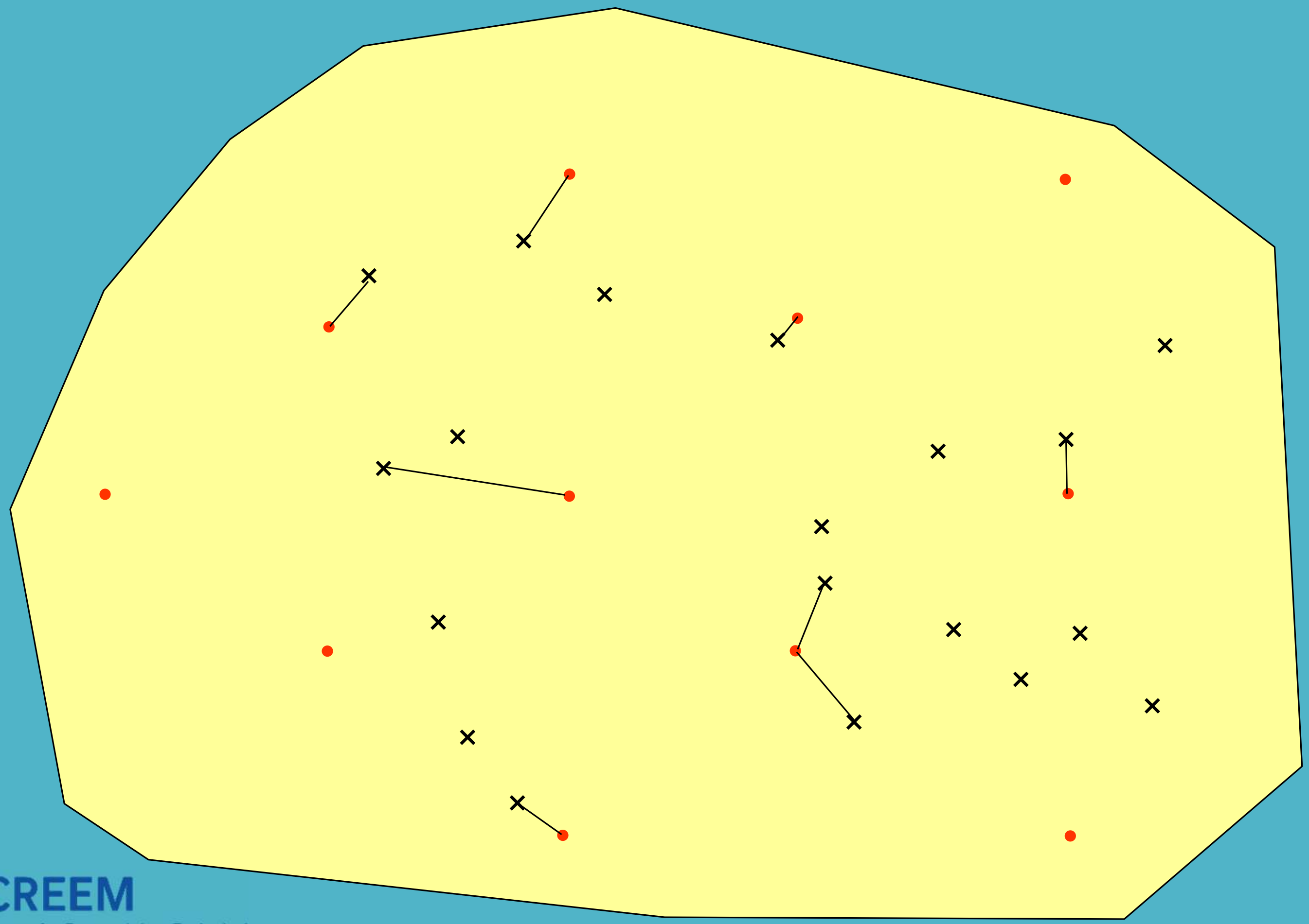
Point transect sampling



Random points or systematic grid of points randomly placed; observer records distance to any detected animals

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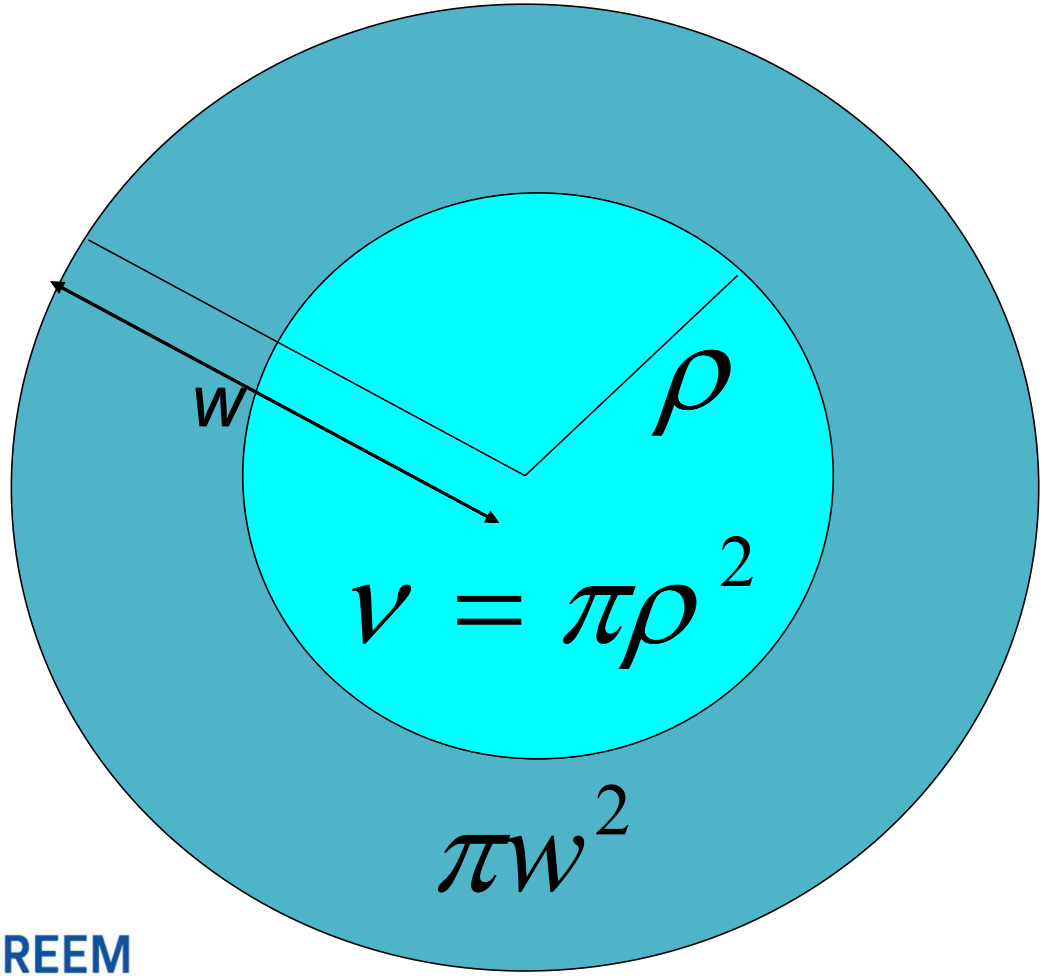
Point transect sampling

For *k* point counts with certain detection to distance *w (plot sampling)*:

$$\hat{D} = \frac{n}{k\pi w^2}$$

How does this change if detection is uncertain?

