Making Distance Sampling Work

- Assumptions and effect of violation
- Reliable distance sampling
- Pooling robustness
- Examples of imperfect data

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Recap of distance sampling

There are two stages to estimating abundance

Stage 1: given n, how many objects are in the surveyed/covered region (of size a), N_a

Need to estimate P_a *(or* $f(0)$ *or ESW, etc.)*

$$\hat{N}_a = {}^{n}\!/_{\hat{P}_a}$$

Stage 2: given $\hat{N}_a$, how many objects are in study region (of size A), N

'Scale up' from what we see in the survey region to the whole study region

$$\hat{N} = \frac{\hat{N}_a}{{}^{a}\!/_{A}}$$

Assumptions for estimating N_a (stage 1)

1. **Animals distributed independently of line or point**

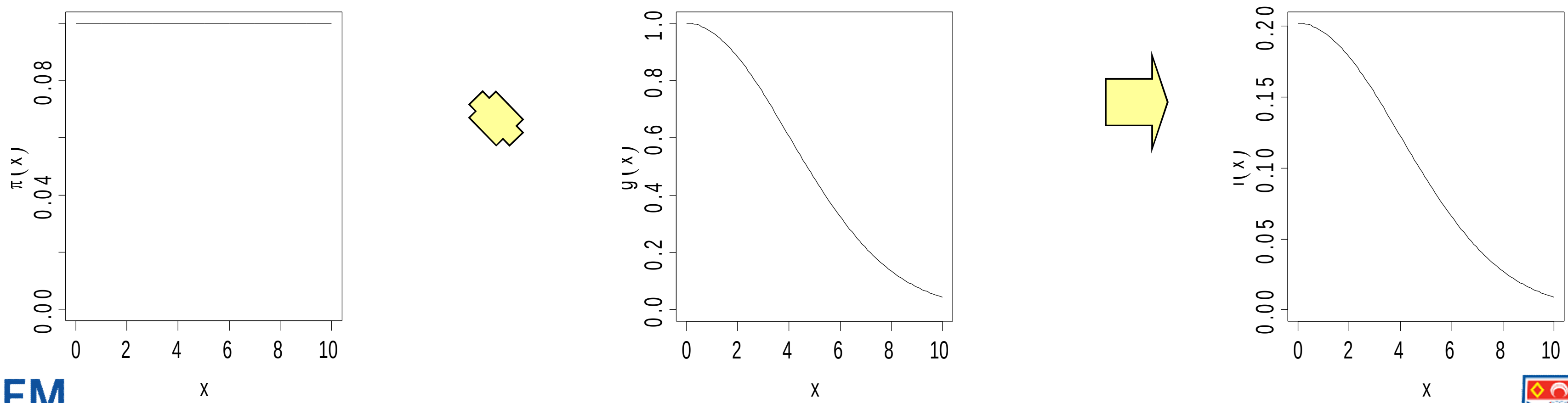
   This ensures the true distribution of animals with respect to the line or point is known

   Violated by non-random line/point placement

   Substantial violation can produce substantial bias (e.g. roadside counts)

e.g. for line transects

True distribution of animals | Detection function, $g(x)$ | Observed distribution, $f(x)$



Assumptions for estimating N_a (stage 1)

2. **All animals on the line or point are detected i.e. $g(0)=1$**

   It is a critical assumption - violation causes negative bias

   e.g. if $g(0)=0.8$, estimates of N are 80% of true N on average

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Assumptions for estimating N_a (stage 1)

3. Observation process is a 'snapshot'

Other ways to phrase this:

Observers are moving much faster than the animals

Animals do not move before they can be detected

Problems of independent/non-responsive movement

An animal moving independently of the observer (compared to moving in response to the observer) produces positive bias; size of bias depends on relative rate of movement of observer and animal, and type of survey.

Point transect methods in particular need to use 'snapshot' method.

Assumptions for estimating N_a (stage 1)

3. Observation process is a 'snapshot' (continued…)

Problems of responsive movement

Responsive movement can cause large bias

It can occur ***within*** *a single line/point or* ***between*** *lines/points*

If animals are 'driven' from one line/point to the next ahead of the observer, positive bias will result.

Note: movement independent of observer outwith 'snapshot' is fine – in this case, the same animal can be detected on multiple lines/transects

Assumptions for estimating N_a (stage 1)

4. **Distances are measured accurately**

   Random errors cause bias.

