Assessing trends in otter *Lutra lutra* populations: range edge surveys and occupancy/detectability models

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Habitats Directive

ART. 11
"…surveillance of the conservation status of the natural habitats and species…"

ART. 17
"Every six years… a report on the implementation of the measures taken under this Directive. This report shall include… the main results of the surveillance referred to in Article 11."

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Report under art. 17

The report under art. 17 of Habitats Directive requires 6 years TREND assessment

RANGE **POPULATION**

ETC/BD treated member states' data Mammals, Lutra lutra, Mediterranean. Annex: II*, IV

MS	RANGE (km²)				POPULATION				HABITAT (km²)				Future prosp.	Overall assesm.	Grids spatial data (km²)				Quality		
	Surface	%XR	TREND	Ref.	Size&Unit	%XP	TREND	Ref.	Area	%XH	TREND	Suitable			Range	%GR	Distribution	%GD	Range	Population	Habitat
FR	9557	6.3	+	<9557	N/A x	N/A	+	<	N/A	N/A	N/A	N/A	Poor	FV	23200	8.3	12400	5	P (1990-2006)	M ()	M ()
EL	28548	18.7	X	N/A	317 - 317 grids	N/A	X	N/A	N/A	N/A	X	N/A	Unk.	XX	33400	11.9	33400	13.4	P (12/2006)	P (12/2006)	()
IT	30636	20	+	N/A	317 - 317 loc.	N/A	+	N/A	N/A	N/A	N/A	N/A	Poor	U1+	30800	11	16000	6.4	G (12/2006)	G (12/2006)	()
PT	84138.33	55	=	~84138.33	2000 - 10000 indiv.	N/A	X	~10000	4060.24	100	=	8120.48	Good	FV	193600	68.9	188000	75.3	P (2005)	P (2005)	M (2005

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Status of a population

DEMOGRAPHIC STUDIES OF WILDLIFE POPULATIONS

3 **LEVELS** for data collection	**STATE VARIABLES** to characterize current status of a population
A. individual organisms →	abundance
B. individual species →	**occupancy** (or extent of occurrence)
C. the ecological community or multiple species →	species richness

MacKenzie *et al.* 2005

OCCUPANCY

OCCUPANCY is the proportion of area or sites occupied by a specie

e.g. (x occupied 10 km squares/y of total squares)

The occupancy parameter is a surrogate of species range or population size

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OCCUPANCY

OCCUPANCY is a useful parameter to assess otter status and trends

STANDARD SPRAINT SURVEYS provide relatively reliable and low-cost presence-absence data, enabling national scale assessment of otter distribution and **occupancy**

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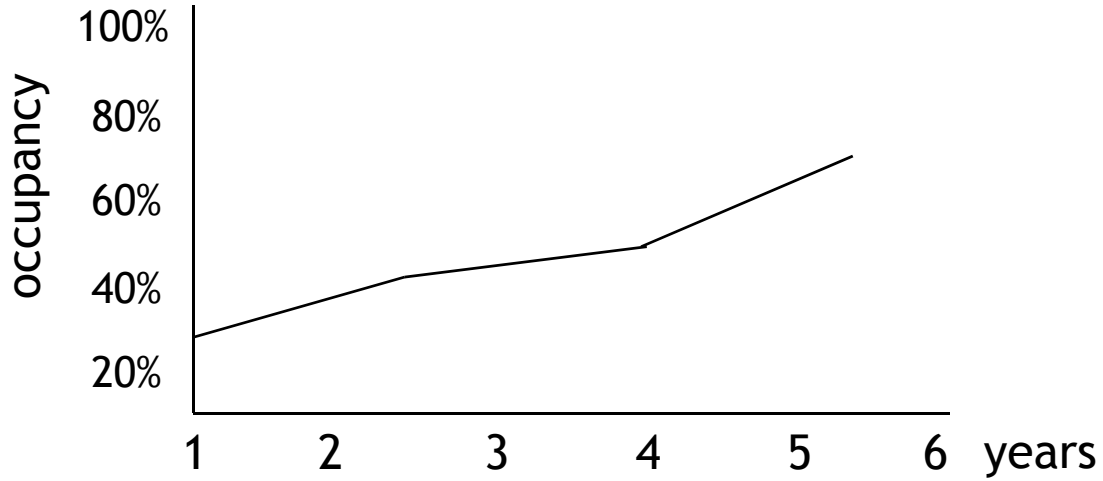
TRENDS IN OCCUPANCY