Effective radius and effective area



ρ = effective radius

ν = effective area

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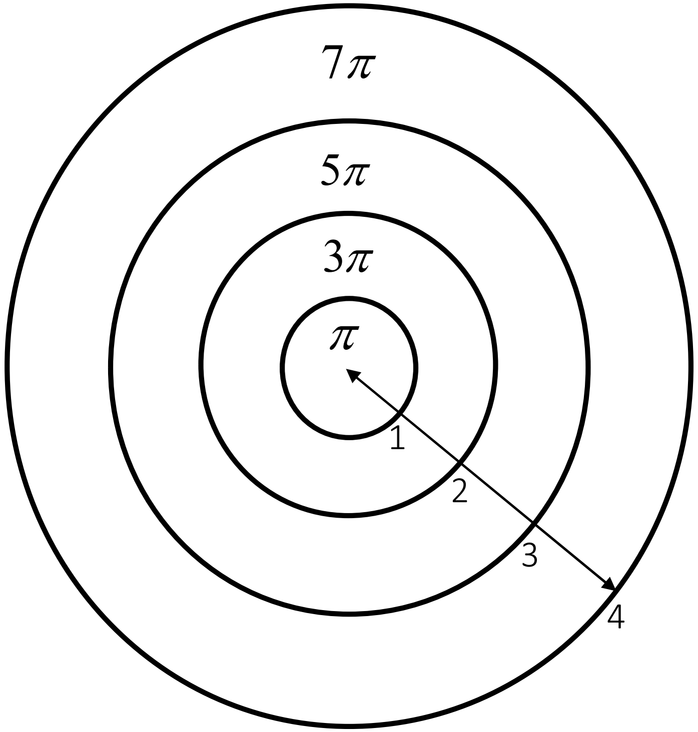
Covered area: $a = k\pi w^2$

Proportion detected: $P_a = \dfrac{k\pi\rho^2}{k\pi w^2} = \dfrac{\rho^2}{w^2}$

Estimated density: $\hat{D} = \dfrac{n}{a\hat{P}_a} = \dfrac{n}{k\pi w^2 \times \hat{\rho}^2 / w^2} = \dfrac{n}{k\pi\hat{\rho}^2}$

Area and hence number of animals increases linearly with distance:



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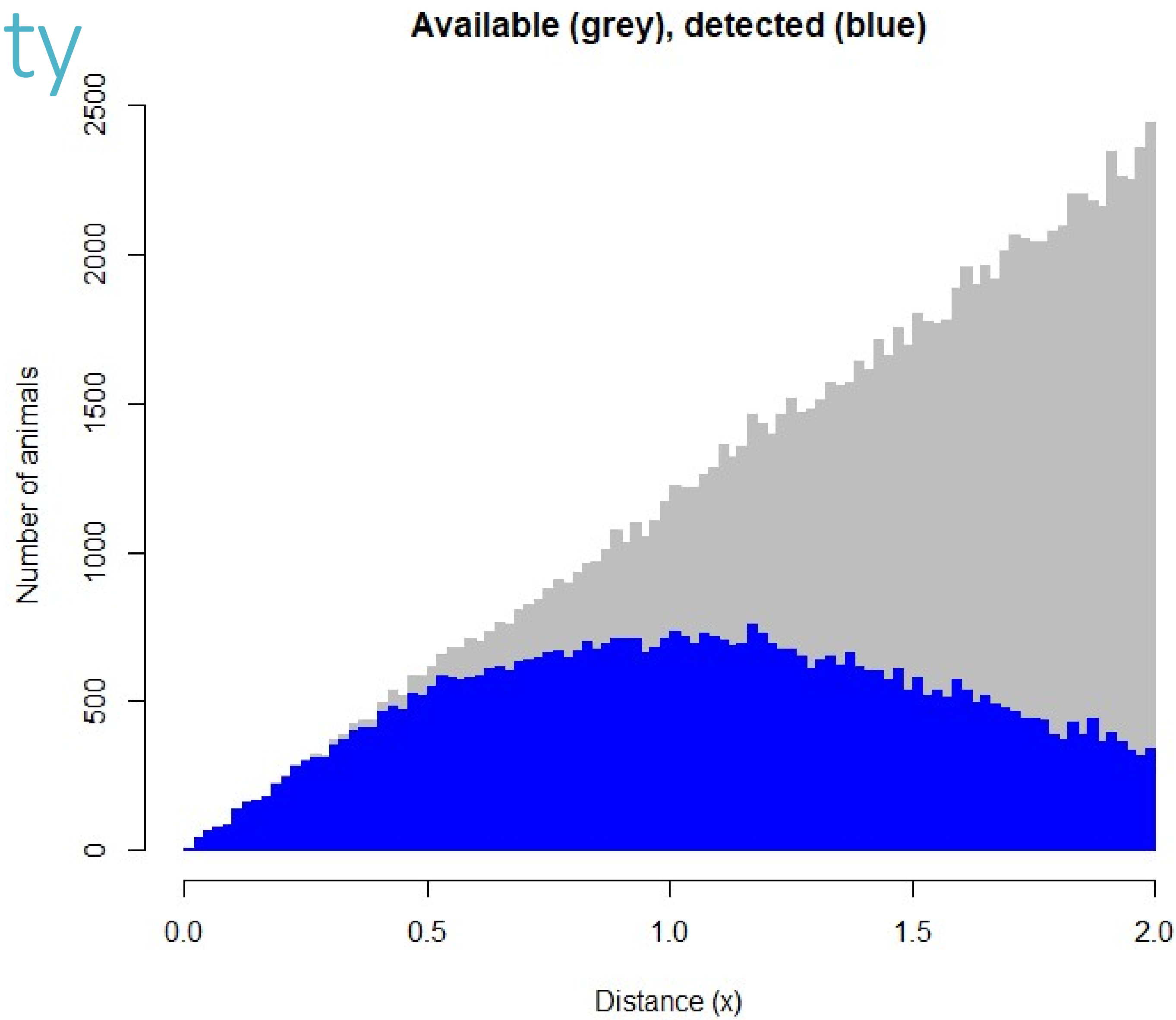
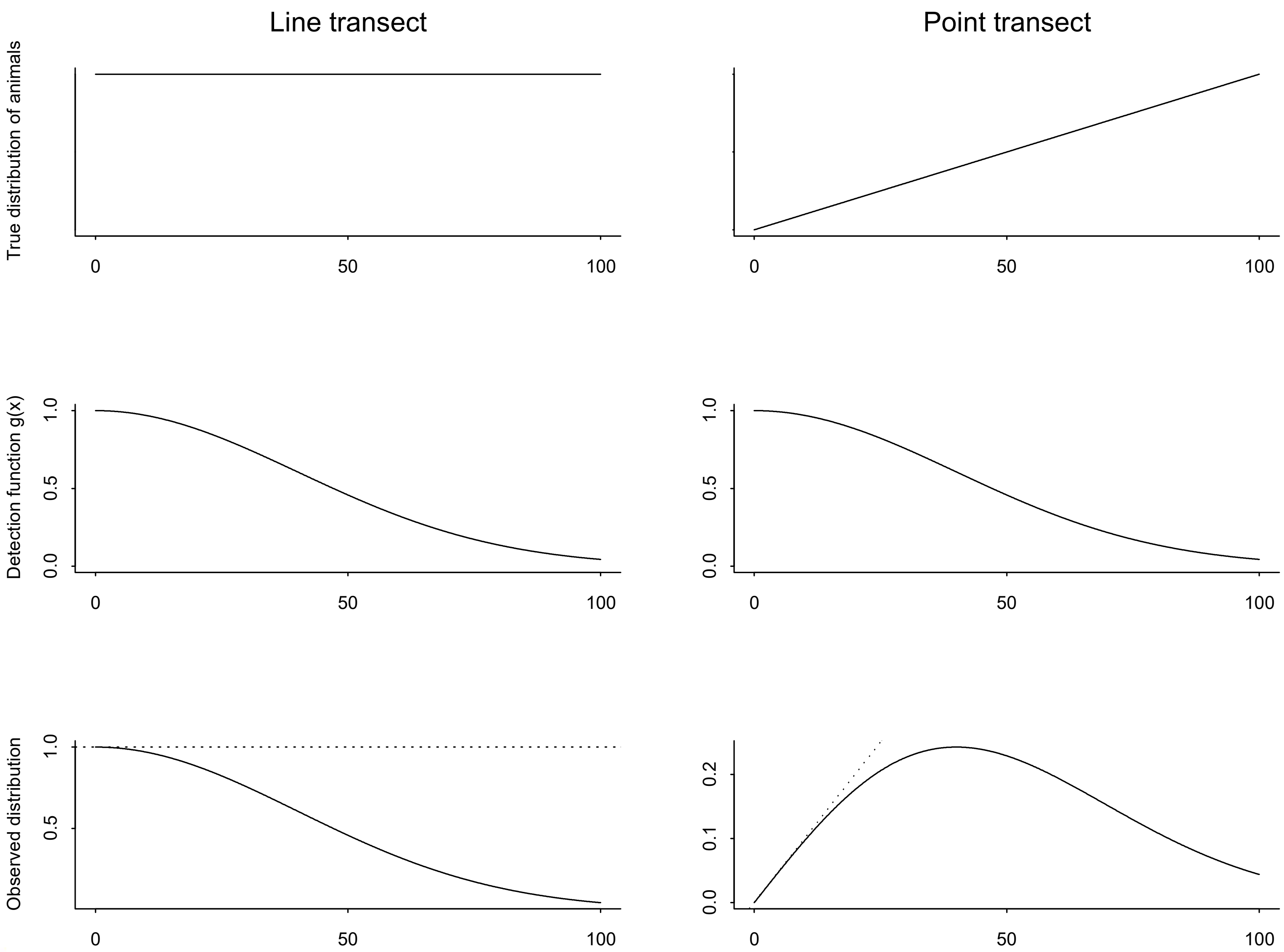
Probability density function





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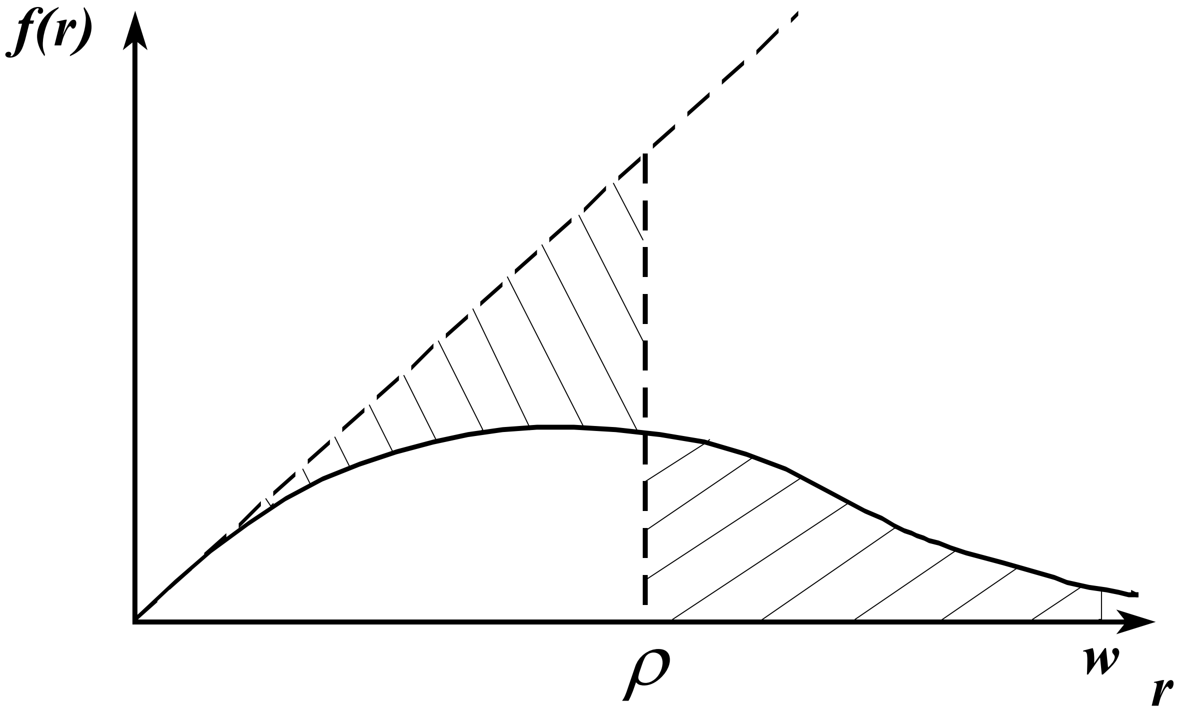
The effective radius ρ …



… is the distance such that as many birds beyond ρ are detected as are missed within ρ of the point.

