

## **Conservation of otter (*Lutra lutra*) in a Mediterranean area: the importance of habitat quality and temporal variation in water availability**

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## Abstract

1. This study analyses quantitatively the association between habitat characteristics and annual variation in water availability on otter (*Lutra lutra* L.) distribution in a large Mediterranean area (13717 km<sup>2</sup>) in southern Spain
2. There was a strong positive correlation between habitat quality, estimated after the two first components of a Principal Component Analysis of a matrix habitat variables x sites, and an index of otter presence/absence, otter presence being most probable in unpolluted and undisturbed sites and surrounded by woodland.
3. After univariate analysis, the main freshwater habitat features were statistically different between sites with presence of otters and sites lacking them. In general, otters occurred in medium-sized fluvial habitats, with high bankside vegetation cover, unpolluted, with low or very low human disturbance and surrounded by forests or dehesas (Mediterranean-like savannah).
4. Water availability, inferred from the water balance, strongly influenced otter distribution and the type of water body mostly used. As water availability increased so did the otter distribution range and during these periods they tended to colonise low-order streams. During periods of water shortage, otters were most probably found in high-order streams and reservoirs, the only sites that kept water.
5. In conclusion, otter distribution in Mediterranean areas is strongly influenced by two factors: 1) man-induced habitat degradation and 2) natural variability in water availability. The addition of the second factor to the first one introduces additional risks to the survival of otter populations in Mediterranean areas compared with more northerly and humid areas, usually only subjected to the first threatening factor.

*keywords:* otter ecology, mustelids, aquatic mammals, stream habitat, water balance, Mediterranean climate, Spain

*running-head title:* otter conservation in southern Spain

## Introduction

The otter (*Lutra lutra* L.) depends largely upon water availability. Other ultimate factors that determine distribution and habitat selection by river otters (e.g. *L. lutra* and *L. canadensis*) are food availability and the presence of adequate cover (Melquist and Hornocker, 1983; Bas *et al.*, 1984; Dubuc *et al.*, 1990; Kruuk *et al.*, 1993; Kruuk, 1995; Prenda and Granado-Lorencio, 1996). However, otters are affected not only by prey and habitat structure, usually provided by bankside vegetation (see Mason and Macdonald, 1986, and references therein), but also by the characteristics of the surrounding areas, water pollution and human disturbance (Chanin and Jefferies, 1978; Macdonald and Mason, 1983; Bas *et al.*, 1984; Adrián *et al.*, 1985; Delibes *et al.*, 1991).

In the Mediterranean area where the climate is characterised by a long dry summer and a high interannual variation in precipitation, water balance (rainfall minus evapotranspiration) is usually negative, sometimes for very long drought periods. This hydric stress is responsible for strong irregularities in water flow in most Mediterranean streams, which fluctuate between catastrophic flash floods in autumn-spring and intermittent flows or completely dry channels during summer. Thus, there is no stable water supply in most Mediterranean river basins. It poses a major question on otter temporal distribution and habitat use in this kind of river system, because such annual changes in habitat structure and resource availability should affect the otter's distribution (Macdonald and Mason, 1982; Adrián *et al.*, 1985). Delibes (1990) observed that otters in Spain tended to occur in areas where annual rainfall exceeded 400 mm and also that their distribution expanded as annual rainfall increased (Delibes, 1993).

Previous work on otter distribution in Mediterranean regions did not directly address quantitatively the impact of water availability on this species and only few studies have established any direct quantitative relationship between global habitat quality and otter habitat use (Prenda and Granado-Lorencio, 1996). However, several authors have found a positive correlation between otter presence and particular habitat features, such as bankside cover (Adrián *et al.*, 1985; Macdonald and Mason, 1985; Delibes *et al.*, 1991). With respect to water supply and otters a few general observations have been made. For example, Macdonald and Mason

(1982) found signs of otters throughout much of Portugal during August, including in dry river beds with scattered pools. Similarly, Broyer *et al.* (1988) observed otters even in practically desert regions in Morocco.

