ROAD MORTALITY AND PERMEABILITY
for otters in a Mediterranean region

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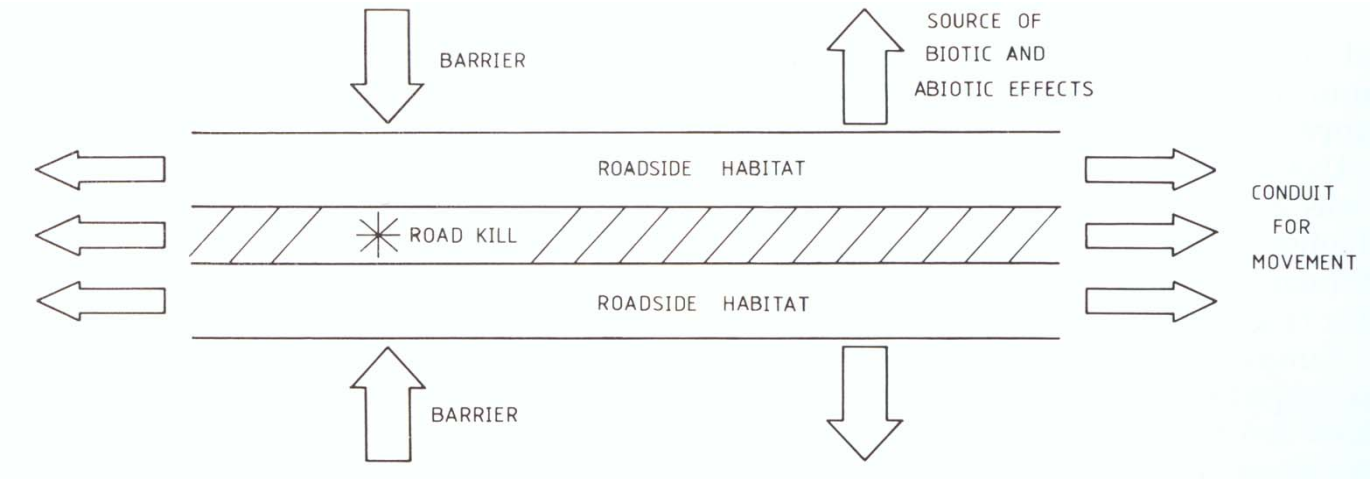
EOW'08 – European Otter Workshop – Slovenia (5th – 10th October)

TALK OUTLINE

- Roads and road ecology in Portugal
- Project goals
- Study area and methods
- Temporal patterns of road-kills
- Spatial patterns of road kills
- Highways permeability
- New challenges

Ecological Effects of Roads



Habitat loss and destruction

Population fragmentation

Vehicle collision and kill

Barrier or “filter” effect

Edge effect

ROADS IN PORTUGAL

PRN 2000

One of the most dense networks in Europe (> 22 000 km)

- National roads (NR)
- Municipal roads (MR)
- Highways (HW)

> 10% (2 500 km)

- **Principal itineraries (IP)**
- **Complementary itineraries (IC)**

ROADS IN PORTUGAL – European Context

	Extensão da rede de auto-estradas em km		Variação da extensão da rede de auto-estradas		Densidade de rede (km por 1000 km^2)		Variação da densidade da rede		Densidade da rede País / Densidades rede da UE 15	
	1990	1999	km	%	1990	1999	km/km^2	%	1990	1999
Austria	1445	1613	168	11,6	17,2	19,2	2,0	11,6	1,366	1,215
Bélgica	1631	1682	51	3,1	53,4	55,1	1,7	3,1	4,242	3,487
Dinamarca	601	861	260	43,3	14,0	20,0	6,0	43,3	1,109	1,266
Finlândia	225	467	242	107,6	0,7	1,4	0,7	107,6	0,054	0,089
França	6824	9303	2479	36,3	12,5	17,1	4,6	36,3	0,996	1,082
Alemanha	10809	11427	618	5,7	30,3	32,0	1,7	5,7	2,403	2,025
Grécia	190	500	310	163,2	1,4	3,8	2,4	163,2	0,115	0,241
Irlanda	26	94	68	261,5	0,4	1,4	1,0	261,5	0,031	0,089
Itália	6193	6453	260	4,2	20,5	21,4	0,9	4,2	1,631	1,354
Luxemburgo	78	115	37	47,4	30,2	44,5	14,3	47,4	2,397	2,816
Holanda	2092	2360	268	12,8	51,0	57,5	6,5	12,8	4,047	3,639
Portugal	**316**	**1252**	**936**	**296,2**	**3,4**	**13,6**	**10,2**	**296,2**	**0,273**	**0,861**
Espanha	4693	8257	3564	75,9	9,3	16,4	7,1	75,9	0,740	1,038
Suécia	939	1428	489	52,1	2,3	3,5	1,2	52,1	0,183	0,222
Reino Unido	3181	3421	240	7,5	13,2	14,2	1,0	7,5	1,048	0,899
UE 15	**39243**	**49233**	**9990**	**25,5**	**12,6**	**15,8**	**3,2**	**25,5**		

Costa, A. & C. Silva (2003), Faculdade de Engenharia da Universidade do Porto

Environmental Impact Assessments

Lei de Bases do Ambiente

(Decreto–Lei nº 11/1987)

Lei de Impactes Ambientais de Projectos

(Decreto-Lei nº 69/2000)

1994

Seminário "*Avaliação de impacte ambiental de projectos rodoviários*"

Espinho, 16 – 19 Março

2005

ROAD ECOLOGY IN PORTUGAL

Research chronology:

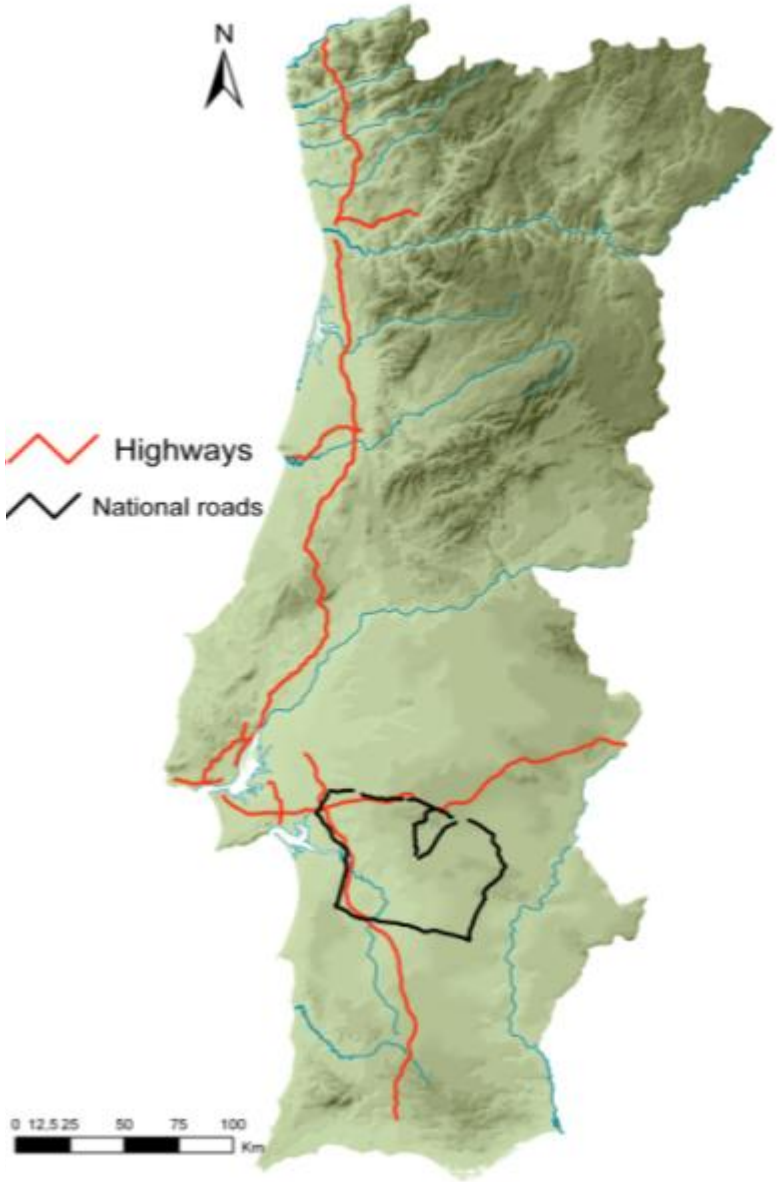
- 1994 – J. Marques (RNET – EN118, 20 km)
- 2000 – I. Franco (distritos Évora e Beja – EN114, EN258 e EN260, 7,5km/cd)
- 2001 – F. Ascensão(Alto Alentejo – IP2 (2 troços) e EN4, 25 km/cd)
- 2002 – C. Santos (PNDI – EN 221, 19km e EMs, 18km)
- 2004 – J.C. Brito & F. Álvares (PNPG)
- 2005 – J. Petronilho & C. Dias (PFL)
- 2005 – F. Ascensão & A. Mira (Alto Alentejo)
- 2006 – C. Silva (Alto Alentejo)
- 2007 - L. Gomes (Alto Alentejo)
- 2007 - F. Ascensão & A. Mira (Alto Alentejo)
- 2008 – Grilo et al. (Alto Alentejo – Highways & national roads)

PROJECT GOALS

- Investigate carnivore road-kill patterns, particularly in highways
- Identify factors promoting road-kills
- Analyse highways permeability on the basis of existing passages
- Provide mitigation recommendations

FUNDING AGENCY: BRISA, Auto-estradas de Portugal S.A.

