A Wildlife Simulation Package

WiSP

Walter Zucchini[1], David Borchers[2], Stefan Kirchfeld[1] and Martin Erdelmeier[1]

Institut für Statistik und Ökonometrie

[1] University of Göttingen

Research Unit for Wildlife Population Assessment

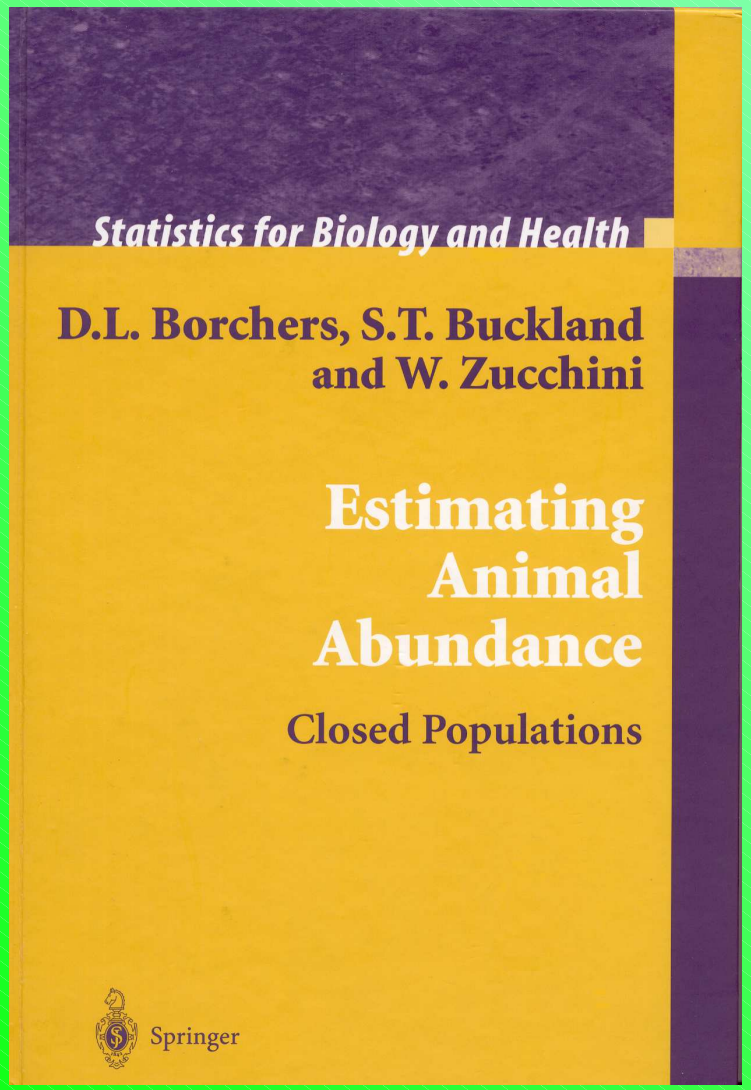
University of St Andrews

[2] University of St. Andrews

Contributors: Alexey Botvinnik, Günter Kratz, Oliver Kellenberger, Jürgen Meinecke

Wildlife Simulation Package

Illustrates the concepts and methodology in:



WiSP **is a library for R**

CRAN

The Comprehensive R Archive Network

Wildlife Simulation Package

A software package that

- **illustrates the concepts in animal abundance estimation**
  State model, observation model

- **simulates all aspects of the modelling methodology**
  Population, survey design, sampling, estimation

- **enables experimentation with assumptions and methods**
  When, why and how models give the wrong answers

Concepts in animal abundance estimation

State model

Describes the spatial distribution and characteristics of animals in a region

Who lives here and where are they?

Population: group size, composition (gender, type), position, exposure

Survey design

Describes the covered region, survey units, effort (observers/traps)

Where, how, and how hard we look.

Survey design: plot sampling, removal methods, mark-recapture, distance sampling, etc.

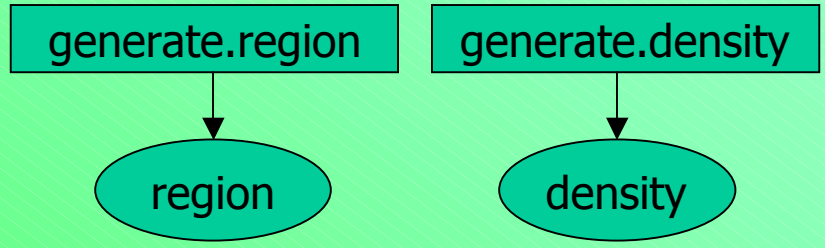
Observation model

Describes the probability that animals with given characteristics are detected.

What we assume we are likely to see.

Detection probability: certain, constant, distance dependent, covariate-dependent