However, to assess TRENDS in site occupancy, (e.g. range expansion or contraction), it is necessary to **REPEAT SURVEYS over different points in time** with consequent <u>increase in effort and cost</u>!



at least two sampling seasons or preferably more than two

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ASSESSING TRENDS

Vital rates of occupancy dynamics

LCR - LOCAL COLONISATION RATE

e.g. the proportion of colonized 10 km-squares by otter in a defined timeframe

LER - LOCAL EXTINCTION RATE

e.g. the proportion of 10 km-squares where the otter go extinct in a defined timeframe

Trend = LCR – LCR,
or occupancy at time1/occupancy at time 2

Therefore, to assess and investigate TRENDS, these parameters are to be estimated

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ASSESSING TRENDS

TWO OR MORE REPEATED SURVEYS for the entire country in a 6-year period

may be EXPENSIVE, and NOT COST-EFFECTIVE APPROACH

ASSESSING TRENDS

CORE VS RANGE PERIPHERY

The biogeographical and ecological literature reports that the distribution centre is stable over the time and colonization and extinction events occur at range boundaries (e.g. Brown 1996)

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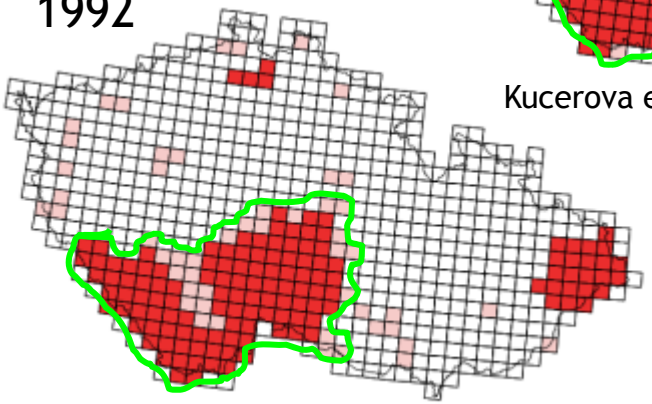
ASSESSING TRENDS

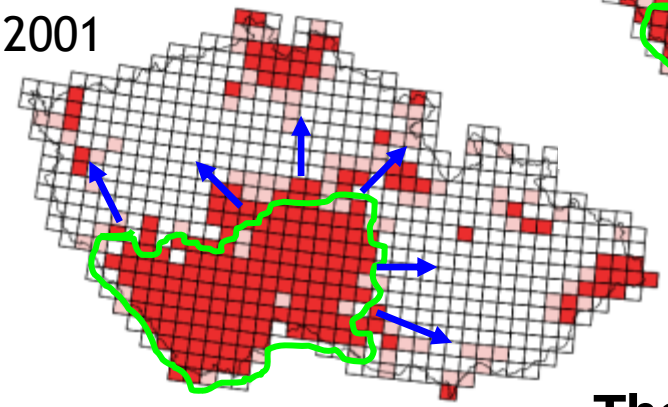
CORE VS RANGE PERIPHERY

Czech otter expansion

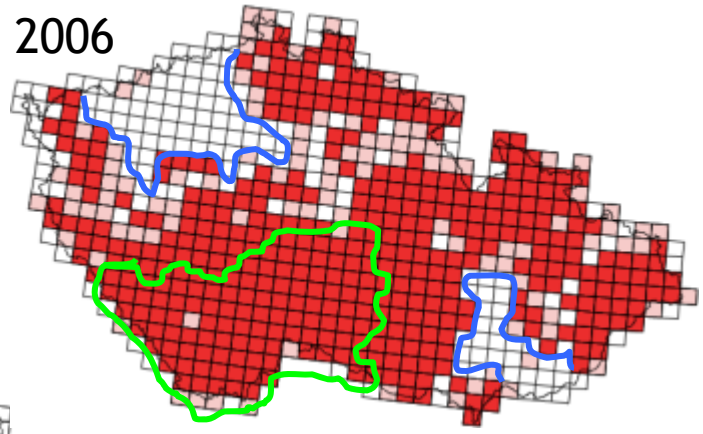
Polednikova et al., Okrana Pryrody 62 (3), 2007



Toman 1992



Kucerova et al. 2001



Polednik et al. 2006

The Czech core area of otter distribution was stable.
Many colonization events occurred at the periphery (range edges)