STUDY AREA



Two scales of approach:

1. National scale: BRISA Highway network (1014 Km)

Road-kill patterns and promoting descriptors

2. Regional scale (Alentejo): 256 Km BRISA Highway network & 318 Km national roads (running parallel for ≈100Km)

Highways vs national roads mortality
Highway permeability

SURVEY METHODS – Highways road-kills

2ª EDIÇÃO
Setembro de 2004

SURVEY METHODS – Highways road-kills

MONITORIZAÇÃO DA FAUNA

DATA E LOCALIZAÇÃO					IDENTIFICAÇÃO	ESTADO		
dia	km	sentido	hora estimada	sublanço	código geral ou específico	morto	ferido	vivo*
2	450,000	O-E	08h40		RP23	X		
3	321,000	E-O	14h30		RP2	X		

AUTO-ESTRADA_____

CENTRO OPERACIONAL_____

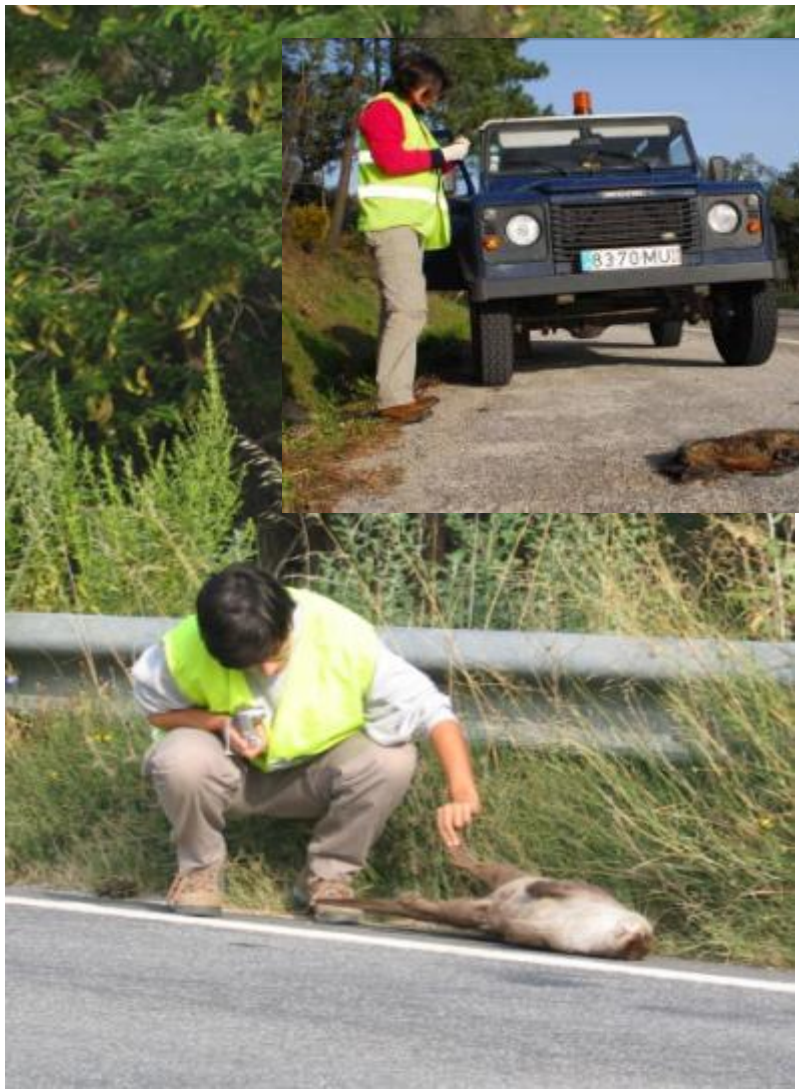
MÊS_____

ÍNDICE DO MANUAL

Observations recorded during routine road checks several times a day (date of collection, species, and location, at a scale resolution of 100 m).

SURVEY METHODS – National Roads road-kills

Conducted by one observer by car at low speed (~30 kmh-1), twice a month (date of collection, species, sex, age class and GPS location)

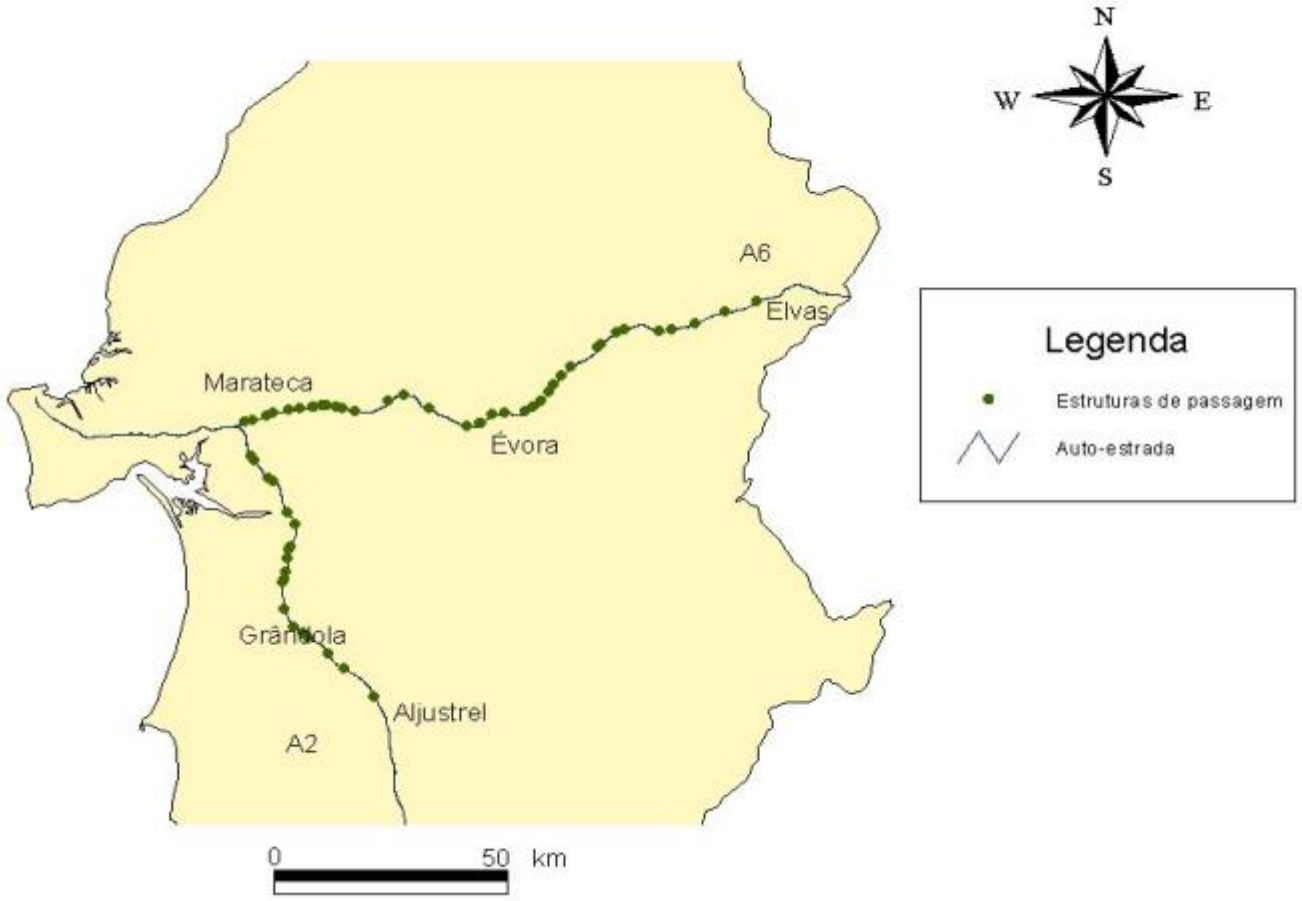


Necropsies and tissue samples collection

SURVEY METHODS – Highways Permeability

Culverts and underpasses monitored in the dry season using a combination of methods

57 culverts and underpasses (2004 / 2005)