Abundance estimation process in *WiSP*

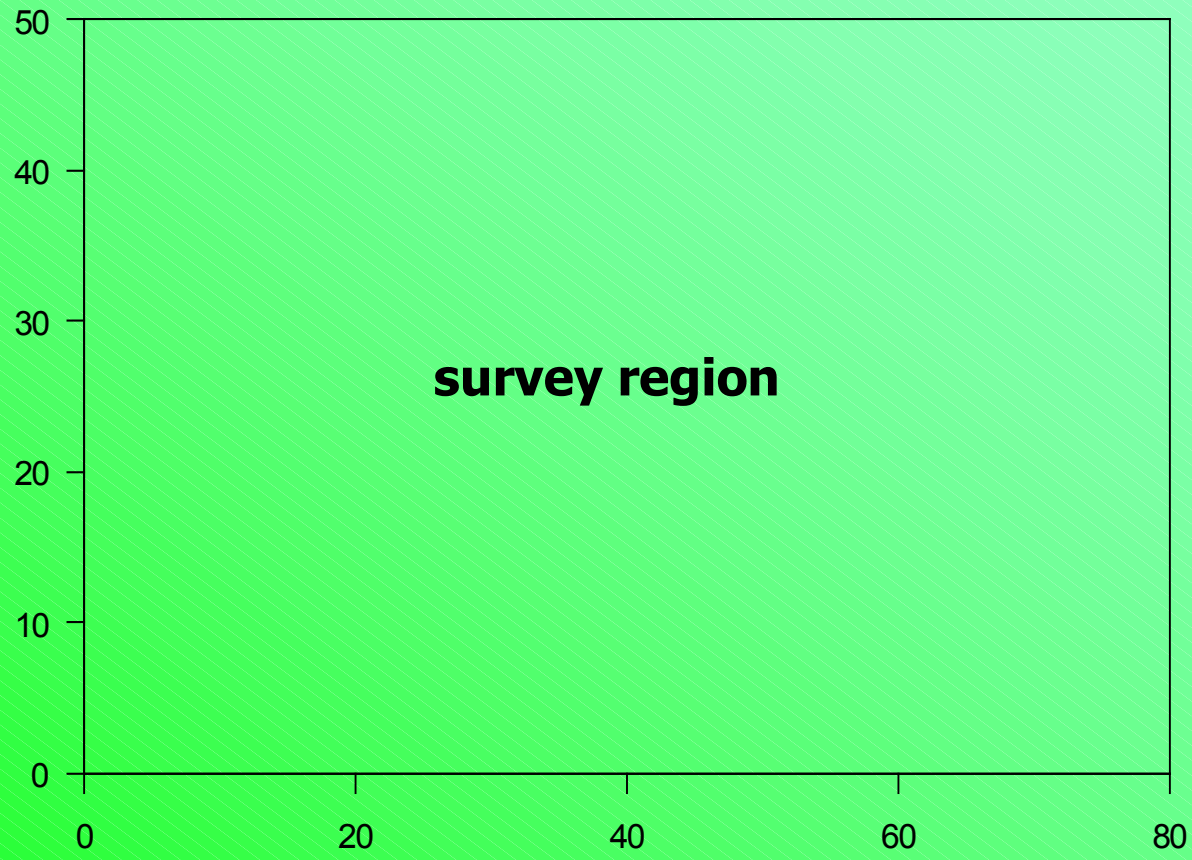


1.) Define survey region & population density

functions objects

Generating a survey region

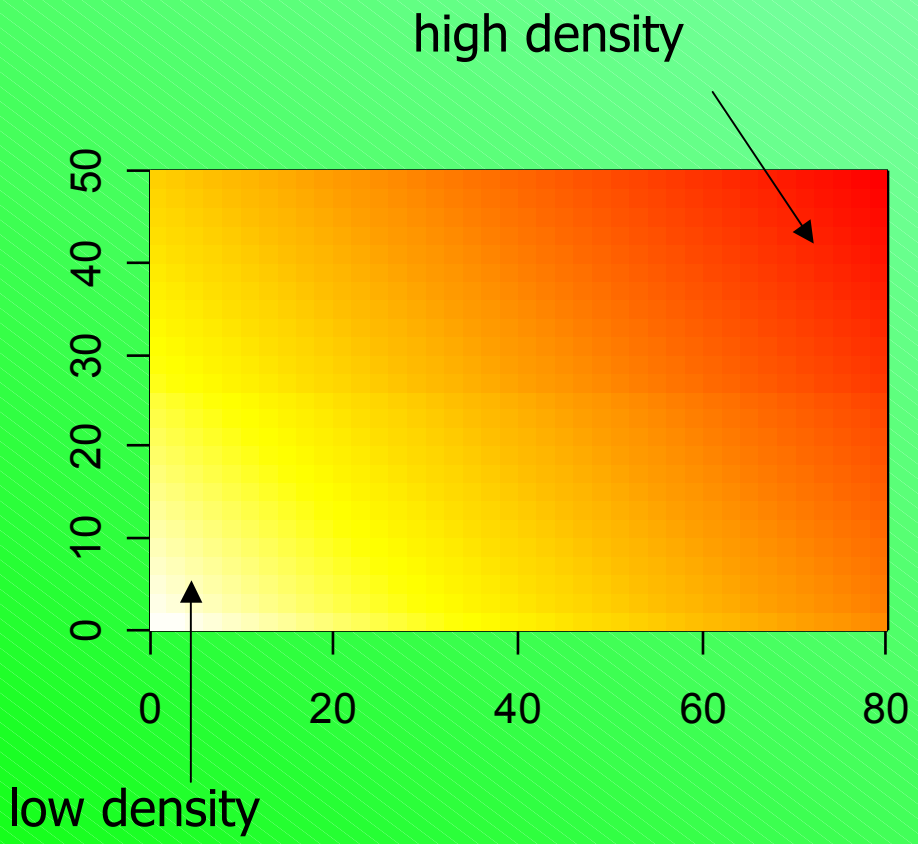
Survey region = An area of given height and width

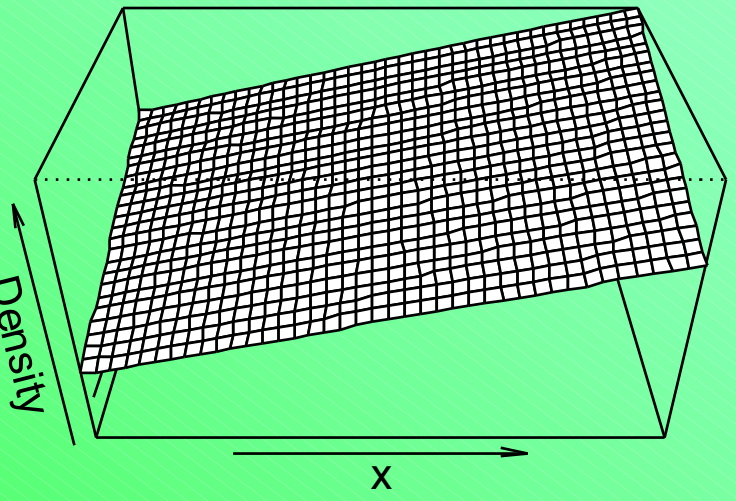


Generating a population density (1)

The population density defines the spatial distribution of animals in the survey region.

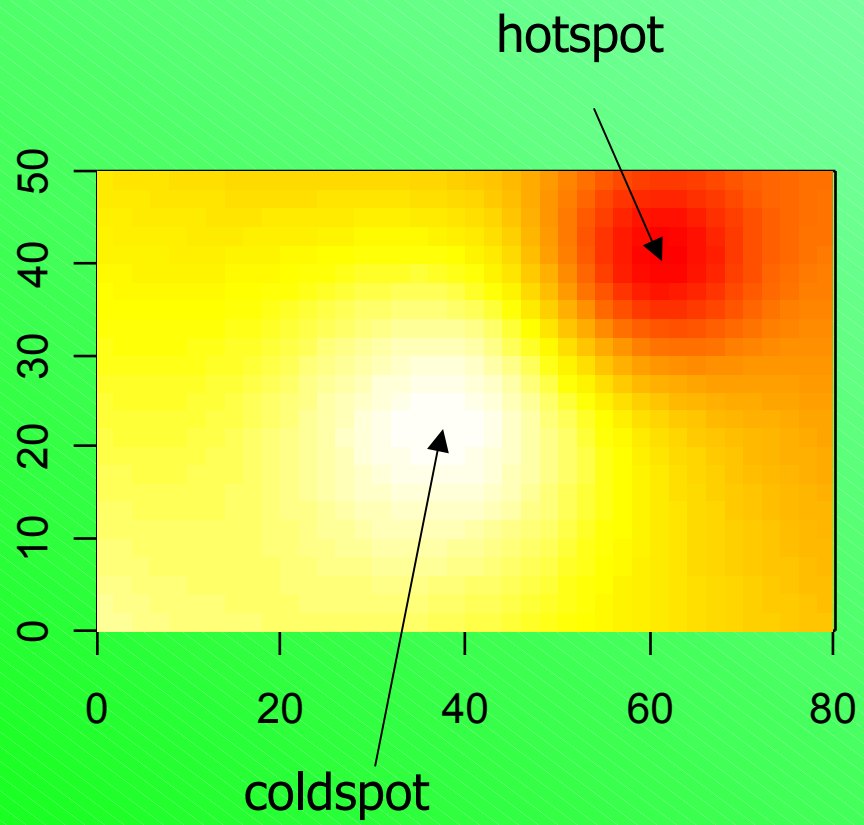
Simple density with linear trend:

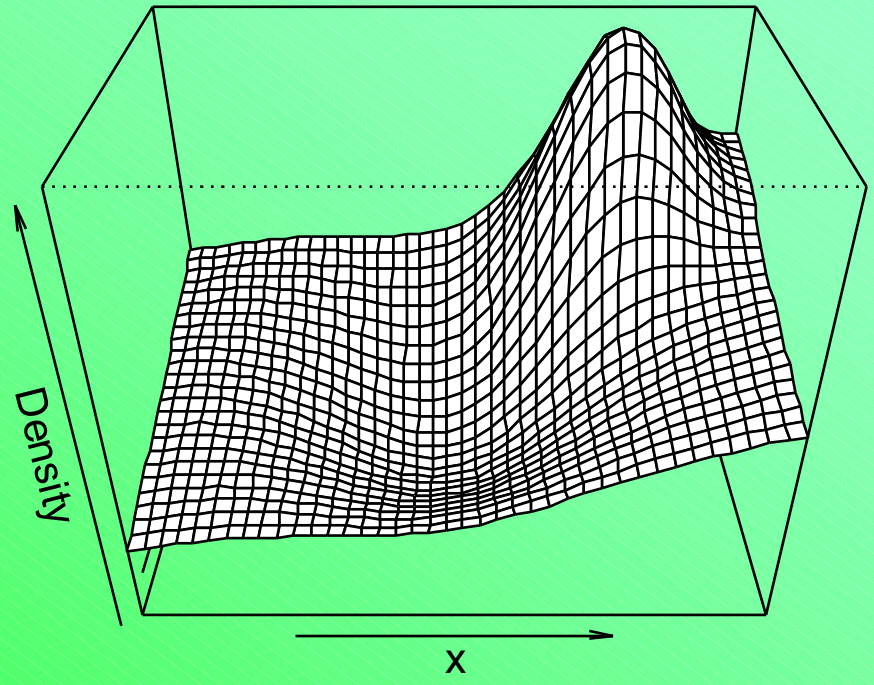




Generating a population density (2)