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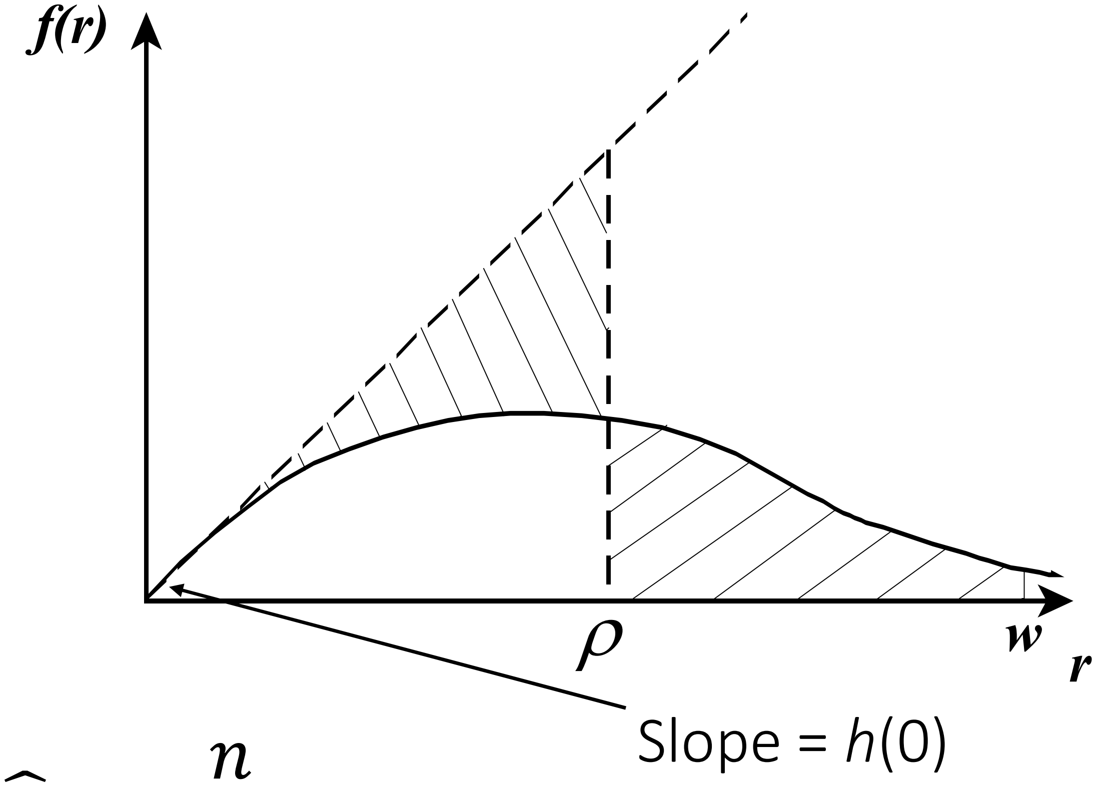
Area under curve:

$$\int_0^w f(r)dr = 1$$

Area of triangle:

$$\frac{\rho \times \rho f'(0)}{2} = \frac{\rho^2 h(0)}{2}$$



Hence $\hat{\rho}^2 = \frac{2}{\hat{h}(0)}$ recall $\widehat{D} = \frac{n}{k\pi\hat{\rho}^2}$

so that $\hat{D} = \frac{n\hat{h}(0)}{2\pi k}$

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Notation: point transects

Known constants and data:

k = number of points

n = no. of animals or clusters detected

r_i = distance of i^{th} detected animal or cluster from the point, $i = 1, \ldots, n$

w = truncation distance for r

A= size of region of interest

a = size of covered region = $k\pi w^2$

s_i = size of i^{th} detected cluster, $i = 1, \ldots, n$

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Point transect notation (continued)

Functions:

$g(r)$ = detection function

$f(r)$ = probability density function (pdf) of detection distances

$h(r) = f'(r)$ = slope of pdf $f(r)$

$h(0)$ = slope of pdf evaluated at $r=0$

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Comparative study[a]

1. Point transect, 5-minute counts (9.8 hrs)
2. Point transect, snapshot method (8.4 hrs)
3. Cue counting, 5 mins per point (10.0 hrs)
4. Line transect sampling (7.9 hrs)
5. Territory mapping

[a]Buckland, S.T. 2006. Point-transect surveys for songbirds: robust methodologies. The Auk 123:345-357.

Focal species in Montrave study

Chaffinch
Fringilla coelebs

Robin
Erithacus rubecula

Great tit
Parus major

Wren
Troglodytes troglodytes

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Study area, Montrave Estate

Parkland and
mixed woodland
33.2 ha
k = 32 points

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The data

	Chaffinch	Great tit	Robin	Wren
5min (w=110m) n:	74	44	57	132
Snapshot (w=110m) n:	63	18	50	117
Cue count (w=92.5m) n:	627	177	785	765
Cue rate:				
Sample size	33	12	26	43
Mean	7.9	8.2	17.9	7.3
Line transect (w=95m) n:	73	32	80	155
Territories:	25	7	28	43

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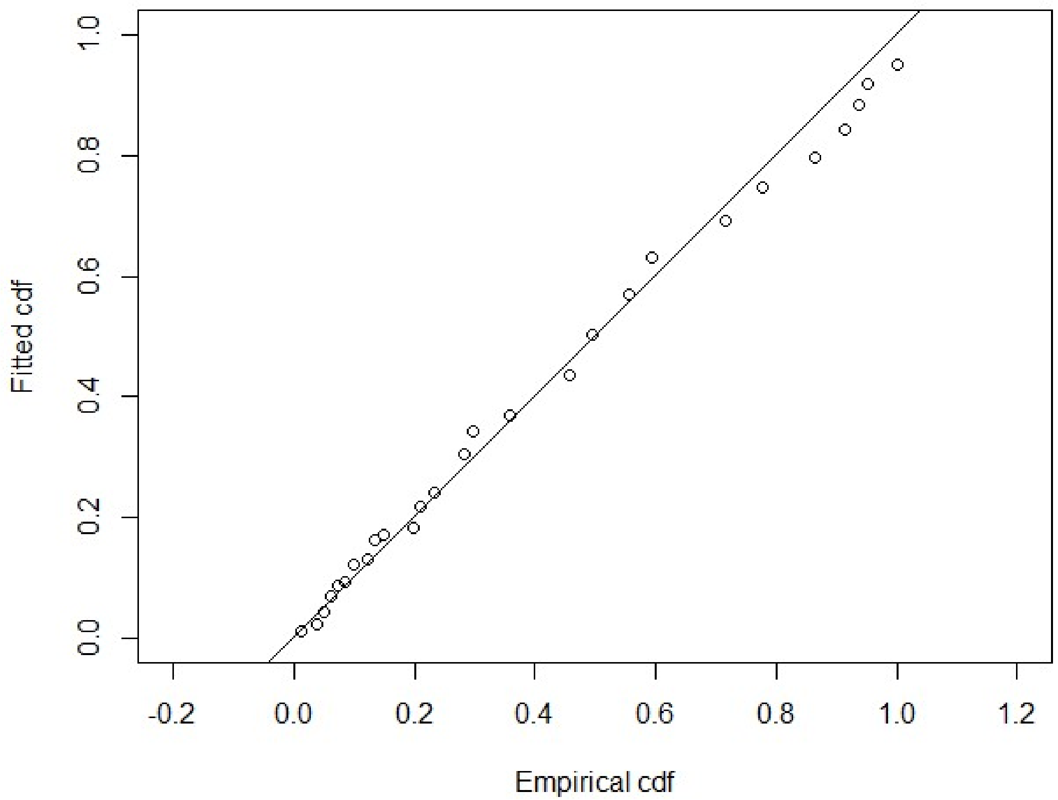
Example analyses: chaffinch