   Bias is generally small for line transect estimators,

   Can be large for point transect estimators.

   Both are sensitive to systematic bias and to rounding to 0 distance (or angle).

   Can use grouped data collection.

5. **Detections are independent**

   Violation has little effect. (Model selection methods for $g(x)$, such as AIC, are somewhat affected)

Assumptions for estimating *N* given N_a (stage 2)

1. Lines or points are located according to a survey design with appropriate randomization

    We use properties of the survey design to extrapolate from the surveyed/covered region to the study region ('design-based')

    Non-random survey design means density in surveyed/covered region may not be representative of density in study region. Also variance may be biased.

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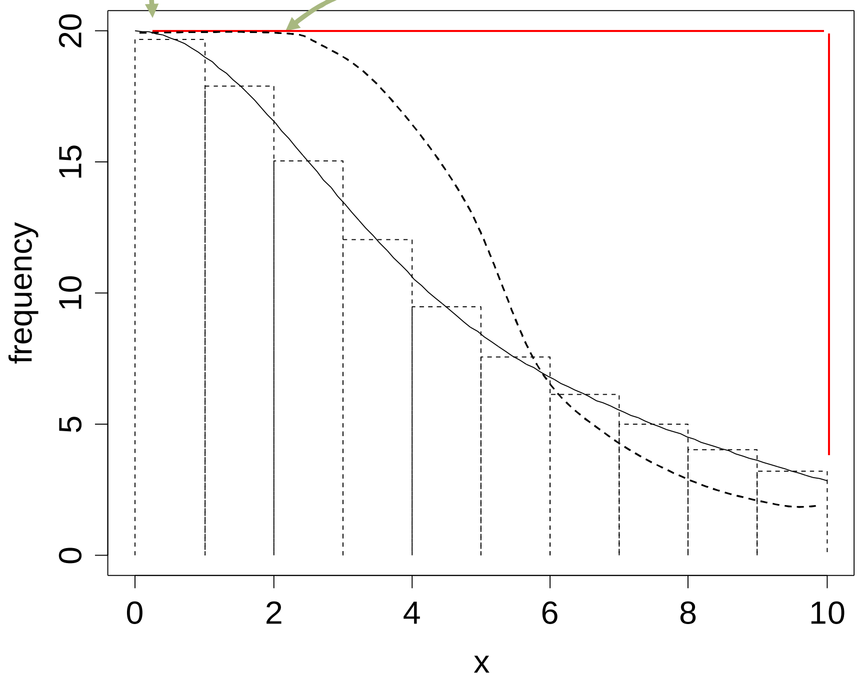
Reliable distance sampling (1)

1. Reliable estimation of P_a (or $f(0)$ or ESW, etc.)

In addition to the assumptions, we would like:

SHAPE CRITERION
Detection function should have a 'shoulder' (i.e. $g'(0)=0$)

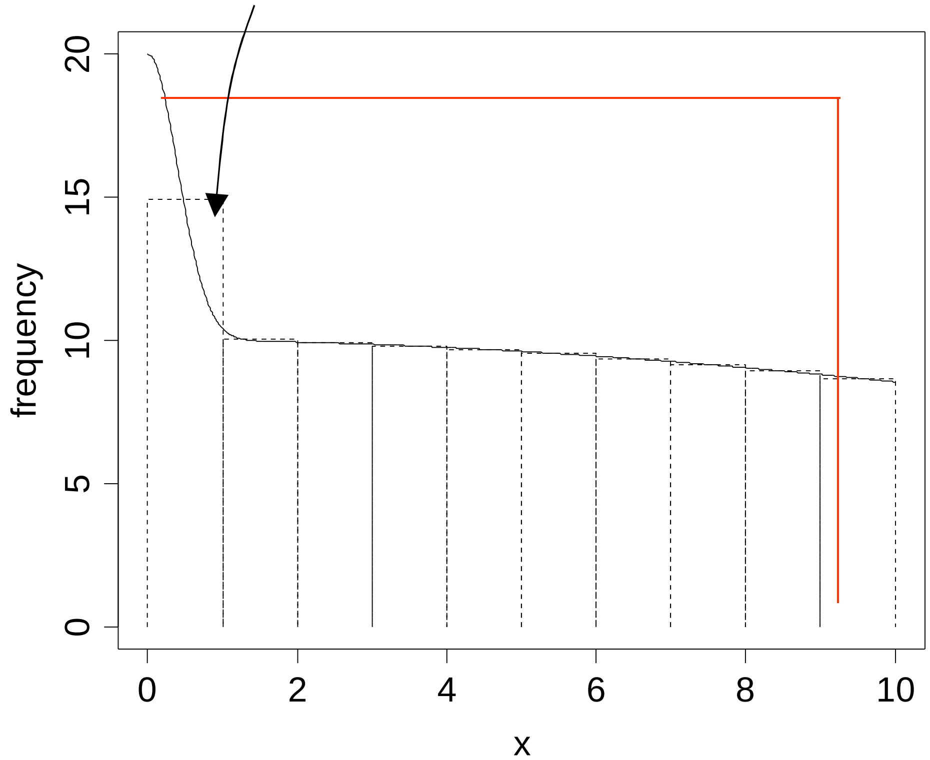
Data that have a wide shoulder are preferable



