29801   0.3457   0.3978   0.5130
f[10, 1]      0.08409  0.24749   0.3715   0.5518   1.6233
f[11, 1]      0.08426  0.24688   0.3701   0.5524   1.6401
f[12, 1]      0.08452  0.24782   0.3715   0.5526   1.6229
f[13, 1]      0.08277  0.24704   0.3709   0.5525   1.6182
f[14, 1]      0.08439  0.24734   0.3713   0.5517   1.6285
```

```
f[15, 1]      0.08330  0.24760   0.3705   0.5506   1.6293
f[1, 2]       0.03674  0.08482   0.1206   0.1638   0.2673
f[2, 2]       0.30569  0.40366   0.4642   0.5318   0.6798
f[3, 2]       0.23596  0.32637   0.3823   0.4437   0.5820
f[4, 2]       0.21793  0.30135   0.3517   0.4081   0.5355
f[5, 2]       0.24797  0.33100   0.3822   0.4379   0.5591
f[6, 2]       0.30372  0.39774   0.4544   0.5172   0.6563
f[7, 2]       0.47861  0.60527   0.6832   0.7660   0.9435
f[8, 2]       0.19755  0.27172   0.3181   0.3692   0.4804
f[9, 2]       0.21952  0.29801   0.3457   0.3978   0.5130
f[10, 2]      0.08409  0.24749   0.3715   0.5518   1.6233
f[11, 2]      0.10542  0.30964   0.4652   0.6925   2.0502
f[12, 2]      0.10483  0.31000   0.4649   0.6890   2.0566
f[13, 2]      0.10520  0.31070   0.4647   0.6915   2.0277
f[14, 2]      0.10483  0.30919   0.4638   0.6897   2.0444
f[15, 2]      0.10428  0.31048   0.4659   0.6905   2.0489
mean.f        0.22897  0.32221   0.3714   0.4269   0.5977
mean.p        0.74301  0.76475   0.7759   0.7870   0.8071
mean.sad      0.90459  0.92378   0.9322   0.9403   0.9570
mean.sjuv     0.23823  0.32577   0.3695   0.4164   0.5319
sad[1, 1]     0.89689  0.92489   0.9364   0.9486   0.9777
sad[2, 1]     0.84774  0.90619   0.9229   0.9347   0.9531
sad[3, 1]     0.89272  0.92269   0.9339   0.9450   0.9705
sad[4, 1]     0.90054  0.92581   0.9367   0.9483   0.9739
sad[5, 1]     0.89067  0.92169   0.9329   0.9434   0.9668
sad[6, 1]     0.87710  0.91683   0.9292   0.9399   0.9614
sad[7, 1]     0.87643  0.91618   0.9285   0.9391   0.9597
sad[8, 1]     0.89474  0.92390   0.9351   0.9470   0.9751
sad[9, 1]     0.87729  0.91962   0.9324   0.9444   0.9739
sad[10, 1]    0.84623  0.91804   0.9319   0.9443   0.9754
sad[11, 1]    0.84649  0.91793   0.9318   0.9444   0.9750
sad[12, 1]    0.84613  0.91807   0.9319   0.9443   0.9754
sad[13, 1]    0.84629  0.91809   0.9319   0.9444   0.9751
sad[14, 1]    0.84750  0.91791   0.9319   0.9444   0.9752
sad[1, 2]     0.89689  0.92489   0.9364   0.9486   0.9777
sad[2, 2]     0.84774  0.90619   0.9229   0.9347   0.9531
sad[3, 2]     0.89272  0.92269   0.9339   0.9450   0.9705
```

```
sad[4, 2]     0.90054  0.92581   0.9367   0.9483   0.9739
sad[5, 2]     0.89067  0.92169   0.9329   0.9434   0.9668
sad[6, 2]     0.87710  0.91683   0.9292   0.9399   0.9614
sad[7, 2]     0.87643  0.91618   0.9285   0.9391   0.9597
sad[8, 2]     0.89474  0.92390   0.9351   0.9470   0.9751
sad[9, 2]     0.87729  0.91962   0.9324   0.9444   0.9739
sad[10, 2]    0.87377  0.92020   0.9319   0.9427   0.9688
sad[11, 2]    0.87395  0.92033   0.9319   0.9428   0.9689
sad[12, 2]    0.87269  0.92017   0.9320   0.9427   0.9689
sad[13, 2]    0.87334  0.92025   0.9320   0.9428   0.9688
sad[14, 2]    0.87348  0.92029   0.9319   0.9428   0.9691
sjuv[1]       0.18980  0.32108   0.3957   0.4803   0.6601
sjuv[2]       0.27586  0.38362   0.4493   0.5206   0.6584
sjuv[3]       0.36018  0.50212   0.5860   0.6679   0.8089
sjuv[4]       0.15699  0.23967   0.2898   0.3413   0.4422
sjuv[5]       0.15036  0.25130   0.3118   0.3739   0.5028
sjuv[6]       0.26127  0.36423   0.4250   0.4906   0.6199
sjuv[7]       0.08006  0.16099   0.2154   0.2754   0.3901
sjuv[8]       0.11192  0.19403   0.2461   0.3011   0.4077
sjuv[9]       0.28447  0.38499   0.4462   0.5136   0.6512
sjuv[10]      0.08020  0.26139   0.3683   0.4928   0.7997
sjuv[11]      0.08023  0.26182   0.3681   0.4931   0.7999
sjuv[12]      0.08058  0.26174   0.3689   0.4925   0.7987
sjuv[13]      0.08093  0.26054   0.3683   0.4918   0.8022
sjuv[14]      0.08057  0.26064   0.3686   0.4923   0.8013
```

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] 0.651
```

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

```
[1] 0.477
```

Probabilidad de que reducir la variabilidad sea mejor que el control

```
> round(mean(ipm$'Ntot[15, 3]' >  ipm$'Ntot[15, 1]'), 3)
[1] 0.507
> 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] 0.985
> round(sd(ipm$'Ntot[15, 4]' >  ipm$'Ntot[15, 1]'), 3)
[1] 0.122
```

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.

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