Assessment and estimation of population size

Estimated parameters

- **N'- Population size** (individuals, pairs, … etc.) How many individuals/pairs, … are in the studied area?

  It is not always possible to measure the total population size, so it is common to use the number of individuals per unit area or volume:

- **D'- density (population density),** number of individuals/pairs are in unit area (ind./m^2, ind./ha, ind./km^2, … etc)

- **Distribution of the individuals/pairs**

  (uniform/ random/ aggregated)

Survey methods for population estimation

- I. Complete count (cenzus)
- II. Estimation
  - II. 1. Expert judgment
  - II. 2. Sampling methods
    - II. 2. a) Quadrat sampling
    - II. 2. b) Mark-Recapture Method

I. - Complete count (cenzus)

- Counting every individual in the population (rarely feasible)

- A direct method where every individual in the population is counted. This is mostly feasible for small or immobile populations, such as trees in a forest plot or animals in a confined area.

II. – Estimation

II. 1. - Expert judgment

A qualitative method of population estimation where experienced professionals provide informed estimates based on observations, prior knowledge, and indirect evidence.

When is it used?

When direct counting or statistical sampling is impractical.For rare, elusive, or hard-to-survey species.In remote or inaccessible locations.When rapid assessment is needed.

Advantages: -Useful when data is scarce. - Can incorporate ecological knowledge and patterns. - Fast and cost-effective compared to large-scale surveys.

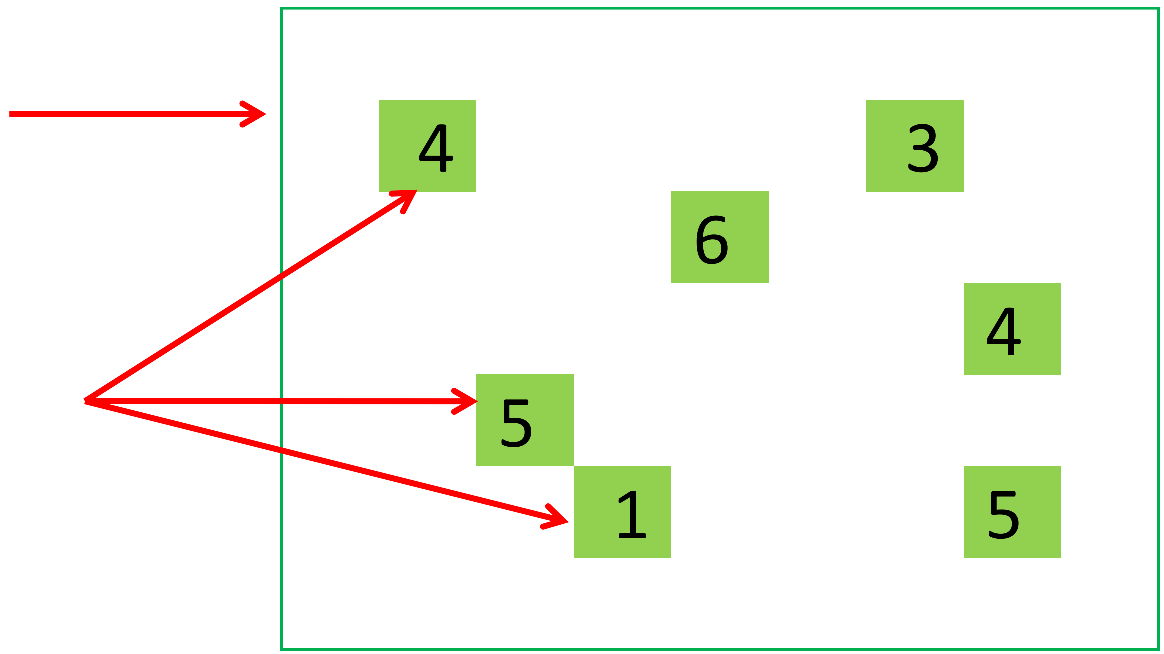
Disadvantages: - Subjective and prone to bias.- Less reliable than quantitative methods. - Difficult to validate without independent data.

II. 2. - Sampling methods

The study area is divided into smaller sections (quadrats), and individuals are counted within randomly selected quadrats. The data is then extrapolated to estimate the entire population. Commonly used in plant ecology and slow-moving organisms.

