

# A method to compare strategies in endangered species conservation. The Amphibian *Bufo bufo* metapopulation in the alpine Rhine valley as a case study.

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## INTRODUCTION

AMPHIBIANS are a vertebrate taxonomic group that appears to be particularly sensitive to environmental changes resulting from human activities. Among the several factors that may be responsible for reducing both amphibian distribution and numbers are increased UV radiation, habitat degradation and obstacles for between-habitat movements. In the case of pond-breeding amphibians in highly fragmented landscapes, habitat management may rely both on increasing water body numbers, quality and persistence, and on landscape complementation (that is the need for connectivity between aquatic breeding sites and suitable terrestrial habitat). In the Bündner Herrschaft district in the upper Rhine valley (Canton of the Grisons, Switzerland) for example, some ponds that serve as breeding sites for amphibians have been rehabilitated for the purpose of conservation and attempts are made to further improve these sites and to add additional sites if justified on conservation grounds. Both these types of intervention require considerable investments that have to be made on the basis of careful evaluation of different strategies. If such habitats fall into intensively managed agricultural, residential land or even industrial sites, decision making in favour of conservation is easier when based on objective quantitative ground. Thereby, regulatory or fiscal measures may be considered together with participatory activities.

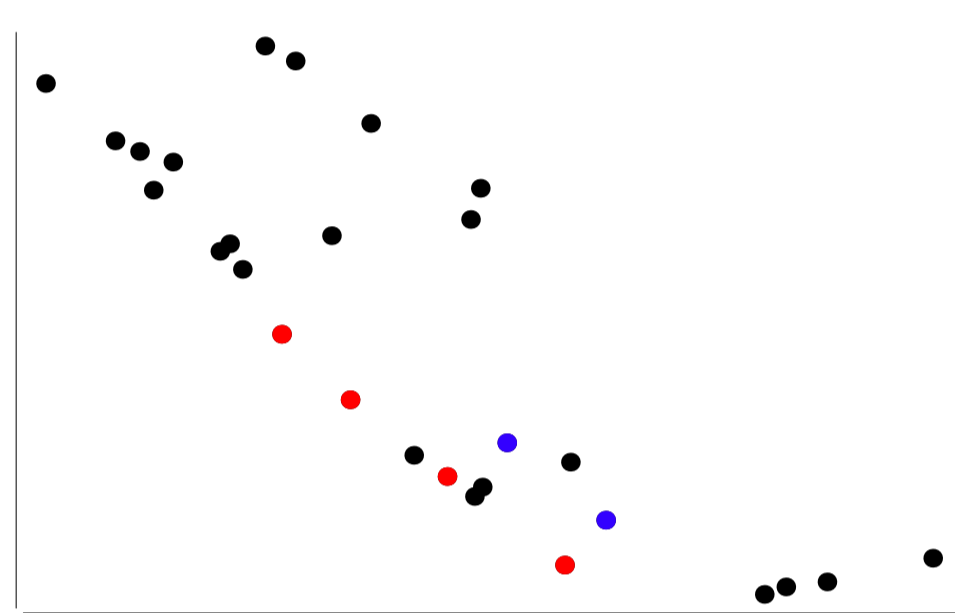
## OBJECTIVE

### The development of quantitative methods for the comparison of different habitat management strategies.

We propose the use of the *Kullback-Leibler* (KL) divergence ([5]). A metapopulation model, also known as *Incidence Function Model* (IFM) ([3]), allowed the estimation of probabilities for breeding sites occupancy in relation to management options that are evaluated through the KL-divergence. This evaluation requires the definition of a reference measure. The approach is developed for Common European Toad *Bufo bufo* (Linnaeus) populations in the Bündner Herrschaft district that serves as a case study. The strategies for evaluation have been defined by Dr. Josef Hartmann, Cantonal Bureau for Nature and Landscape (Chur, Switzerland). Importantly, these strategies have been defined a priori on the basis of economics of land use rather than considerations regarding the metapopulation dynamics described by the model.