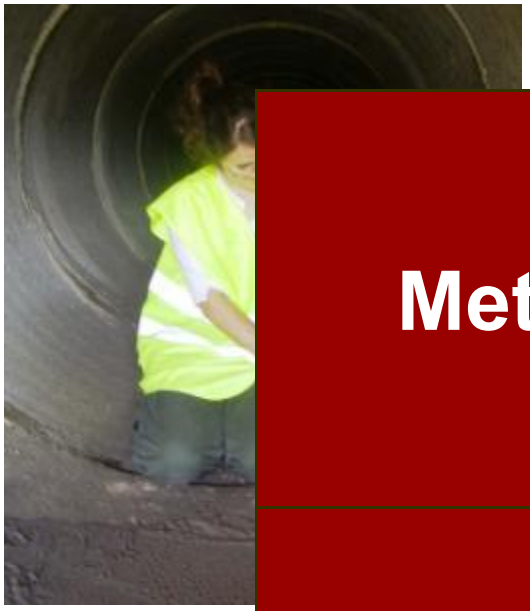
SURVEY METHODS – Highways Permeability

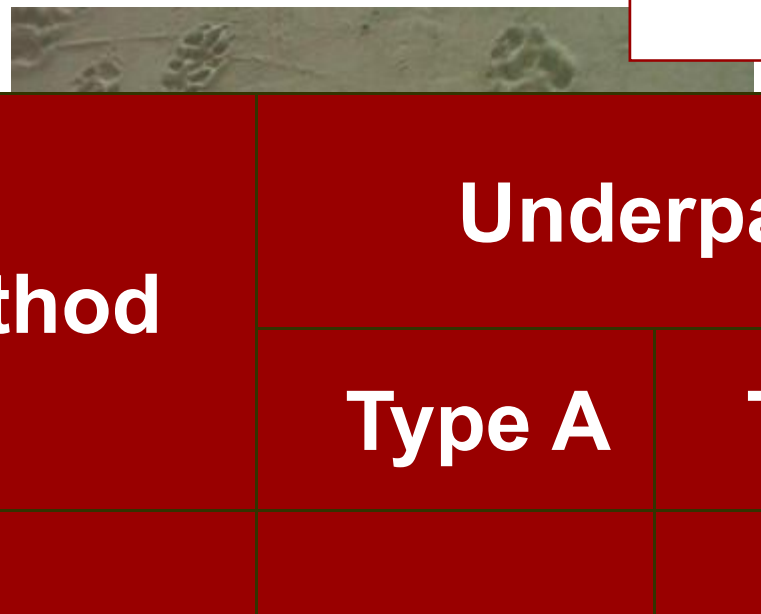
Culverts and Underpasses monitoring

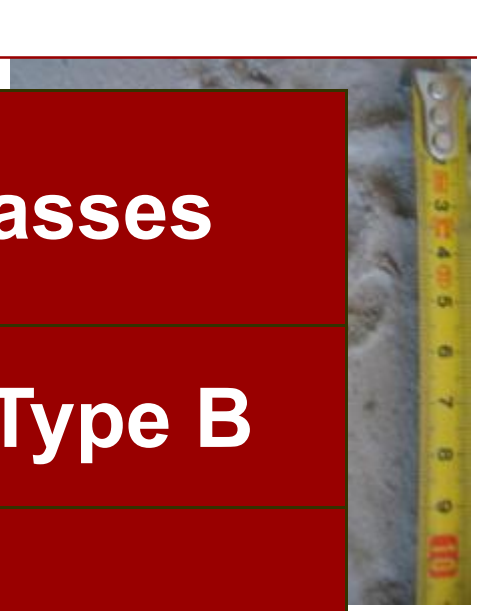
SURVEY METHODS – Highways Permeability

Culverts and Underpasses monitoring

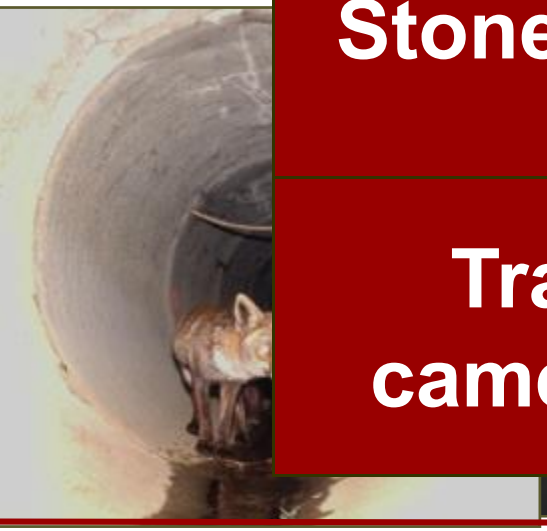
Global passage Index = 0,951
1089 passages / 1145 operational days





