

Simulated Data

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Package Prep and Library

```
library(Distance)
```

```
## Loading required package: mrds

## This is mrds 2.2.8
## Built: R 4.3.1; ; 2023-06-25 01:34:29 UTC; windows

##
## Attaching package: 'Distance'

## The following object is masked from 'package:mrds':
##
##      create.bins
```

```
library(mrds)
library(dsims)
```

```
## Loading required package: dssd

## The legacy packages maptools, rgdal, and rgeos, underpinning the sp package,
## which was just loaded, will retire in October 2023.
## Please refer to R-spatial evolution reports for details, especially
## https://r-spatial.org/r/2023/05/15/evolution4.html.
## It may be desirable to make the sf package available;
## package maintainers should consider adding sf to Suggests:.
## The sp package is now running under evolution status 2
##      (status 2 uses the sf package in place of rgdal)

## rgeos version: 0.6-3, (SVN revision 696)
## GEOS runtime version: 3.11.2-CAPI-1.17.2
## Please note that rgeos will be retired during October 2023,
## plan transition to sf or terra functions using GEOS at your earliest convenience.
## See https://r-spatial.org/r/2023/05/15/evolution4.html for details.
## GEOS using OverlayNG
## Linking to sp version: 2.0-0
## Polygon checking: TRUE
```

```
library(sf)
```

```
## Linking to GEOS 3.11.2, GDAL 3.6.2, PROJ 9.2.0; sf_use_s2() is TRUE
```

```
library(dssd)
library(knitr)
library(tidyverse)
```

```
## -- Attaching core tidyverse packages ----- tidyverse 2.0.0 --
## v dplyr      1.1.2      v readr      2.1.4
## v forcats    1.0.0      v stringr   1.5.0
## v ggplot2    3.4.2      v tibble    3.2.1
## v lubridate  1.9.2      v tidyr     1.3.0
## v purrr      1.0.1
```

```
## -- Conflicts ----- tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()     masks stats::lag()
## i Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to become errors
```

```
library(reshape)
```

```
##
## Attaching package: 'reshape'
##
## The following object is masked from 'package:lubridate':
##
##     stamp
##
## The following object is masked from 'package:dplyr':
##
##     rename
##
## The following objects are masked from 'package:tidyr':
##
##     expand, smiths
```

```
library(ggplot2)
library(pbapply)
#install.packages("devtools")
library(devtools)
```

```
## Loading required package: usethis
```

```
#install_github("DistanceDevelopment/dssd", build_vignettes = TRUE)
#install_github("DistanceDevelopment/dsims", build_vignettes = TRUE)
```

Working with Dsims creating the region for study

This creates a 3000 by 2000 meter region which we can add a population distribution to, creating a functional study area. Below is a plot of the region with no population.

```

# Find the file path to the example shapefile in dssd
#shapefile.name <- system.file("extdata", "StAndrew.shp", package = "dssd")

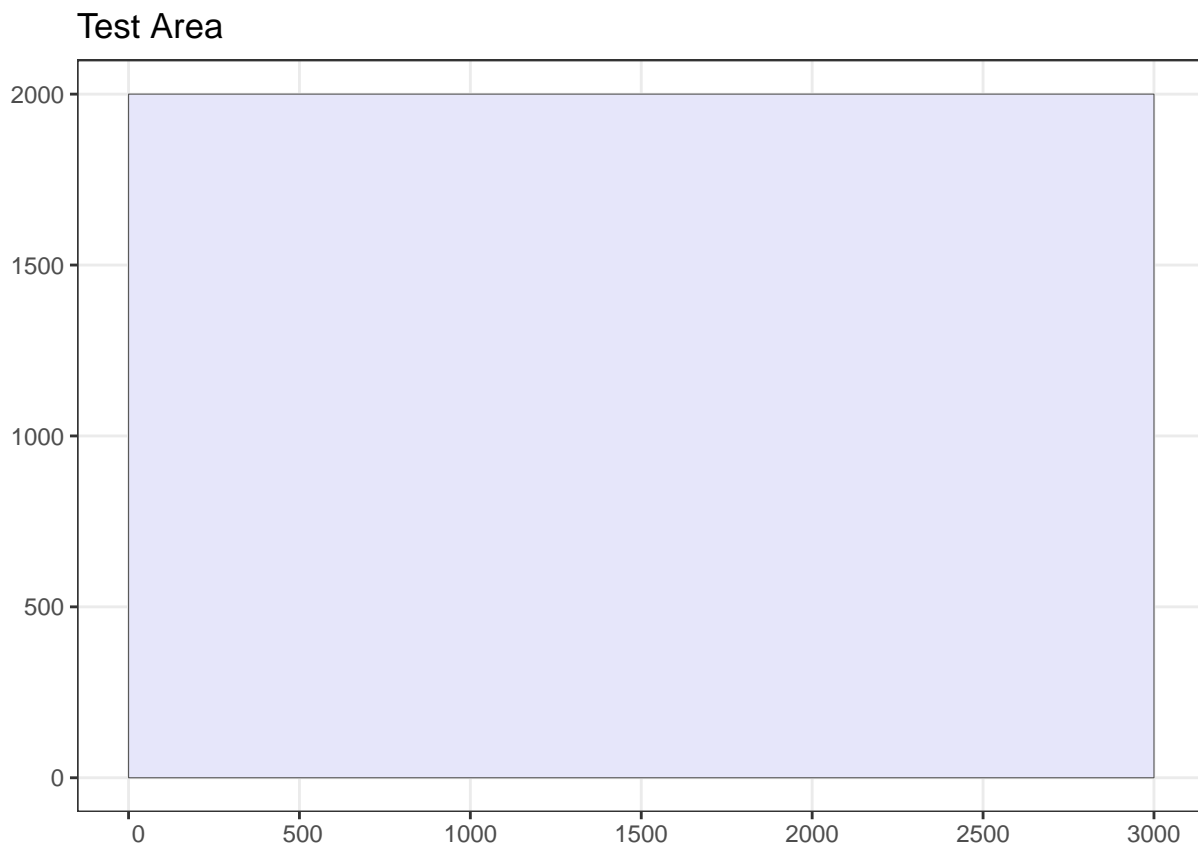
study_area <- matrix(c(0, 0, 3000, 0, 3000, 2000, 0, 2000, 0, 0), ncol = 2, byrow = TRUE)
study_area_data <- data.frame(ID = 1)
study_area_sf <- st_sf(geometry =
  st_sfc(st_polygon(list(study_area))), data = study_area_data)

print(study_area_sf)

## Simple feature collection with 1 feature and 1 field
## Geometry type: POLYGON
## Dimension:      XY
## Bounding box:   xmin: 0 ymin: 0 xmax: 3000 ymax: 2000
## CRS:            NA
##   ID              geometry
## 1  1 POLYGON ((0 0, 3000 0, 3000...

# Create the survey region object
region <- make.region(region.name = "Test Area",
  shape = study_area_sf,
  units = "m")
plot(region)

```

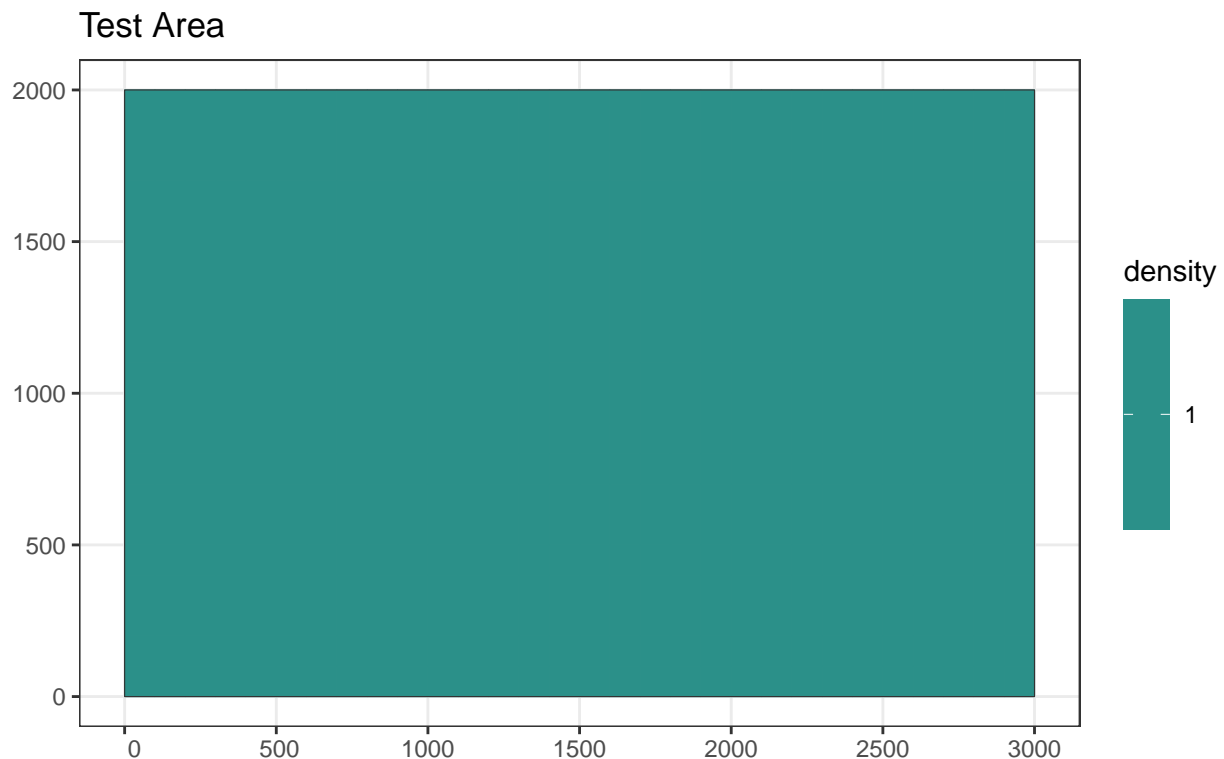


This chunk adds a uniform population density to the study area, allowing us to perform analysis on the study

area. Below is a density plot of our study region, the uniform color corresponds to the uniform population distribution.

```
# We first create a flat density grid
density <- make.density(region = region,
                        x.space = 100,
                        y.space = 100,
                        constant = 1)

plot(density, region, scale = 1)
```