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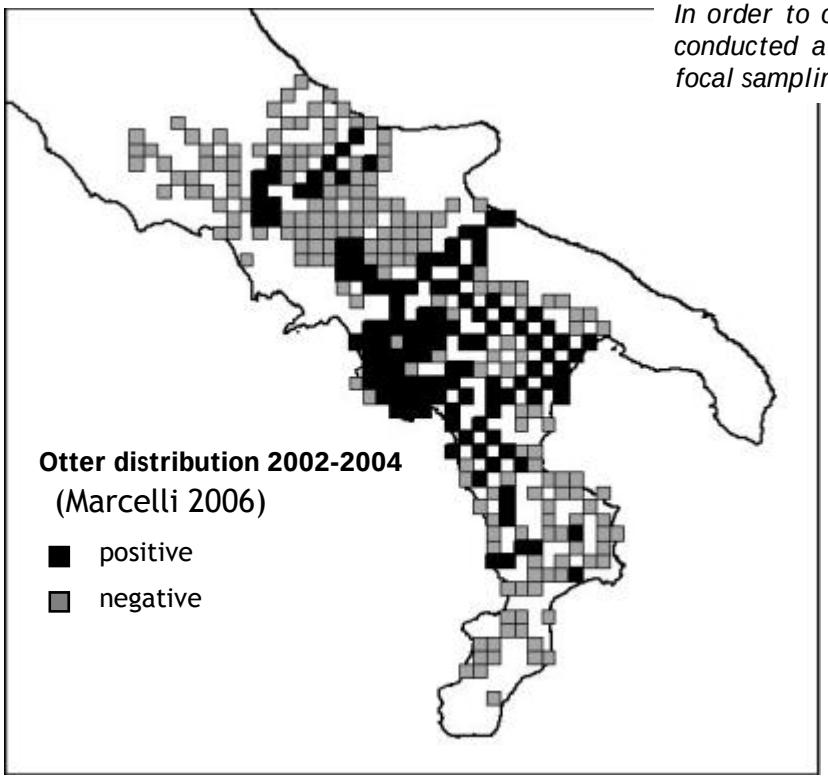
ASSESSING TRENDS

CORE VS RANGE PERIPHERY

How to optimize survey effort in assessing otter trends?

CORE VS RANGE PERIPHERY

Italian example



Optimizing survey effort: edge areas selection

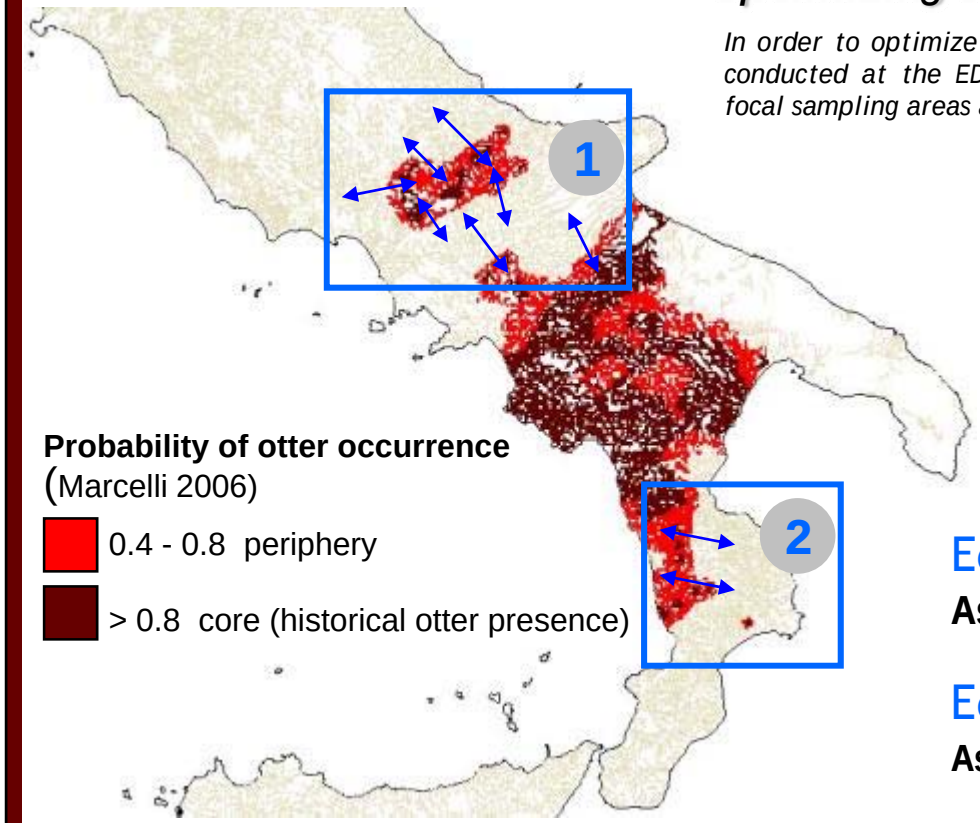
In order to optimize sampling efforts, REPEATED SURVEYS may be conducted at the EDGES of otter range distribution by selecting focal sampling areas and monitoring objectives