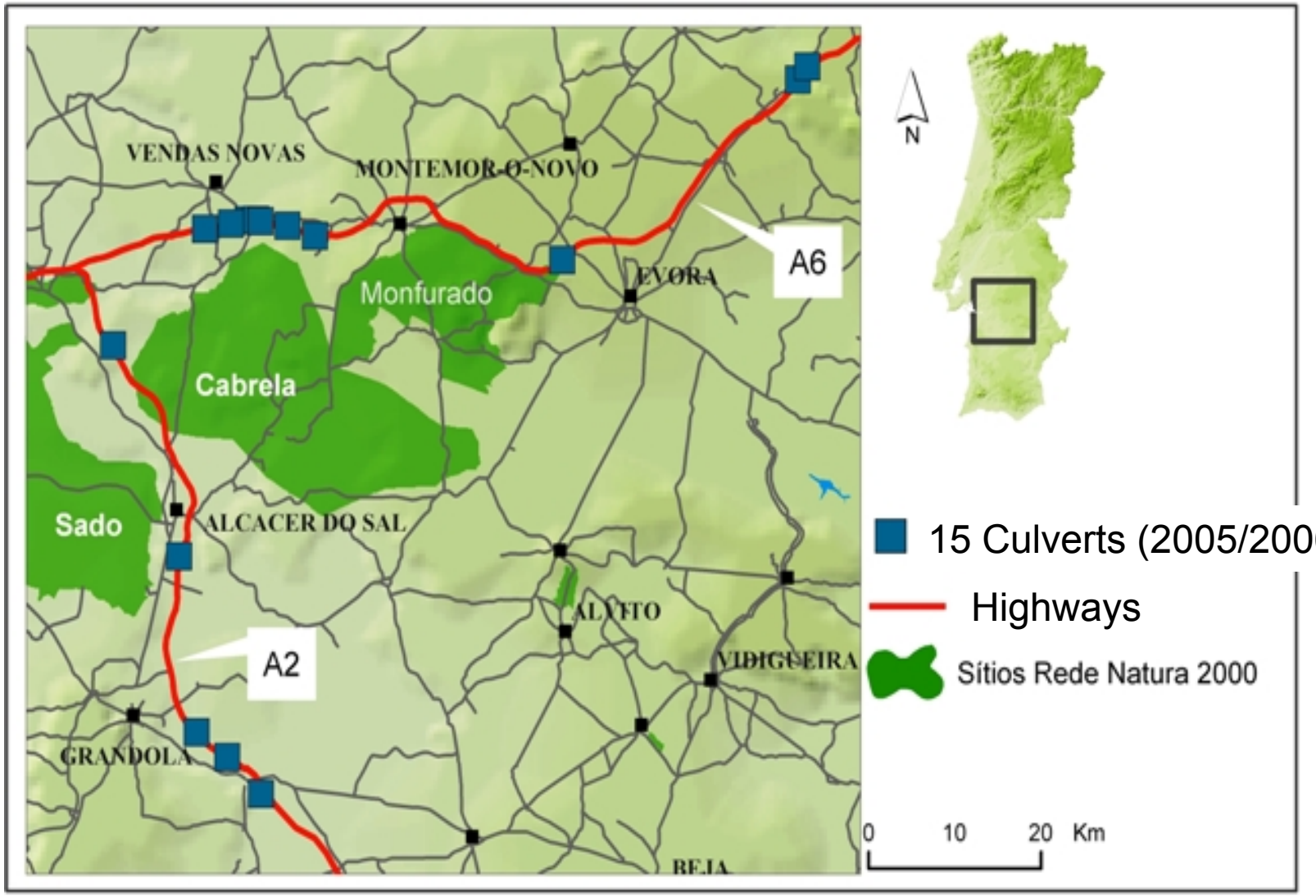


Method	Underpasses	
	Type A	Type B
Stone dust	163	348
Trap cameras	14	145

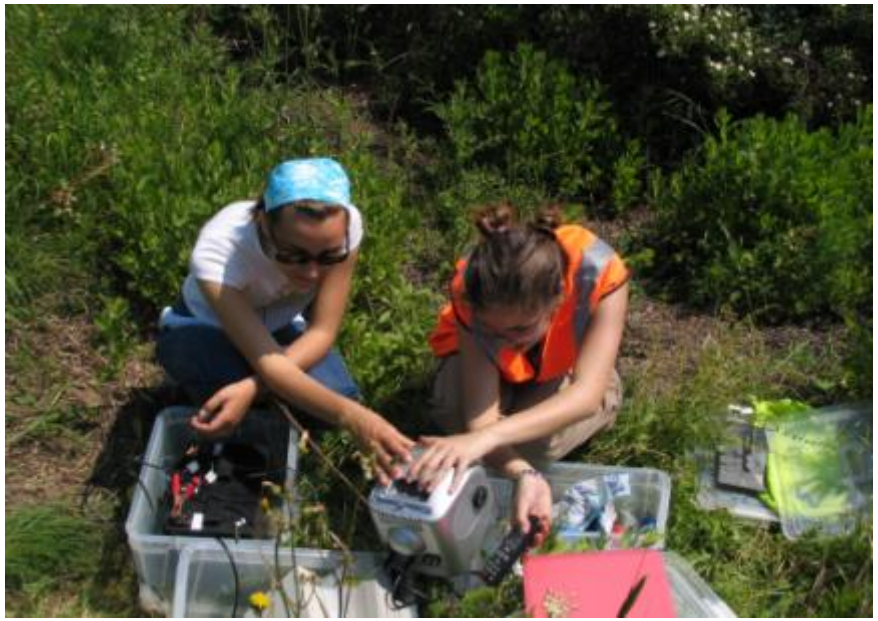


SURVEY METHODS – Highways Permeability

Culverts monitored seasonally using track stations and video-surveillance



SURVEY METHODS – Highways Permeability



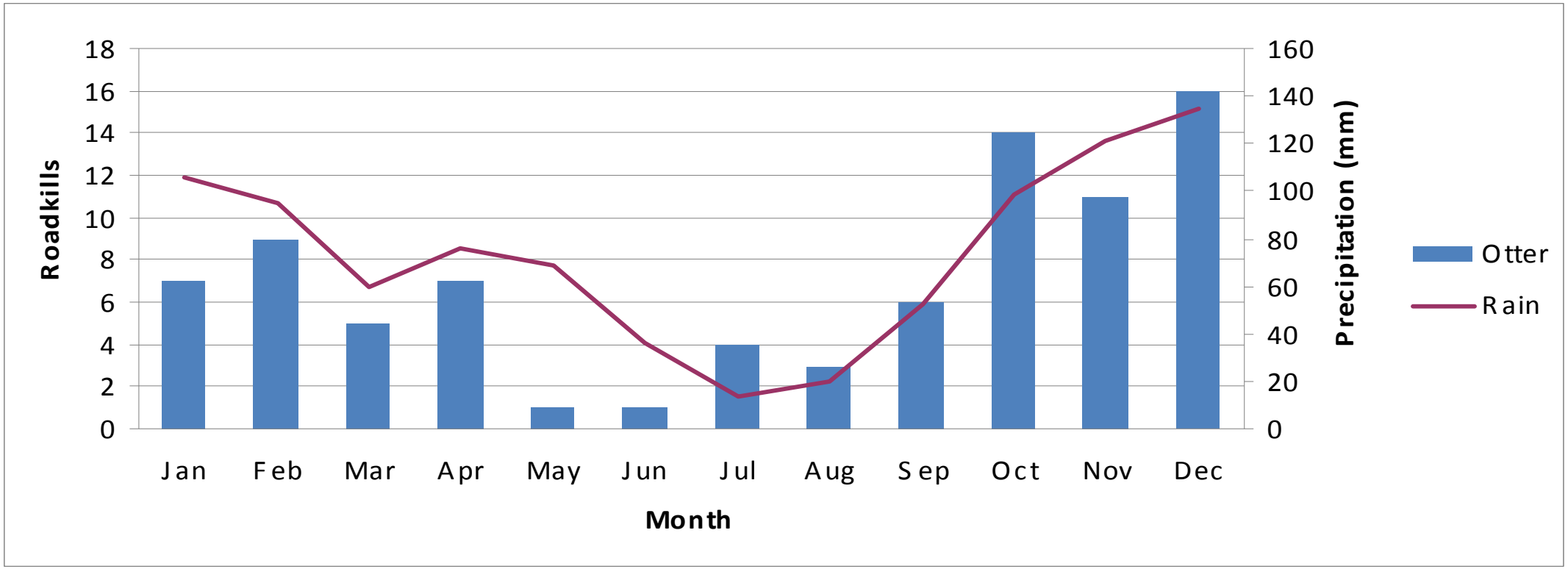
Video-surveillance

TEMPORAL PATTERNS OF ROAD KILLS

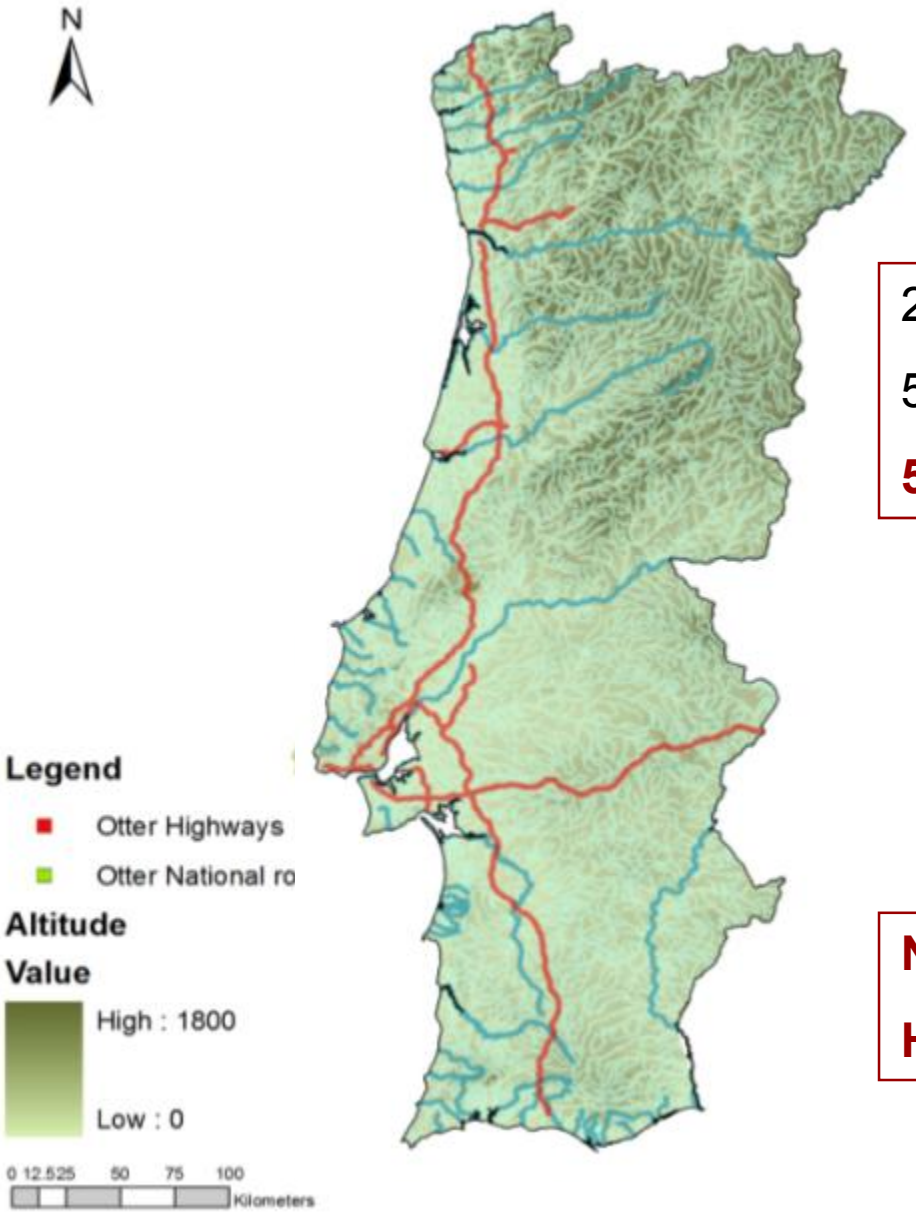
Time frame: 2002 - 2007

83 otter road kills (BRISA highways + Alentejo national roads)

6♀♀ : 7♂♂ / 2J : 22A



SPATIAL PATTERNS OF ROAD KILLS



BRISA Highways

Time frame: 2002 – 2007 (1014 Km)

2723 carnivore road-kills (45,0 carnivores / 100 Km / year)

579 mustelids road-kills (9,5 mustelids / 100 Km / year)

55 otter road-kills (0,9 otters / 100 Km / year)