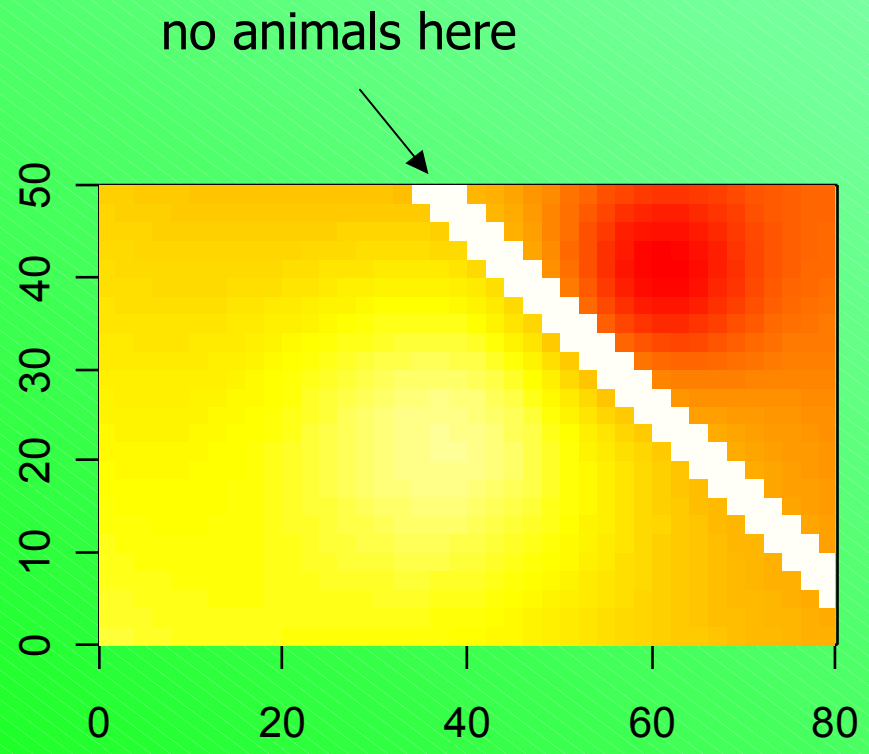
Increase complexity by adding hotspots and coldspots:

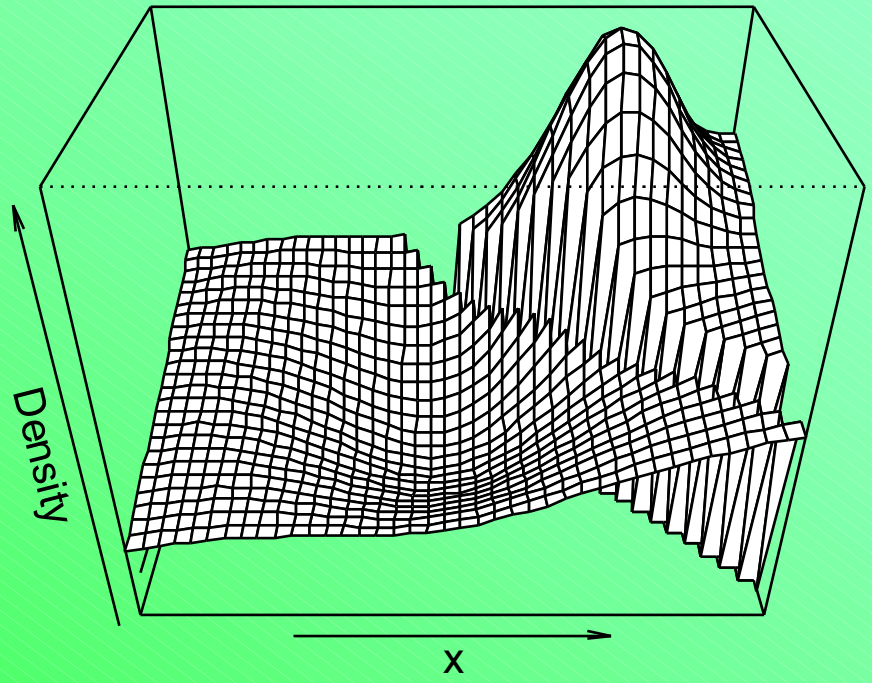




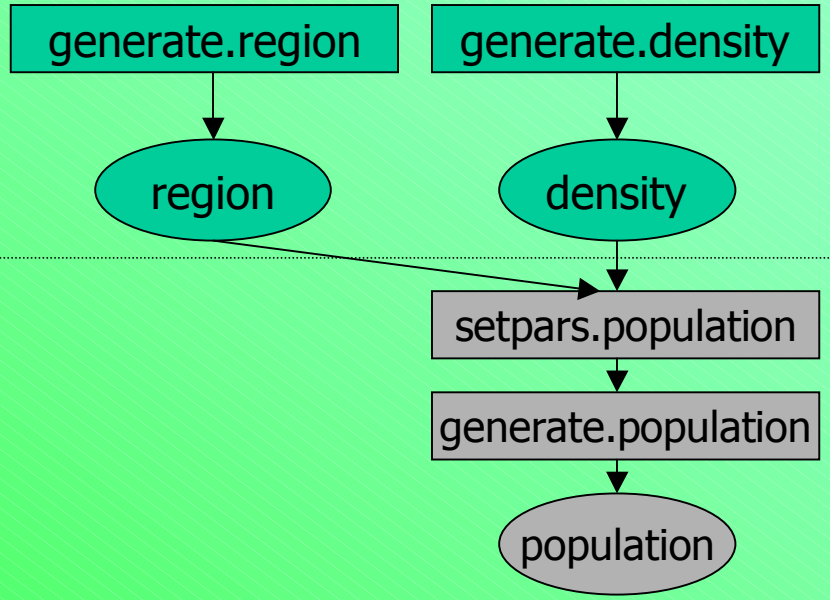
Generating a population density (3)

Add more complexity: Strips of constant density





Abundance estimation process



1.) Define survey region & population density

2.) Generate population

functions

objects

Generating a population

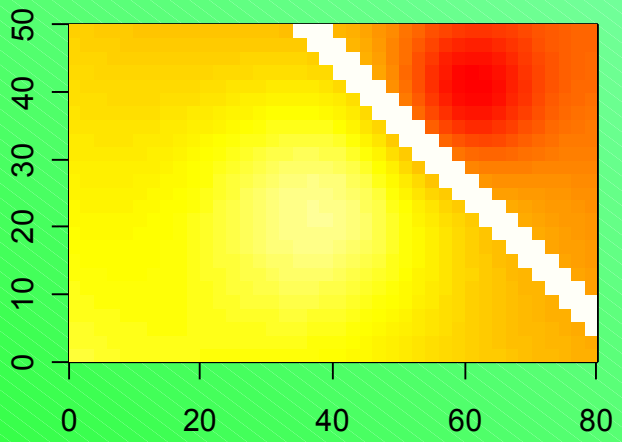
The population specifies the positions and characteristics of groups and individuals

Population parameters

- region
- density
- probability distributions of group and individual characteristics (group sizes and exposures)
- number of groups