Studied area

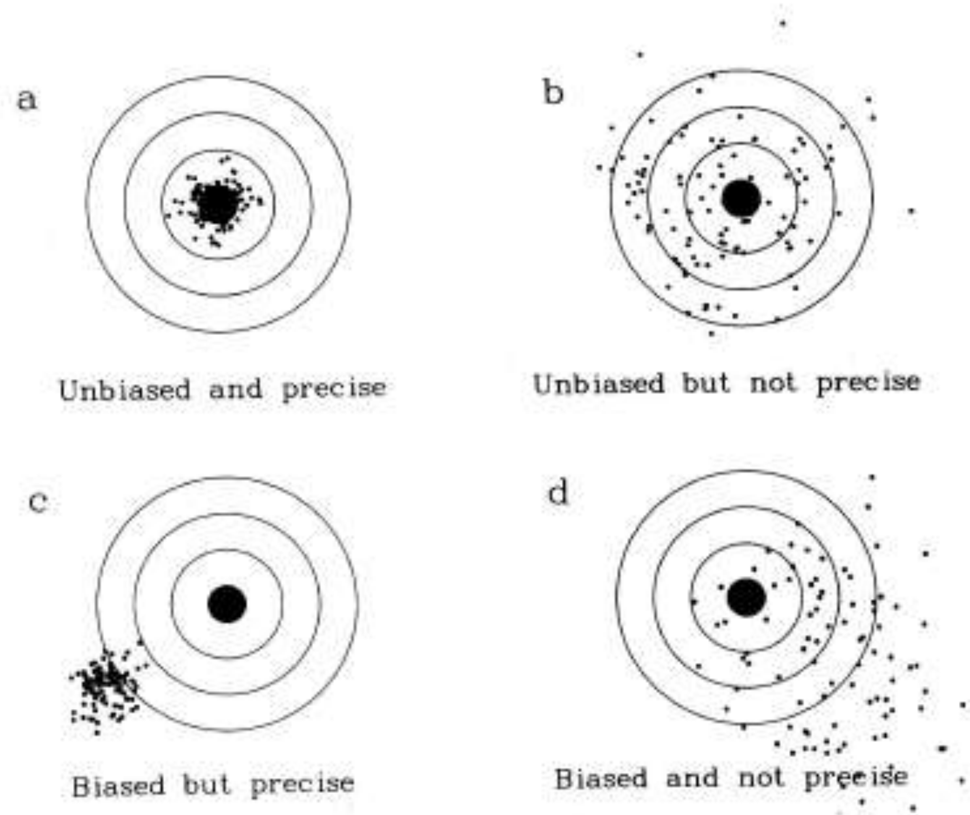
Sampled quadrats

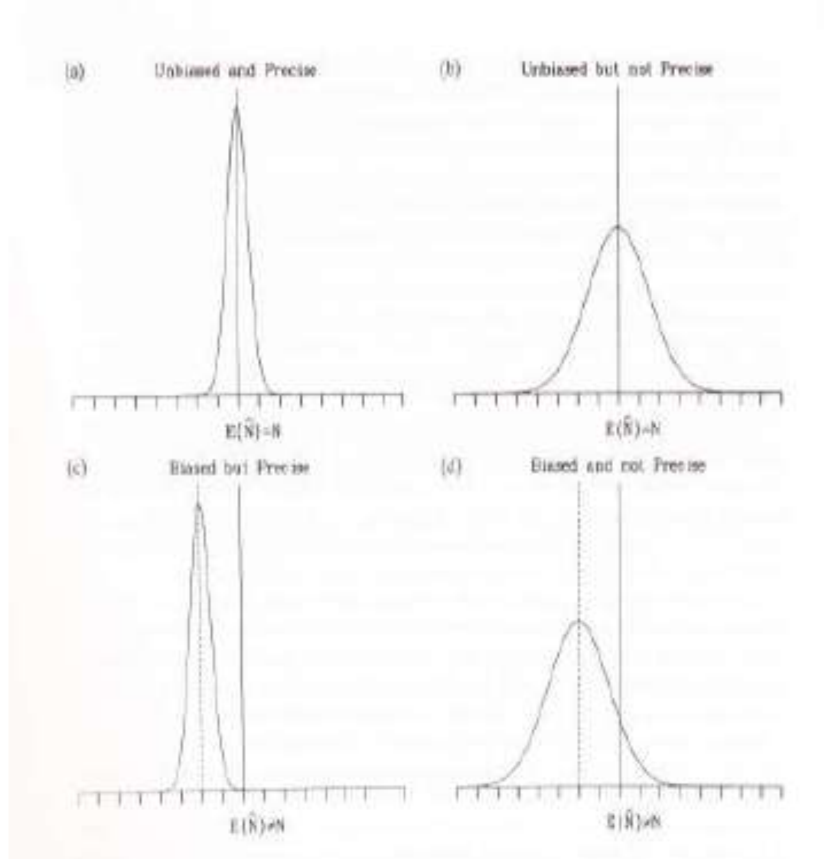


II. 2. - Sampling methods

Reliability of the estimation: accuracy and precision

– **Accurate: not biased,** – **Precise: low variation**





II. 2. - Sampling methods

- The bias of estimation indicates to what extent the estimated population size deviates from the actual population size in our case. In any study based on estimation, it is crucial to minimize this bias, avoiding underestimation or overestimation of the given value.

A proper sampling strategy can help avoid or reduce this bias.

- The precision of the estimate indicates how precise the estimated population size is, and within which minimum and maximum values the actual size can fall based on our estimation.

Increasing the size of the sampled area and using a stratified sampling method can improve the accuracy of the estimate.