Alentejo

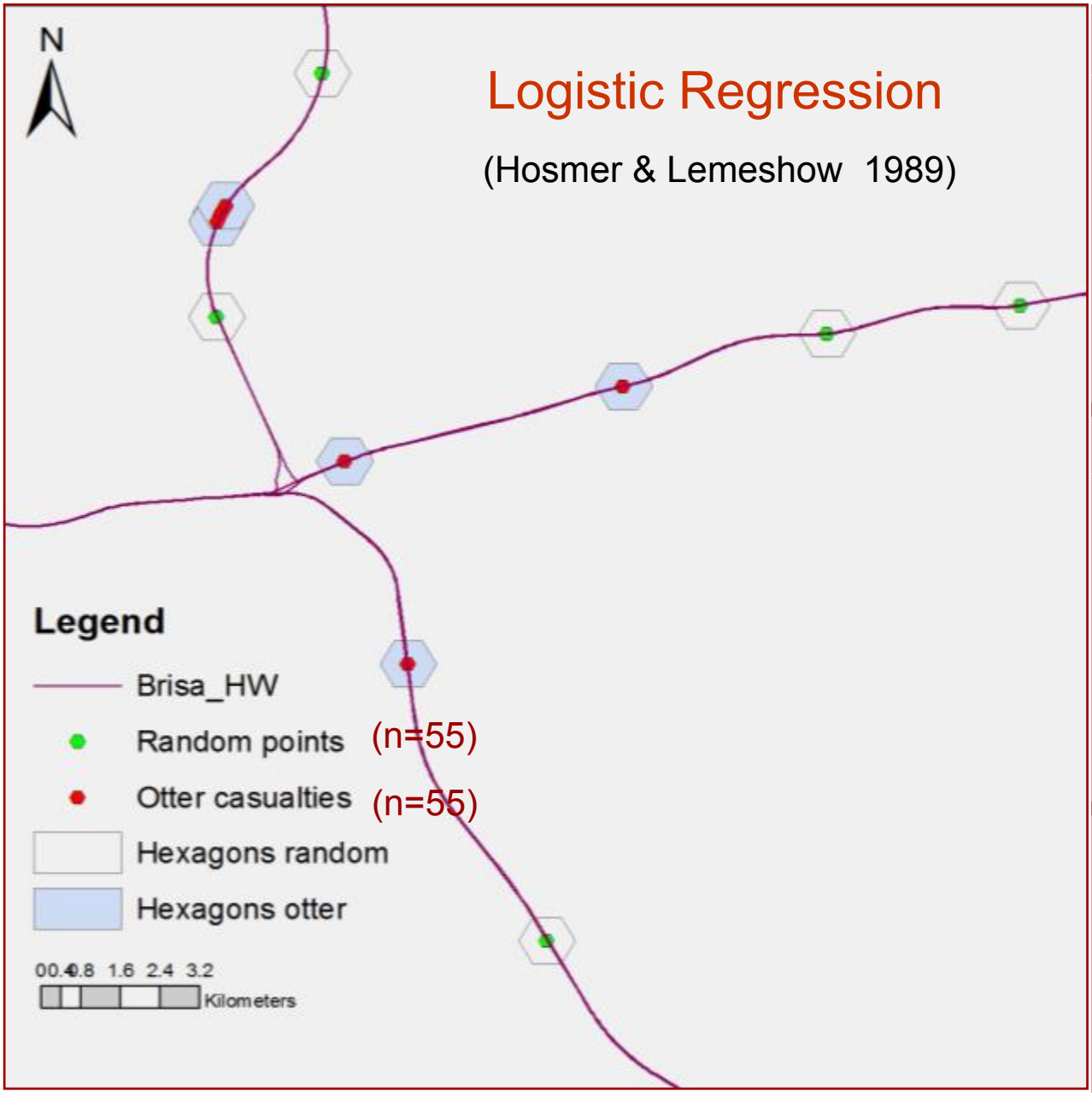
Time frame: Jul 2003 – December 2007

(318 Km NR + 256 Km HW)

NR - 29 otter road-kills (2,0 otters / 100 Km / year)

HW - 20 otter road-kills (1,7 otters / 100 Km / year)

SPATIAL PATTERNS OF ROAD KILLS



Land-use & Orography Descriptors

PIMPIBEUC - Pine and eucalyptus plantations
ORCREGADIO – Intensive agriculture
OPENMONOPEN – Open areas
CLOSEMONCLOSE – Closed areas
MEAN_ALT – Mean altitude
MEAN_SLOPE – Mean slope

Road-related Descriptors

TRAFFIC – nr vehicles / day
ROAD LENGTH – meters
PASSAGES – total number
CULVERTS – number
UNDERPASSES – number
VIADUCTS – number

Water-related Descriptors

WATERLINES – meters
DIST_MIN_RIVERS – meters
DIST_MIN_RESERVOIRS – meters
DIST_MIN – meters

Land-use & Orography Descriptors

Classification Table[a]

Observed			Predicted Response 0	Predicted Response 1	Percentage Correct
Step 1	Response	0	40	14	74,1
		1	20	35	63,6
		Overall Percentage			68,8
Step 4	Response	0	40	14	74,1
		1	16	39	70,9
		Overall Percentage			72,5

a. The cut value is ,500

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	Mean_Slope	-,780	,948	,676	1	,411	,458
	PibPIMEuc	-,134	,253	,279	1	,598	,875
	orcharregadio	-,645	,290	4,949	1	,026	,524
	OpenMonop	1,456	,642	5,152	1	,023	4,290
	Constant	-1,643	1,474	1,241	1	,265	,193
Step 4[a]	orcharregadio	-,682	,286	5,699	1	,017	,506
	OpenMonop	1,639	,600	7,467	1	,006	5,151
	Constant	-2,274	1,267	3,220	1	,073	,103

a. Variable(s) entered on step 1: Mean_Slope, PibPIMEuc, orcharregadio, OpenMonop.

Road-related Descriptors

Classification Table[a]

Observed			Predicted		
			Response		
			0	1	Percentage Correct
Step 3	Response	0	28	26	51.9
		1	19	36	65.5
		Overall Percentage			58.7

a. The cut value is .500

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 3[a]	Traffic	-1.200	.528	5.171	1	.023	.301
	Constant	4.857	2.136	5.170	1	.023	128.691

a. Variable(s) entered on step 1: Road_Lenght, Passages2, Traffic.

SPATIAL PATTERNS OF ROAD KILLS

Water-related Descriptors

Classification Tablea

Observed			Predicted		
			Response		
			0	1	Percentage Correct
Step 3	Response	0	31	23	57.4
		1	23	32	58.2
		Overall Percentage			57.8

a. The cut value is .500

Variables in the Equation

		B	S.E.	Wald	df		
Step 3[a]	Waterlines	.278	.132	4.409	1	.036	1.320
	Dist_min_waterlines	-.979	.452	4.694	1	.030	.376
	Constant	2.753	1.407	3.829	1	.050	15.688

a. Variable(s) entered on step 1: Waterlines, Dist_min_rivers, Dist_min_waterlines, Dist_min_albufeiras.

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	123,338[a]	,225	,300

a. Estimation terminated at iteration number 5 because parameter estimates changed by less than ,001.

Classification Table[a]

Observed			Predicted Response		
			0	1	Percentage Correct
Step 1	Response	0	40	14	74,1
		1	18	37	67,3
		Overall Percentage			70,6

a. The cut value is ,500

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1	Dist_min_waterlines	-,855	,526	2,642	1	,104	,425
	Waterlines	,345	,146	5,544	1	,019	1,412
	Traffic	-,979	,591	2,740	1	,098	,376
	OpenMonop	1,396	,610	5,245	1	,022	4,039
	orcharregadio	-,719	,305	5,572	1	,018	,487
	Constant	4,466	3,349	1,779	1	,182	87,014