In southern Spain otters still maintain healthy populations, mostly localised in areas of low human population density (Delibes, 1990). To test the effects both of habitat quality (type and structure of water body, cover, characteristics of the surrounding areas, water pollution and human disturbance) and water availability on otter distribution the following questions were asked: 1) What are the most important differences in habitat features between sites with otters and sites lacking them?; 2) Is there any quantitative relationship between general habitat quality and otter distribution?; 3) Does water availability influence otter distribution? Finally, the probable consequences of the response of otters to water shortage in Mediterranean freshwater habitats were examined.

## **Study Area**

The study area of 13.717 km<sup>2</sup>, comprises Córdoba province (S Spain) (38° N-5° W) (Figure 1). This area is bisected by the Guadalquivir River into northern and southern sectors, which differ both ecologically (geology, vegetation, fauna, etc.) and socio-economically (demography, economic development, etc.) (López-Ontiveros, 1985). Human population density in the northern sector is rather low (usually below 18 km<sup>-2</sup>) while the southern sector is more densely populated. A summary of some environmental features of the study area is given in Table 1.

The climate is Mediterranean with a negative water balance caused by a long summer dry period (between May and October). Rainfall is very irregular, both within and between years with maximum rainfall in autumn and winter.

The original vegetation in the area is characterised by Mediterranean sclerophyllous species, although nowadays, as in most of the Mediterranean basin, it is highly modified by human activities, especially in the extensive agricultural lands of the southern sector. The northern sector is dominated by natural forests, 'dehesas' and 'maquis'. In general, olive groves are the dominant agriculture crop (Table 1).

The study area is drained by two main rivers, the Guadiana which occupies a small zone in the North, and the Guadalquivir. Most streams in the Guadiana basin are usually surrounded by dense riparian forests and characterised by low slopes, wide channels and unpolluted waters (A.M.A., 1989). The Guadalquivir basin displays a large asymmetry between the left and right margins. The right margin presents a high drainage density, with many first and second order high slope streams that flow into the main river. The left margin drainage basin is made up of very few long streams, characterised by a low slope and affected by high pollution level in many reaches (A.M.A., 1995). In all cases the river flow regime is typically Mediterranean, highly influenced by climatic factors and subsequently with a long drought period.

## **Methods**

### **Field surveys**

The area was surveyed four times between 1984 and 1995: 1) October-December 1984, 2) July-December 1992, 3) July 1993-May 1994 and 4) July 1995-February-1996. A total of 561 sites, located in 132 distinct water bodies (103 streams, 24 reservoirs, one irrigation channel and four ponds), were surveyed during the study, distributed temporally as follows: 56 in the first survey period (1), 261 in (2), 98 in (3) and 146 in (4). Survey site selection was based on 1:50.000 cartographic maps (National Grid of Spain): each sheet was divided into four quadrats (covering approx. 140 km<sup>2</sup> each) and, within each, most water bodies (mostly streams) were surveyed.

A survey site was a stream reach or reservoir shore with a minimum length of 200 m (even if otter signs were found immediately) and a maximum of 600 m (Lenton *et al.*, 1980; Elliot, 1983; Delibes, 1990; Delibes *et al.*, 1991). The species was considered absent from a site if no signs (scent marks, spraints or footprints) were found within 600 m. When otter density is very low, signs of their presence are similarly very limited so otter can remain undetected (Broyer and Erome, 1983; Macdonald, 1983; Libois *et al.*, 1990). Thus, when a 600 m stretch had been surveyed and scored negative for otter signs, the stream was also surveyed in several additional sites, both upstream and downstream, usually 5 km apart from

the original site. Within the same stream, the nearest sites (usually < 5 km apart) were grouped as a single site, when their habitat characteristics were similar.

Also, in large streams and in reservoirs otters presence can similarly remain undetected due to their preference to spraint on only one bank (Lenton *et al.*, 1980). To avoid this problem, large streams were surveyed on both banks and reservoirs along most of their shores.

Otter signs (scent marks, spraints or footprints) were used exclusively as indicators of otter presence, independently of their number or marking sites found. Therefore, marking intensity (e.g. spraints 100 m<sup>-1</sup>) was not noted.