ASSESSING TRENDS

Range edge surveys

CORE VS RANGE PERIPHERY

Italian example



Optimizing survey effort: edge areas selection

In order to optimize sampling efforts, REPEATED SURVEYS may be conducted at the EDGES of otter range distribution by selecting focal sampling areas and monitoring objectives

Edge area 1

Assessing northern expansion/contraction

Edge area 2

Assessing southern expansion/contraction

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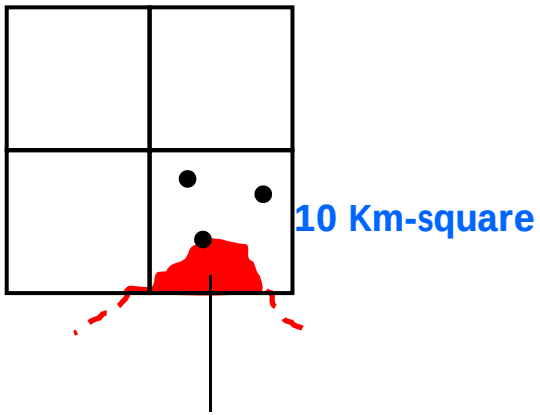
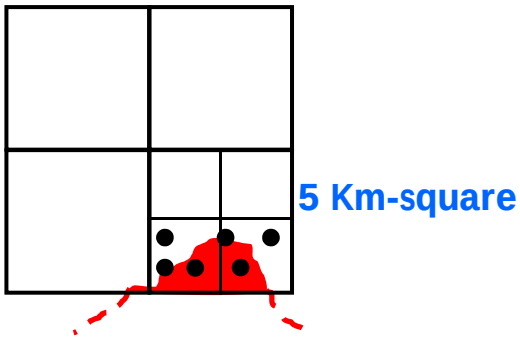
RANGE EDGE SURVEYS *selecting survey scale*

Detecting slow rates of otter populations within a 6-year period may be difficult at the standard scale of 10 km





The probability of detecting the new otter area is greater in the 5 km sampling scheme than in the 10 km sampling scheme

Edge surveys should be conducted at finer spatial scales (e.g. 5 km)

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RANGE EDGE SURVEYS *dealing with low detectability*

PROBLEM: DETECTION NOT 100% ACCURATE

"A species may go undetected in a survey of sampling unit even when the species is actually present within the unit"

(FALSE ABSENCE)

MacKenzie *et al.* 2005

ISSUE FOR STANDARD OTTER SURVEYS: the probability of detecting spraints given otter presence (detection probability), is less than one

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RANGE EDGE SURVEYS *dealing with low detectability*

The probability of detecting spraints, or the probability of collecting false absences, is dependent upon several factors

- surveyor skill
- season (e.g. Fusillo *et al.* 2007)
- environmental conditions
- geographic location in the species range

RANGE EDGE SURVEYS *dealing with low detectability*

Typically, unaccounted for false absences will lead to **underestimates of the true level of occupancy**

Furthermore, the **relative change in occupancy will only be valid if the detection probability is constant over time**

Naïve estimates (positive squares/tot squares) of occupancy and trends are biased

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RANGE EDGE SURVEYS *dealing with low detectability*

$$\text{TREND} = \frac{(\text{True occupancy})_1}{(\text{True occupancy})_2} = \frac{\text{naïve estimation} * p_1}{\text{naïve estimation} * p_2}$$

p = detection probability

For example, if surveyor skill or sampling effort increase in recent surveys ($p2 > p_1$) false recovery of otter may be declared

estimation of p is necessary!