Area Under the Curve

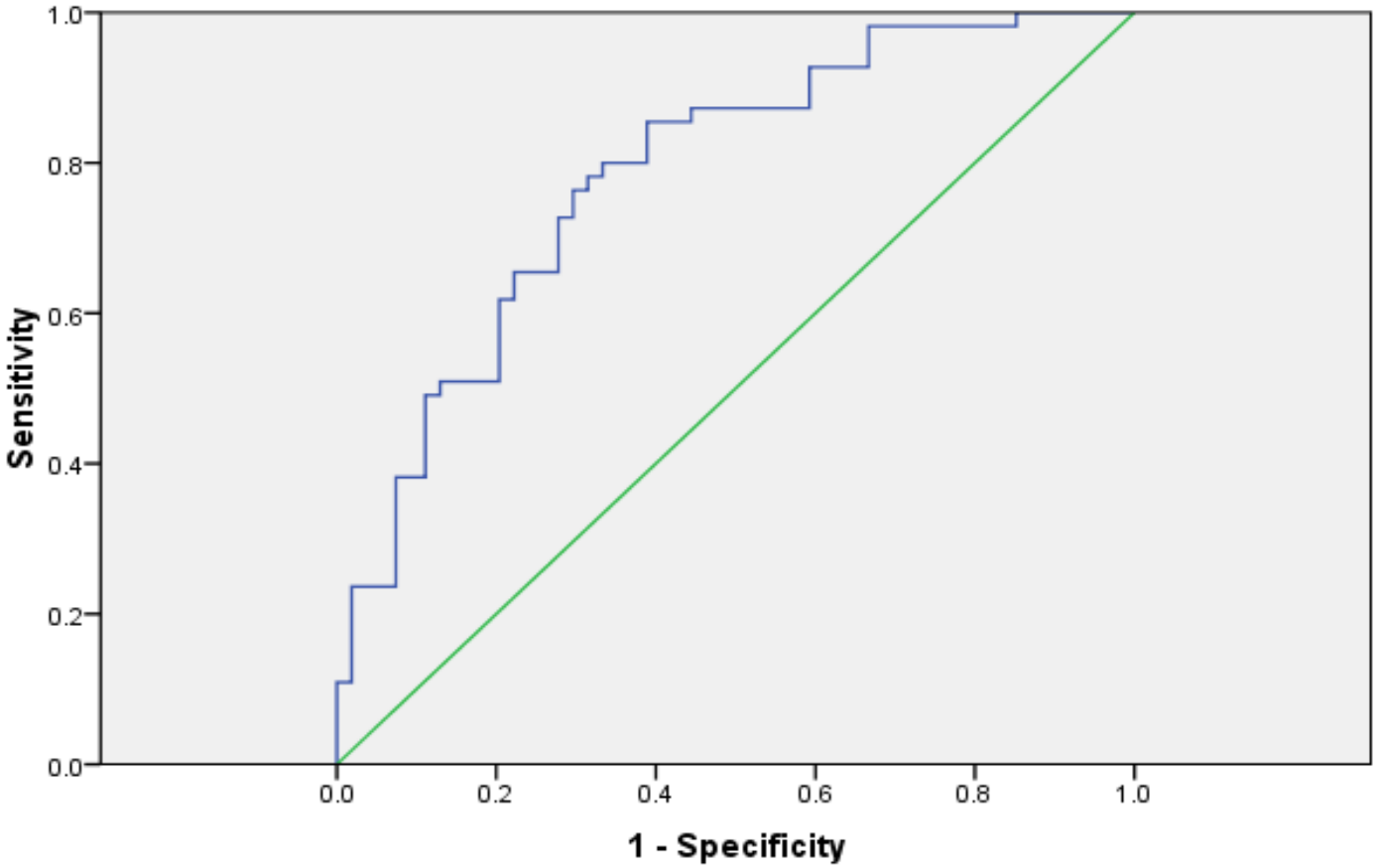
Test Result Variable(s): Probabilidade

Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
			Lower Bound	Upper Bound
.786	.043	.000	.701	.871

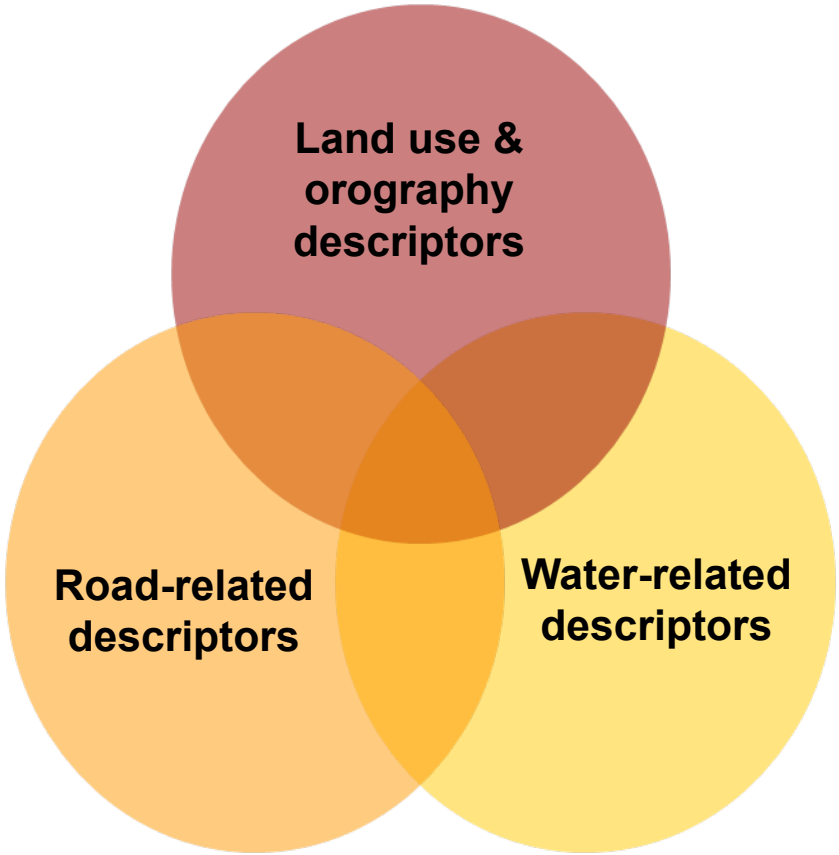
a. Under the nonparametric assumption

b. Null hypothesis: true area = 0.5

ROC Curve



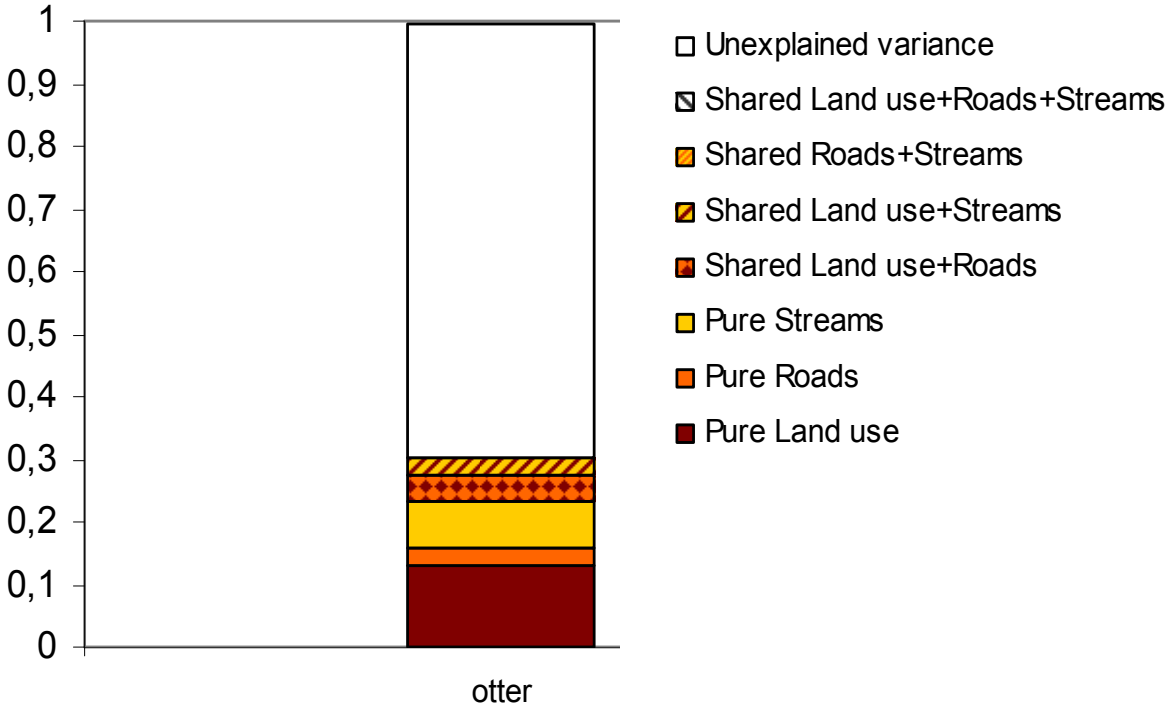
SPATIAL PATTERNS OF ROAD KILLS



Variance Decomposition

(Lawler & Edwards Jr 2006)