At each survey site, several habitat variables, usually considered of potential importance to otters (see Mason and Macdonald, 1986; Prenda and Granado-Lorencio, 1996), and otter presence or absence (1 or 0) were noted. Table 2 lists the different categories used for each variable and its associated quantitative scale. Channel width was visually estimated usually between 5-10 times per site. The most frequent channel width per site was assigned to one of seven categories. Channel depth was measured with a rigid metre rule (usually between 5-10 times per site). The final estimate per site used was the most frequent depth category recorded (Table 2). The most frequent flow velocity per site was visually assigned to one of three categories. The dominant bank substrate, bankside vegetation cover, bankside dominant vegetation type, land use and human disturbance in the surrounding areas were all visually estimated and classified into the categories presented in Table 2.

Channel quality refers to the general state of the watercourse and was divided into three categories: natural; altered (with apparent human modifications such as dredging, bankside vegetation cutting, etc.); man-made. Water pollution was visually assigned to one of three categories: nil (more or less transparent water without odours or any other apparent sign indicative of pollution, such as foam); medium-high (water with clear signs of pollution, such as strong odour, turbid colour, foam, etc.); low (sites not assigned to either of the previous categories). Human disturbance usually refers to the distance to human settlements. It fluctuates between sites far from human influence (nil or very low)

to sites inside urban areas (very intense). The stream order was assigned after Strahler (1974) based on cartographic maps 1:200,000.

### **Statistical analysis**

Chi-square tests were performed on random use or preferences of single habitat variables, comparing the frequency distribution of each habitat variable use (only positive sites, i.e. sites with signs of otters) and availability (all sites surveyed). If the frequency distributions for habitat variable use and availability did not differ significantly ( $P > 0.05$ ), the otter was considered to be using that variable at random. Conversely, significant differences indicated preferences for certain values of that variable. Initially, this analysis was performed independently for each survey. The variables that did not provide significant differences between use and availability in at least three surveys were discarded from subsequent analysis (flow velocity, bank dominant substrate, bankside dominant vegetation and channel quality). As for most variables the different comparisons for each survey produced very similar results, all data were grouped in just one general use and availability frequency distribution.

Second, the correlation between the habitat quality and otter presence/absence was tested. Habitat quality was determined by principal component analysis (PCA) of environmental variables x sites (8 variables-columns x 561 sites-rows). The environmental variables were quantitatively transformed from categories according to Table 2. The PC scores that explained most variance and had a sound ecological meaning were selected (here PC1 and PC2 scores). These two PCs summarised the eight variables included in the analysis. The study area was divided into 15 x 10 km quadrats, and the mean habitat quality per quadrat was calculated as the mean of the PC1 and PC2 scores, respectively, of the sites inside each quadrat. Otter presence/absence per quadrat was estimated as the frequency of positive sites throughout the four surveys. Then, to test for habitat preferences or random habitat use, the PC1 and PC2 were used as independent variables in a multiple regression model against otter presence/absence.

The effect of water availability on otter presence/absence was tested by a regression of the water balance (rainfall minus evaporation) and an index of water pollution (Table 2) per survey period against the percentage of positive sites for the same survey periods. The water balance data were obtained from a representative meteorological station located in the study area (Pozoblanco Meteorological Station, Spanish National Institute of Meteorology). This analysis considered only the fluvial reaches that were surveyed in the four periods.

## Results

### Habitat quality and otter signs distribution

Otters occurred in fluvial habitats 2-20 m wide and 1-2 m deep, with more than 25% of bankside vegetation cover, unpolluted, with low or very low human disturbance and surrounded by forests or *dehesas* (Figure 2) ( $\chi^2$  analysis,  $P < 0.0001$ ). On the contrary, otters signs were not usually found in shallow narrow streams (less than 0.5 m deep and less than 1 m wide), polluted, with intense or very intense human disturbance and surrounded by crop-pastures (Figure 2). Four variables (water current, channel quality, dominant bank substrate and bankside dominant vegetation type) were discarded from this analysis as they were not apparently selected by otters in any of the survey periods ( $\chi^2$  analysis,  $P > 0.05$ ).

