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Selection of bio-indicators to assess the possible landscape ecological effects of climate change

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Abstract

Past climate changes have led to considerable changes in the species composition of ecosystems. The recent increase in average global temperature is rather strong compared to previous warming periods and, if climate models are correct, future warming will be even stronger. Especially in Europe where the landscape has been greatly fragmented by human activities, the ongoing and projected changes in climate will pose an additional stress on the natural biodiversity. This paper will discuss a method for the selection of bio-indicators to assess the possible landscape-ecological effects of climate change, and presents some preliminary results of the selection of indicator species for the Netherlands.

1. INTRODUCTION

In this paper, some results are presented of a short pilot-study to find suitable bio-indicators to assess effects of climate change on biodiversity in Europe. Since species determine the structure and functioning of ecosystems, these bio-indicators can be used to assess the climate-sensitivity of natural end semi-natural ecosystems and landscapes.

The main purpose of the study is to develop criteria for the selection of species (bio-indicators) that are suitable for assessing the (potential) response of natural ecosystems to climate change "in the field". The complexity of the potential effects of climate change on species as well as on landscape-ecological processes, together with the simultaneous occurrence of many other influences on the landscape (e.g. land use, eutrophication, acid precipitation) [1], makes it essential, but at the same time quite difficult, to select appropriate indicator-species.

2. SOME CRITERIA FOR SELECTING INDICATOR SPECIES

In order to select potential indicator-species, they must be screened on a number of criteria based on the response features and practical constraints. As a start a few criteria are listed in table 1 , but future research will probably refine these further and may add more.

Table 1: Some criteria for selecting bio-indicators for climate change

Climate sensitivity
Habitat constraints
Position within distribution range
Presence and abundance
Dispersal capacity
Functional position in the ecosystem
Suitability for monitoring

Depending on the aim for which indicator species are to be used, i.e the response-feature to be monitored, which may be physiology, phenology, inter-specific interactions or abundance/distribution or a combination of these features, a selection of criteria should be used. These criteria could then serve as a type of "filter" to reduce the available species-list in a given region to a few suitable indicator-species.

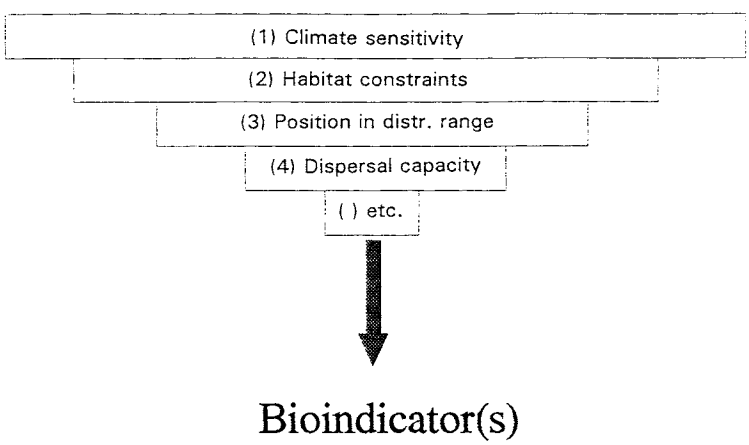

Figure 1:
"Filter" showing the succesive application of criteria to select indicator species for climate change

3. SELECTION OF POSSIBLE INDICATOR SPECIES FOR CLIMATE CHANGE IN THE NETHERLANDS

The expected climate change in the Netherlands will probably result in winters that are more atlantic (higher temperatures and wetter), while the summer-period will be more continental (higher temperatures and drier).

Changes in climate and weather will particularly influence plant and animal species which: (a) occur at the border of their geographical distribution, (b) do not occur in their preferential habitat (marginal habitats), and (c) are able to adjust rapidly by changing their distribution area or which are just not able to do so and thus will be threatened by extinction.

Various studies have been carried out in the Netherlands on the possible effects of global (esp. climate) change on ecosystems and species to various degrees of detail, including on terrestrial plants [3-5], aquatic plants [6], mammals [7-8], birds [9-10], butterflies [11-12] and dragonflies [13]. Most of these studies were carried out within the framework of a project initiated and sponsored by the Dutch Ministry of Housing, Physical Planning and Environment under the title Flora and Fauna 2030 [14] and the so-called LICC project [1].

