CLIMATE CHANGE AND HABITAT FRAGMENTATION: IDENTIFYING AREAS THAT NEED ADAPTATION

VOS, C. C. [1] *& BAVECO, H* [2]

[1] Wageningen University and Research Centre (WUR), Alterra, Wageningen, Netherlands., claire.vos@wur.nl

[2] Wageningen University and Research Centre (WUR), Alterra, Wageningen, Netherlands., hans.baveco@wur.nl

Keywords: climate change, fragmentation, land use change, connectivity measures, identifying appropriate conservation and restoration objectives

Introduction

Many species already have shifted their range as a response to climate change (e.g., Parmesan & Yohe 2003). Bioclimate envelope modelling studies project further range shifts for a variety of taxa in the 21 century (Harrison *et al.* 2006). Whether species can actually colonize new climate space depends both on species and landscape characteristics (Opdam & Wascher 2004). In many parts of Europe, natural or semi-natural ecosystems have become fragmented. Intensive agriculture and a dense network of infrastructure in the landscape surrounding nature areas add to the low matrix permeability for dispersing species. The persistence of species in fragmented landscapes is determined by the spatial cohesion of habitat networks (Opdam, Verboom & Pouwels 2003). This raises the question whether the current distribution of nature areas in Europe allows species affected by both climate change and habitat fragmentation to expand their range into new climate space.
We developed a method to identify where the spatial cohesion of ecosystem patterns at a large spatial scale might be inadequate to allow species to respond to a changing climate. Subsequently, we developed strategies for spatially adapting the Natura 2000 network .

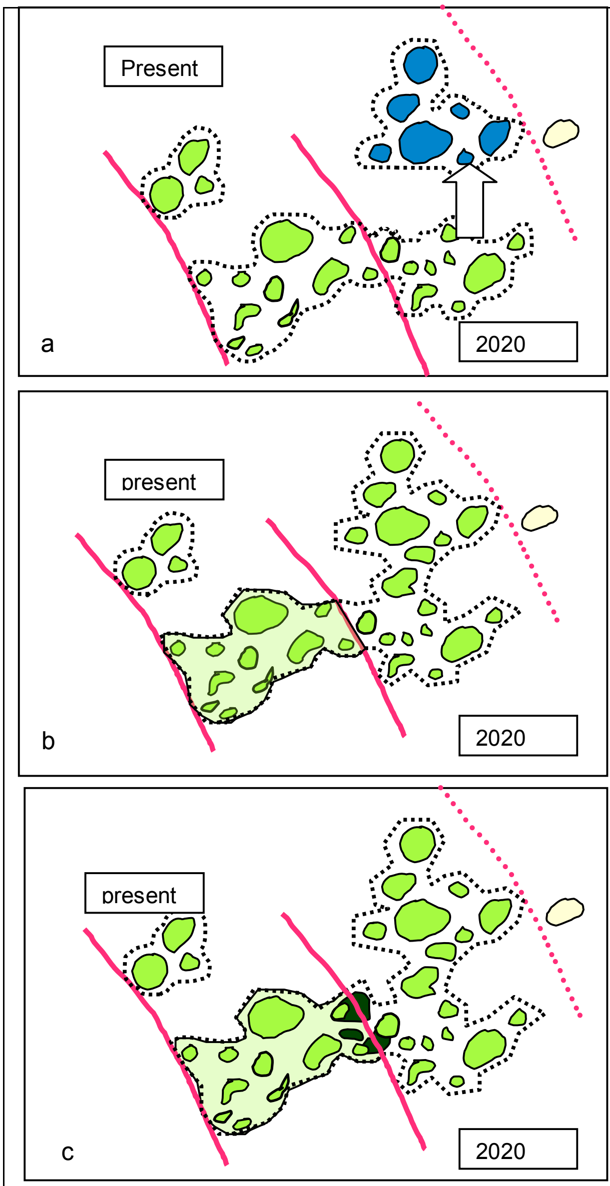
Materials and methods

We analyzed the spatial cohesion of three types of ecosystems (forest, wetland and natural grassland) for Northwest Europe, currently and with climate change. We estimated changes in suitable climate space using the bioclimatic model SPECIES (Pearson *et al.* 2002). For each ecosystem type, three species were selected that showed a shift in suitable climate space. Secondly, species were chosen which differed in terms of habitat fragmentation sensitivity, individual area requirements per reproductive unit, dispersal capacity and sensitivity to barriers in the landscape (Vos *et al.* 2001, Opdam *et al.* 2008). The following species were selected: forest ecosystem: black woodpecker (*Dryocopus martius*), middle spotted woodpecker (*Dendrocopos medius*) and agile frog (*Rana dalmatina*); wetlands: bittern (*Botaurus stellaris*), marsh warbler (*Acrocephalus palustris*) and large heath butterfly (*Coenonympha tullia*); natural grasslands: brown