A wide shoulder makes it easier to estimate area under rectangle (or $f(0)$, etc.)

(1) Reliable estimation of P_a

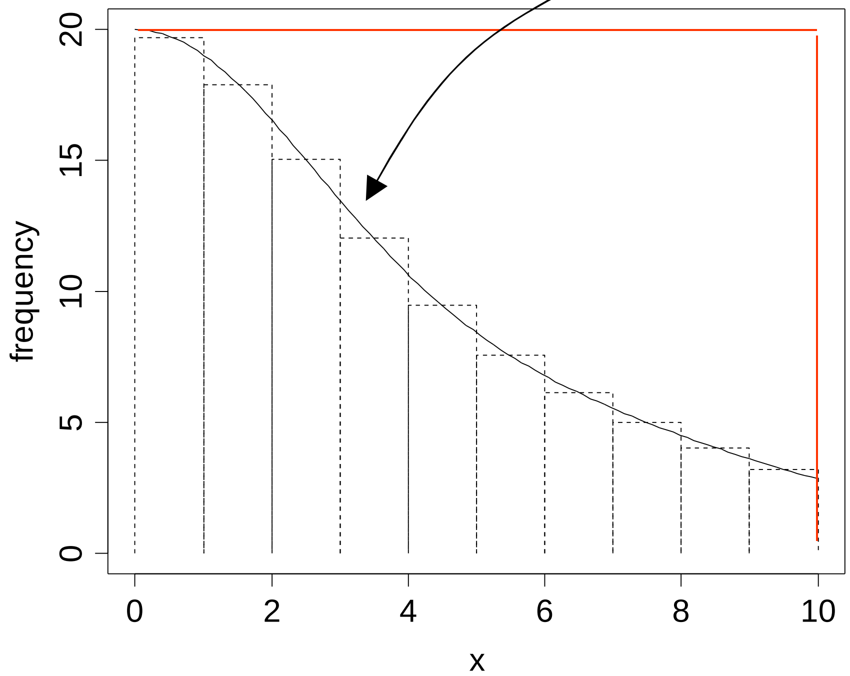
Good field methods will avoid a ‘spike’ like this



Avoid a) rounding distances (and angles) to zero,
b) ‘guarding the trackline’

(1) Reliable estimation of P_a (cont.)

Flexible detection function model can fit the data (see later)



Sample size of observations (~60-80)

- less for detection functions with 'easy' shapes
- more for point transects and 'difficult shapes'.