This chunk turns our uniform density into a dataset, allowing us to see its raw form. This raw data would be similar to data that we may collect on line transect surveys.

```
density.data <- density@density.surface[[1]]
head(density.data)
```

```
## Simple feature collection with 6 features and 4 fields
## Geometry type: POLYGON
## Dimension:      XY
## Bounding box:   xmin: 0 ymin: 0 xmax: 600 ymax: 100
## CRS:            NA
##   strata density    x    y geometry
## 1 Test Area      1  50  50 POLYGON ((0 0, 0 100, 100 1...
## 2 Test Area      1 150  50 POLYGON ((100 0, 100 100, 2...
```

```
## 3 Test Area      1 250 50 POLYGON ((200 0, 200 100, 3...
## 4 Test Area      1 350 50 POLYGON ((300 0, 300 100, 4...
## 5 Test Area      1 450 50 POLYGON ((400 0, 400 100, 5...
## 6 Test Area      1 550 50 POLYGON ((500 0, 500 100, 6...
```

This chunk defines the population distribution. First, the covariates are defined, in our case, group size. The group size in this data averages 2 and follows a zero-truncated Poissant distribution. This group size distribution is fed into the model along with the region and population density that we defined previously. Here we also specify our population size, in number of groups.

```
# Create a covariate list describing the distribution of cluster sizes
s <- 20
#covariates <- list(size = list(distribution = "ztruncpois", mean = s))

covariate.list <- list()
covariate.list$size <- list(list(distribution = "ztruncpois", mean = s))

# Define the population description
pop.desc <- make.population.description(region = region,
                                       density = density,
                                       covariates = covariate.list,
                                       N = 500,
                                       fixed.N = TRUE)
```

Here we define our detection function by defining our scale parameter and our truncation distance.

```
# test values for beta_0: 4, 5, 6, 7, 8
#test values for beta_1: .052, .053, .054, .055, .056

beta_0_11 <- 4
beta_1_11 <- 0.052

beta_0_12 <- 4
beta_1_12 <- 0.053

beta_0_13 <- 4
beta_1_13 <- 0.054

beta_0_14 <- 4
beta_1_14 <- 0.055

beta_0_15 <- 4
beta_1_15 <- 0.056

beta_0_21 <- 5
beta_1_21 <- 0.052

beta_0_22 <- 5
beta_1_22 <- 0.053

beta_0_23 <- 5
beta_1_23 <- 0.054

beta_0_24 <- 5
```

```

beta_1_24 <- 0.055

beta_0_25 <- 5
beta_1_25 <- 0.056

beta_0_31 <- 6
beta_1_31 <- 0.052

beta_0_32 <- 6
beta_1_32 <- 0.053

beta_0_33 <- 6
beta_1_33 <- 0.054

beta_0_34 <- 6
beta_1_34 <- 0.055

beta_0_35 <- 6
beta_1_35 <- 0.056

beta_0_41 <- 7
beta_1_41 <- 0.052

beta_0_42 <- 7
beta_1_42 <- 0.053

beta_0_43 <- 7
beta_1_43 <- 0.054

beta_0_44 <- 7
beta_1_44 <- 0.055

beta_0_45 <- 7
beta_1_45 <- 0.056

beta_0_51 <- 8
beta_1_51 <- 0.052

beta_0_52 <- 8
beta_1_52 <- 0.053

beta_0_53 <- 8
beta_1_53 <- 0.054

beta_0_54 <- 8
beta_1_54 <- 0.055

beta_0_55 <- 8
beta_1_55 <- 0.056

s_times_beta1_11 <- list(size = log(s*beta_1_11))
s_times_beta1_12 <- list(size = log(s*beta_1_12))
s_times_beta1_13 <- list(size = log(s*beta_1_13))

```

```

s_times_beta1_14 <- list(size = log(s*beta_1_14))
s_times_beta1_15 <- list(size = log(s*beta_1_15))
s_times_beta1_21 <- list(size = log(s*beta_1_21))
s_times_beta1_22 <- list(size = log(s*beta_1_22))
s_times_beta1_23 <- list(size = log(s*beta_1_23))
s_times_beta1_24 <- list(size = log(s*beta_1_24))
s_times_beta1_25 <- list(size = log(s*beta_1_25))
s_times_beta1_31 <- list(size = log(s*beta_1_31))
s_times_beta1_32 <- list(size = log(s*beta_1_32))
s_times_beta1_33 <- list(size = log(s*beta_1_33))
s_times_beta1_34 <- list(size = log(s*beta_1_34))
s_times_beta1_35 <- list(size = log(s*beta_1_35))
s_times_beta1_41 <- list(size = log(s*beta_1_41))
s_times_beta1_42 <- list(size = log(s*beta_1_42))
s_times_beta1_43 <- list(size = log(s*beta_1_43))
s_times_beta1_44 <- list(size = log(s*beta_1_44))
s_times_beta1_45 <- list(size = log(s*beta_1_45))
s_times_beta1_51 <- list(size = log(s*beta_1_51))
s_times_beta1_52 <- list(size = log(s*beta_1_52))
s_times_beta1_53 <- list(size = log(s*beta_1_53))
s_times_beta1_54 <- list(size = log(s*beta_1_54))
s_times_beta1_55 <- list(size = log(s*beta_1_55))

w <- 100

detect.hn_11 <- make.detectability(key.function = "hn",
                                   scale.param = beta_0_11,
                                   cov.param = s_times_beta1_11,
                                   truncation = w)

detect.hn_12 <- make.detectability(key.function = "hn",
                                   scale.param = beta_0_12,
                                   cov.param = s_times_beta1_12,
                                   truncation = w)

detect.hn_13 <- make.detectability(key.function = "hn",
                                   scale.param = beta_0_13,
                                   cov.param = s_times_beta1_13,
                                   truncation = w)

detect.hn_14 <- make.detectability(key.function = "hn",
                                   scale.param = beta_0_14,
                                   cov.param = s_times_beta1_14,
                                   truncation = w)

detect.hn_15 <- make.detectability(key.function = "hn",
                                   scale.param = beta_0_15,
                                   cov.param = s_times_beta1_15,
                                   truncation = w)

detect.hn_21 <- make.detectability(key.function = "hn",
                                   scale.param = beta_0_21,
                                   cov.param = s_times_beta1_21,

```

```

        truncation = w)

detect.hn_22 <- make.detectability(key.function = "hn",
                                   scale.param = beta_0_22,
                                   cov.param = s_times_beta1_22,
                                   truncation = w)

detect.hn_23 <- make.detectability(key.function = "hn",
                                   scale.param = beta_0_23,
                                   cov.param = s_times_beta1_23,
                                   truncation = w)

detect.hn_24 <- make.detectability(key.function = "hn",
                                   scale.param = beta_0_24,
                                   cov.param = s_times_beta1_24,
                                   truncation = w)

detect.hn_25 <- make.detectability(key.function = "hn",
                                   scale.param = beta_0_25,
                                   cov.param = s_times_beta1_25,
                                   truncation = w)

detect.hn_31 <- make.detectability(key.function = "hn",
                                   scale.param = beta_0_31,
                                   cov.param = s_times_beta1_31,
                                   truncation = w)

detect.hn_32 <- make.detectability(key.function = "hn",
                                   scale.param = beta_0_32,
                                   cov.param = s_times_beta1_32,
                                   truncation = w)

detect.hn_33 <- make.detectability(key.function = "hn",
                                   scale.param = beta_0_33,
                                   cov.param = s_times_beta1_33,
                                   truncation = w)

detect.hn_34 <- make.detectability(key.function = "hn",
                                   scale.param = beta_0_34,
                                   cov.param = s_times_beta1_34,
                                   truncation = w)

detect.hn_35 <- make.detectability(key.function = "hn",
                                   scale.param = beta_0_35,
                                   cov.param = s_times_beta1_35,
                                   truncation = w)

detect.hn_41 <- make.detectability(key.function = "hn",
                                   scale.param = beta_0_41,
                                   cov.param = s_times_beta1_41,
                                   truncation = w)

detect.hn_42 <- make.detectability(key.function = "hn",

```



```

        scale.param = beta_0_42,
        cov.param = s_times_beta1_42,
        truncation = w)

detect.hn_43 <- make.detectability(key.function = "hn",
        scale.param = beta_0_43,
        cov.param = s_times_beta1_43,
        truncation = w)

detect.hn_44 <- make.detectability(key.function = "hn",
        scale.param = beta_0_44,
        cov.param = s_times_beta1_44,
        truncation = w)

detect.hn_45 <- make.detectability(key.function = "hn",
        scale.param = beta_0_45,
        cov.param = s_times_beta1_45,
        truncation = w)

detect.hn_51 <- make.detectability(key.function = "hn",
        scale.param = beta_0_51,
        cov.param = s_times_beta1_51,
        truncation = w)

detect.hn_52 <- make.detectability(key.function = "hn",
        scale.param = beta_0_52,
        cov.param = s_times_beta1_52,
        truncation = w)

detect.hn_53 <- make.detectability(key.function = "hn",
        scale.param = beta_0_53,
        cov.param = s_times_beta1_53,
        truncation = w)

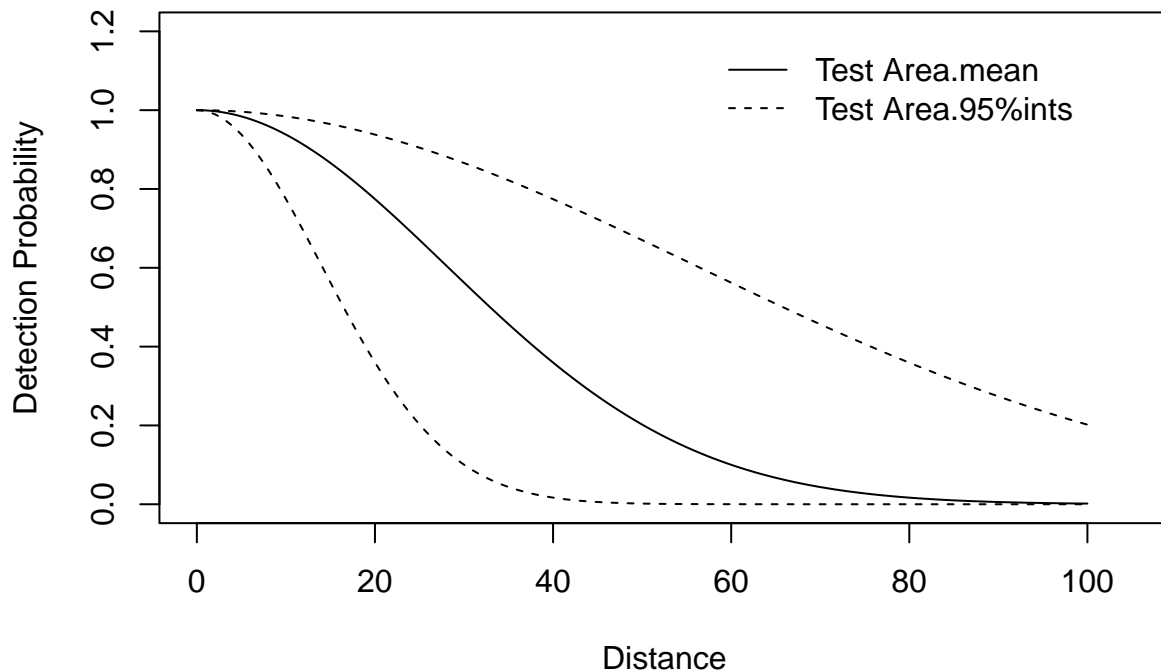
detect.hn_54 <- make.detectability(key.function = "hn",
        scale.param = beta_0_54,
        cov.param = s_times_beta1_54,
        truncation = w)

detect.hn_55 <- make.detectability(key.function = "hn",
        scale.param = beta_0_55,
        cov.param = s_times_beta1_55,
        truncation = w)

# We can now visualise these detection functions
plot(detect.hn_33, pop.desc)