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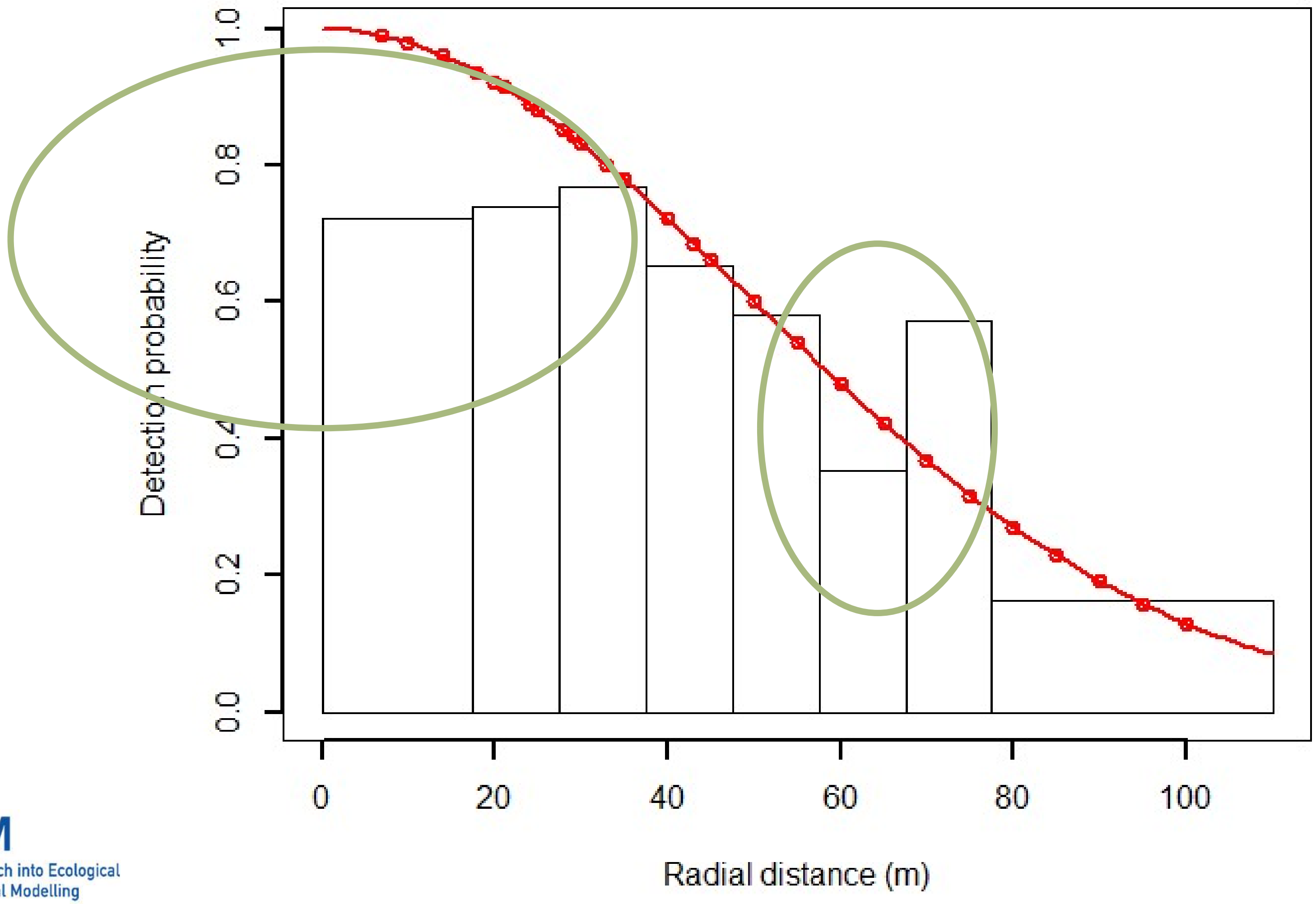
K-S and C-von M tests

```
Distance sampling Kolmogorov-Smirnov test
Test statistic = 0.0978209 p-value = 1
 (p-value calculated from 100/100 bootstraps)

Distance sampling Cramer-von Mises test (unweighted)
Test statistic = 0.119375 p-value = 0.497973
```