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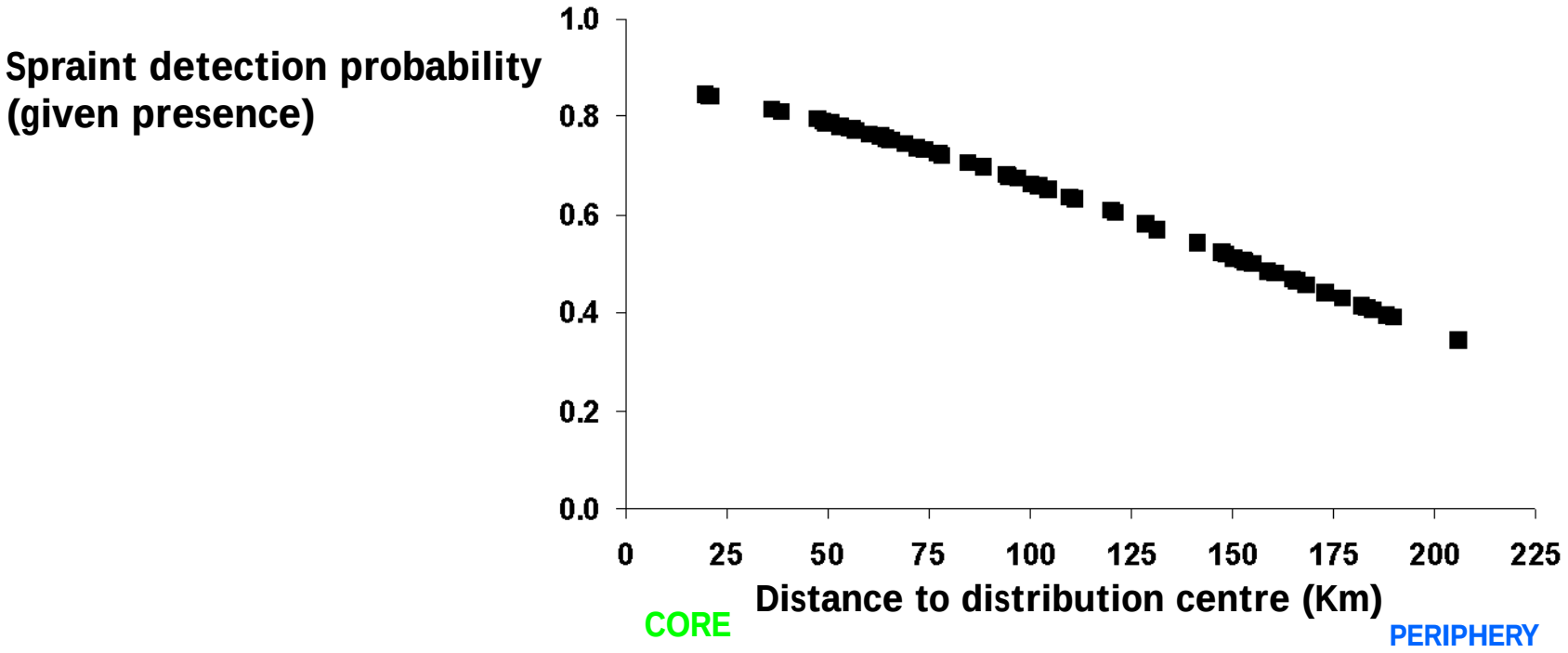
RANGE EDGE SURVEYS *dealing with low detectability*

The probability of spraint detection (given otter presence) may be especially low at the EDGES OF SPECIES DISTRIBUTION, due to low local population abundance.

RANGE EDGE SURVEYS *dealing with low detectability*

In Italy we found up to 70% probability of collecting false absences at distribution edges



Modified from Marcelli 2006

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Consequences of low detectability at range edges

1 Range size will be underestimated

2 Colonization events may be undetected

3 Temporal variation in detection probability can lead to biased estimates of trends in occupancy

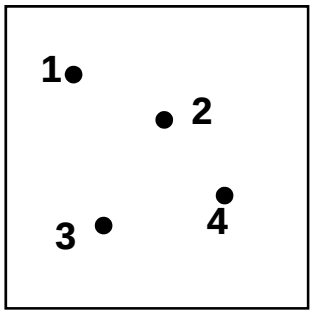
RANGE EDGE SURVEYS *dealing with low detectability*

Minimizing false absences: multiple surveys

To counter the effect of imperfect detection, one solution has been to conduct multiple surveys of the sampling units within a relatively short time frame (sampling season) to minimize the possibility of false absence (e.g. Polednik et al 2006 for otters)

Multiple visits

10 Km-square (sampling unit)



PROBLEM: How many visits and which site type (bridge, 600 m stream stretch etc) give some confidence, eg 95% probability of detecting spraints if otter is present?