Two habitat gradients were identified from the PCA analysis of environmental variables x sites (Table 3). According to the PC1, the habitat could be ordered between larger rivers, highly polluted and disturbed, with little bankside vegetation cover and surrounded by urban areas or crop-pastures, and sites surrounded by forests with opposite characteristics. The PC2 produced another habitat gradient (Table 3), that varied between smaller polluted and disturbed streams and larger water bodies surrounded by woodland. The otter presence/absence (percentage of positive sites per quadrat) was positively correlated both to PC1 and PC2 (multiple regression model,  $F_{88} = 71.2$ ,  $R^2 = 61.5\%$ ,  $P < 0.00001$ ). PC1 explained 46.7% of variance and PC2 14.7%. Thus, otter signs were most usually found in unpolluted and undisturbed sites surrounded by woodland. As there were strong differences between the northern and southern parts of the study area (both

divided by the Guadalquivir River) and the sites surveyed in the southern part were all negative for otters, the same analysis was carried out for the northern part alone. The result was the same as for the whole region (multiple regression model,  $F_{76}=39.0$ ,  $R^2=56.3\%$ ,  $P<0.00001$ ). The same analysis was repeated, but excluding all those quadrats that lacked any otter sign, thus avoiding the effect of habitat potentially suitable to otters but where they were absent. Again the result was the same (multiple regression model,  $F_{65}=34.2$ ,  $R^2=50.5\%$ ,  $P<0.00001$ ). Here, PC1 explained 36.4% of variance and PC2 14.1%.

### **Water availability and otter distribution**

Water in the Mediterranean area suffers from periodic deficits, both annually (mostly during the summer) and interannually, that influence the physical and hydrological characteristics of water bodies (flow values, watercourse length and water volume in reservoirs). These shifts in habitat availability for otters might be related to otter presence/absence (e.g. the percentage of positive surveys per period). Thus, the water balance for each survey period (an indicator of water availability for otters) was regressed on otter presence/absence (Figure 3) (here, as before, only those fluvial reaches that were similarly surveyed in the four periods were considered). Both variables were positively correlated ( $R^2=88.6$ ,  $P=0.05$ ), meaning that as water availability changed so did the otter distribution range. An inverse relationship was observed for water pollution (Figure 3), although for this variable the correlation only reached marginal significance ( $R^2=70.3$ ,  $P=0.09$ ). Thus, the reduction in water availability not only limits the potential distribution range for otters, but also determines a parallel reduction in water quality.

The annual water balance determines mean water flow in streams. During dry periods water tends to flow only in the highest order streams, while in rainy years most streams, including the smallest, keep some flow. Otter presence/absence parallel these changes in water flow. During dry periods otters used significantly higher order streams than in rainy periods (Figure 4a, Kruskal-Wallis test,  $KW=9.3$ ,  $P=0.025$ ). This showed that the distribution range of otters increases in wet years (Figure 1). Similarly, otter use of reservoirs increases when

water flow is reduced in dry years (Figure 4b), because reservoirs are the only water bodies, apart from large streams, that keep some water in these periods. In the study area the presence of otter signs in reservoirs was at its maximum with respect to streams in the 1994 survey (Figure 4b), i. e. during an intensely dry period. In contrast, in wet years reservoir use was much reduced, except in 1995-96 when surveys were undertaken only a few months after the previous dry period (Figure 4b).

## **Discussion**

### **The importance of habitat quality on otter distribution**

The habitat quality of the sites where otters occur in southern Spain are rather similar to those observed for otters from other geographical areas (Macdonald and Mason, 1982, 1983; Elliot, 1983; Adrián *et al.*, 1985; Taylor *et al.*, 1988). From the 11 habitat variables analysed in this work, only seven had some influence on otter distribution. To discriminate which of these variables had a greater influence is rather difficult because most environmental variables affecting otters are usually correlated. For example, remote sites far from human influence, as forested mountainous lands in southern Spain, tend to be undisturbed, unpolluted, with high bankside cover, etc.- just the opposite of sites in urban areas or surrounded by intensive agricultural fields. Otters may be affected by the synergistic effect of several habitat variables rather than by only one isolated factor.