Detection function



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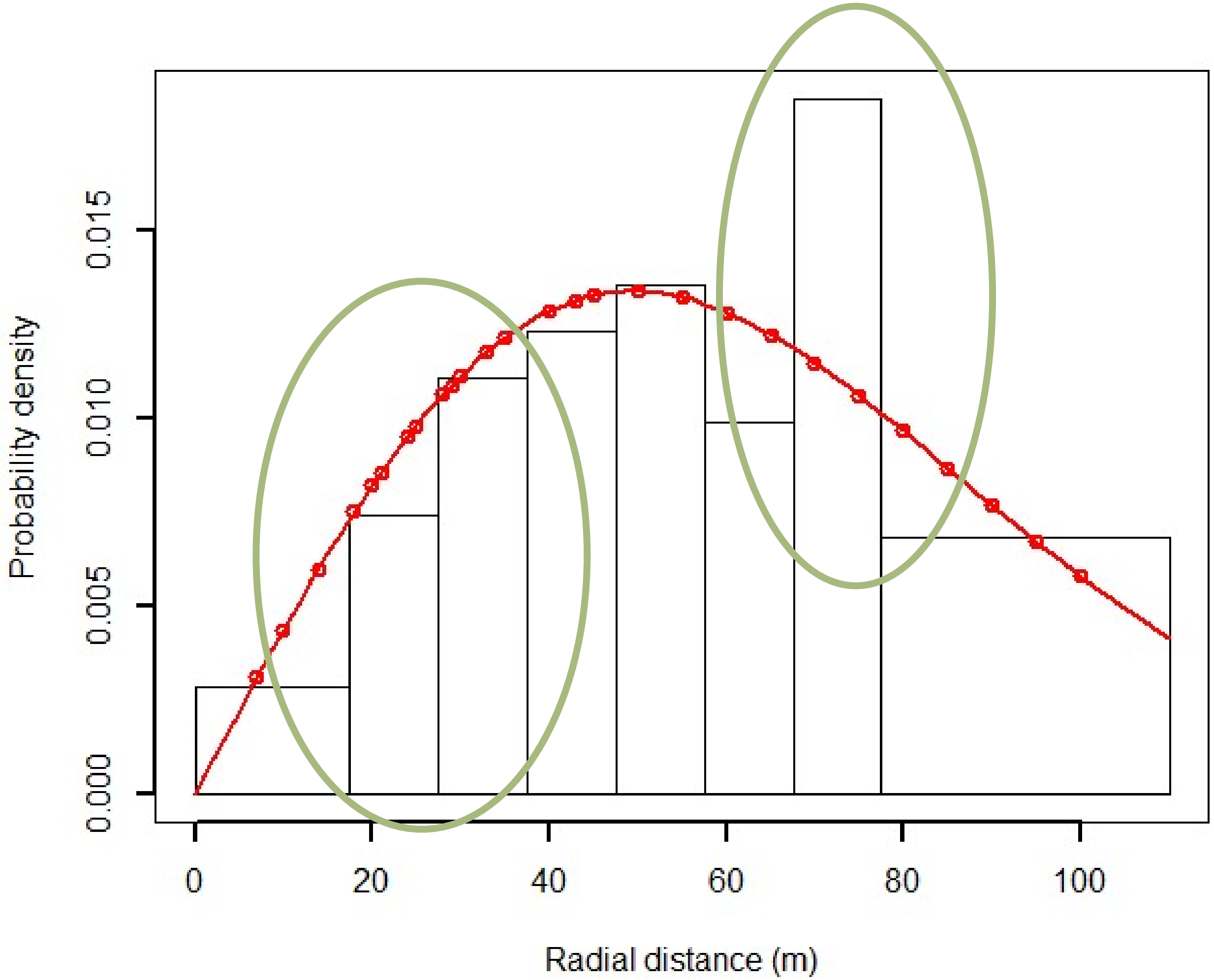
Probability density function



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Chi-square gof test

```
Goodness of fit results for ddf object

Chi-square tests
            [0,17.5] (17.5,27.5] (27.5,37.5] (37.5,47.5]
Observed  4.0000000   6.0000000   9.0000000 10.00000000
Expected  5.3587946   7.2910947   9.4176515 10.57407254
Chisquare 0.3445407   0.2286248   0.0185219  0.03116673

            (47.5,57.5] (57.5,67.5] (67.5,77.5]  (77.5,110]
Observed  11.000000000   8.0000000   15.000000 18.00000000
Expected  10.768415022  10.1474426    8.946303 18.49622571
Chisquare  0.004980455   0.4544504    4.096356  0.01331298

              Total
Observed  81.000000
Expected  81.000000
Chisquare  5.191954

P = 0.51944 with 6 degrees of freedom
```

Estimation summary

```
Summary for distance analysis
Number of observations :  81
Distance range         :  0  -  110

Model : Half-normal key function
AIC   : 742.9418

                       Estimate          SE         CV
Average p             0.3708652  0.05784886 0.1559835
N in covered region 218.4081865 39.12979423 0.1791590

Summary statistics:
    Region Area CoveredArea Effort  n  k       ER     se.ER     cv.ER
1 Montrave 33.2    243.2849     64 81 32 1.265625 0.1269691 0.1003213

Abundance:
  Label Estimate       se        cv      lcl      ucl       df
1 Total 29.80518 5.527653 0.1854595 20.70305 42.90909 110.9021

Density:
  Label  Estimate        se        cv       lcl      ucl       df
1 Total 0.8977464 0.1664956 0.1854595 0.6235858 1.292442 110.9021
```

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Estimation summary (cont.)

```
Measurement Units
---------------------------------
Density: Numbers/hectares
    EDR: metres

Component percentages of variance:
.Label Detection    ER
 Total      70.74 29.26
```

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Estimated densities

Method	Chaffinch		Great Tit		European Robin		Winter Wren	
	$\hat{D}$	95% CL	$\hat{D}$	95% CL	$\hat{D}$	95% CL	$\hat{D}$	95% CL
Conventional point sampling	1.03	0.74-1.43	0.58	0.36-0.94	0.52	0.26-1.06	1.29	0.80-2.11
Snapshot	0.90	0.62-1.29	0.22	0.13-0.39	0.60	0.38-0.94	1.02	0.80-1.32
Cue-count	0.71	0.45-1.23	0.26	0.09-0.76	0.82	0.52-1.31	1.21	0.82-1.79
Line transect	0.64	0.46-0.90	0.26	0.16-0.42	0.69	0.47-1.00	1.07	0.87-1.31
Territory mapping	0.75		0.21		0.84		1.30	

Estimated hours of fieldwork to obtain a 10% CV for estimated density

Method	Common chaffinch	Great tit	European robin	Winter wren
Conventional point sampling	28	60	131	61
Snapshot	29	70	44	14
Cue-count	56	352	57	40
Line transect	22	49	29	11

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Simulation study, three investigations

1. All assumptions satisfied:
   half-normal model, 1000 replicates

2. Overlapping points:
   Point separation 100m, effective detection radius 106m

3. Edge effect (similar to Montrave study area):
   no sampling in buffer zone, birds detected outside study area boundary not recorded

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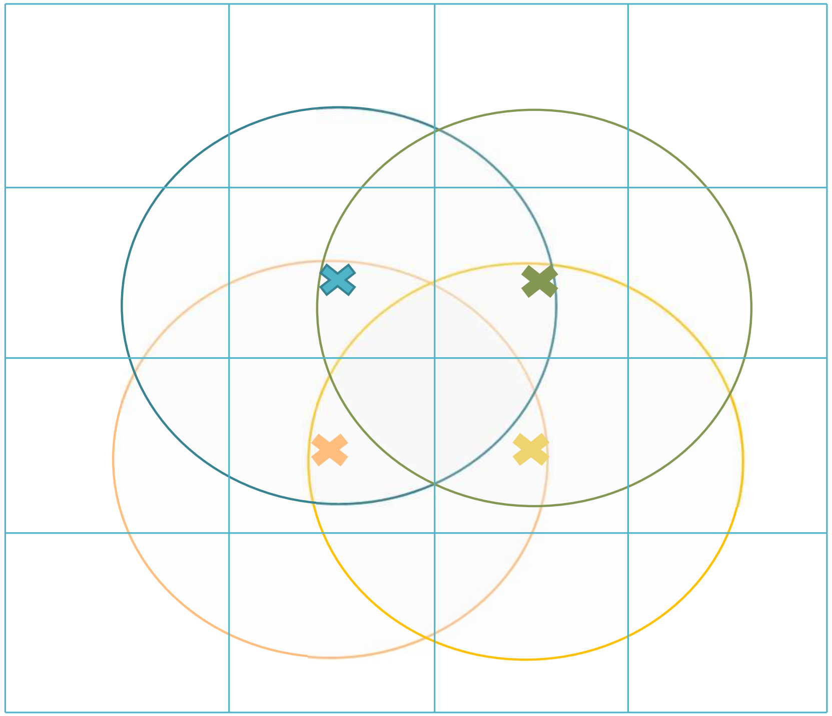
Overlapping point transects