```

Covariate: size (continuous)

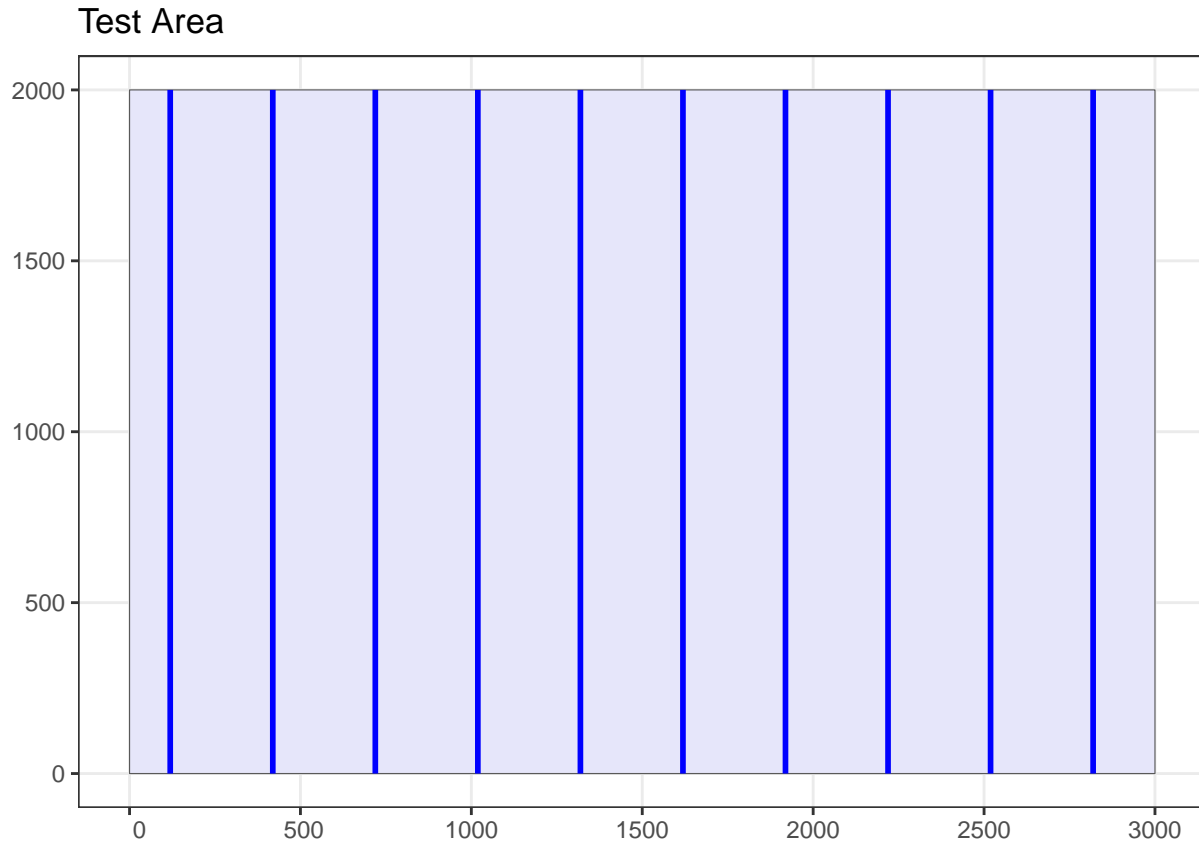


Here we define our survey design as a line transect survey with systematic (parallel) lines. We define our spacing between survey lines and again our truncation distance. The plot below lets us visualize the survey tracks.

A note on truncation distance: while we can define our truncation distance in multiple places, note the effective truncation distance from the detection function.

```
# Define the design
design <- make.design(region = region,
  transect.type = "line",
  design = "systematic",
  spacing = 300,
  truncation = 100)
```

```
transects <- generate.transects(design)
plot(region, transects)
```



The next two code chunks define our analyses and simulations, using our survey design, population description, and detection function. The four results tables are a map of the transects through the study area, a map of the population on the study area, a third plot with both of the previous elements, displaying the groups which were detected, and finally the detection increment histogram.

```
ds.analyses_standard <- make.ds.analysis(dfmodel = list(~1),
  key = c("hn"),
  truncation = 100,
  criteria = "AIC")

ds.analyses_size_cov <- make.ds.analysis(dfmodel = list(~size),
  key = c("hn"),
  truncation = 100,
  criteria = "AIC")
```

```
sim_11_standard <- make.simulation(reps = 1000,
  design = design,
  population.description = pop.desc,
  detectability = detect.hn_11,
  ds.analysis = ds.analyses_standard)

sim_12_standard <- make.simulation(reps = 1000,
  design = design,
  population.description = pop.desc,
  detectability = detect.hn_12,
  ds.analysis = ds.analyses_standard)
```

```

sim_13_standard <- make.simulation(reps = 1000,
  design = design,
  population.description = pop.desc,
  detectability = detect.hn_13,
  ds.analysis = ds.analyses_standard)

sim_14_standard <- make.simulation(reps = 1000,
  design = design,
  population.description = pop.desc,
  detectability = detect.hn_14,
  ds.analysis = ds.analyses_standard)

sim_15_standard <- make.simulation(reps = 1000,
  design = design,
  population.description = pop.desc,
  detectability = detect.hn_15,
  ds.analysis = ds.analyses_standard)

sim_21_standard <- make.simulation(reps = 1000,
  design = design,
  population.description = pop.desc,
  detectability = detect.hn_21,
  ds.analysis = ds.analyses_standard)

sim_22_standard <- make.simulation(reps = 1000,
  design = design,
  population.description = pop.desc,
  detectability = detect.hn_22,
  ds.analysis = ds.analyses_standard)

sim_23_standard <- make.simulation(reps = 1000,
  design = design,
  population.description = pop.desc,
  detectability = detect.hn_23,
  ds.analysis = ds.analyses_standard)

sim_24_standard <- make.simulation(reps = 1000,
  design = design,
  population.description = pop.desc,
  detectability = detect.hn_24,
  ds.analysis = ds.analyses_standard)

sim_25_standard <- make.simulation(reps = 1000,
  design = design,
  population.description = pop.desc,
  detectability = detect.hn_25,
  ds.analysis = ds.analyses_standard)

sim_31_standard <- make.simulation(reps = 1000,
  design = design,
  population.description = pop.desc,
  detectability = detect.hn_31,
  ds.analysis = ds.analyses_standard)

```

```

sim_32_standard <- make.simulation(reps = 1000,
  design = design,
  population.description = pop.desc,
  detectability = detect.hn_32,
  ds.analysis = ds.analyses_standard)

sim_33_standard <- make.simulation(reps = 1000,
  design = design,
  population.description = pop.desc,
  detectability = detect.hn_33,
  ds.analysis = ds.analyses_standard)

sim_34_standard <- make.simulation(reps = 1000,
  design = design,
  population.description = pop.desc,
  detectability = detect.hn_34,
  ds.analysis = ds.analyses_standard)

sim_35_standard <- make.simulation(reps = 1000,
  design = design,
  population.description = pop.desc,
  detectability = detect.hn_35,
  ds.analysis = ds.analyses_standard)

sim_41_standard <- make.simulation(reps = 1000,
  design = design,
  population.description = pop.desc,
  detectability = detect.hn_41,
  ds.analysis = ds.analyses_standard)

sim_42_standard <- make.simulation(reps = 1000,
  design = design,
  population.description = pop.desc,
  detectability = detect.hn_42,
  ds.analysis = ds.analyses_standard)

sim_43_standard <- make.simulation(reps = 1000,
  design = design,
  population.description = pop.desc,
  detectability = detect.hn_43,
  ds.analysis = ds.analyses_standard)

sim_44_standard <- make.simulation(reps = 1000,
  design = design,
  population.description = pop.desc,
  detectability = detect.hn_44,
  ds.analysis = ds.analyses_standard)

sim_45_standard <- make.simulation(reps = 1000,
  design = design,
  population.description = pop.desc,
  detectability = detect.hn_45,

```

```

ds.analysis = ds.analyses_standard)

sim_51_standard <- make.simulation(reps = 1000,
  design = design,
  population.description = pop.desc,
  detectability = detect.hn_51,
  ds.analysis = ds.analyses_standard)

sim_52_standard <- make.simulation(reps = 1000,
  design = design,
  population.description = pop.desc,
  detectability = detect.hn_52,
  ds.analysis = ds.analyses_standard)

sim_53_standard <- make.simulation(reps = 1000,
  design = design,
  population.description = pop.desc,
  detectability = detect.hn_53,
  ds.analysis = ds.analyses_standard)

sim_54_standard <- make.simulation(reps = 1000,
  design = design,
  population.description = pop.desc,
  detectability = detect.hn_54,
  ds.analysis = ds.analyses_standard)

sim_55_standard <- make.simulation(reps = 1000,
  design = design,
  population.description = pop.desc,
  detectability = detect.hn_55,
  ds.analysis = ds.analyses_standard)