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RANGE EDGE SURVEYS *dealing with low detectability*

Modeling approach: detection probability estimation

There have been a number of recently developed techniques (e.g. Azuma *et al.* 1990, Mackenzie *et al.* 2002; Royle and Nichols 2003; Tyre *et al.* 2003) that advocate a more efficient use of multiple visits data **estimating detection probability that lead to unbiased estimate of occupancy and trends**

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RANGE EDGE SURVEYS *dealing with low detectability*

The modeling approach as described by Mackenzie *et al*. (2002, 2003) is the most flexible

MacKenzie D.I., Nichols J.D., Lachman G.B., Droege S., Royle J.A. and Langtimm C.A. 2002. Estimating site occupancy rates when detection probabilities are less than one. Ecology 83: 2248–2255.

MacKenzie D.I., Nichols J.D., Hines J.F., Knutson M.G.., Royle J.A. and Franklin A. D. 2003. Estimating site occupancy, colonization and local extinction when a species is detected imperfectly. Ecology 84: 2200–2207.

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OCCUPANCY/DETECTABILY MODELS

Modeling approach: detection probability estimation

Multiple visits data

Site 1		*Site 2*		…
1st	0	1st	0	
2nd	1	2nd	1	
3rd	0	3rd	1	
4th	1	4th	1	
…		…		

0 = non detection

1 = non detection

Multiple surveys

- Simultaneous in a habitat patch (10 km-square)
- Different temporal occasion on a site
- One or more sampling seasons

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OCCUPANCY/DETECTABILY MODELS

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Estimation-based approach
(Mackenzie et al. 2002, 2003)

- Likelihood estimation
- Logistic regression

PRESENCE software
http://www.proteus.co.nz/

ENVIRONMENTAL COVARIATES

Temporal and spatial covariates (e.g. season, habitat) for both p and occupancy

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OCCUPANCY/DETECTABILY MODELS

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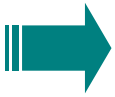

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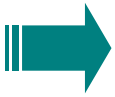

Sampling season detection probabilty/ies

p1, p2 ...

Unbiased estimate of occupancy and trends
point estimate and interval confidence

OCCUPANCY/DETECTABILY MODELS

Occupancy/detectability model by MacKenzie has high potentiality for otter ecologists providing a robust and formal statistical approach:

- **Unbiased estimates of occupancy, extinction and colonization rates**

OCCUPANCY/DETECTABILITY MODELS

Occupancy/detectability model by MacKenzie has high potentiality for otter ecologists providing a robust and formal statistical approach:

- Unbiased estimates of occupancy, extinction and colonization rates
- **Unbiased estimates of the effect of landscape-habitat factors on otter distribution (distribution/habitat modeling)**

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OCCUPANCY/DETECTABILITY MODELS

Occupancy/detectability model by MacKenzie has high potentiality for otter ecologists providing a robust and formal statistical approach:

- Unbiased estimates of occupancy, extinction and colonization rates
- Unbiased estimates of the effect of landscape-habitat factors on botter distribution (distribution/habitat modeling)
- **Assessing factors influencing detection probability (season, habitat, effort, etc)**

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OCCUPANCY/DETECTABILITY MODELS

Occupancy/detectability model by MacKenzie has high potentiality for otter ecologists providing a robust and formal statistical approach:

- Unbiased estimates of occupancy, extinction and colonization rates
- Unbiased estimates of the effect of landscape-habitat factors on botter distribution (distribution/habitat modeling)
- Assessing factors influencing detection probability (season, habitat, effort, etc)
- **Assessing sampling effort required to reduce false absence to a minimum level (eg 5%)**

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RANGE EDGE SURVEYS AND OCCUPANCY/DETECTABILITY MODELS

- May enable a better allocation of money/sampling effort

✓ 2 surveys at report time (e.g. 2006 and 2012)

✓ Entire country

Naïve estimation of occupancy (% of presence sites) and trends (crude comparison of naïve site occupation)

✓ 3-4 surveys at and between report times

✓ Range edges

Robust estimation of occupancy (probability of occupancy ψ) and trends (colonisation/extinction probabilities) through the application of occupancy-detectability models

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THANK YOU!

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