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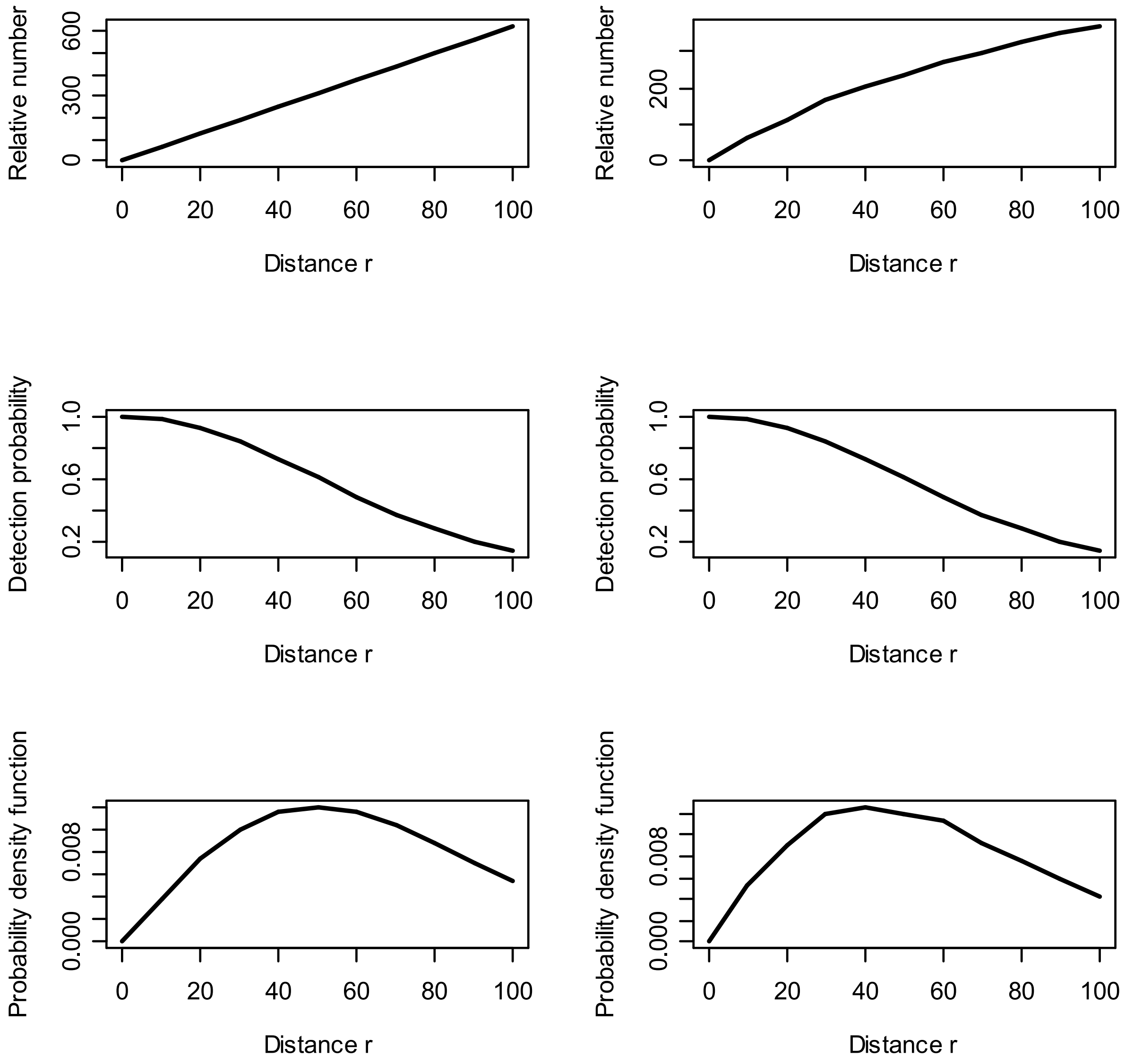
Edge effect simulation



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Simulation results – true density = 1

	Popn 1	Popn 2	Popn 3	Popn 3, *w*=80m
$\bar{n}$	353	354	41	32
mean	1.0029	1.0056	0.9509	0.9961
sd	0.0706	0.0815	0.1924	0.3160
se(mean)	0.0022	0.0026	0.0061	0.0100
mean(se)	0.0754	0.0750	0.2099	0.3557

Popn 1: all assumptions hold
Popn 2: overlapping plots
Popn 3: edge effect

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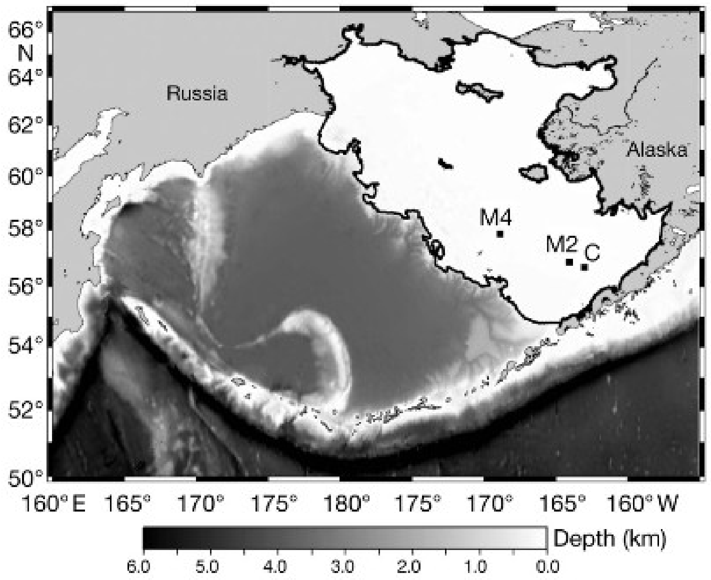
Point transects with marine mammals

- Seafloor mounted acoustic recording packages deployed and listening for right whale “up-calls”
- Example of cue counting
- Analysis incorporated
  - false-positive proportion in call classification,
  - ambient noise as covariate,
  - left truncation because of inexact distance estimation at small distances