```

```

sim_11_size_cov <- make.simulation(reps = 1000,
  design = design,
  population.description = pop.desc,
  detectability = detect.hn_11,
  ds.analysis = ds.analyses_size_cov)

sim_12_size_cov <- make.simulation(reps = 1000,
  design = design,
  population.description = pop.desc,
  detectability = detect.hn_12,
  ds.analysis = ds.analyses_size_cov)

sim_13_size_cov <- make.simulation(reps = 1000,
  design = design,
  population.description = pop.desc,
  detectability = detect.hn_13,
  ds.analysis = ds.analyses_size_cov)

sim_14_size_cov <- make.simulation(reps = 1000,
  design = design,
  population.description = pop.desc,

```

```

        detectability = detect.hn_14,
        ds.analysis = ds.analyses_size_cov)

sim_15_size_cov <- make.simulation(reps = 1000,
    design = design,
    population.description = pop.desc,
    detectability = detect.hn_15,
    ds.analysis = ds.analyses_size_cov)

sim_21_size_cov <- make.simulation(reps = 1000,
    design = design,
    population.description = pop.desc,
    detectability = detect.hn_21,
    ds.analysis = ds.analyses_size_cov)

sim_22_size_cov <- make.simulation(reps = 1000,
    design = design,
    population.description = pop.desc,
    detectability = detect.hn_22,
    ds.analysis = ds.analyses_size_cov)

sim_23_size_cov <- make.simulation(reps = 1000,
    design = design,
    population.description = pop.desc,
    detectability = detect.hn_23,
    ds.analysis = ds.analyses_size_cov)

sim_24_size_cov <- make.simulation(reps = 1000,
    design = design,
    population.description = pop.desc,
    detectability = detect.hn_24,
    ds.analysis = ds.analyses_size_cov)

sim_25_size_cov <- make.simulation(reps = 1000,
    design = design,
    population.description = pop.desc,
    detectability = detect.hn_25,
    ds.analysis = ds.analyses_size_cov)

sim_31_size_cov <- make.simulation(reps = 1000,
    design = design,
    population.description = pop.desc,
    detectability = detect.hn_31,
    ds.analysis = ds.analyses_size_cov)

sim_32_size_cov <- make.simulation(reps = 1000,
    design = design,
    population.description = pop.desc,
    detectability = detect.hn_32,
    ds.analysis = ds.analyses_size_cov)

sim_33_size_cov <- make.simulation(reps = 1000,

```

```

        design = design,
        population.description = pop.desc,
        detectability = detect.hn_33,
        ds.analysis = ds.analyses_size_cov)

sim_34_size_cov <- make.simulation(reps = 1000,
        design = design,
        population.description = pop.desc,
        detectability = detect.hn_34,
        ds.analysis = ds.analyses_size_cov)

sim_35_size_cov <- make.simulation(reps = 1000,
        design = design,
        population.description = pop.desc,
        detectability = detect.hn_35,
        ds.analysis = ds.analyses_size_cov)

sim_41_size_cov <- make.simulation(reps = 1000,
        design = design,
        population.description = pop.desc,
        detectability = detect.hn_41,
        ds.analysis = ds.analyses_size_cov)

sim_42_size_cov <- make.simulation(reps = 1000,
        design = design,
        population.description = pop.desc,
        detectability = detect.hn_42,
        ds.analysis = ds.analyses_size_cov)

sim_43_size_cov <- make.simulation(reps = 1000,
        design = design,
        population.description = pop.desc,
        detectability = detect.hn_43,
        ds.analysis = ds.analyses_size_cov)

sim_44_size_cov <- make.simulation(reps = 1000,
        design = design,
        population.description = pop.desc,
        detectability = detect.hn_44,
        ds.analysis = ds.analyses_size_cov)

sim_45_size_cov <- make.simulation(reps = 1000,
        design = design,
        population.description = pop.desc,
        detectability = detect.hn_45,
        ds.analysis = ds.analyses_size_cov)

sim_51_size_cov <- make.simulation(reps = 1000,
        design = design,
        population.description = pop.desc,
        detectability = detect.hn_51,
        ds.analysis = ds.analyses_size_cov)

```



```

sim_52_size_cov <- make.simulation(reps = 1000,
                                   design = design,
                                   population.description = pop.desc,
                                   detectability = detect.hn_52,
                                   ds.analysis = ds.analyses_size_cov)

sim_53_size_cov <- make.simulation(reps = 1000,
                                   design = design,
                                   population.description = pop.desc,
                                   detectability = detect.hn_53,
                                   ds.analysis = ds.analyses_size_cov)

sim_54_size_cov <- make.simulation(reps = 1000,
                                   design = design,
                                   population.description = pop.desc,
                                   detectability = detect.hn_54,
                                   ds.analysis = ds.analyses_size_cov)

sim_55_size_cov <- make.simulation(reps = 1000,
                                   design = design,
                                   population.description = pop.desc,
                                   detectability = detect.hn_55,
                                   ds.analysis = ds.analyses_size_cov)

```

The tables below summarize our statistical results. This final plot provides a histogram of the population estimates from each simulation.

```

sim_11_standard <-
  run.simulation(simulation = sim_11_standard, run.parallel = TRUE)
sim_12_standard <-
  run.simulation(simulation = sim_12_standard, run.parallel = TRUE)
sim_13_standard <-
  run.simulation(simulation = sim_13_standard, run.parallel = TRUE)
sim_14_standard <-
  run.simulation(simulation = sim_14_standard, run.parallel = TRUE)
sim_15_standard <-
  run.simulation(simulation = sim_15_standard, run.parallel = TRUE)
sim_21_standard <-
  run.simulation(simulation = sim_21_standard, run.parallel = TRUE)
sim_22_standard <-
  run.simulation(simulation = sim_22_standard, run.parallel = TRUE)
sim_23_standard <-
  run.simulation(simulation = sim_23_standard, run.parallel = TRUE)
sim_24_standard <-
  run.simulation(simulation = sim_24_standard, run.parallel = TRUE)
sim_25_standard <-
  run.simulation(simulation = sim_25_standard, run.parallel = TRUE)
sim_31_standard <-
  run.simulation(simulation = sim_31_standard, run.parallel = TRUE)
sim_32_standard <-
  run.simulation(simulation = sim_32_standard, run.parallel = TRUE)
sim_33_standard <-
  run.simulation(simulation = sim_33_standard, run.parallel = TRUE)

```

```

sim_34_standard <-
  run.simulation(simulation = sim_34_standard, run.parallel = TRUE)
sim_35_standard <-
  run.simulation(simulation = sim_35_standard, run.parallel = TRUE)
sim_41_standard <-
  run.simulation(simulation = sim_41_standard, run.parallel = TRUE)
sim_42_standard <-
  run.simulation(simulation = sim_42_standard, run.parallel = TRUE)
sim_43_standard <-
  run.simulation(simulation = sim_43_standard, run.parallel = TRUE)
sim_44_standard <-
  run.simulation(simulation = sim_44_standard, run.parallel = TRUE)
sim_45_standard <-
  run.simulation(simulation = sim_45_standard, run.parallel = TRUE)
sim_51_standard <-
  run.simulation(simulation = sim_51_standard, run.parallel = TRUE)
sim_52_standard <-
  run.simulation(simulation = sim_52_standard, run.parallel = TRUE)
sim_53_standard <-
  run.simulation(simulation = sim_53_standard, run.parallel = TRUE)
sim_54_standard <-
  run.simulation(simulation = sim_54_standard, run.parallel = TRUE)
sim_55_standard <-
  run.simulation(simulation = sim_55_standard, run.parallel = TRUE)

```

```

sim_11_size_cov <-
  run.simulation(simulation = sim_11_size_cov, run.parallel = TRUE)

```

Summary of warnings and errors:

```

## Error: No models could be fitted. (Model number: 1) (occurred 3 time(s) in repetition(s): 245, 248,
## simpleWarning in ddf.ds(model = dsmodel, data, meta.data = meta.data, control = control, : Model fit
##
## (Model number: 1) (occurred 3 time(s) in repetition(s): 245, 248, 864)
## None of the models converged for this dataset. (occurred 3 time(s) in repetition(s): 245, 248, 864)
## Low number of detections (<20), models may become unstable or give errors especially if complex mode
## -----

```

```

sim_12_size_cov <-
  run.simulation(simulation = sim_12_size_cov, run.parallel = TRUE)

```

Summary of warnings and errors:

```

## Error: No models could be fitted. (Model number: 1) (occurred 9 time(s) in repetition(s): 46, 54, 6
## simpleWarning in ddf.ds(model = dsmodel, data, meta.data = meta.data, control = control, : Model fit
##
## (Model number: 1) (occurred 9 time(s) in repetition(s): 46, 54, 66, 95, 275, 623, 695, 842, 931)