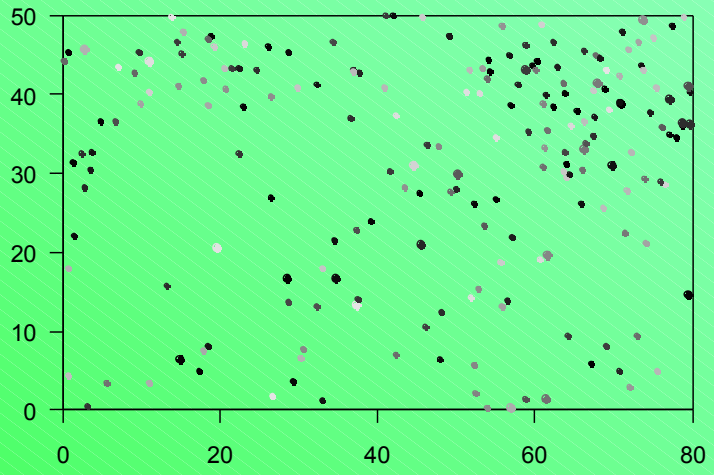
Generating a population

region and density



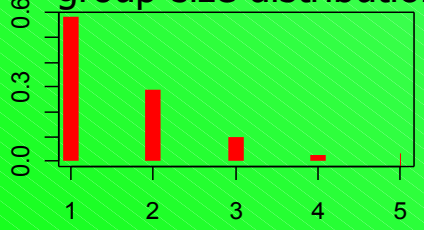
Generate population

Population

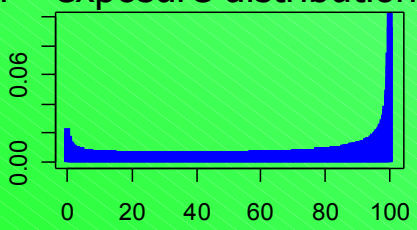


population parameters

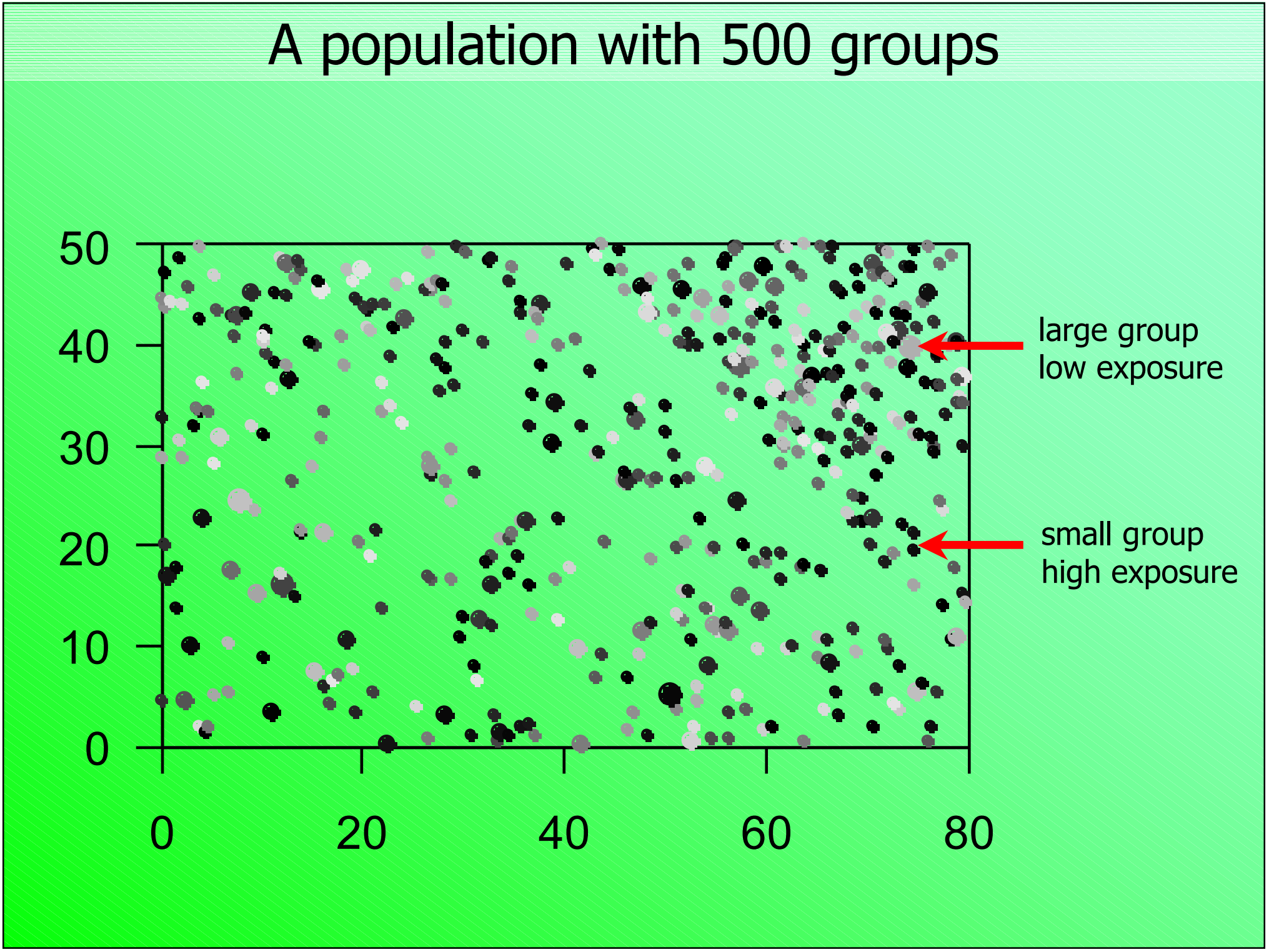
group-size distribution



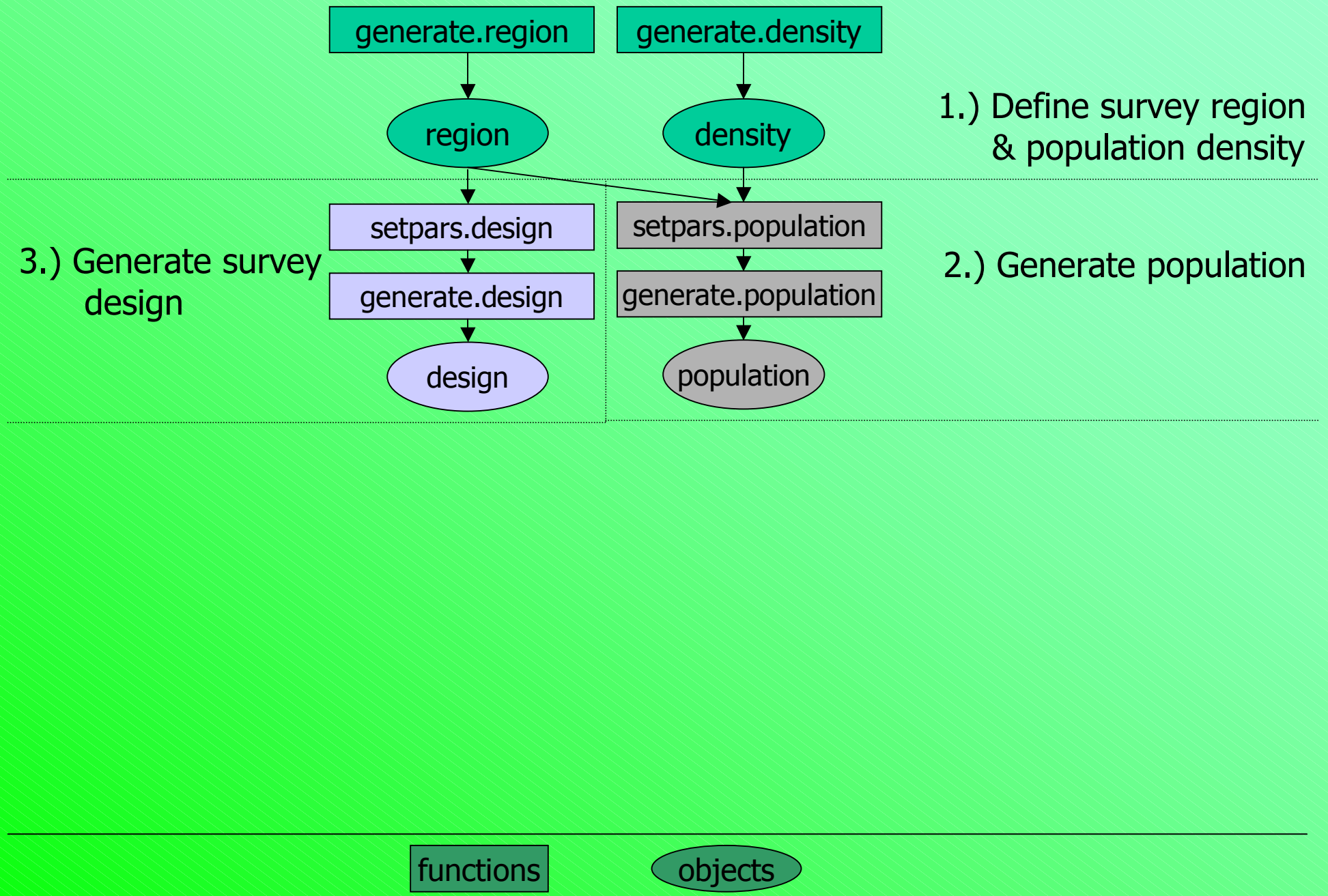
exposure distribution



A population with 500 groups



Abundance estimation process in *WiSP*



Survey designs for closed populations

- **plot sampling** — Count all animals in a selected sub-region

- **removal methods**
  - simple removal — Repeatedly remove some
  - catch-effort — & take account of the effort
  - change-in-ratio — & do so for each type

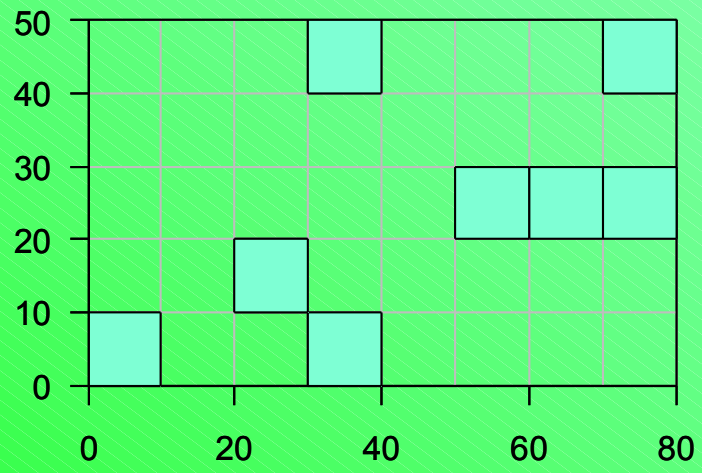
- **mark-recapture**
  - various — Repeatedly capture, mark, return

- **distance sampling**
  - line transect — Count along a transect – record the distances
  - point transect — Count within a circle – record the distances