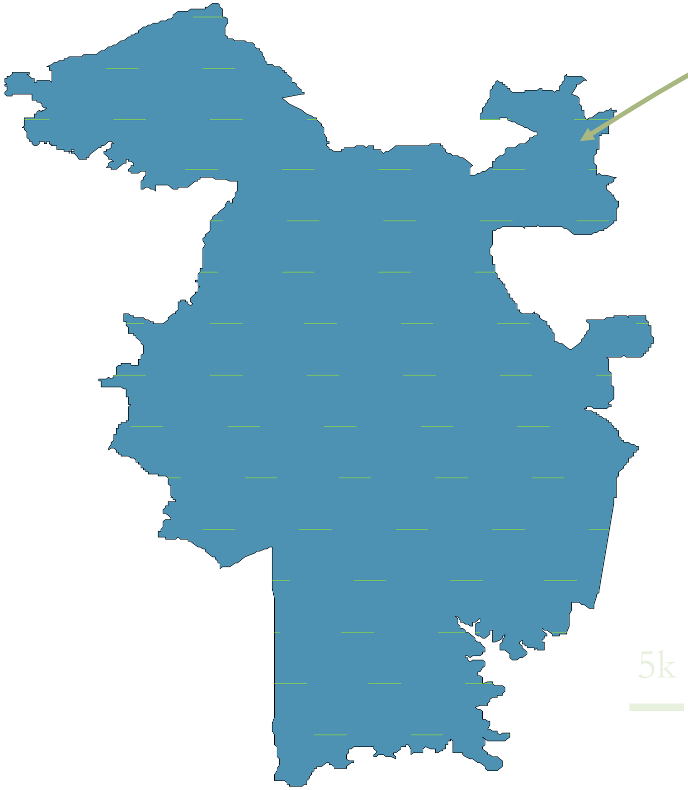
Reliable distance sampling (2)

2. Reliable estimation of N from N_a

In addition to the assumption of randomized design, we would like a 'large' sample of lines or points (20 or more), evenly distributed through the study region

see lecture on survey design

e.g. surveys of tiger prey in India



Photos: Ullas Karanth

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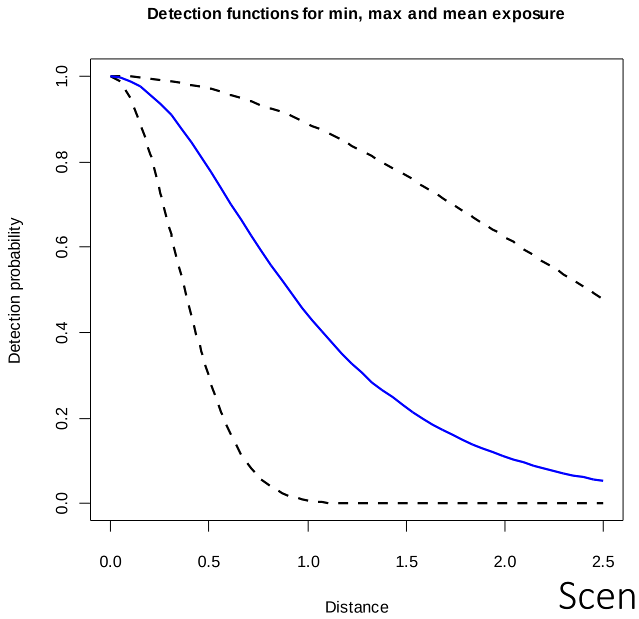
Pooling robustness

Individuals can have quite different detection functions, but this produces little bias (up to a point!)

'Pooling robustness' = robust to pooling of multiple detection functions

e.g. Simulation study (unpublished!) Truth = 1000 animals

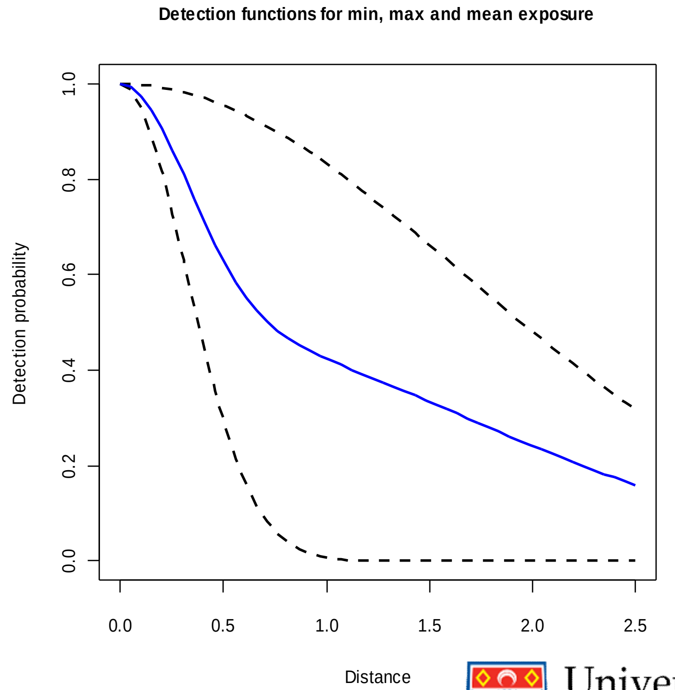


Scenario 1: animals have a gamma distribution of detection functions between min and max shown.