## DATA

The Bündner Herrschaft district is located in Southeastern Switzerland and comprises a closed area delimited by the Rhine river in the West, the Landquart river in the South, high mountains in the Northeast and intensively used land of the Liechtenstein Principality in the North.



Dr. Josef Hartmann, Cantonal Bureau for Nature and Landscape, Chur (Switzerland) proposed two strategies. Strategy SA (RED) was selected because the establishment of four new sites along the Rhine was relatively cost-efficient, but its contribution to Amphibian conservation unknown. Strategy SB (BLUE) was assumed to increase connectivity of habitats.

Figure 1: Original sites: BLACK. Option SA: RED. Option SB: BLUE.

For each site  $i$  ( $i = 1, \dots, 22$ ) we know: coordinates of the centroid, area, presence/ absence of the species and the quality of the terrestrial habitat that links site  $i$  to every other site. The quality is classified by 3 categories (i.e. bad, good and very good) for the passage of amphibians.

## RESULTS

In (1), the distance  $d_{ij}$  has been scaled by 1, 2 or 5 to take into account the degree of difficulty that amphibians encounter when passing from one site to another. Expert's opinion was used to fix  $\alpha$ .

ESTIMATION		COMPARISON	
Strategy	$(A_0, x, y)$	Strategy	KL
S22 (22 siti existing)	(50, 0.412, 508.2)	S22 (22 existing sites)	37.06
SA0 (+ 4 empty sites)	(100, 0.488, 581.8)	SA0 (+ 4 empty sites)	37.61
SA1 (+ 4 not empty sites)	(32, 0.379, 213.9)	<b>SA1 (+ 4 not empty sites)</b>	<b>48.65</b>
SB0 (+ 2 empty sites)	(100, 0.446, 449.8)	SB0 (+ 2 empty sites)	37.45
SB1 (+2 not empty sites)	(35.93, 0.414, 550.6)	SB1 (+2 not empty sites)	43.43

Noteworthy, the estimate of  $y$  is very sensitive to the so selected scalars. This problem has to be further investigated.

As expected, the increase in the number of sites increases KL. However, the creation of new habitats is of little value if they do not offer suitable conditions for the establishment of a stable local population. In fact, if these sites are not occupied, the value of KL increases only slightly. On the other side, a significant increase in KL results from occupied sites.

## DISCUSSION

To our knowledge, two index introduced in literature to assess the extinction risk of a metapopulation could be naturally considered for comparison purposes:

1. the expected extinction time  $T_{ext}$  of the metapopulation, ([2]);
2. the metapopulation persistence capacity  $\lambda_M$ , ([6]).

Despite its clear interpretation, and intuitive appeal for comparison,  $T_{ext}$  can not be used in practice for computational difficulties when  $n > 20$ , ([4]).  $\lambda_M$  comes from a *deterministic* model and it has several meaningful interpretations, taking into account the actual spatial configuration of the fragmented landscape. However, it is impossible to derive a general analytical expression for it and even if sometimes it is possible to use some approximations, they do not have general validity. ([6]). Therefore it is clear that there is a need for simple alternative measures permitting a sensible discrimination among several scenarios.

The expected transition time  $1/E_i$  from occupancy to extinction can have a wide range among the sites so that any conclusion coming from it seems to be in contrast with the basic assumption of stationarity of the IFM. Then, we have supposed that a measure which does not depend on future dynamical developments of the system would be more sensible, and we have concentrated on the comparison of the estimated distributions, that is, of the estimated incidences. The Kullback-Leibler information (or divergence) is well-known and widely used in statistics, however only recently it appeared in the ecological literature, mainly in connection with estimation and model selection problems ([1]). The choice of  $P_0$  as previously described represents only a first attempt, based on some simple ecological considerations. Other meaningful reference measures could be chosen; in any case, the "global improvement" property is a natural requirement to be satisfied by any sensible measure. The fact that the Kullback-Leibler divergence is unbounded could be a drawback: the assessment of the degree of improvement provided from each strategy, with respect to the others, is made difficult. A bounded index could be perhaps more appropriate.

## References

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