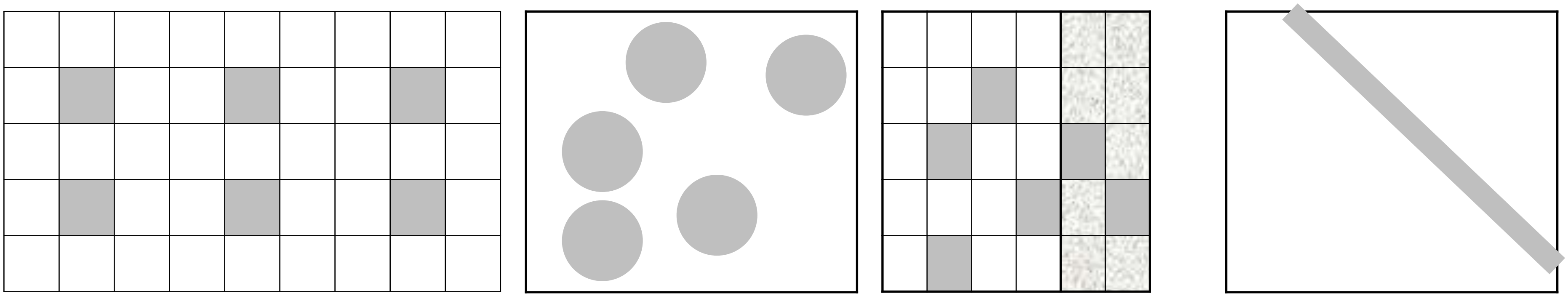
II. 2. - Sampling methods

II. 2. a) - <u>Quadrat sampling</u>

- **Shape of samling unit:**

  1 - quadrat: square, rectangular, circular

  2 - transect



II. 2. - Sampling methods

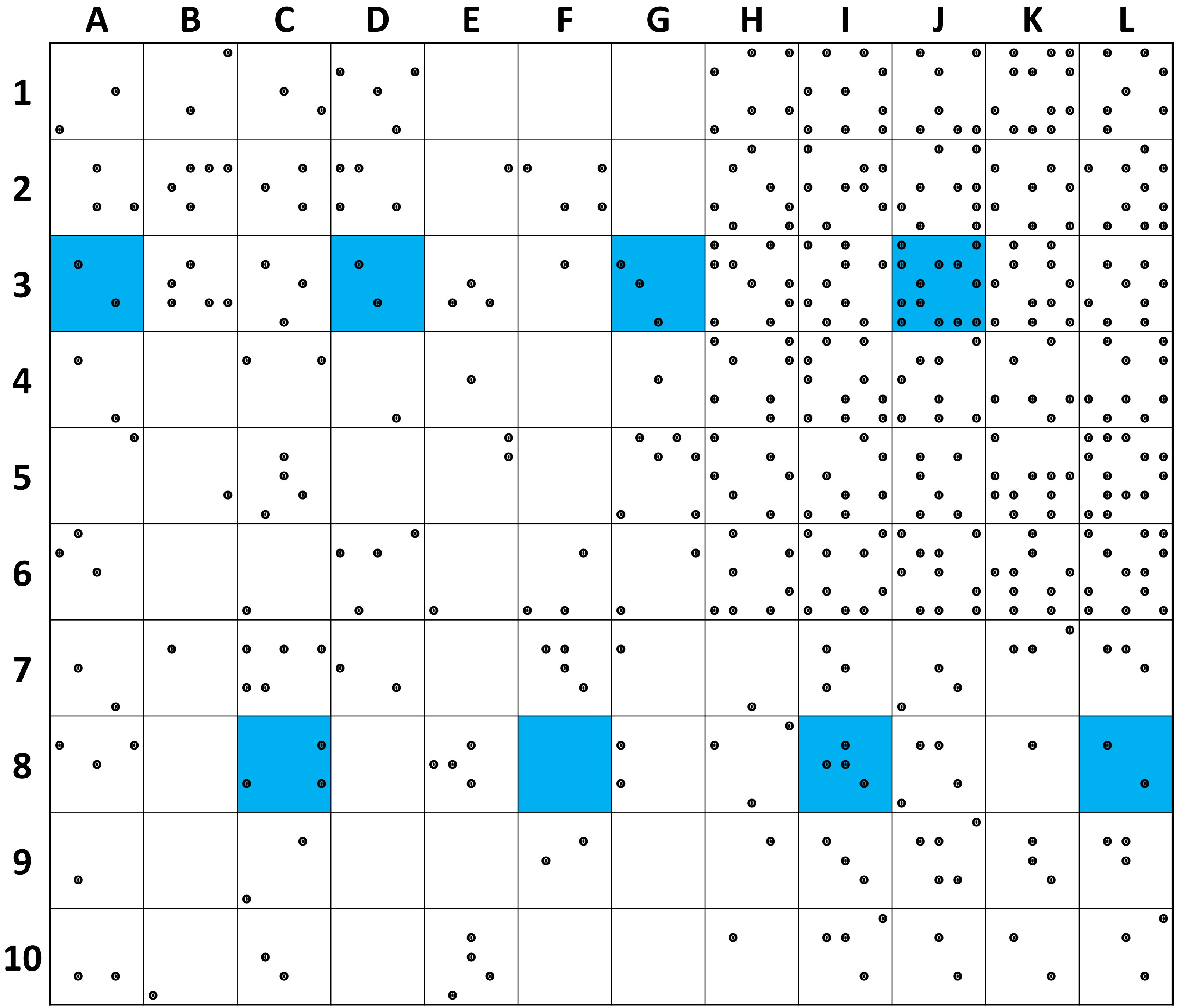
II. 2. a) - Quadrat sampling

- Size and number of sampling units:
- Ideally, the size of the quadrats should be large enough to ensure that at least one individual falls within each quadrat.
- All individuals within the quadrat should be countable.
- Increasing the number of quadrats can improve the accuracy of the estimate.
- The total area of the surveyed quadrats should ideally be 5-10% of the entire area to be studied.

II. 2. - Sampling methods

II. 2. a) - <u>Quadrat sampling</u>

- Sampling strategy – designating sampling locations in the area to be surveyed:
- Systematic sampling: The sampling locations are designated based on a predetermined system (e.g., at the corner points of a grid).
- Simple random sampling: The sampling locations are chosen randomly.
- Stratified random sampling: If the population distribution is not homogeneous across the area, it is useful to divide the area into parts with similar individual densities (create strata), and then randomly designate sampling locations within each stratum.


A B C D E F G H I J K L
1 2 3 4 5 6 7 8 9 10

II. 2. - Sampling methods

II. 2. a) - Quadrat sampling

If the following data is available:

- the total sampling area size (A)
- the area of one quadrat (sampling unit) (a)
- the number of quadrats actually surveyed (r)
- the number of individuals counted in the designated quadrats (ni)

then we can perform the estimation of the population size and density (population density/individual density) for the given area.