However, some variables are known to be more important to otters than others, including land use in the surroundings, human disturbance or bankside cover. Detailed analysis of these variables has shown that several of them are associated. For example, Melquist and Hornocker (1983) observed that Canadian otters (*Lutra canadensis*) showed a high degree of tolerance to human disturbance if shelter, usually provided by bankside cover, was adequate. A similar result was found by Macdonald and Mason (1982), Elliot (1983) and Green *et al.* (1984) for European otters (*L. Lutra*). Thus the importance of disturbance is conditioned by the availability of shelter. In this study human disturbance was negatively correlated with bankside cover.

Over an extensive area and time period the probability of finding otter signs was correlated to a habitat gradient. This gradient in otter habitat conditions fluctuated from highly polluted and/or disturbed streams up to undisturbed, unpolluted streams, with high cover availability, especially on both banks and in the surrounding areas. Thus, otter presence varied according to predictable changes in habitat conditions. Otters preferred the habitats represented by the most positive extreme of the habitat gradient and rejected the most negative. This large-scale observation adds weight to hypotheses on the synergistic effect of several habitat variables on otter distribution (Delibes, 1990).

### **The importance of water availability on otter distribution**

Water balance, a direct indicator of water availability (Delibes, 1990), is strongly correlated with otter distribution. In southern Spain water balance is usually negative, but it still fluctuates between higher or lower negative values. Water availability is the most important environmental factor for otter distribution (Broyer *et al.*, 1988; Delibes, 1990), as this species feeds almost exclusively on aquatic prey (López-Nieves and Hernando, 1984; Mason and Macdonald, 1986). Yet, water in Mediterranean areas is in short supply and water availability changes dramatically both within and between years. Thus, the water bodies potentially inhabited by otters suffer from periodic enlargement and reduction. For example, during summer most small or medium-sized streams dry up and the only water remains in a few scattered pools where environmental conditions degrade progressively (warming up, eutrophication, loss of oxygen concentration and anoxia, higher densities of fish and other vertebrates). This degradation is still stressed in streams receiving sewage inputs (Prenda and Gallardo, 1986). A similar succession is observed throughout the long periods of drought, although over an extended time period. This reduction in habitat size may force otters to concentrate in certain aquatic patches containing food and other habitat features (Macdonald and Mason, 1982; Broyer *et al.*, 1988; Taylor *et al.*, 1988; Delibes *et al.*, 1991). Conversely, during rainy periods otter distribution may increase as habitat patches that lacked water during drought are recolonised.

How are otter populations affected by this strong environmental fluctuation? (Figure 5). Otter population density in Mediterranean areas may fluctuate accordingly to water availability. During drought periods, food shortages and increases in territorial behaviour may cause an elevation in otter mortality (Kruuk *et al.*, 1993), although no data are available from the study area on this aspect. However, otter distribution range after an extreme drought increases to the previous level in a short period of time -about one year- (Figure 4a), less than the time necessary to get new independent cubs to recover earlier population densities. The reaches of large streams and reservoirs that contain water even in the driest months may serve as otter refuges during these stressful periods in Mediterranean areas.

In general, Mediterranean otters are similarly affected by habitat degradation and water pollution than otters from temperate areas. But in the Mediterranean regions, the fluctuations in water availability, both seasonal and interannual, stress the problems derived from the habitat degradation and, especially, the water pollution, with respect to more northerly locations (Figure 5). During winter, as a consequence of frequent catastrophic flash floods, fish suffer from drift and dilution (the same fish in much larger water volume). The result is that temporally (from a few days to months) there can be an important reduction in prey availability. It may force otters to look for alternative prey. During summer or longer drought periods the reduced flow can determine a strong reduction in water quality and an increase in contaminant concentration (Prenda and Gallardo, 1996). It may reduce prey availability and/or increase otter mortality. The final consequence can be an otter population bottleneck, from which this mustelid can quickly recover in a subsequent rainy period (Figure 5).

This large variability in otter distribution between rainy and drought periods may pose a cautionary tale when interpreting large-scale censuses to monitor otter population status in Mediterranean areas. As otter distribution range expands and contracts very quickly, the fact that in a certain survey period otter distribution area may have enlarged with respect to any previous survey, does not necessarily mean that populations are thriving and that the threats to the species have disappeared. In contrast, these threats can merely be temporarily buffered (e.g.

pollution reduction as a consequence of contaminant dilution in the larger water flow predominant during rainy periods) but not necessarily eliminated.