Not a recommended allocation of survey effort; proof of concept

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Right whale abundance estimates

- Detection probability of 0.29 (CV=2%) from fitted model
- Density estimate of 0.26 whales per 10000km^2 (CV=29%)
- Abundance in shelf region of Bering Sea: 25 (CI: 13-47)

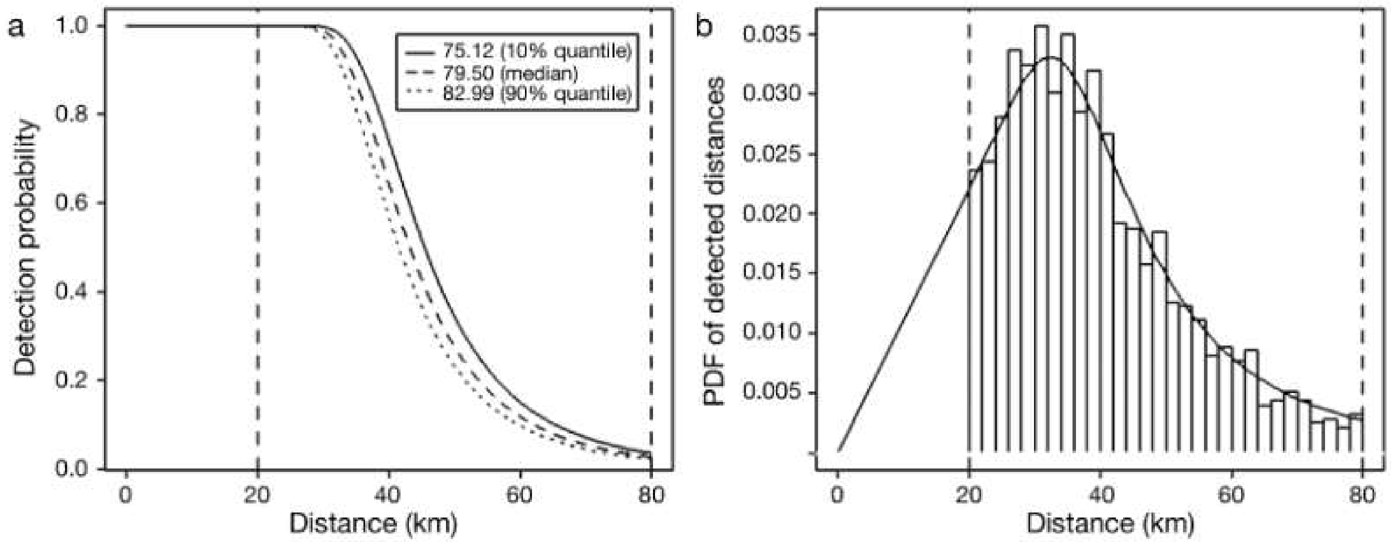

Fig. 2. Distances to detected right whale calls and fitted model: (a) shows the detection function (as a function of distance, for 3 values of the noise covariate, namely the 10, 50, and 90% quantile of the observed distribution) and (b) corresponds to the probability density function (PDF) of detection distances, and goodness-of-fit could be judged based on this plot. Vertical dashed lines represent the left and right truncation distances

See Marques, Munger, Thomas, Wiggins and Hildebrand (2011) Estimating North Pacific right whale density using passive acoustic cue counting. Endangered Species Research 13:163-172.

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Camera traps as point transects

Methods in Ecology and Evolution
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Research Article | Free Access

Distance sampling with camera traps

Eric J. Howe, Stephen T. Buckland, Marie-Lyne Després-Einspenner, Hjalmar S. Kühl

First published: 10 May 2017 | https://doi.org/10.1111/2041-210X.12790 | Citations: 39

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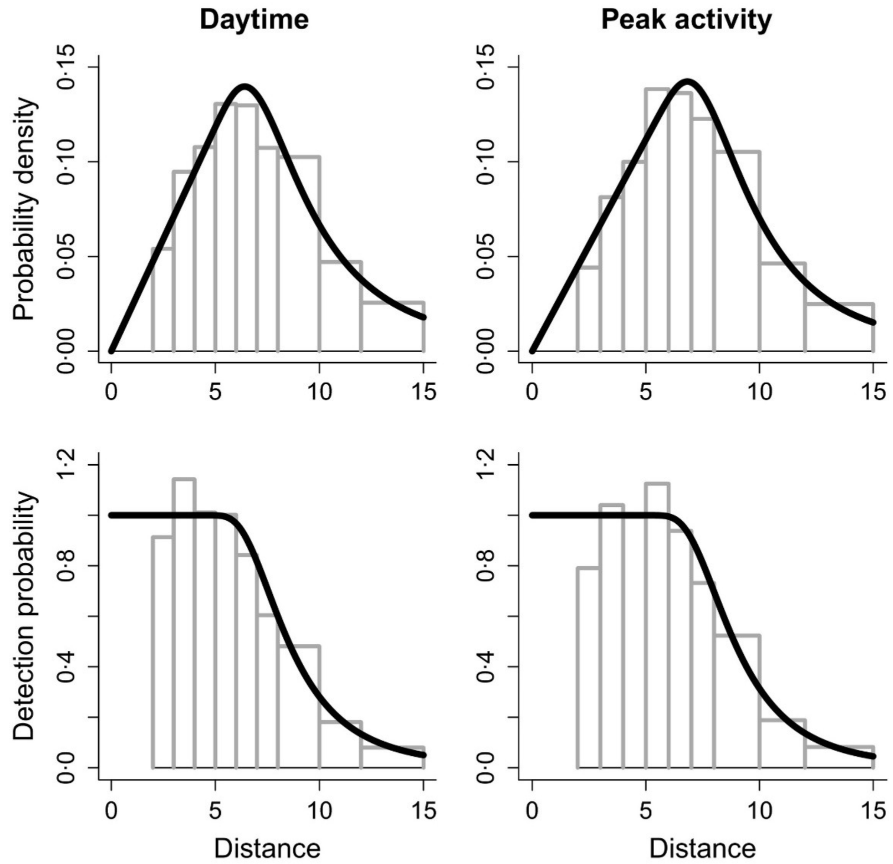
Summary

1. Reliable estimates of animal density and abundance are essential for effective wildlife conservation and management. Camera trapping has proven efficient for sampling multiple species, but statistical estimators of density from camera trapping data for species that cannot be individually identified are still in development.
2. We extend point-transect methods for estimating animal density to accommodate data from camera traps, allowing researchers to exploit existing distance sampling theory and software for designing studies and analysing data. We tested it by simulation, and used it to estimate densities of Maxwell's duikers (*Philantomba maxwellii*) in Taï National Park, Côte d'Ivoire.



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