```

```
## None of the models converged for this dataset. (occurred 9 time(s) in repetition(s): 46, 54, 66, 95)
```

```
## -----
```

```
sim_13_size_cov <-  
  run.simulation(simulation = sim_13_size_cov, run.parallel = TRUE)
```

```
## Summary of warnings and errors:
```

```
## Error: No models could be fitted. (Model number: 1) (occurred 36 time(s) in repetition(s): 5, 18, 31, 55, 108, 116, 127, 140, 191, 200)
```

```
## simpleWarning in ddf.ds(model = dsmodel, data, meta.data = meta.data, control = control, : Model fit failed  
##
```

```
## (Model number: 1) (occurred 36 time(s) in repetition(s): 5, 18, 31, 55, 108, 116, 127, 140, 191, 200)
```

```
## None of the models converged for this dataset. (occurred 36 time(s) in repetition(s): 5, 18, 31, 55, 108, 116, 127, 140, 191, 200)
```

```
## -----
```

```
sim_14_size_cov <-  
  run.simulation(simulation = sim_14_size_cov, run.parallel = TRUE)
```

```
## Summary of warnings and errors:
```

```
## Error: No models could be fitted. (Model number: 1) (occurred 99 time(s) in repetition(s): 11, 24, 26, 29, 64, 68, 80, 91, 92, 113, 127, 140, 191, 200)
```

```
## simpleWarning in ddf.ds(model = dsmodel, data, meta.data = meta.data, control = control, : Model fit failed  
##
```

```
## (Model number: 1) (occurred 99 time(s) in repetition(s): 11, 24, 26, 29, 64, 68, 80, 91, 92, 113, 127, 140, 191, 200)
```

```
## None of the models converged for this dataset. (occurred 99 time(s) in repetition(s): 11, 24, 26, 29, 64, 68, 80, 91, 92, 113, 127, 140, 191, 200)
```

```
## -----
```

```
sim_15_size_cov <-  
  run.simulation(simulation = sim_15_size_cov, run.parallel = TRUE)
```

```
## Summary of warnings and errors:
```

```
## Error: No models could be fitted. (Model number: 1) (occurred 113 time(s) in repetition(s): 16, 21, 22, 27, 28, 32, 36, 37, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99)
```

```
## simpleWarning in ddf.ds(model = dsmodel, data, meta.data = meta.data, control = control, : Model fit failed  
##
```

```
## (Model number: 1) (occurred 113 time(s) in repetition(s): 16, 21, 22, 27, 28, 32, 36, 37, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99)
```

```
## None of the models converged for this dataset. (occurred 113 time(s) in repetition(s): 16, 21, 22, 27, 28, 32, 36, 37, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99)
```

```
## -----
```

```
sim_21_size_cov <-  
  run.simulation(simulation = sim_21_size_cov, run.parallel = TRUE)
```

```
## Summary of warnings and errors:
```

```
## Error: No models could be fitted. (Model number: 1) (occurred 4 time(s) in repetition(s): 203, 206,
```

```
## simpleWarning in ddf.ds(model = dsmodel, data, meta.data = meta.data, control = control, : Model fit  
##
```

```
## (Model number: 1) (occurred 4 time(s) in repetition(s): 203, 206, 237, 623)
```

```
## None of the models converged for this dataset. (occurred 4 time(s) in repetition(s): 203, 206, 237,
```

```
## -----
```

```
sim_22_size_cov <-  
  run.simulation(simulation = sim_22_size_cov, run.parallel = TRUE)
```

```
## Summary of warnings and errors:
```

```
## Error: No models could be fitted. (Model number: 1) (occurred 15 time(s) in repetition(s): 68, 96, 1
```

```
## simpleWarning in ddf.ds(model = dsmodel, data, meta.data = meta.data, control = control, : Model fit  
##
```

```
## (Model number: 1) (occurred 15 time(s) in repetition(s): 68, 96, 116, 187, 199, 255, 398, 404, 441
```

```
## None of the models converged for this dataset. (occurred 15 time(s) in repetition(s): 68, 96, 116, 1
```

```
## -----
```

```
sim_23_size_cov <-  
  run.simulation(simulation = sim_23_size_cov, run.parallel = TRUE)
```

```
## Summary of warnings and errors:
```

```
## Error: No models could be fitted. (Model number: 1) (occurred 73 time(s) in repetition(s): 7, 10, 1
```

```
## simpleWarning in ddf.ds(model = dsmodel, data, meta.data = meta.data, control = control, : Model fit  
##
```

```
## (Model number: 1) (occurred 73 time(s) in repetition(s): 7, 10, 17, 18, 29, 68, 74, 86, 91, 127, 1
```

```
## None of the models converged for this dataset. (occurred 73 time(s) in repetition(s): 7, 10, 17, 18
```

```
## -----
```

```
sim_24_size_cov <-  
  run.simulation(simulation = sim_24_size_cov, run.parallel = TRUE)
```

```

## Summary of warnings and errors:

## Error: No models could be fitted. (Model number: 1) (occurred 128 time(s) in repetition(s): 3, 8, 27, 35, 38, 40, 41, 47, 62, 94, 108)

## simpleWarning in ddf.ds(model = dsmodel, data, meta.data = meta.data, control = control, : Model fit failed
## (Model number: 1) (occurred 128 time(s) in repetition(s): 3, 8, 27, 35, 38, 40, 41, 47, 62, 94, 108)

## None of the models converged for this dataset. (occurred 128 time(s) in repetition(s): 3, 8, 27, 35, 38, 40, 41, 47, 62, 94, 108)

## -----

sim_25_size_cov <-
  run.simulation(simulation = sim_25_size_cov, run.parallel = TRUE)

## Summary of warnings and errors:

## Error: No models could be fitted. (Model number: 1) (occurred 115 time(s) in repetition(s): 15, 26, 34, 54, 55, 59, 75, 84, 99, 108, 152, 291, 385, 696, 842)

## simpleWarning in ddf.ds(model = dsmodel, data, meta.data = meta.data, control = control, : Model fit failed
## (Model number: 1) (occurred 115 time(s) in repetition(s): 15, 26, 34, 54, 55, 59, 75, 84, 99, 108, 152, 291, 385, 696, 842)

## None of the models converged for this dataset. (occurred 115 time(s) in repetition(s): 15, 26, 34, 54, 55, 59, 75, 84, 99, 108, 152, 291, 385, 696, 842)

## -----

sim_31_size_cov <-
  run.simulation(simulation = sim_31_size_cov, run.parallel = TRUE)

## Summary of warnings and errors:

## Error: No models could be fitted. (Model number: 1) (occurred 5 time(s) in repetition(s): 152, 291, 385, 696, 842)

## simpleWarning in ddf.ds(model = dsmodel, data, meta.data = meta.data, control = control, : Model fit failed
## (Model number: 1) (occurred 5 time(s) in repetition(s): 152, 291, 385, 696, 842)

## None of the models converged for this dataset. (occurred 5 time(s) in repetition(s): 152, 291, 385, 696, 842)

## -----

sim_32_size_cov <-
  run.simulation(simulation = sim_32_size_cov, run.parallel = TRUE)

## Summary of warnings and errors:

## Error: No models could be fitted. (Model number: 1) (occurred 34 time(s) in repetition(s): 4, 16, 9, 15, 26, 34, 54, 55, 59, 75, 84, 99, 108, 152, 291, 385, 696, 842)