### **The role of reservoirs on otter distribution and conservation in Mediterranean areas**

Melquist and Hornocker (1983) suggested that the availability of adequate escape cover and shelter and less disturbance were probably important reasons for Canadian otters preferring streams, instead of lakes, reservoirs and ponds. These Idaho water bodies were mostly used by otters when human disturbance decreased during winter. In southern Spain streams were similarly preferred by otters, but reservoirs were used where they were available. There were no observation of any preference or rejection for this sort of man-made water body. In Sweden there were no obvious differences in otter signs between regulated and unregulated rivers related to regulation (Nilsson and Dynesius, 1994). This study suggest that reservoirs could be important habitats for otters during long periods of large water shortage. In the study area during most of the extreme drought period 1993-94 the only permanent water bodies were reservoirs and very few isolated pools in some large streams. Otter signs during this period were only found in such water bodies. When this drought ended, otters quickly recolonised the remaining area that previously lacked water. According to these results, reservoirs act as otter refuges during Mediterranean droughts. Notwithstanding, most reservoirs surveyed in this work were small to medium-sized (usually less than 30 hm<sup>3</sup>) and none of them seemed to act as barriers impeding otter dispersal, both upstream and downstream.

Some authors have observed fewer otter signs in reservoirs than in any other water body, especially streams or rivers (Macdonald and Mason, 1982). The reservoirs apparently seem to be poor otter habitats due to frequent and unpredictable water level fluctuations and the lack of bankside cover. On the other hand, it is more difficult to find otter signs in most reservoirs than in streams (Delibes, 1990). Thus, in many cases otters may go unnoticed in reservoirs, which are probably reported as sites lacking otters during conventional otter surveys. In this study otter signs were detected in 62.5% of reservoirs surveyed. Similarly, one

of us (J. P., personal observation) found signs of otters in 90% of hydroelectric production reservoirs in the northern half of Portugal. The role of reservoirs on otter distribution and conservation in Mediterranean areas, especially during drought periods, should be further investigated.

In conclusion, otter distribution in Mediterranean areas is strongly influenced by two factors: 1) man-induced habitat degradation and 2) natural variability in water availability. The addition of the second factor to the first one introduces additional risks to the survival of otter populations in Mediterranean areas compared with more northerly and humid areas, usually only subjected to the first threatening factor.

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Table 1. Summary of environmental data of the study area (Córdoba province, southern Spain).

	<b>Mean</b>	<b>Range</b>
rainfall (mm yr <sup>-1</sup> )	647	375 - 1168
Mean annual temperature (°C)	16.6	15.3 - 17.6
human population density (km <sup>-2</sup> )	63.9	12.4 - 149.8
altitude (m)	550	100 - 1570
water quality: BOD (mg L <sup>-1</sup> )	83.9	0.6 - 167.1
water quality: conductivity (μs cm <sup>-1</sup> )	1532	270 - 6780
	<b>Number</b>	<b>Total capacity (hm<sup>3</sup>)</b>
reservoirs (>5 hm <sup>3</sup> )	16	2510
	<b>Land use (km<sup>2</sup>)</b>	<b>%</b>
crop and pastures	3754	27.4
olive grove	2935	21.4
<i>dehesas</i>	3572	26.0
tree plantations, woodland and maquis	3456	25.2

Table 2. Qualitative scales used to estimate selected variables of otter habitat

Scale	water body	width (m)	depth (m)	Flow velocity	bank dominant substrate	water pollution <sup>1</sup>	bankside vegetation cover	bankside dominant vegetation type	channel quality	land use	human disturbance <sup>2</sup>
1	irrigation channel	<1	<0.5	no current or very slow	large rocks	nil	nil	nil	man made	urban	nil or very low
2	pond	1-2	0.5-1	slow	pebble-cobble	low	<10%	helophytes	Altered <sup>3</sup>	crop-pastures	low
3	small stream	>2-5	>1-2	moderate or high	fine gravel	medium-high	10-25%	trees	natural	Dehesa <sup>4</sup>	moderate
4	reservoir	>5-10	>2		sand		>25-50%	bushes		olive grove	intense
5	large stream	>10-20					>50-75%			tree plantations	very intense
6		>20-40					>75%			natural forest	
7		>40									