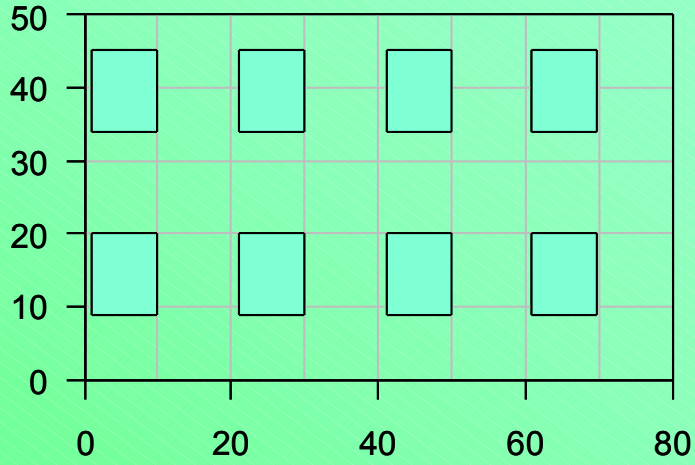
- **nearest object**
  - single nearest object — Measure distance to nearest object detected

Survey designs

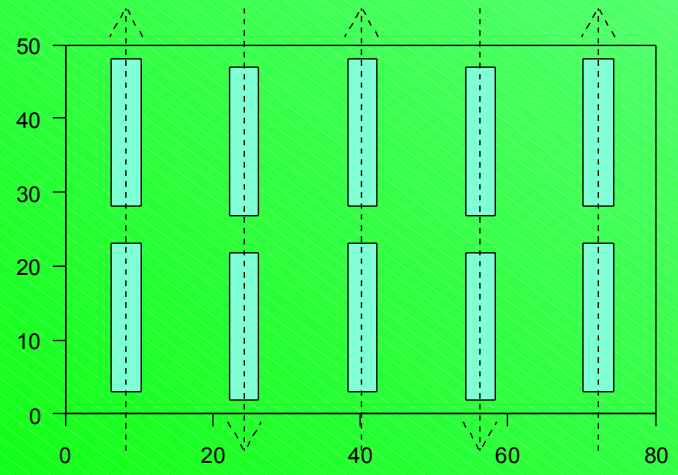
plot sampling (random)



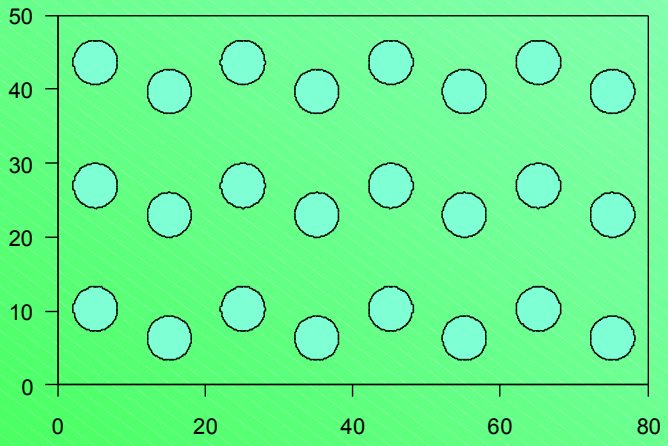
plot sampling (regular)