```

```
## simpleWarning in ddf.ds(model = dsmodel, data, meta.data = meta.data, control = control, : Model fit
##
## (Model number: 1) (occurred 34 time(s) in repetition(s): 4, 16, 90, 101, 120, 136, 138, 187, 224, 2
##
## None of the models converged for this dataset. (occurred 34 time(s) in repetition(s): 4, 16, 90, 10
##
## -----
```

```
sim_33_size_cov <-
  run.simulation(simulation = sim_33_size_cov, run.parallel = TRUE)
```

```
## Summary of warnings and errors:
##
## Error: No models could be fitted. (Model number: 1) (occurred 79 time(s) in repetition(s): 12, 17, 3
##
## simpleWarning in ddf.ds(model = dsmodel, data, meta.data = meta.data, control = control, : Model fit
##
## (Model number: 1) (occurred 79 time(s) in repetition(s): 12, 17, 35, 50, 63, 68, 93, 133, 134, 138
##
## None of the models converged for this dataset. (occurred 79 time(s) in repetition(s): 12, 17, 35, 5
##
## -----
```

```
sim_34_size_cov <-
  run.simulation(simulation = sim_34_size_cov, run.parallel = TRUE)
```

```
## Summary of warnings and errors:
##
## Error: No models could be fitted. (Model number: 1) (occurred 106 time(s) in repetition(s): 3, 26, 4
##
## simpleWarning in ddf.ds(model = dsmodel, data, meta.data = meta.data, control = control, : Model fit
##
## (Model number: 1) (occurred 106 time(s) in repetition(s): 3, 26, 42, 53, 56, 61, 65, 69, 76, 83, 9
##
## None of the models converged for this dataset. (occurred 106 time(s) in repetition(s): 3, 26, 42, 5
##
## -----
```

```
sim_35_size_cov <-
  run.simulation(simulation = sim_35_size_cov, run.parallel = TRUE)
```

```
## Summary of warnings and errors:
##
## Error: No models could be fitted. (Model number: 1) (occurred 81 time(s) in repetition(s): 1, 11, 2
##
## simpleWarning in ddf.ds(model = dsmodel, data, meta.data = meta.data, control = control, : Model fit
##
## (Model number: 1) (occurred 81 time(s) in repetition(s): 1, 11, 26, 53, 76, 83, 110, 115, 119, 122
##
## None of the models converged for this dataset. (occurred 81 time(s) in repetition(s): 1, 11, 26, 53
##
## -----
```

```
sim_41_size_cov <-
  run.simulation(simulation = sim_41_size_cov, run.parallel = TRUE)
```

```
## Summary of warnings and errors:
```

```
## Error: No models could be fitted. (Model number: 1) (occurred 11 time(s) in repetition(s): 28, 81, 118, 155, 192, 229, 266, 303, 340, 377, 414, 451, 488, 525, 562, 599, 636, 673, 710, 747, 784, 821, 858, 895, 932, 969, 1006, 1043, 1080, 1117, 1154, 1191, 1228, 1265, 1302, 1339, 1376, 1413, 1450, 1487, 1524, 1561, 1598, 1635, 1672, 1709, 1746, 1783, 1820, 1857, 1894, 1931, 1968, 2005, 2042, 2079, 2116, 2153, 2190, 2227, 2264, 2301, 2338, 2375, 2412, 2449, 2486, 2523, 2560, 2597, 2634, 2671, 2708, 2745, 2782, 2819, 2856, 2893, 2930, 2967, 3004, 3041, 3078, 3115, 3152, 3189, 3226, 3263, 3300, 3337, 3374, 3411, 3448, 3485, 3522, 3559, 3596, 3633, 3670, 3707, 3744, 3781, 3818, 3855, 3892, 3929, 3966, 4003, 4040, 4077, 4114, 4151, 4188, 4225, 4262, 4299, 4336, 4373, 4410, 4447, 4484, 4521, 4558, 4595, 4632, 4669, 4706, 4743, 4780, 4817, 4854, 4891, 4928, 4965, 5002, 5039, 5076, 5113, 5150, 5187, 5224, 5261, 5298, 5335, 5372, 5409, 5446, 5483, 5520, 5557, 5594, 5631, 5668, 5705, 5742, 5779, 5816, 5853, 5890, 5927, 5964, 6001, 6038, 6075, 6112, 6149, 6186, 6223, 6260, 6297, 6334, 6371, 6408, 6445, 6482, 6519, 6556, 6593, 6630, 6667, 6704, 6741, 6778, 6815, 6852, 6889, 6926, 6963, 7000, 7037, 7074, 7111, 7148, 7185, 7222, 7259, 7296, 7333, 7370, 7407, 7444, 7481, 7518, 7555, 7592, 7629, 7666, 7703, 7740, 7777, 7814, 7851, 7888, 7925, 7962, 8000, 8037, 8074, 8111, 8148, 8185, 8222, 8259, 8296, 8333, 8370, 8407, 8444, 8481, 8518, 8555, 8592, 8629, 8666, 8703, 8740, 8777, 8814, 8851, 8888, 8925, 8962, 9000, 9037, 9074, 9111, 9148, 9185, 9222, 9259, 9296, 9333, 9370, 9407, 9444, 9481, 9518, 9555, 9592, 9629, 9666, 9703, 9740, 9777, 9814, 9851, 9888, 9925, 9962, 10000)
```

```
## simpleWarning in ddf.ds(model = dsmodel, data, meta.data = meta.data, control = control, : Model fit failed. (Model number: 1) (occurred 11 time(s) in repetition(s): 28, 81, 118, 155, 192, 229, 266, 303, 340, 377, 414, 451, 488, 525, 562, 599, 636, 673, 710, 747, 784, 821, 858, 895, 932, 969, 1006, 1043, 1080, 1117, 1154, 1191, 1228, 1265, 1302, 1339, 1376, 1413, 1450, 1487, 1524, 1561, 1598, 1635, 1672, 1709, 1746, 1783, 1820, 1857, 1894, 1931, 1968, 2005, 2042, 2079, 2116, 2153, 2190, 2227, 2264, 2301, 2338, 2375, 2412, 2449, 2486, 2523, 2560, 2597, 2634, 2671, 2708, 2745, 2782, 2819, 2856, 2893, 2930, 2967, 3004, 3041, 3078, 3115, 3152, 3189, 3226, 3263, 3300, 3337, 3374, 3411, 3448, 3485, 3522, 3559, 3596, 3633, 3670, 3707, 3744, 3781, 3818, 3855, 3892, 3929, 3966, 4003, 4040, 4077, 4114, 4151, 4188, 4225, 4262, 4299, 4336, 4373, 4410, 4447, 4484, 4521, 4558, 4595, 4632, 4669, 4706, 4743, 4780, 4817, 4854, 4891, 4928, 4965, 5002, 5039, 5076, 5113, 5150, 5187, 5224, 5261, 5298, 5335, 5372, 5409, 5446, 5483, 5520, 5557, 5594, 5631, 5668, 5705, 5742, 5779, 5816, 5853, 5890, 5927, 5964, 6001, 6038, 6075, 6112, 6149, 6186, 6223, 6260, 6297, 6334, 6371, 6408, 6445, 6482, 6519, 6556, 6593, 6630, 6667, 6704, 6741, 6778, 6815, 6852, 6889, 6925, 6962, 7000, 7037, 7074, 7111, 7148, 7185, 7222, 7259, 7296, 7333, 7370, 7407, 7444, 7481, 7518, 7555, 7592, 7629, 7666, 7703, 7740, 7777, 7814, 7851, 7888, 7925, 7962, 8000, 8037, 8074, 8111, 8148, 8185, 8222, 8259, 8296, 8333, 8370, 8407, 8444, 8481, 8518, 8555, 8592, 8629, 8666, 8703, 8740, 8777, 8814, 8851, 8888, 8925, 8962, 9000, 9037, 9074, 9111, 9148, 9185, 9222, 9259, 9296, 9333, 9370, 9407, 9444, 9481, 9518, 9555, 9592, 9629, 9666, 9703, 9740, 9777, 9814, 9851, 9888, 9925, 9962, 10000)
```

```
## (Model number: 1) (occurred 11 time(s) in repetition(s): 28, 81, 228, 359, 477, 797, 802, 832, 841, 850, 859, 868, 877, 886, 895, 904, 913, 922, 931, 940, 949, 958, 967, 976, 985, 994, 1000)
```

```
## None of the models converged for this dataset. (occurred 11 time(s) in repetition(s): 28, 81, 228, 359, 477, 797, 802, 832, 841, 850, 859, 868, 877, 886, 895, 904, 913, 922, 931, 940, 949, 958, 967, 976, 985, 994, 1000)
```

```
## -----
```

```
sim_42_size_cov <-
  run.simulation(simulation = sim_42_size_cov, run.parallel = TRUE)
```

```
## Summary of warnings and errors:
```

```
## Error: No models could be fitted. (Model number: 1) (occurred 53 time(s) in repetition(s): 11, 19, 27, 35, 43, 51, 59, 67, 75, 83, 91, 99, 107, 115, 123, 131, 139, 147, 155, 163, 171, 179, 187, 195, 203, 211, 219, 227, 235, 243, 251, 259, 267, 275, 283, 291, 299, 307, 315, 323, 331, 339, 347, 355, 363, 371, 379, 387, 395, 403, 411, 419, 427, 435, 443, 451, 459, 467, 475, 483, 491, 499, 507, 515, 523, 531, 539, 547, 555, 563, 571, 579, 587, 595, 603, 611, 619, 627, 635, 643, 651, 659, 667, 675, 683, 691, 699, 707, 715, 723, 731, 739, 747, 755, 763, 771, 779, 787, 795, 803, 811, 819, 827, 835, 843, 851, 859, 867, 875, 883, 891, 899, 907, 915, 923, 931, 939, 947, 955, 963, 971, 979, 987, 995, 1000)
```

```
## simpleWarning in ddf.ds(model = dsmodel, data, meta.data = meta.data, control = control, : Model fit failed. (Model number: 1) (occurred 53 time(s) in repetition(s): 11, 19, 46, 47, 83, 100, 108, 150, 197, 204, 212, 220, 228, 236, 244, 252, 260, 268, 276, 284, 292, 300, 308, 316, 324, 332, 340, 348, 356, 364, 372, 380, 388, 396, 404, 412, 420, 428, 436, 444, 452, 460, 468, 476, 484, 492, 500, 508, 516, 524, 532, 540, 548, 556, 564, 572, 580, 588, 596, 604, 612, 620, 628, 636, 644, 652, 660, 668, 676, 684, 692, 700, 708, 716, 724, 732, 740, 748, 756, 764, 772, 780, 788, 796, 804, 812, 820, 828, 836, 844, 852, 860, 868, 876, 884, 892, 900, 908, 916, 924, 932, 940, 948, 956, 964, 972, 980, 988, 996, 1000)
```

```
## (Model number: 1) (occurred 53 time(s) in repetition(s): 11, 19, 46, 47, 83, 100, 108, 150, 197, 204, 212, 220, 228, 236, 244, 252, 260, 268, 276, 284, 292, 300, 308, 316, 324, 332, 340, 348, 356, 364, 372, 380, 388, 396, 404, 412, 420, 428, 436, 444, 452, 460, 468, 476, 484, 492, 500, 508, 516, 524, 532, 540, 548, 556, 564, 572, 580, 588, 596, 604, 612, 620, 628, 636, 644, 652, 660, 668, 676, 684, 692, 700, 708, 716, 724, 732, 740, 748, 756, 764, 772, 780, 788, 796, 804, 812, 820, 828, 836, 844, 852, 860, 868, 876, 884, 892, 900, 908, 916, 924, 932, 940, 948, 956, 964, 972, 980, 988, 996, 1000)
```

```
## None of the models converged for this dataset. (occurred 53 time(s) in repetition(s): 11, 19, 46, 47, 83, 100, 108, 150, 197, 204, 212, 220, 228, 236, 244, 252, 260, 268, 276, 284, 292, 300, 308, 316, 324, 332, 340, 348, 356, 364, 372, 380, 388, 396, 404, 412, 420, 428, 436, 444, 452, 460, 468, 476, 484, 492, 500, 508, 516, 524, 532, 540, 548, 556, 564, 572, 580, 588, 596, 604, 612, 620, 628, 636, 644, 652, 660, 668, 676, 684, 692, 700, 708, 716, 724, 732, 740, 748, 756, 764, 772, 780, 788, 796, 804, 812, 820, 828, 836, 844, 852, 860, 868, 876, 884, 892, 900, 908, 916, 924, 932, 940, 948, 956, 964, 972, 980, 988, 996, 1000)
```

```
## -----
```

```
sim_43_size_cov <-
  run.simulation(simulation = sim_43_size_cov, run.parallel = TRUE)
```

```
## Summary of warnings and errors:
```

```
## Error: No models could be fitted. (Model number: 1) (occurred 120 time(s) in repetition(s): 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160, 161, 162, 163, 164, 165, 166, 167, 168, 169, 170, 171, 172, 173, 174, 175, 176, 177, 178, 179, 180, 181, 182, 183, 184, 185, 186, 187, 188, 189, 190, 191, 192, 193, 194, 195, 196, 197, 198, 199, 200, 201, 202, 203, 204, 205, 206, 207, 208, 209, 210, 211, 212, 213, 214, 215, 216, 217, 218, 219, 220, 221, 222, 223, 224, 225, 226, 227, 228, 229, 230, 231, 232, 233, 234, 235, 236, 237, 238, 239, 240, 241, 242, 243, 244, 245, 246, 247, 248, 249, 250, 251, 252, 253, 254, 255, 256, 257, 258, 259, 260, 261, 262, 263, 264, 265, 266, 267, 268, 269, 270, 271, 272, 273, 274, 275, 276, 277, 278, 279, 280, 281, 282, 283, 284, 285, 286, 287, 288, 289, 290, 291, 292, 293, 294, 295, 296, 297, 298, 299, 300, 301, 302, 303, 304, 305, 306, 307, 308, 309, 310, 311, 312, 313, 314, 315, 316, 317, 318, 319, 320, 321, 322, 323, 324, 325, 326, 327, 328, 329, 330, 331, 332, 333, 334, 335, 336, 337, 338, 339, 340, 341, 342, 343, 344, 345, 346, 347, 348, 349, 350, 351, 352, 353, 354, 355, 356, 357, 358, 359, 360, 361, 362, 363, 364, 365, 366, 367, 368, 369, 370, 371, 372, 373, 374, 375, 376, 377, 378, 379, 380, 381, 382, 383, 384, 385, 386, 387, 388, 389, 390, 391, 392, 393, 394, 395, 396, 397, 398, 399, 400, 401, 402, 403, 404, 405, 406, 407, 408, 409, 410, 411, 412, 413, 414, 415, 416, 417, 418, 419, 420, 421, 422, 423, 424, 425, 426, 427, 428, 429, 430, 431, 432, 433, 434, 435, 436, 437, 438, 439, 440, 441, 442, 443, 444, 445, 446, 447, 448, 449, 450, 451, 452, 453, 454, 455, 456, 457, 458, 459, 460, 461, 462, 463, 464, 465, 466, 467, 468, 469, 470, 471, 472, 473, 474, 475, 476, 477, 478, 479, 480, 481, 482, 483, 484, 485, 486, 487, 488, 489, 490, 491, 492, 493, 494, 495, 496, 497, 498, 499, 500, 501, 502, 503, 504, 505, 506, 507, 508, 509, 510, 511, 512, 513, 514, 515, 516, 517, 518, 519, 520, 521, 522, 523, 524, 525, 526, 527, 528, 529, 530, 531, 532, 533, 534, 535, 536, 537, 538, 539, 540, 541, 542, 543, 544, 545, 546, 547, 548, 549, 550, 551, 552, 553, 554, 555, 556, 557, 558, 559, 560, 561, 562, 563, 564, 565, 566, 567, 568, 569, 570, 571, 572, 573, 574, 575, 576, 577, 578, 579, 580, 581, 582, 583, 584, 585, 586, 587, 588, 589, 590, 591, 592, 593, 594, 595, 596, 597, 598, 599, 600, 601, 602, 603, 604, 605, 606, 607, 608, 609, 610, 611, 612, 613, 614, 615, 616, 617, 618, 619, 620, 621, 622, 623, 624, 625, 626, 627, 628, 629, 630, 631, 632, 633, 634, 635, 636, 637, 638, 639, 640, 641, 642, 643, 644, 645, 646, 647, 648, 649, 650, 651, 652, 653, 654, 655, 656, 657, 658, 659, 660, 661, 662, 663, 664, 665, 666, 667, 668, 669, 670, 671, 672, 673, 674, 675, 676, 677, 678, 679, 680, 681, 682, 683, 684, 685, 686, 687, 688, 689, 690, 691, 692, 693, 694, 695, 696, 697, 698, 699, 700, 701, 702, 703, 704, 705, 706, 707, 708, 709, 710, 711, 712, 713, 714, 715, 716, 717, 718, 719, 720, 721, 722, 723, 724, 725, 726, 727, 728, 729, 730, 731, 732, 733, 734, 735, 736, 737, 738, 739, 740, 741, 742, 743, 744, 745, 746, 747, 748, 749, 750, 751, 752, 753, 754, 755, 756, 757, 758, 759, 760, 761, 762, 763, 764, 765, 766, 767, 768, 769, 770, 771, 772, 773, 774, 775, 776, 777, 778, 779, 780, 781, 782, 783, 784, 785, 786, 787, 788, 789, 790, 791, 792, 793, 794, 795, 796, 797, 798, 799, 800, 801, 802, 803, 804, 805, 806, 807, 808, 809, 810, 811, 812, 813, 814, 815, 816, 817, 818, 819, 820, 821, 822, 823, 824, 825, 826, 827, 828, 829, 830, 831, 832, 833, 834, 835, 836, 837, 838, 839, 840, 841, 842, 843, 844, 845, 846, 847, 848, 849, 850, 851, 852, 853, 854, 855, 856, 857, 858, 859, 860, 861, 862, 863, 864, 865, 866, 867, 868, 869, 870, 871, 872, 873, 874, 875, 876, 877, 878, 879, 880, 881, 882, 883, 884, 885, 886, 887, 888, 889, 890, 891, 892, 893, 894, 895, 896, 897, 898, 899, 900, 901, 902, 903, 904, 905, 906, 907, 908, 909, 910, 911, 912, 913, 914, 915, 916, 917, 918, 919, 920, 921, 922, 923, 924, 925, 926, 927, 928, 929, 930, 931, 932, 933, 934, 935, 936, 937, 938, 939, 940, 941, 942, 943, 944, 945, 946, 947, 948, 949, 950, 951, 952, 953, 954, 955, 956, 957, 958, 959, 960, 961, 962, 963, 964, 965, 966, 967, 968, 969, 970, 971, 972, 973, 974, 975, 976, 977, 978, 979, 980, 981, 982, 983, 984, 985, 986, 987, 988, 989, 990, 991, 992, 993, 994, 995, 996, 997, 998, 999, 1000)
```

```
## simpleWarning in ddf.ds(model = dsmodel, data, meta.data = meta.data, control = control, : Model fit failed. (Model number: 1) (occurred 120 time(s) in repetition(s): 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160, 161, 162, 163, 164, 165, 166, 167, 168, 169, 170, 171, 172
```

```
## Summary of warnings and errors:
```

```
sim_45_size_cov <-  
  run.simulation(simulation = sim_45_size_cov, run.parallel = TRUE)
```

```
sim_51_size_cov <-  
  run.simulation(simulation = sim_51_size_cov, run.parallel = TRUE)
```

```
sim_52_size_cov <-  
  run.simulation(simulation = sim_52_size_cov, run.parallel = TRUE)
```



```
## simpleWarning in ddf.ds(model = dsmodel, data, meta.data = meta.data, control = control, : Model fit
##
## (Model number: 1) (occurred 62 time(s) in repetition(s): 1, 16, 30, 107, 124, 147, 149, 160, 166, 1
##
## None of the models converged for this dataset. (occurred 62 time(s) in repetition(s): 1, 16, 30, 107
## -----
```

```
sim_53_size_cov <-
  run.simulation(simulation = sim_53_size_cov, run.parallel = TRUE)
```

```
## Summary of warnings and errors:
## Error: No models could be fitted. (Model number: 1) (occurred 103 time(s) in repetition(s): 38, 39,
##
## simpleWarning in ddf.ds(model = dsmodel, data, meta.data = meta.data, control = control, : Model fit
##
## (Model number: 1) (occurred 103 time(s) in repetition(s): 38, 39, 43, 57, 60, 68, 69, 71, 72, 74, 9
##
## None of the models converged for this dataset. (occurred 103 time(s) in repetition(s): 38, 39, 43, 5
## -----
```

```
sim_54_size_cov <-
  run.simulation(simulation = sim_54_size_cov, run.parallel = TRUE)
```

```
## Summary of warnings and errors:
## Error: No models could be fitted. (Model number: 1) (occurred 72 time(s) in repetition(s): 4, 9, 10
##
## simpleWarning in ddf.ds(model = dsmodel, data, meta.data = meta.data, control = control, : Model fit
##
## (Model number: 1) (occurred 72 time(s) in repetition(s): 4, 9, 10, 29, 48, 67, 76, 86, 99, 102, 10
##
## None of the models converged for this dataset. (occurred 72 time(s) in repetition(s): 4, 9, 10, 29,
## -----
```