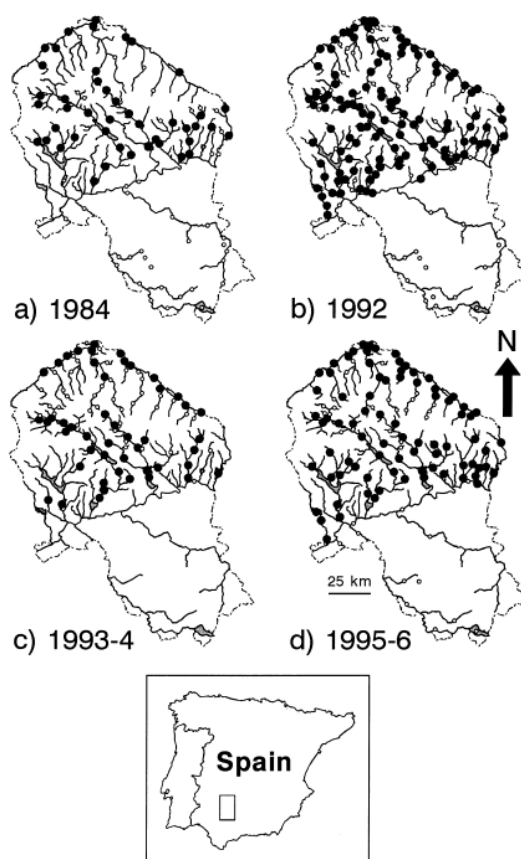
<sup>1,2</sup> See methods for explanation<sup>3</sup> dredged, bankside vegetation cutting, etc.<sup>4</sup> pastures with dispersed trees, usually oak (*Quercus rotundifolia*) naturally grown

Table 3. Product-moment correlation coefficients (r) between the qualitative categories used to describe the otter habitat and both the PC1 and the PC2, which accounted for 33.5 % and 29.4 % of the variance, respectively (n=561).

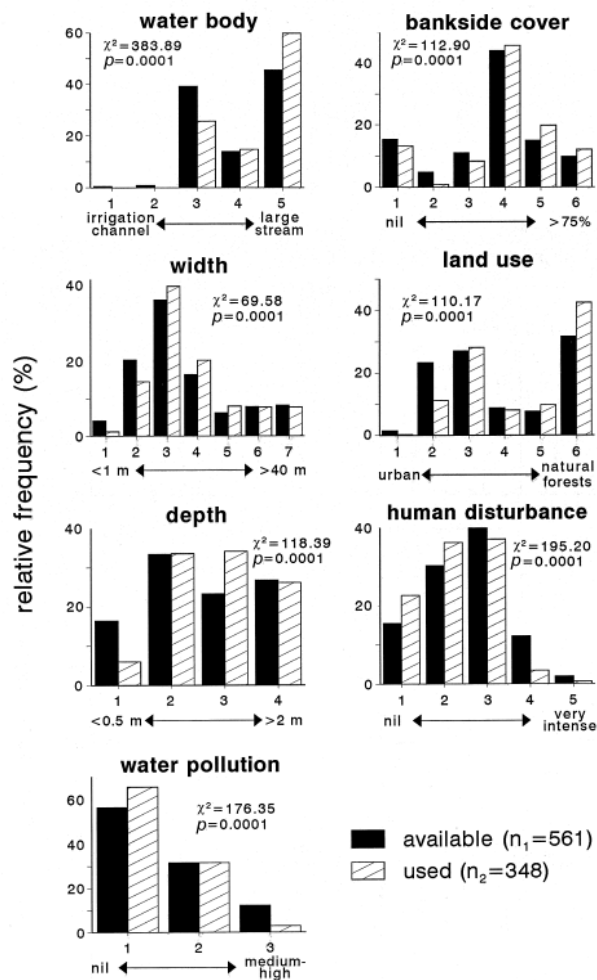
\* P<0.05; \*\* P<0.01, \*\*\* P<0.001

	PC1	PC2
land use	0.69***	0.42***
water pollution	-0.76***	-0.11*
human disturbance	-0.72***	-0.33***
water body	0.01	0.70***
width	-0.47***	0.73***
depth	-0.36***	0.86***
bankside cover	0.65***	0.05