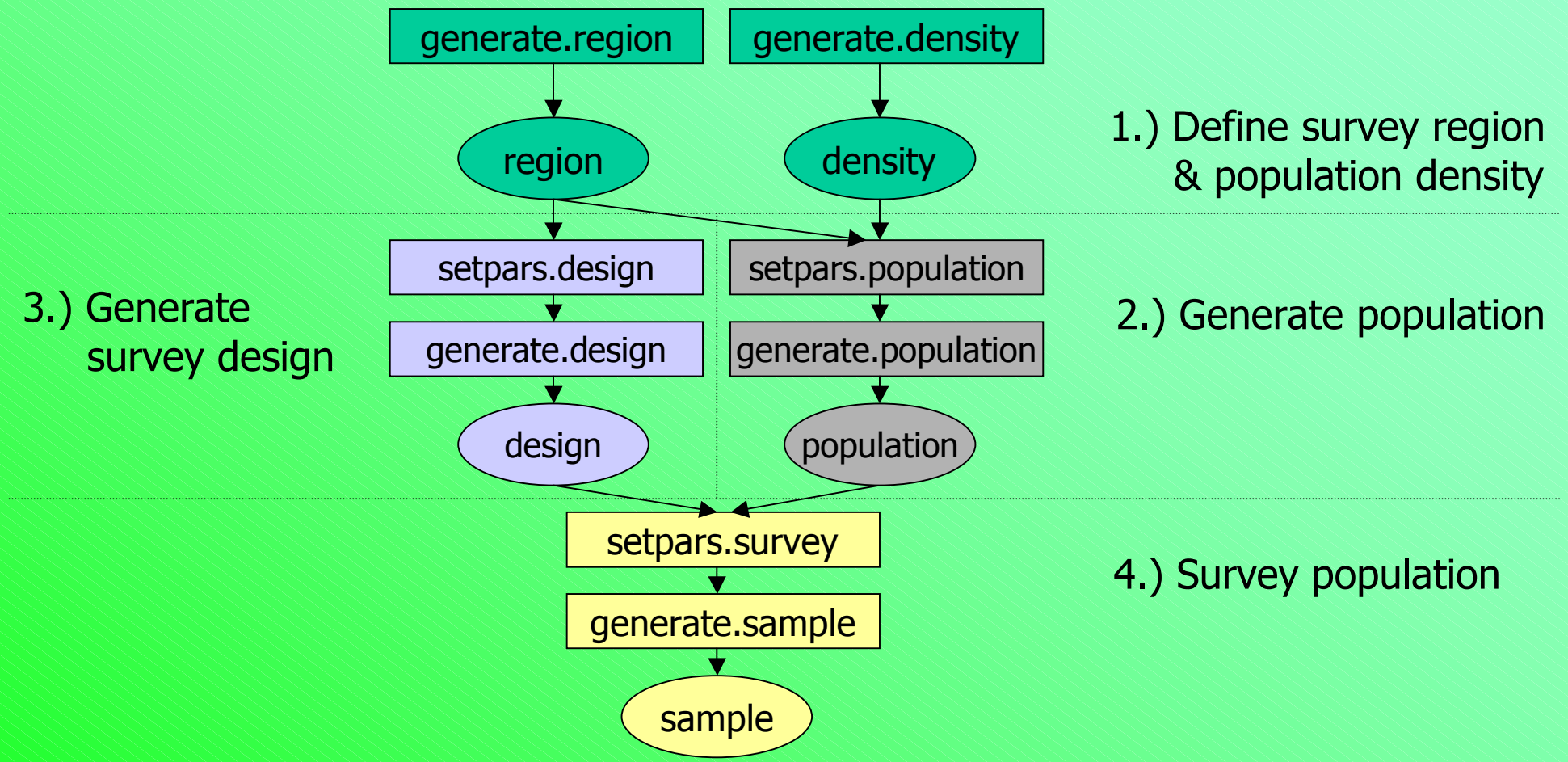
line transect



point transect

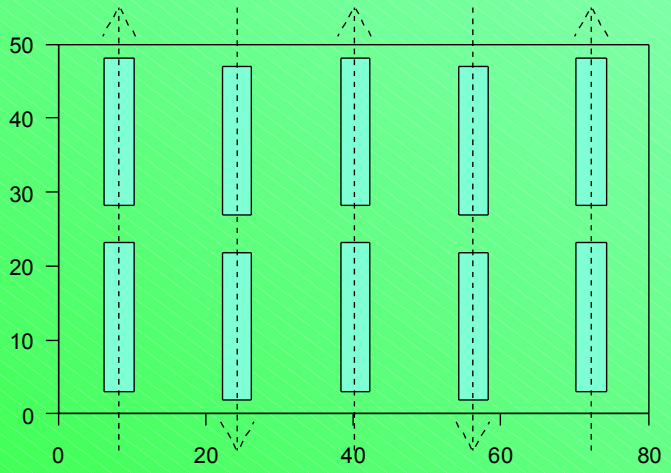


Abundance estimation process in *WiSP*

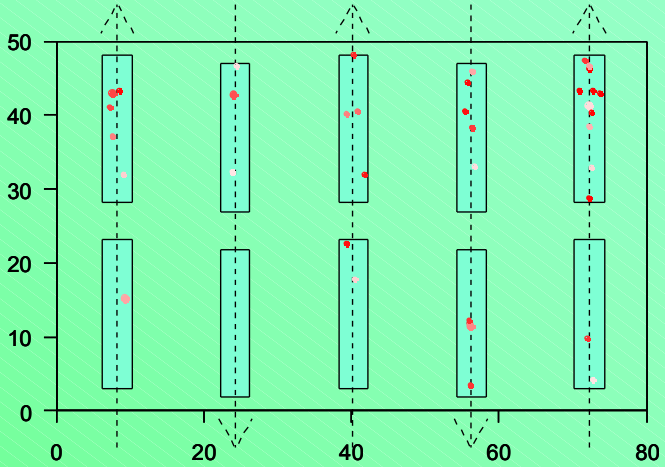


A line-transect survey

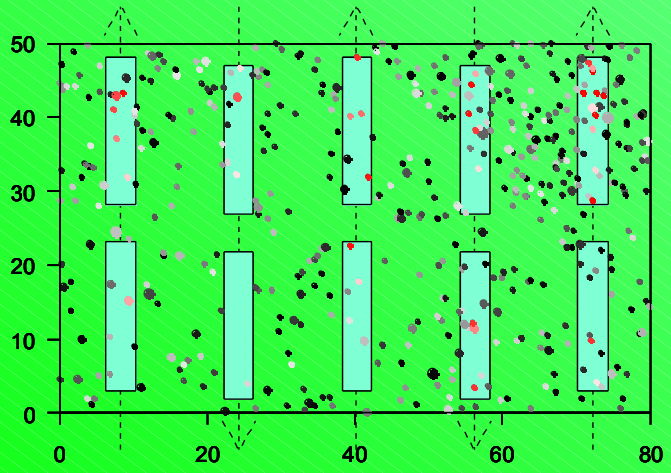
line-transect design



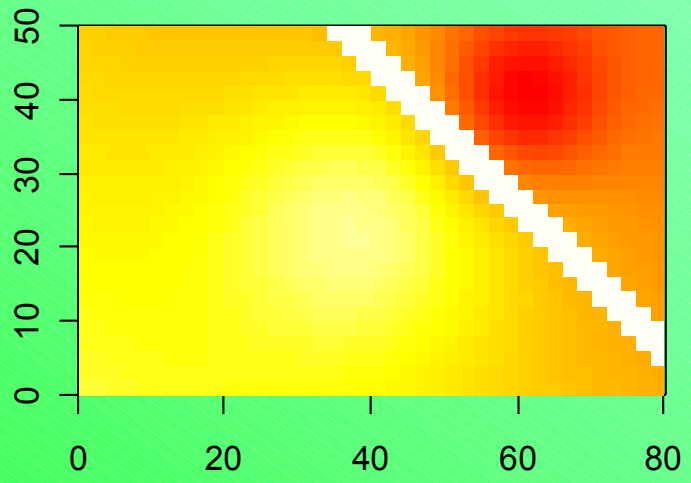
transects and sample



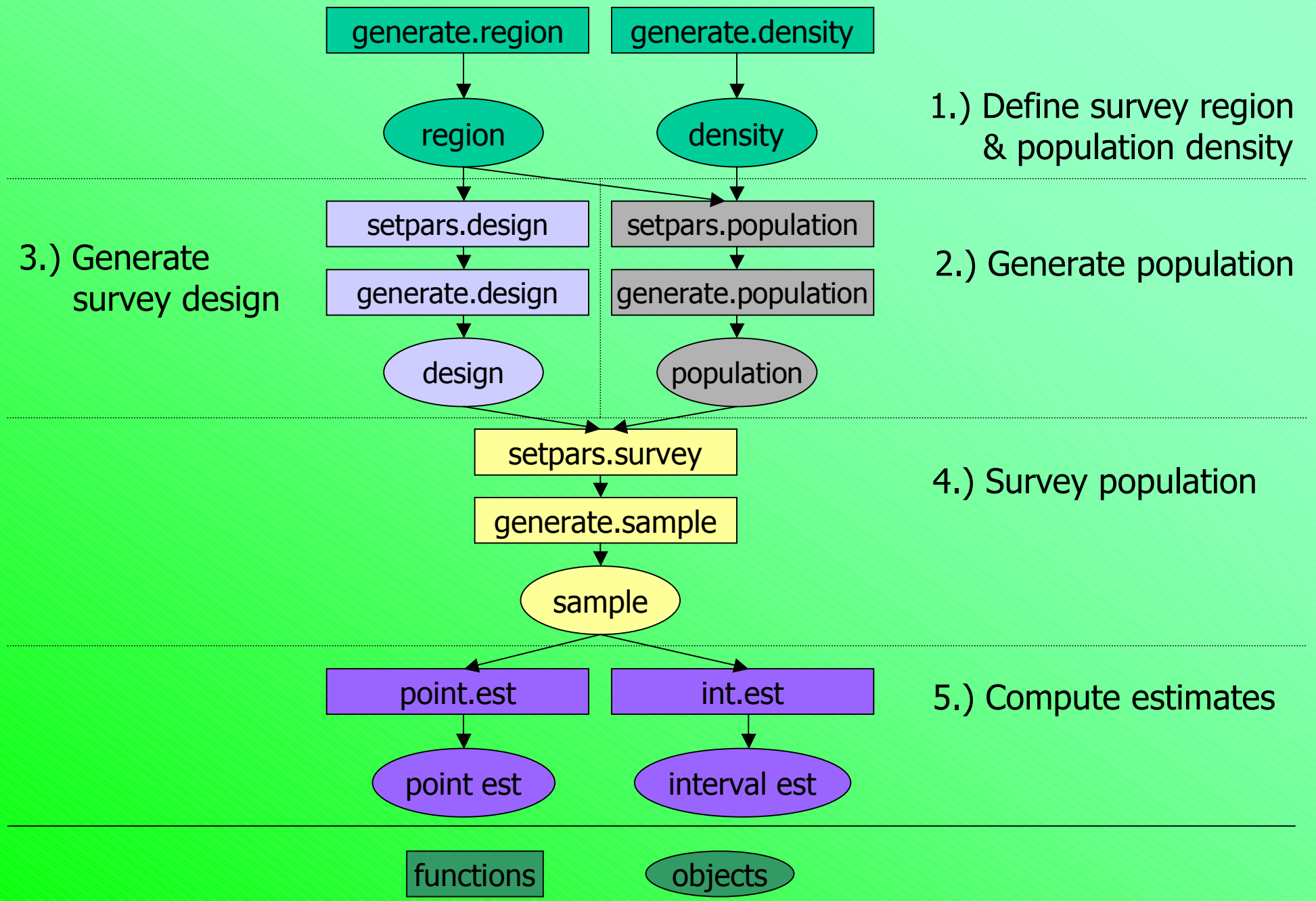
transects and population



population density



Abundance estimation process in *WiSP*



Estimating abundance

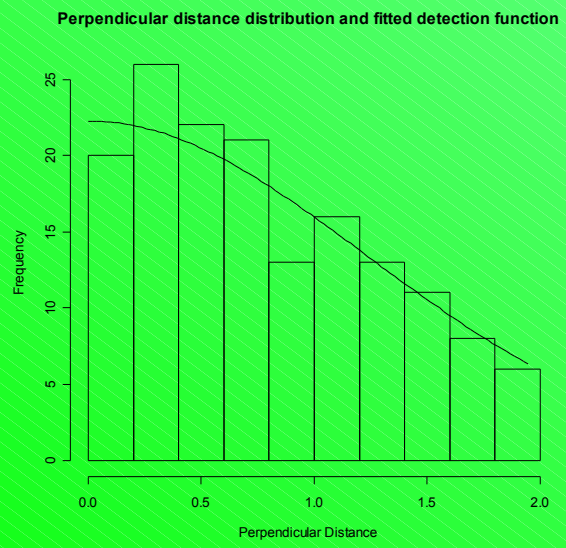
Currently implemented estimation methods in *WiSP*

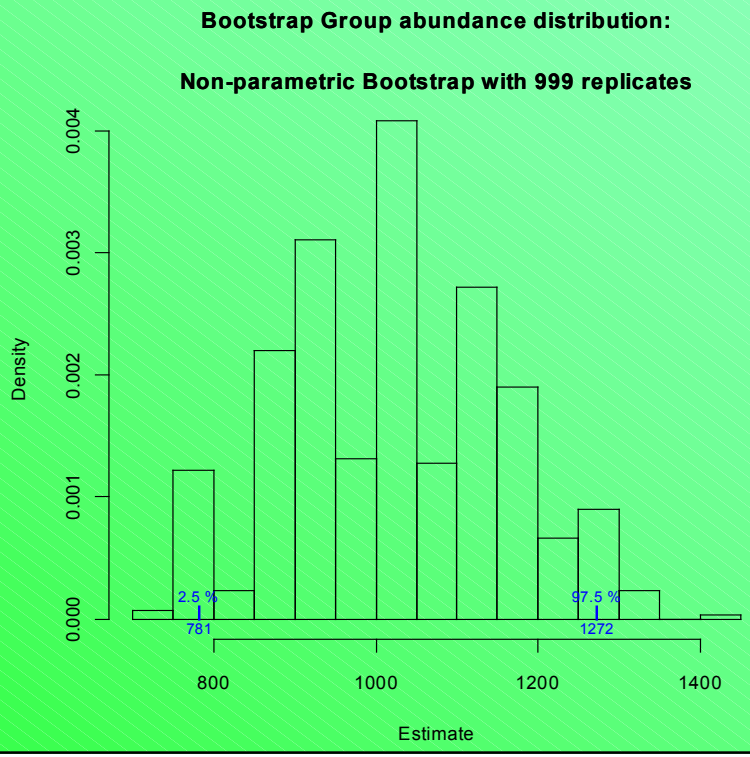
Point estimates:
maximum likelihood
method of moments