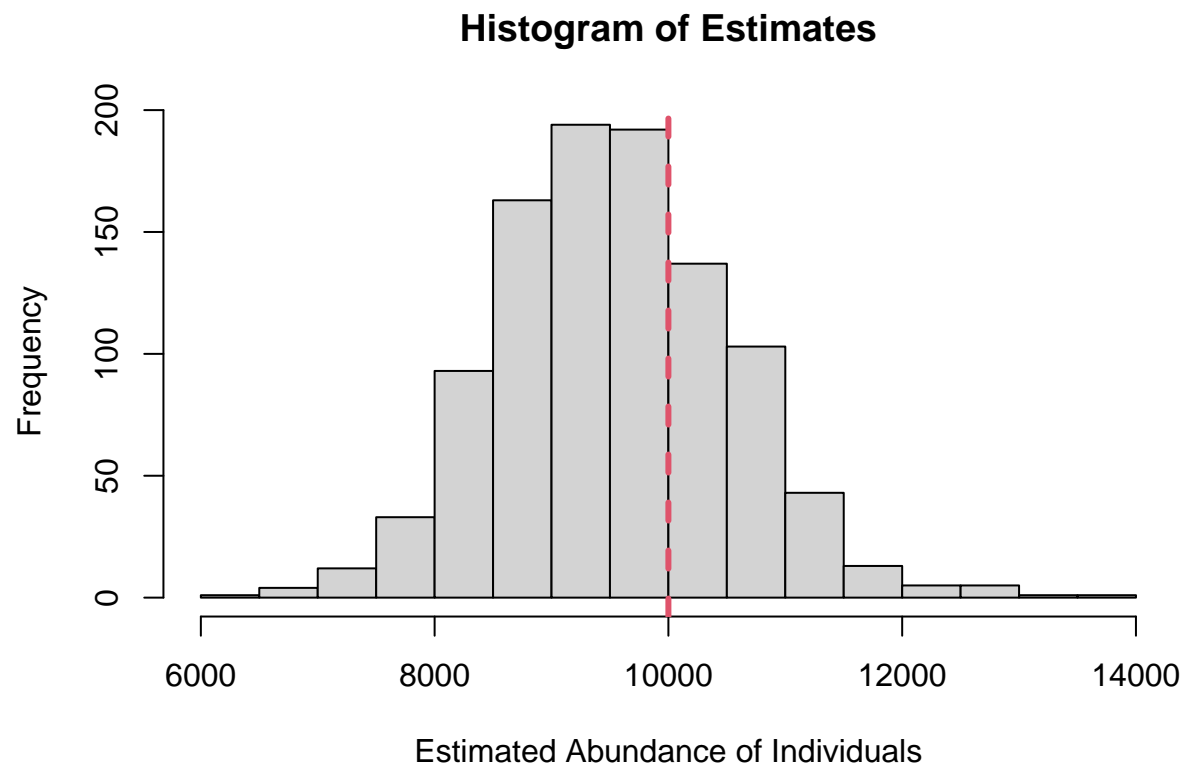
```
sim_55_size_cov <-
  run.simulation(simulation = sim_55_size_cov, run.parallel = TRUE)
```

```
## Summary of warnings and errors:
## Error: No models could be fitted. (Model number: 1) (occurred 30 time(s) in repetition(s): 31, 62,
##
## simpleWarning in ddf.ds(model = dsmodel, data, meta.data = meta.data, control = control, : Model fit
##
## (Model number: 1) (occurred 30 time(s) in repetition(s): 31, 62, 75, 93, 113, 141, 149, 198, 206, 1
##
## None of the models converged for this dataset. (occurred 30 time(s) in repetition(s): 31, 62, 75, 9
## -----
```