- **30% Explained variation**
- **≈ 15% Pure land-use and orography effects**

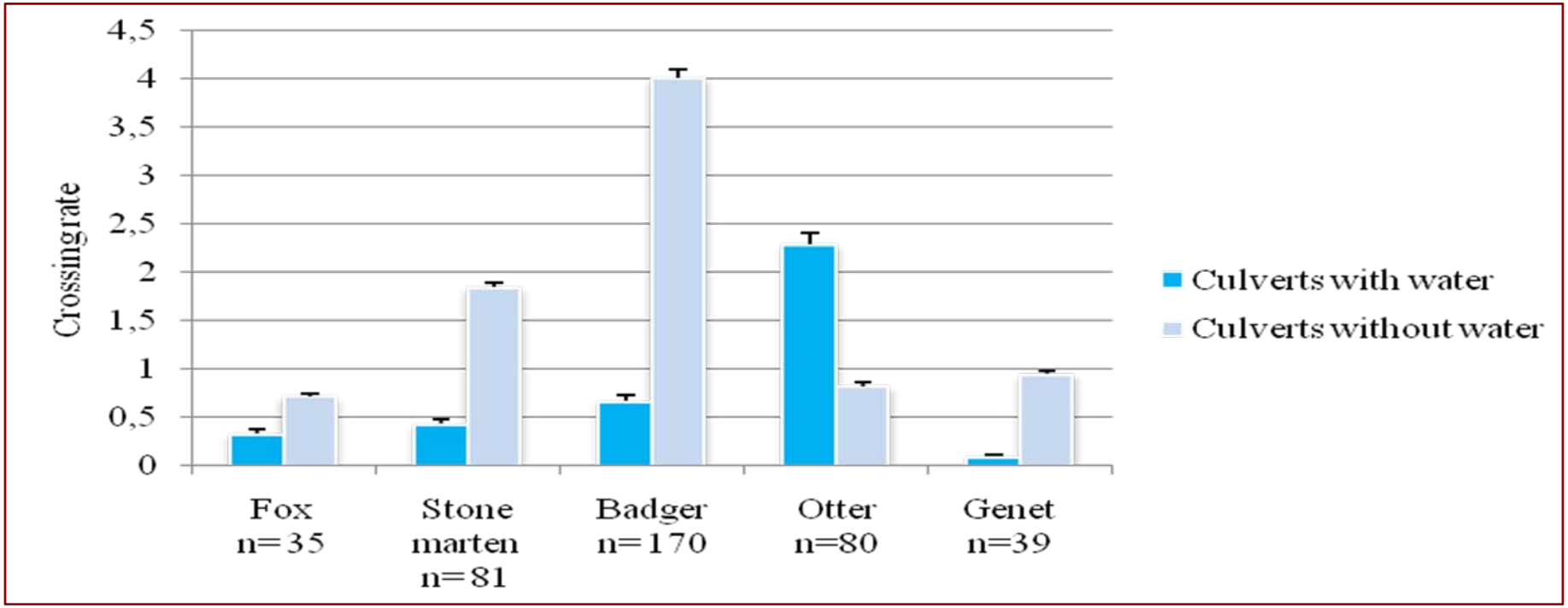


465 carnivore crossings recorded (10 days / season / culvert)

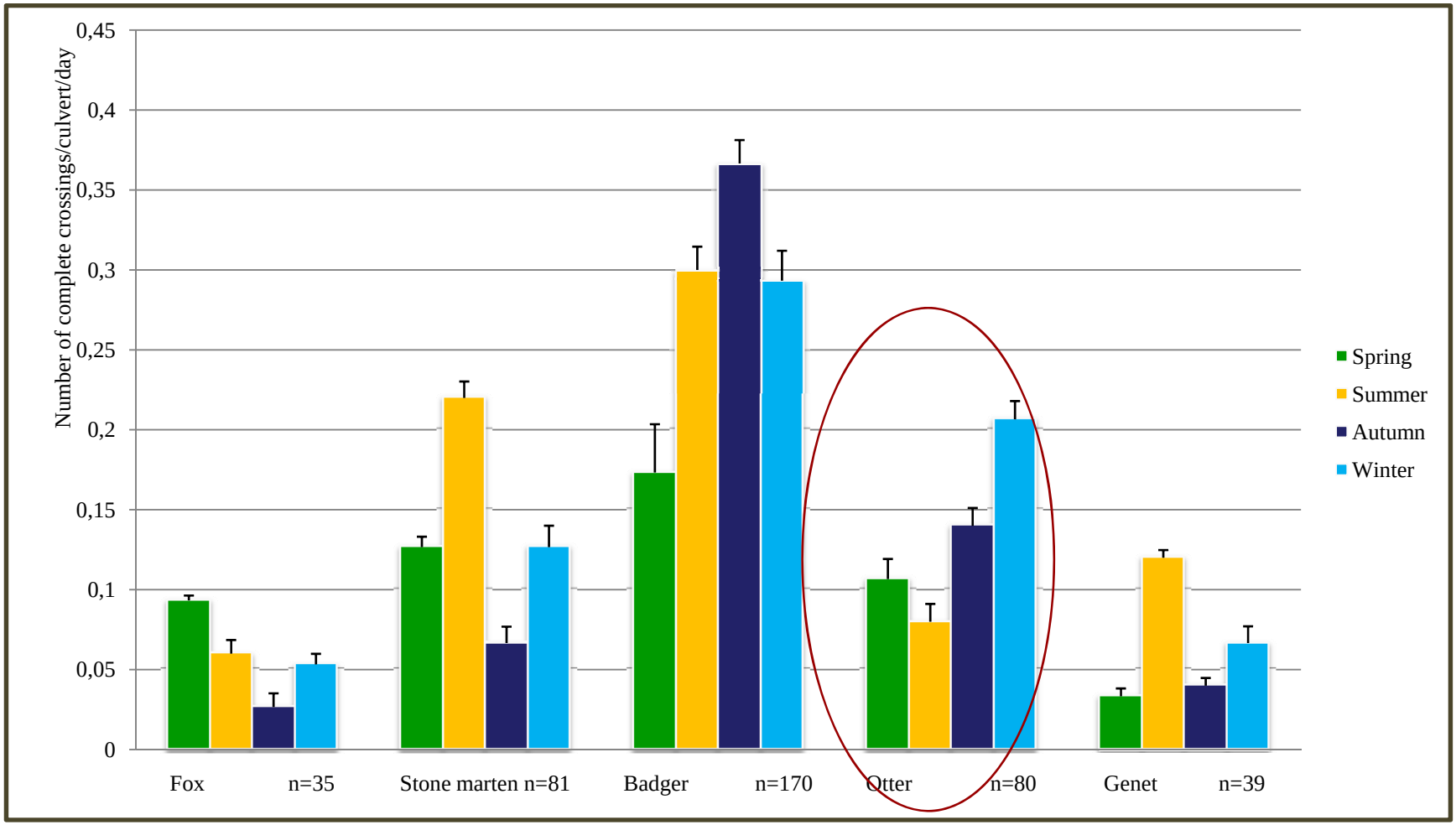
405 complete crossings (0.675±0.012 complete crossings / culvert / day)

60 partial crossings (0.102±0.002 partial crossings / culvert / day)

Otter (n=80, 0.133±0.010 complete crossings / culvert / day)