Interval estimates:
asymptotic
bootstrap
profile likelihood

Example: Line-Transect estimators (True N = 1000)

MLE: 1020
95% CI: (781, 1272)

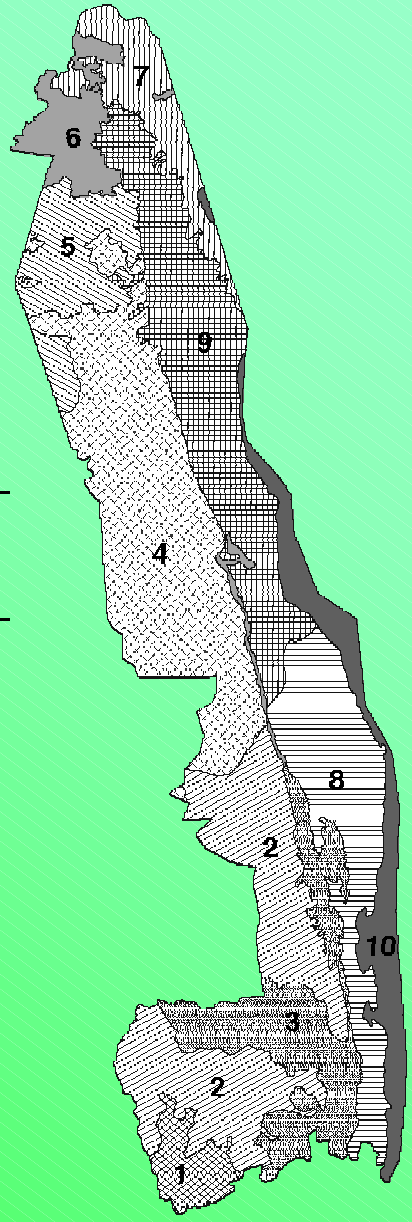




Point-transect estimates of abundance Brown Hyaena (*Crocuta crotuta)*

Brown Hyaena *Crocuta crotuta*

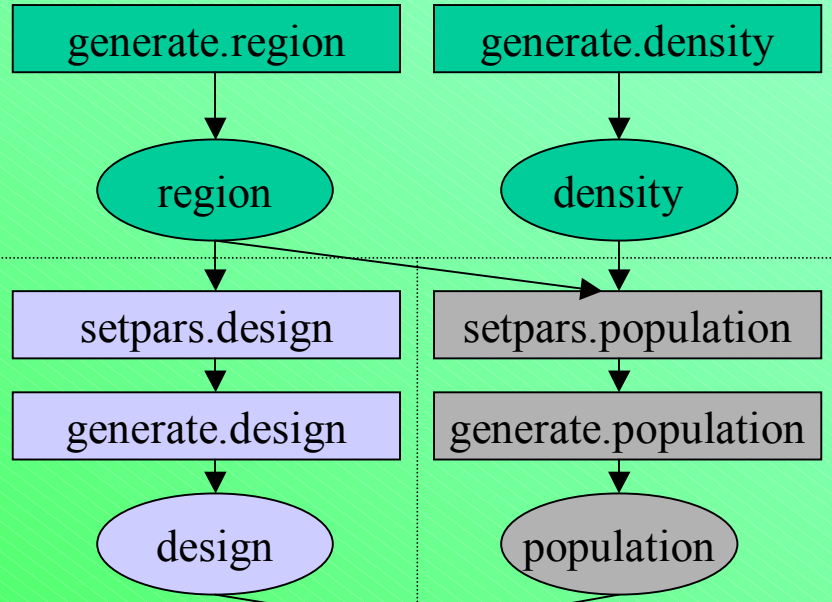
Kruger National Park



Abundance Estimates (Mills, Juritz & Zucchini, 2001)

Habitat	Area	Estimated number	Conf. limits (95%) Lower	Upper
1. Malelane Mountain Bushveld	468	12	–	–
2. Combretum species on granite	3 333	433	312	590
3. Acacia species on bottomland	1 926	407	329	507
4. Mopane-Combretum bush	3 911	723	577	909
5. Mopane-Acacia nigrescens bush	1 222	162	93	305
6. Punda Maria sandveld	680	59	25	101
7. Pafuri rugged veld	997	82	51	103
8. Acacia-nigrescens-Marula sav.	2 241	262	185	382
9. Shrub mopane	3 020	361	273	486
10. Lebombo	1 422	167	106	278

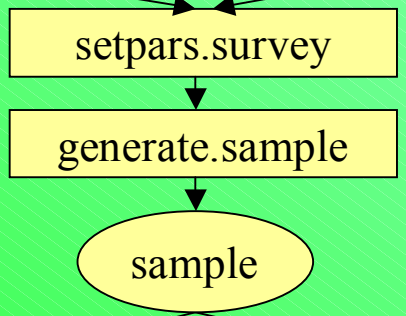
Summary



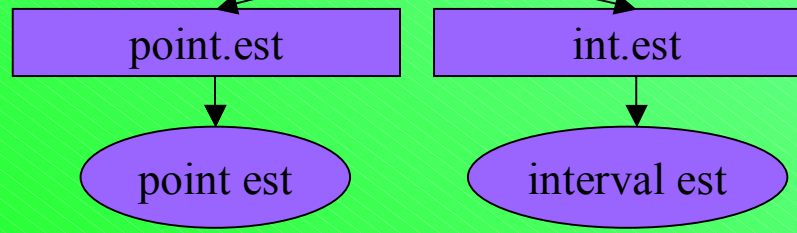
1.) Define survey region & population density

2.) Generate population

3.) Generate survey design



4.) Define **generating observation model** and survey population



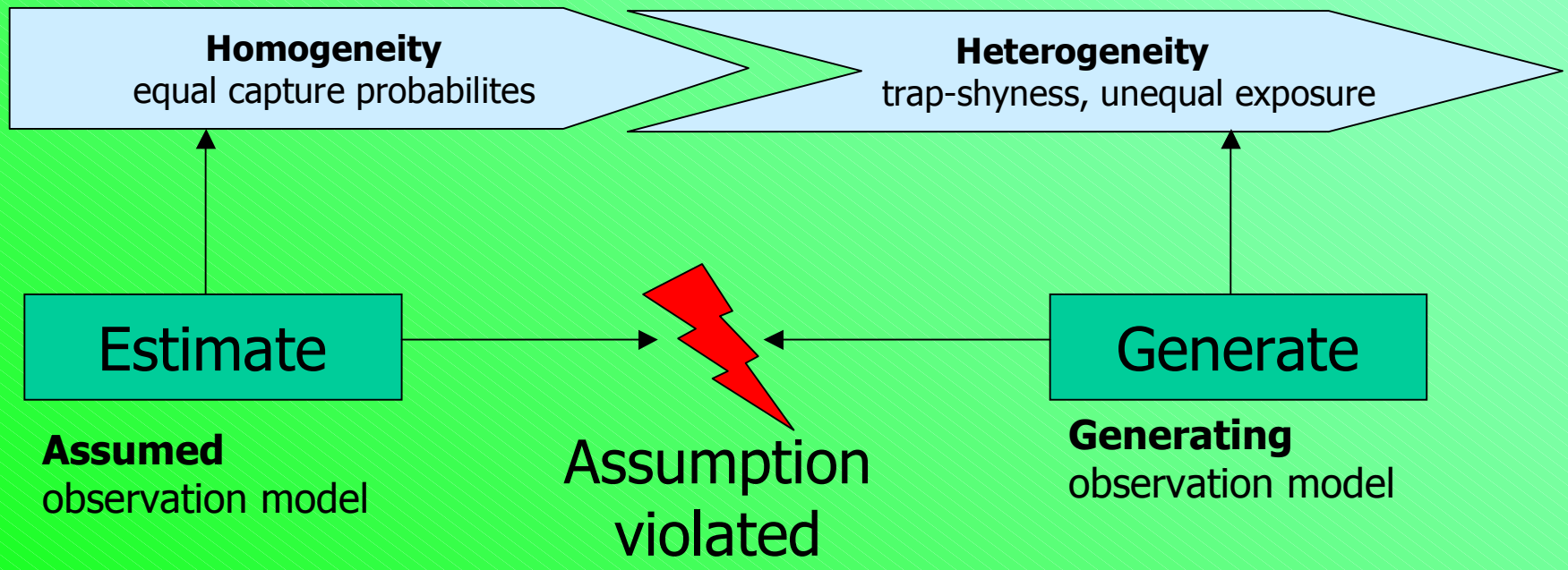
5.) Compute estimates using **assumed observation model**