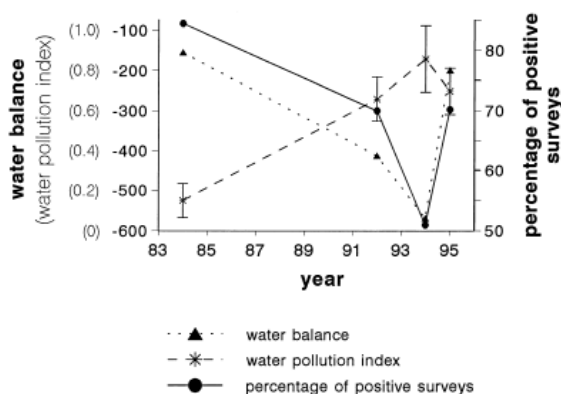
## FIGURE CAPTIONS



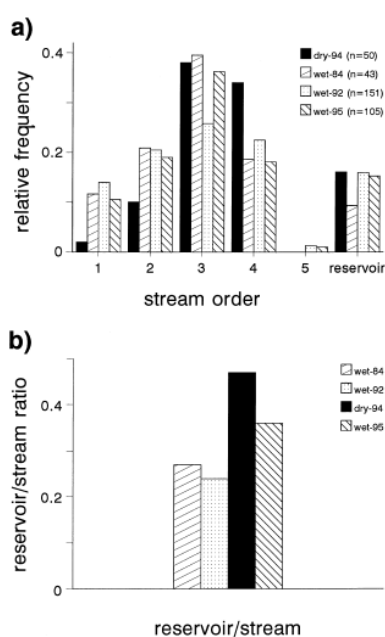
**Fig. 1.** Map of the study area (Córdoba province, southern Spain) indicating the positive (filled circles) and negative sites (open circles) for otters in four study periods; all but 1993-4 were wet years.



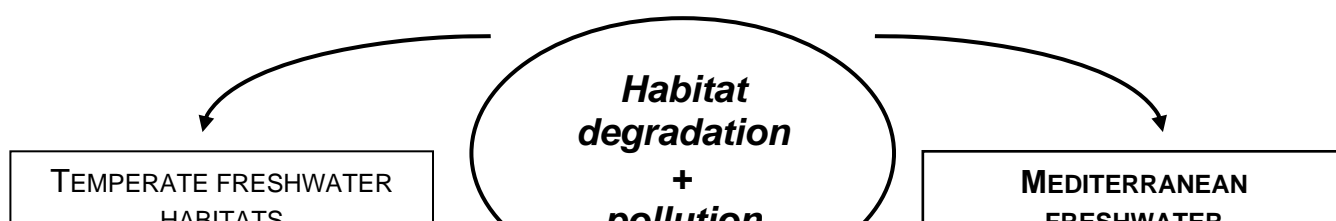
**Fig. 2.** Frequency distribution (%) of selected environmental variables at all sites (filled bars) and at only those sites where otter signs were found (hatched bars).



**Fig. 3.** Temporal evolution of water balance (rainfall minus potential evapotranspiration), the water pollution index (see Methods) and the percentage of other positive sites in a large area in southern Spain. The water pollution index are means  $\pm$  SE (error bars). Observe that 'water balance' and 'percentage of positive surveys' run parallel, the opposite to 'water pollution'.



**Fig. 4.** a) Distribution of otter signs in several order streams and in reservoirs in four different periods (three wet and one dry). b) Ratio between the relative frequency of positive sites in reservoirs vs. the relative frequency of positive sites in streams in the four periods previously mentioned.



*Seasonal  
fluctuations*

*Interannual  
variability*

**Fig. 5.** A model scheme on the hypothetical consequences of climate fluctuations in Mediterranean areas on otter conservation