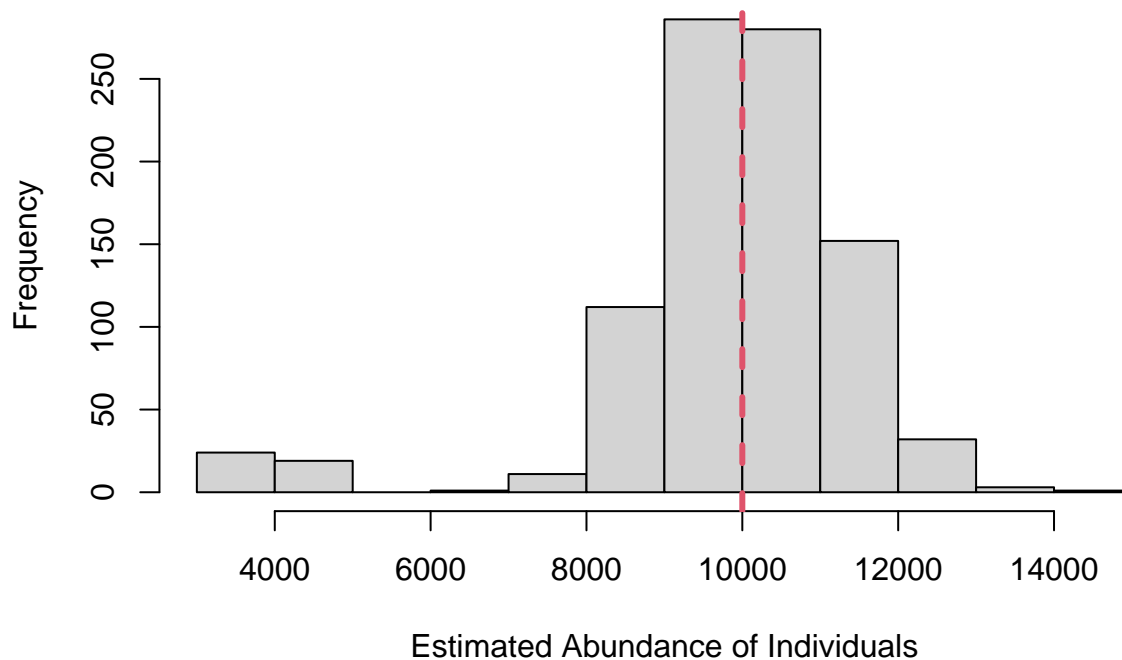
```
sim_55_size_cov_summary <- summary(sim_55_size_cov, description.summary = FALSE)

histogram.N.ests(sim_33_standard)
```



```
histogram.N.ests(sim_33_size_cov)
```

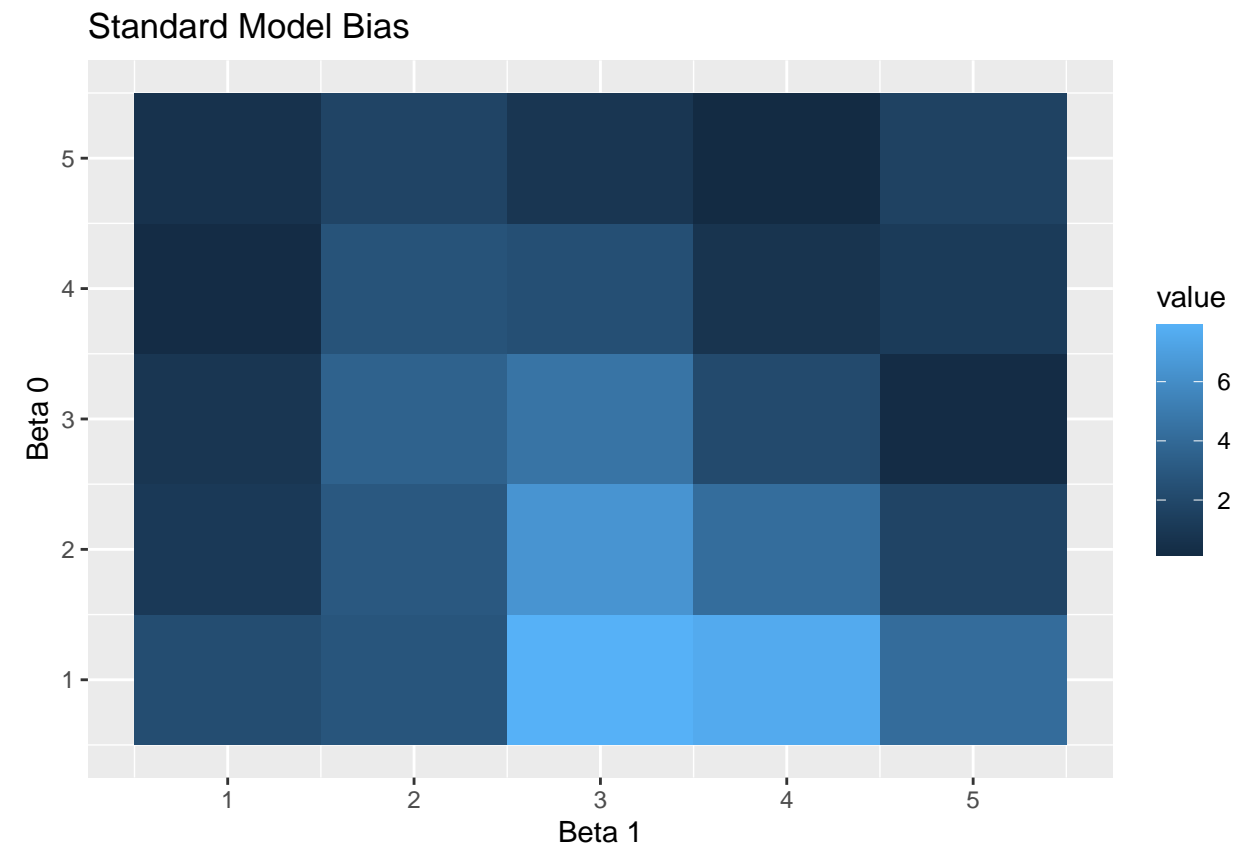
Histogram of Estimates



```
standard_summary_bias <- c(
  abs(sim_11_standard_summary@individuals$N$percent.bias), abs(sim_12_standard_summary@individuals$N$percent.bias),
  abs(sim_13_standard_summary@individuals$N$percent.bias),
  abs(sim_14_standard_summary@individuals$N$percent.bias),
  abs(sim_15_standard_summary@individuals$N$percent.bias),
  abs(sim_21_standard_summary@individuals$N$percent.bias),
  abs(sim_22_standard_summary@individuals$N$percent.bias),
  abs(sim_23_standard_summary@individuals$N$percent.bias),
  abs(sim_24_standard_summary@individuals$N$percent.bias),
  abs(sim_25_standard_summary@individuals$N$percent.bias),
  abs(sim_31_standard_summary@individuals$N$percent.bias),
  abs(sim_32_standard_summary@individuals$N$percent.bias),
  abs(sim_33_standard_summary@individuals$N$percent.bias),
  abs(sim_34_standard_summary@individuals$N$percent.bias),
  abs(sim_35_standard_summary@individuals$N$percent.bias),
  abs(sim_41_standard_summary@individuals$N$percent.bias),
  abs(sim_42_standard_summary@individuals$N$percent.bias),
  abs(sim_43_standard_summary@individuals$N$percent.bias),
  abs(sim_44_standard_summary@individuals$N$percent.bias),
  abs(sim_45_standard_summary@individuals$N$percent.bias),
  abs(sim_51_standard_summary@individuals$N$percent.bias),
  abs(sim_52_standard_summary@individuals$N$percent.bias),
  abs(sim_53_standard_summary@individuals$N$percent.bias),
  abs(sim_54_standard_summary@individuals$N$percent.bias),
  abs(sim_55_standard_summary@individuals$N$percent.bias)
)
```

```
#ROW THEN COLUMN
```

```
standard_summary_bias.data <-  
  matrix(standard_summary_bias, nrow = 5, ncol = 5, byrow = TRUE)  
  
standard_summary_bias.data_melt <- melt(standard_summary_bias.data)  
  
standard_model_output <- ggplot(standard_summary_bias.data_melt, aes(X2, X1)) +  
  geom_tile(aes(fill = value)) +  
  labs(y = "Beta 0", x = "Beta 1", title = "Standard Model Bias")  
standard_model_output
```



```
# scale_x_continuous(limits = c(0.052, 0.056), breaks = seq(0.052, 0.056, 5)) +  
# scale_y_continuous(limits = c(4, 8), breaks = seq(4, 8, 5)) +
```

```
size_cov_summary_bias <- c(  
  abs(sim_11_size_cov_summary@individuals$N$percent.bias), abs(sim_12_size_cov_summary@individuals$N$percent.bias),  
  abs(sim_13_size_cov_summary@individuals$N$percent.bias),  
  abs(sim_14_size_cov_summary@individuals$N$percent.bias),  
  abs(sim_15_size_cov_summary@individuals$N$percent.bias),  
  abs(sim_21_size_cov_summary@individuals$N$percent.bias),  
  abs(sim_22_size_cov_summary@individuals$N$percent.bias),  
  abs(sim_23_size_cov_summary@individuals$N$percent.bias),  
  abs(sim_24_size_cov_summary@individuals$N$percent.bias),
```

```

abs(sim_25_size_cov_summary@individuals$N$percent.bias),
abs(sim_31_size_cov_summary@individuals$N$percent.bias),
abs(sim_32_size_cov_summary@individuals$N$percent.bias),
abs(sim_33_size_cov_summary@individuals$N$percent.bias),
abs(sim_34_size_cov_summary@individuals$N$percent.bias),
abs(sim_35_size_cov_summary@individuals$N$percent.bias),
abs(sim_41_size_cov_summary@individuals$N$percent.bias),
abs(sim_42_size_cov_summary@individuals$N$percent.bias),
abs(sim_43_size_cov_summary@individuals$N$percent.bias),
abs(sim_44_size_cov_summary@individuals$N$percent.bias),
abs(sim_45_size_cov_summary@individuals$N$percent.bias),
abs(sim_51_size_cov_summary@individuals$N$percent.bias),
abs(sim_52_size_cov_summary@individuals$N$percent.bias),
abs(sim_53_size_cov_summary@individuals$N$percent.bias),
abs(sim_54_size_cov_summary@individuals$N$percent.bias),
abs(sim_55_size_cov_summary@individuals$N$percent.bias))

#ROW THEN COLUMN

size_cov_summary_bias.data <-
  matrix(size_cov_summary_bias, nrow = 5, ncol = 5, byrow = TRUE)

size_cov_summary_bias.data_melt <- melt(size_cov_summary_bias.data)

size_cov_model_output <- ggplot(size_cov_summary_bias.data_melt, aes(X2, X1)) +
  geom_tile(aes(fill = value)) +
  labs(y = "Beta 0", x = "Beta 1", title = "Size Covariate Model Bias")
size_cov_model_output

```