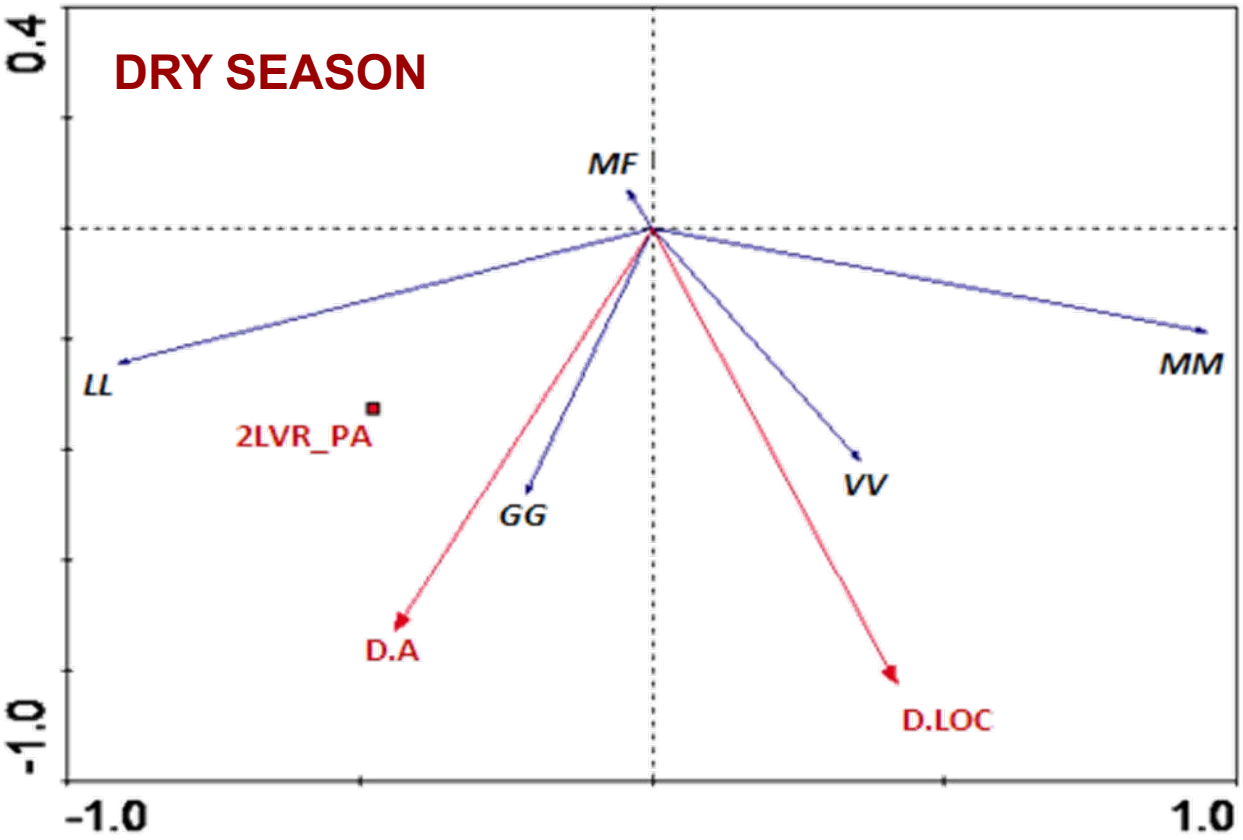


TEMPORAL ANALYSES OF CULVERTS USE



The first two axes explain **48.6%** of the total variance

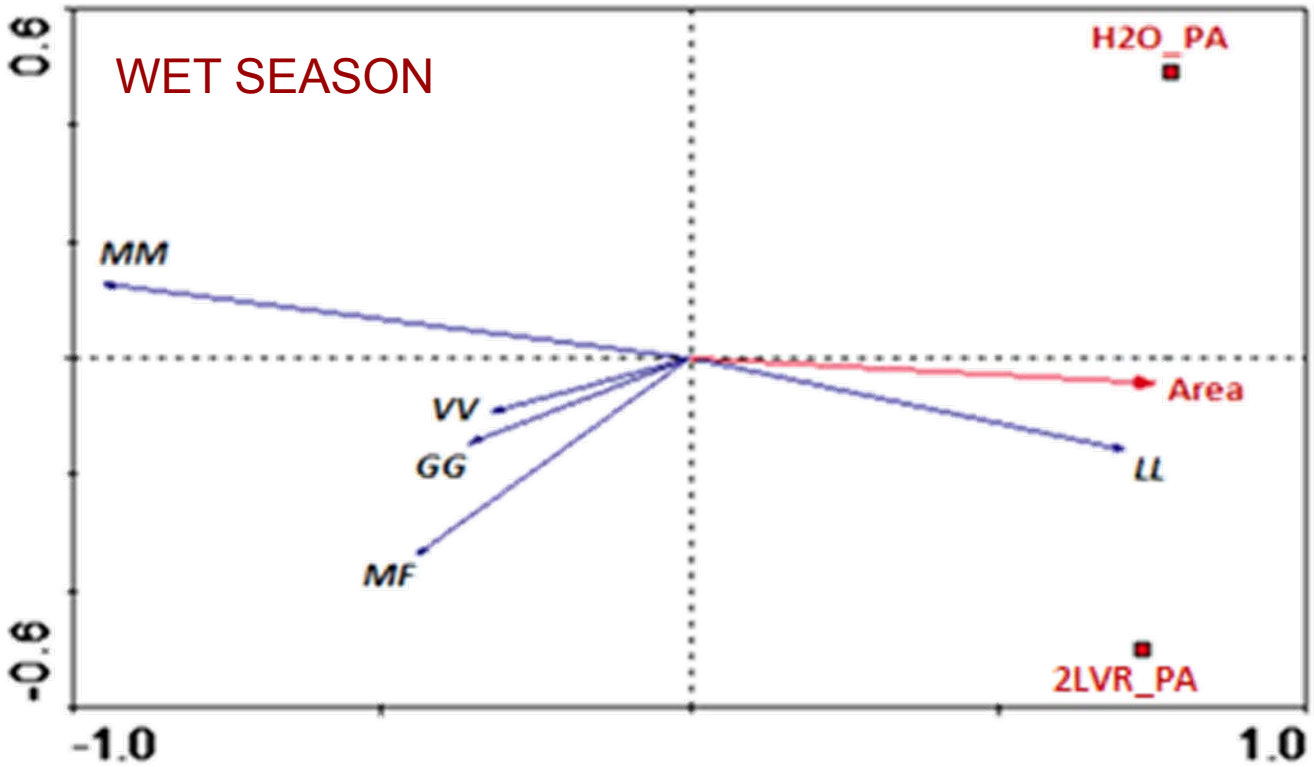
- 2LVR_PA (Presence/Absence of riparian vegetation on both culvert sides) - **18.7%**
- D.A (Distance from the culvert entrance to highway edge) - **16.2%**
- D.LOC (Distance to localities) - **13.7%**



Redundancy Analysis **(Canoco v.4.5, Braak & Smilauer 1998)**

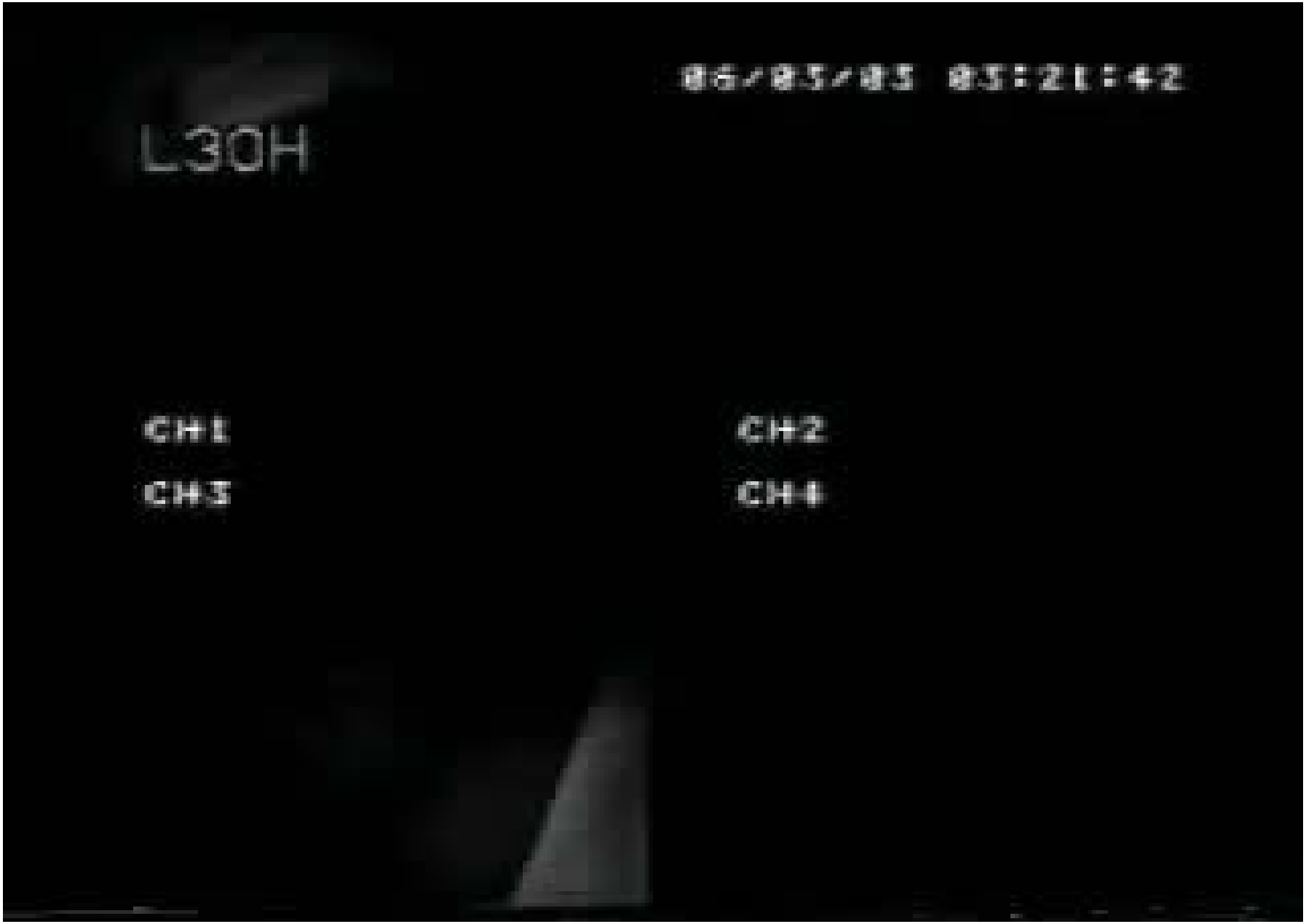
First two axes explain **62.7%** of the total variance

- H2A_PA (Presence/Absence of water inside the culvert) - **37.7%**
- 2LVR_PA (Presence/Absence of riparian vegetation on both culvert sides) - **14.8%**
- Area (Culvert area) - **10.2%**



Redundancy Analysis **(Canoco v.4.5, Braak & Smilauer 1998)**

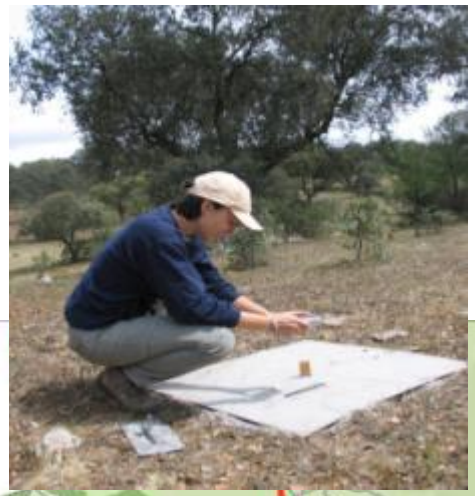
HIGHWAYS PERMEABILITY



HIGHWAYS PERMEABILITY

NEW CHALLENGES

NEW CHALLENGES



NEW CHALLENGES

BETTER REPORTING SYSTEM (SEX & AGE)

AVOID IMAGES LIKE THESE…

FAVOURING SUCH IMAGES!!!