Assessing sensitivity to assumptions

Generating observation model defines the **true** detection/capture probabilities for all animals

Assumed observation model is what we use to carry out the estimation

Mark-recapture method



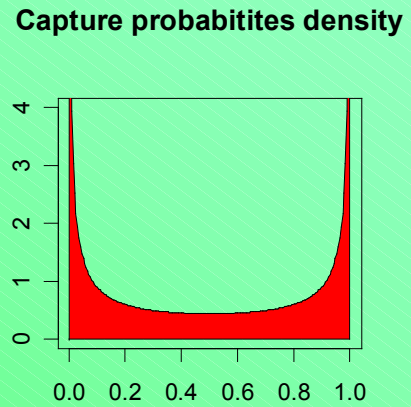
Enables sensitivity analysis

Example of a sensitivity analysis

When, why and how do models give the wrong answers?

Simple mark-recapture model

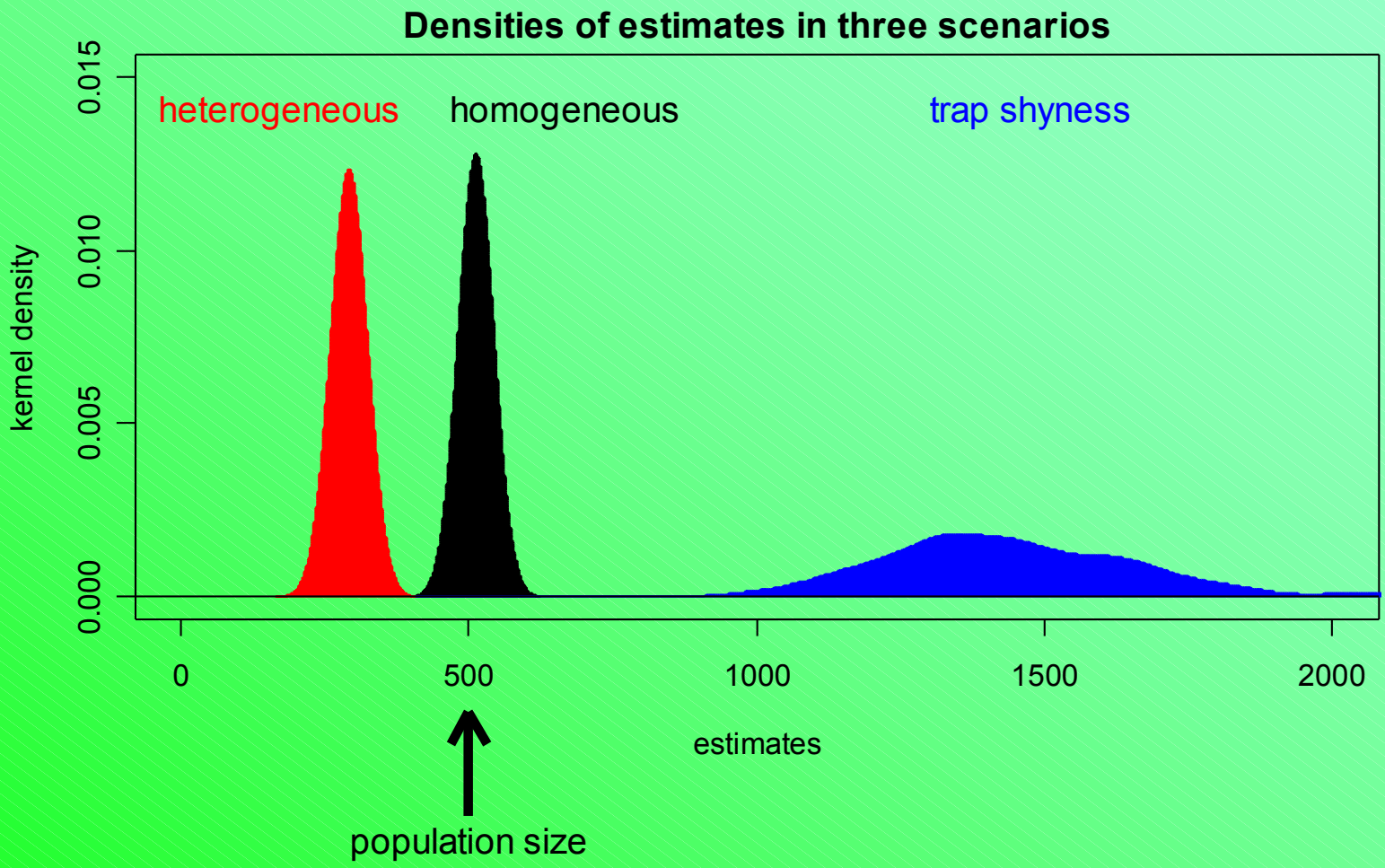
Assumption: Capture probability is the same for all animals in all surveys



Violation 1: Heterogeneity due to exposures
Capture probabilities differ for different animals

Violation 2: Heterogeneity due to trap shyness
Marked animals are less likely to be recaptured

Assessing sensitivity to assumptions



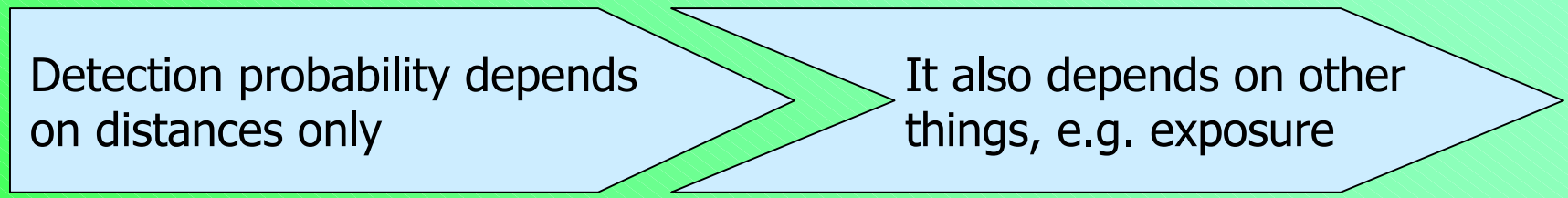
Unequal exposure => Underestimation of abundance

Trap-shyness => Overestimation of abundance

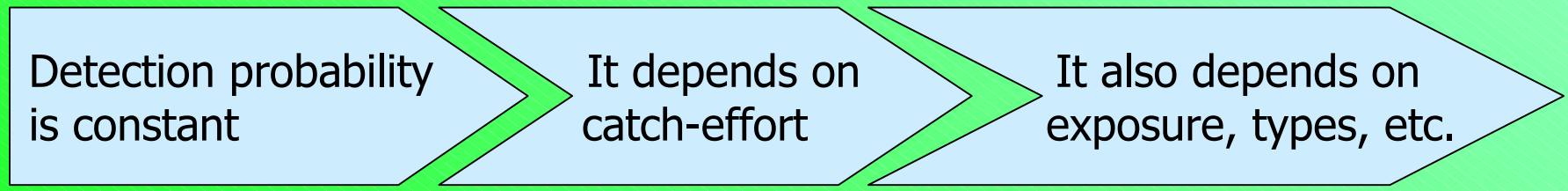
Assessing sensitivity to assumptions

Application to other methods

Transect methods



Change-In-Ratio method



Function and object names

Prefix (action)

setpars.survey
generate.design
plot.design
survey
plot.sample
summary.sample
interval.est
etc.

+

Suffix (method extension)

.cir	catch in ratio
.cr	capture-recapture
.dp	double-platform
.lt	line-transect
.no	nearest object
.pl	plot sampling
.pt	point-transect
.rm	removal

Example:

setpars.survey.pt Set survey parameters for a point transect

Advantages of programming in R

- **Conceptual convenience**

– Easy to keep an overview of the library
– Encourages structured programming
– Simplifies team programming
– Simplifies maintenance and upgrades

- **Availability of generic functions**

– Functions such as **print**(object) **plot**(object) **summary**(object)
identify the class of object and "do the right thing".

is FREE and maintained by SCIENTISTS