hare (*Lepus europaeus*), meadow pipit (*Anthus pratensis*) and pool frog (*Rana lessonae*).
For each species, the configuration of networks of potential suitable habitat in Northwest Europe was calculated with the GRIDWALK dispersal model (Schippers *et al*. 1996). We analyzed the projected shifts in suitable climate space and the distribution of habitat networks for each species. Climate-proof and non climate-proof networks were identified with the CENA (Climate-based Ecological Network Analysis) model (Berry *et al.* 2007). CENA is used to define networks under each of the climate scenarios and to analyze the spatial and temporal relationships between the patches in these networks. In CENA the output of the SPECIES model and the GRIDWALK model are combined and suitable networks are delineated for the present situation and for the predicted climate space in 2020 and 2050. Next the amount of overlap between habitat networks in subsequent climate periods is calculated. The larger the overlap of networks suitable in both present and future climate scenarios the more likely the network will be climate proof. Networks that show no overlap are not climate-proof. For the non-climate proof networks or isolated habitat patches we indicated search areas where adaptation measures are needed.

Results and discussion

Habitat networks are *climate-proof* when there is sufficient overlap between the network in the present suitable climate and the suitable habitat networks after climate change. In figure 1 two adaptation strategies are illustrated: *linking networks* and *increasing colonization capacity*.
For all nine species the amount of suitable habitat protected in Natura 2000 sites declined from the present situation compared to 2050. There are several factors causing this effect. For some species the contraction zone exceeds the expansion zone. This holds for instance for the black woodpecker and the brown hare. A second factor is that suitable habitat in the expansion zone cannot be reached because of habitat fragmentation. A third factor is a decrease in suitable habitat in the expansion zone compared to the contracting zone. For instance the amount of broad leaved forest shows a decline from southeast to northwest in the study area.



a. The blue network is not climate-proof. Although the network is situated in a climate space that becomes suitable in 2020, species will not able to colonize it, as there is no overlap with a network in the present suitable climate space.
The arrow indicates the search area for adaptation measures.

b. Adaptation strategy: *Link networks*.
The creation of new habitat links the blue network to an already climate proof network, thus becoming climate proof.

c. The shaded area indicates the overlap zone in the habitat network between the present and 2020. Populations in the overlap zone form the expanding potential of the species from which new suitable habitats are to be colonized.

Adaptation strategy: *Increase colonizing capacity*.
The colonizing capacity is improved by creating new habitat patches or enlarging existing habitat patches in the overlap zone.

Figure 1.Identifying Climate-proof habitat networks, areas that need adaptation and two adaptation strategies: *Link networks* and *increasing colonizing capacity*.

Conclusions

Our analysis on the impact of climate change showed that the amount of suitable climate-proof habitat will diminish in northwest Europe for all studied species. The spatial cohesion is insufficient for most of the studied species to follow their shifting suitable climate envelope. This might lead to an additional shrinkage of species ranges. When species will go extinct at the contracting side of their range and are not able to colonize the expanding side of their range this will result in a decline of species' ranges and loss of biodiversity on a European level.
Our method allows prioritizing regions where improvement of connectivity is most urgent or potential gain is highest, thus identifying the best locations for European climate corridors.

Acknowledgements

This research formed part of the EU INTERREG IIIB project BRANCH (www.branchproject.org). The study was carried out in cooperation with Pam Berry and Jesse O'Hanley from the Environmental Change Institute, Oxford University, Oxford.

References

Berry, P.M., Jones, A.P., Nicholls, R.J. & Vos, C.C. (2007) Assessment of the vulnerability of terrestrial and coastal habitats and species in Europe to climate change, Annex 2 of Planning for biodiversity in a changing climate - BRANCH project Final Report, Natural England, UK.

Harrison, P.A., Berry, P.M., Butt, N. & New, M. (2006) Modelling climate change impacts on species' distributions at the European scale: Implications for conservation policy. Environmental Science and Policy, 9, 116-128.

Opdam, P., Pouwels, R., Van Rooij, S. Steingröver, E. & Vos, C.C. (2008) Setting biodiversity targets in participatory regional planning: introducing ecoprofiles. Ecology and Society, 13, 20. [online] URL: http://www.ecologyandsociety.org/vol13/iss1/art20/

Opdam, P., Verboom, J. & Pouwels, R. (2003) Landscape cohesion: an index for the conservation potential of landscapes for biodiversity. Landscape Ecology, 18, 113-126.

Opdam, P. & Wascher, D. (2004) Climate change meets habitat fragmentation: linking landscape and biogeographical scale level in research and conservation. Biological Conservation, 117, 285-297.

Parmesan, C. & Yohe, G. (2003) A globally coherent fingerprint of climate change impacts across natural systems. Nature, 421, 37-42.

Pearson, R.G., Dawson, T.P., Berry, P.M. & Harrison, P.A. (2002) SPECIES: A spatial valuation of climate impact on the envelope of species. Ecological Modelling, 154, 289-300

Schippers, P., Verboom J., Knaapen J.P. & Van Apeldoorn R.C. (1996) Dispersal and habitat connectivity in complex heterogeneous landscapes an analysis with a GIS-based random walk model. Ecography, 19, 97-106.

Vos, C.C., Verboom, J., Opdam, P.F.M. & Ter Braak, C.J.F. (2001) Towards ecologically scaled landscape indices. American Naturalist, 157, 24-51.