Using the above mentioned publications and applying some of the criteria described in section 2 of this paper, a preliminary list of indicator species was prepared for herbaceous plants, butterflies, breeding birds and mammals. Only species that are considered as native or well established in the Netherlands have been used.

Method of selection

For the four groups, all species found in the Netherlands were used as a starting point: 1,253 higher plants, 71 butterflies, 179 breeding birds, and 49 mammals. The selection took place in four steps:

Step (1): climate sensitivity

In the first step, a survey based on expert judgements reveiled that 175 of the 1,253 selected plant species in the Netherlands are expected to respond mainly to climate change and much less to other global changes, whereby 165 plants are expected to benefit from climate-warming and 10 are expected to decline [4]. This list was narrowed down further by using the "Ellenberg-value" for temperature and only those species were selected which have a low value (1-3 = plants which indicate cold growing conditions) or high value (7-9 = plants which indicate warm habitats) [15-16].

For animals, such indicator values do not exist and here the climate-sensitivity of the species was qualitatively assessed on the basis of known ecological relations between the species performance and/or distribution and climate factor(s).

Step (2): habitat constraints

Only those species were selected for which adequate habitats can be found at all latitudes in The Netherlands.

Step (3): dispersal capacity

During step 3, only those species which have a good dispersal capacity or of which (local) expansion is already taking place were selected.

Step (4): suitability for monitoring

Finally, the number of suitable indicators was narrowed down further by leaving out those species which may be difficult to monitor, for example because they are too small to recognize, because they lead a "hidden life" or because of taxonomical difficulties or other reasons.

Table 2 shows the results of this selection-procedure for the Netherlands for the four species-groups.

Table 2
Selection of bio-indicators for detecting climate change in the Netherlands

	Vascular plants			**Butterflies**		
Number:	1253		100%	71		100%
	+	-		+	-	
Criterion						
(1)	165	10	14.0%	4	0	5.6%
(*)	31	1	2.6%			
(2)	18	0	1.4%	2	0	2.8%
(3)	18	0	1.4%	2	0	2.8%
(4)	13	0	1.4%	2	0	2.8%
	Breeding birds			**Mammals**		
Number:	179		100%	49		100%
	+	-		+	-	
Criterion						
(1)	9	1	5.6%	0	0	0%
(2)	3	0	1.7%	0	0	0%
(3)	3	0	1.7%	0	0	0%
(4)	3	0	1.7%	0	0	0%

*) based on Ellenberg-values (see text) + = increase, - = decrease

Table 3 gives a preliminary list of species which could be used as climate indicator species in the Netherlands. All are species which are expected to increase in abundance and/or expand their distribution range. It should be emphasised that possible changes in phenology were not considered in the selection procedure.

Table 3
Examples of possible indicator species for climate change in the Netherlands

Vascular plants

C_3 species:
Anchusa officinalis (Alkanet)
Hordeum murinum (Mouse barley)
Medicago minima (Bar medick)
Poa bulbosa (Bulbous meadow-grass)
Sagina apetala
Senecio vernalis
Trifolium scabrum
Trifolium striatum (Knotted Clover)

C_4 species:
Abutilon theophrasti (Velvetleaf)
Cynodon dactylon (Bermuda grass)
Eragrostis minor (Little lovegrass)
Eragrostis pilosa (Indian lovegrass)
Portulaca oleracea (Purslane)

Butterflies
Papilio machaon (Swallowtail)
Nymphalis antiopa (Morning cloak)

Breeding birds
Asio otus (Long-eared Owl)
Cettia cettia (Cetti's Warbler)
Cisticola juncidis (Fan-tailed Warbler)

When research and monitoring proceed, species may be added or deleted on the basis of difficulties encountered or based on new insights in the ecology of the species.
No mammals were selected as bio-indicators, because most potential indicator-species in this group do not only react strongly to climate change, but also to other environmental changes. However, some species such as the Common Hamster (*Cricetus cricetus*) or Common Rabbit (*Oryctolagus cuniculus*) may be added to the list later on.

4. PRELIMINARY CONCLUSIONS

A first application of the proposed method for the selection of bio-indicators showed that only 0-3% of the species within the investigated taxonomic groups (vascular plants, breeding birds, butterflies and mammals) are potentially suitable as indicators for climate change in the Netherlands. All the selected indicator-species are expected to increase in abundance or expand their distribution range. It must be investigated further if this is a bias in the selection method or wether it is an indication of the possibly predominant positive effects of climate change for the investigated species groups in this part of Europe.

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