Parameters and statistical procedures for population size estimation based on density estimation

Data of the area:

- **A :** Size of the study area (e.g.. m^2, ha, km^2, ...)

  1 ha = 10 000 m^2 1 km^2 = 1 000 000 m^2 = 100 ha

- **a :** Size of one quadrat (pl. m^2, ha, km^2, ...)
- **r :** Number of studied quadrats
- **K :** Maximum number of quadrats could cover the study area

$$K = \frac{A}{a}$$

- **Ratio of surveyed area=** $\frac{a * r}{A}$

Parameters and statistical procedures for population size estimation based on density estimation

Data of quadrats:

- **i** **:** The serial number of the surveyed quadrat
- $\mathbf{n_i}$ **:** number of individuals in ith quadrat
- **n'** **:** mean number of individuals in quadrat

$$n' = \frac{\sum_{i=1}^{r} n_i}{r} = \frac{n_1+n_2+n_3+n_4+n_5+\ldots+n_r}{r}$$

- $\mathbf{s_{n'}^2}$ **:** Variance

$$s_{n'}^2 = \frac{\sum_{i=1}^{r} (n_i - n')^2}{(r-1)} = \frac{(n_1-n')^2+(n_2-n')^2+\ldots+(n_r-n')^2}{(r-1)}$$

Data of quadrats:

Serial # of quadrat	# of individuals	Deviance from the mean	Square of deviance
i	n_i	n_i-n'	$(n_i-n')^2$
1	8	3	9
2	5	0	0
3	5	0	0
4	0	-5	25
5	6	1	1
6	6	1	1
Σ =	30		36
n' =	5	(=30/6)	

variance:

$$s_{n'}^2 = \Sigma\,(n_i-n')^2/(r-1) =$$

$$= 36/(6-1) = \underline{7,2}$$

Parameters and statistical procedures for population size estimation based on density estimation

Estimated population size:

- **N'** :

$$N' = n' * K$$

- $S_{N'}^2$: Variance of the population estimate

$$S_{N'}^2 = \frac{K*(K - r)}{r} * s_{n'}^2$$

- $S_{N'}$: Standard deviation of the population estimate

$$S_{N'} = \sqrt{S_{N'}^2}$$

Parameters and statistical procedures for population size estimation based on density estimation

N' 95 %-os Confidencia-interval

The estimated population size (N') is likely to fall within this interval with 95% probability:

- **N' 95 %-os confidencia-interval minimum:**

$$N'_{min} = N' - 1,96 * S_{N'}$$

- **N' 95 %-os confidencia-interval maximum:**

$$N'_{max} = N' + 1,96 * S_{N'}$$

$1,96*S_{N'}$ $1,96*S_{N'}$

$$N'_{min} \le N' \le N'_{max}$$

Parameters and statistical procedures for population size estimation based on density estimation

Data on the distribution of individuals:

Based on the ratio of the variance of the number of individuals per quadrat to the estimated average number of individuals in the quadrats:

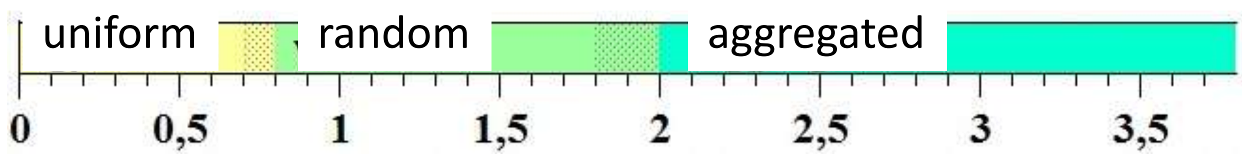
distribution of individuals= $$\frac{s_{n'}^{2}}{n'}$$

If:

<<1, → uniform

≈ 1, → random

>>1), → aggregated



II. 2. – Sampling methods

II. 2. b) – <u>Mark-Recapture Method</u>

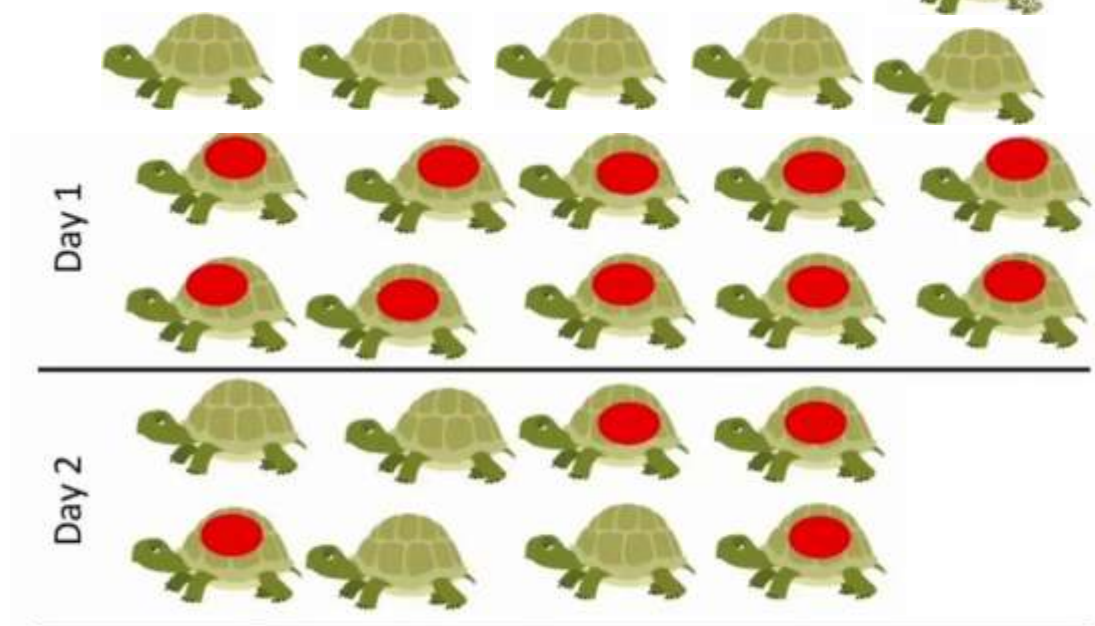
Capture, marking, releasing individuals and later recapture

e.g. bird ringing

II. 2. - Sampling methods

II. 2. b) – Mark-Recapture Method

If a part of a population (n1) is marked in some way and then returned to the original population, followed by mixing and taking another sample (n2), the ratio between the marked individuals in the second sample (m2) and the total number of individuals in the second sample (n2) will be the same as the ratio between all marked individuals (n1) and the total population (N).
Based on this, the total population size can be calculated/estimated.



1. 10 individuals captured and marked in 1st day
2. 8 indiviuduals captured in 2. day, 4 of them marked
3. The estimated population size: 20

$$4/8 = 10/N \quad \rightarrow N = 20$$

II. 2. b) – Mark-Recapture Method

Lincoln index: $$\frac{m_2}{n_2} = \frac{n_1}{N} \rightarrow N = \frac{n_1 * n_2}{m_2}$$

- **N** : Population size
- **n_1** : The number of individuals marked and then released the first time
- **n_2** : The number of individuals caught the second time
- **m_2** : The number of marked individuals (those marked and released during the first capture) among the individuals caught the second time

II. 2. b) – Mark-Recapture Method

- **N’:** Estimated population size

$$N' = \frac{n_1 * n_2}{m_2}$$

- **$S_{N'}^2$:** Variance of population size

$$S_{N'}^2 = \frac{n_1 * n_2 * (n_1 - m_2)^2}{m_2^3}$$

- **$S_{N'}$:** Standard deviation of population size $S_{N'} = \sqrt{S_{N'}^2}$

- N’ 95 %-os confidencia-interval minimum:

$$N'_{min} = N' - 1{,}96 * S_{N'}$$

- N’ 95 %-os confidencia-interval maximum:

$$N'_{max} = N' + 1{,}96 * S_{N'}$$

$$N'_{min} \leq N' \leq N'_{max}$$

Examples

1-3. examples : Quadrat sampling

Elérhető excelben a http://zeus.nyf.hu/~szept/kurzusok.htm oldalon

1. example:

The population size of common oaks is estimated in a 3.6 ha area based on the counting data from quadrats of size 20x20 meters randomly placed in the area.

The following number of common oaks were found in the surveyed quadrats:4, 0, 4, 5, 5, 0.

Estimate the population size of the common oak,its 95% confidence interval and describe the distribution of individuals!