Mean estimate from simulation: 984 animals (SE 2.3). Bias -1.6%

Scenario 2: half of animals have max detection function, half have minimum.

Mean estimate from simulation: 976 animals (SE 2.7). Bias -2.4%



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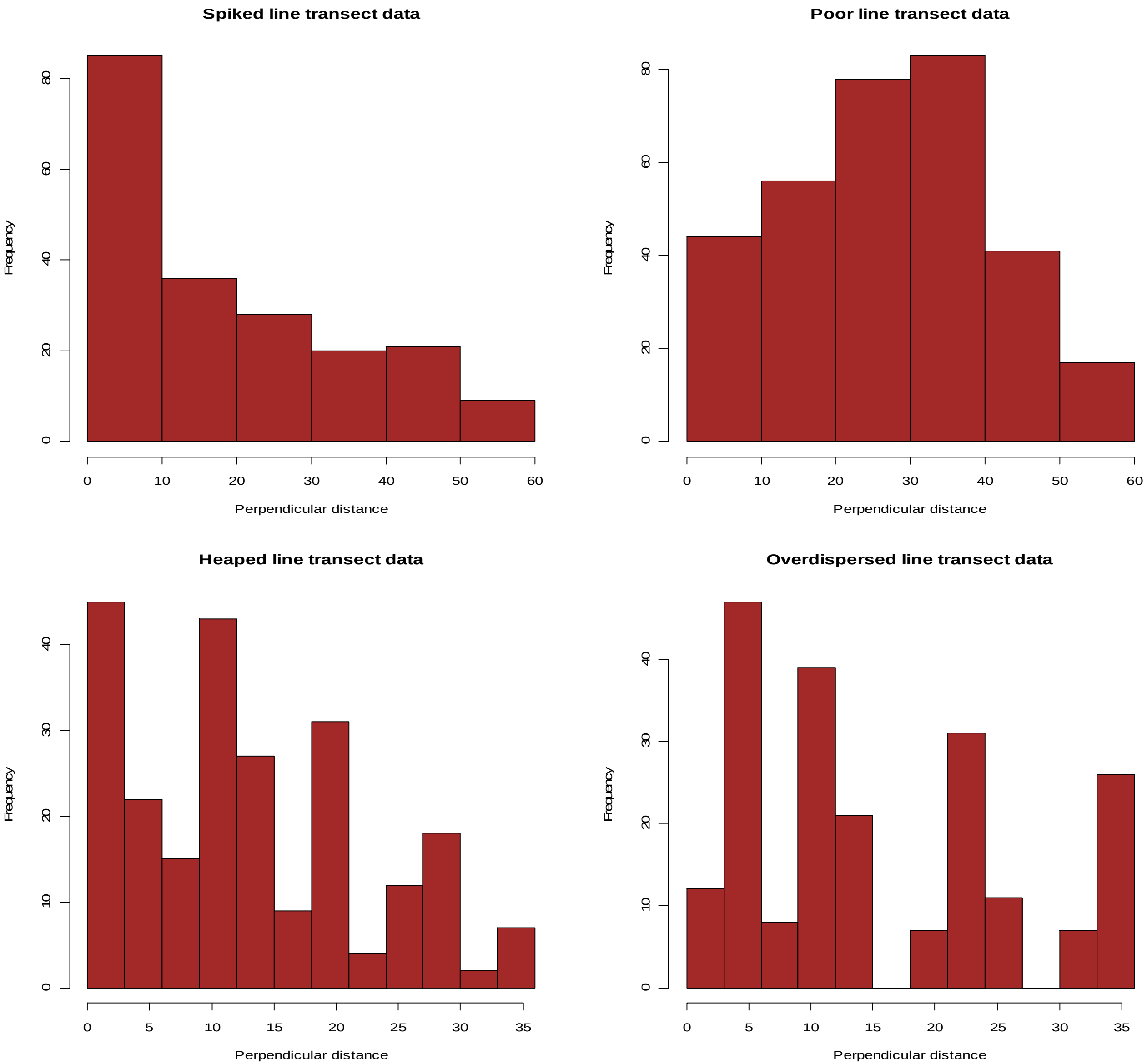
Non-ideal data



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