klimaat voor ruimte
climate changes spatial planning

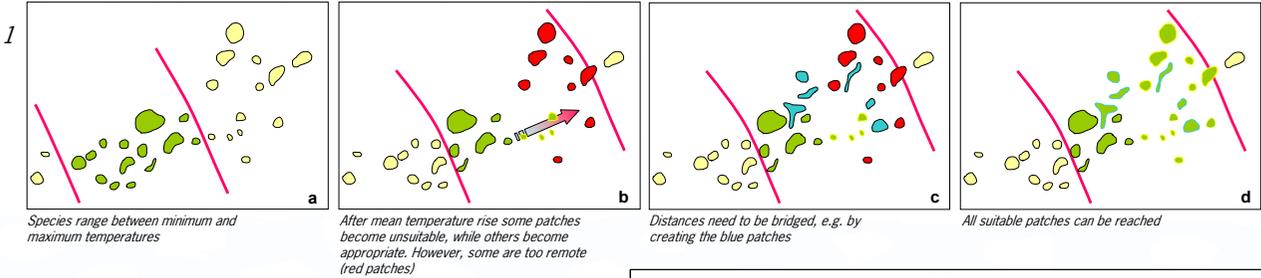# CLIMATE CHANGE AND HABITAT FRAGMENTATION: RANGE SHIFTS FOR DUTCH BUTTERFLY SPECIES

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Shifting ranges: temperature rise and habitat fragmentation

"There is very high confidence (…) that recent warming is strongly affecting terrestrial biological systems, including such changes as poleward and upward shifts in ranges in plant and animal species". This is concluded by the Intergovernmental Panel on Climate Change (IPCC) from its WGII's Fourth Assessment (2007). What is described as a shifting species range is in fact the complex result of extinction of populations at the warm range limit, and colonization and growth of populations into regions that newly came within the cold range limit (Opdam & Wascher 2004). Next to **climate change**, **habitat framentation** is thought to influence extinction and colonization of populations (e.g. Warren et al. 2001). In order to understand the potential risks of climate change to a species, we must consider the dynamics of the populations constituting the geographical range, in relation to the spatial features of the landscapes across the range (Opdam & Wascher 2004).

The **aim** of this study is to quantify the combined effect of temperature rise and habitat fragmentation on the shifting species ranges. With the results, **thresholds for spatial cohesion** can be identified and landscape patterns can be adapted in favour of the considered species, taking climate change into account.

Figure 1: Example of synergetic effects of temperature rise and habitat fragmentation on species range

a: Species range between minimum and maximum temperatures

b: After mean temperature rise some patches become unsuitable, while others become appropriate. However, some are too remote (red patches)

c: Distances need to be bridged, e.g. by creating the blue patches

d: All suitable patches can be reached

Indication for shifting butterfly ranges

For – ectothermic – butterfly species, the shifts in ranges are expected to be affected by the increase in temperature, so that the distribution patterns shift poleward and upward due to climate change (Parmesan et al. 1999). In this study, shifting ranges could be demonstrated using census data of 22 butterfly species originating from the Netherlands, covering the period 1980-2005. Poleward shifts are shown by 19 species, while 3 species shifted southward.

Figure 2: Change in the ranges of the 22 butterfly species over the periods 1980-1985 and 2000-2005. Changes are expressed as the differences between the average X and Y coordinates of the periods 2000-2005 and 1980-1985, where the values of the period 1980-1985 are set to zero. Negative X and Y values represent more southern and western distributions in the 2000-2005 periods, respectively. The spherical lines connect positions with equal distances to the graph origin.
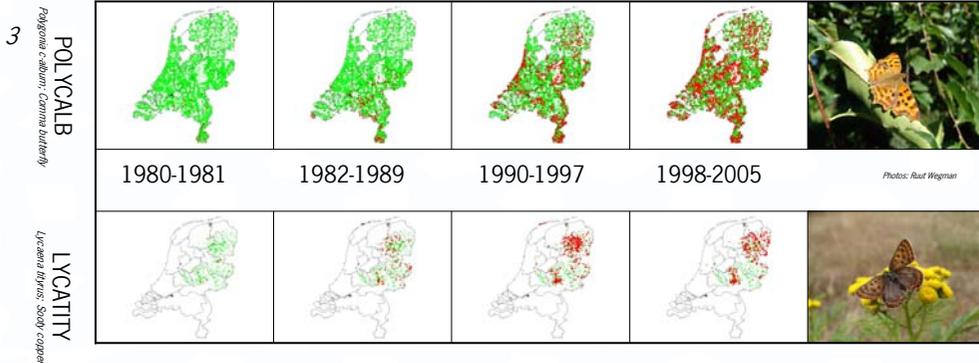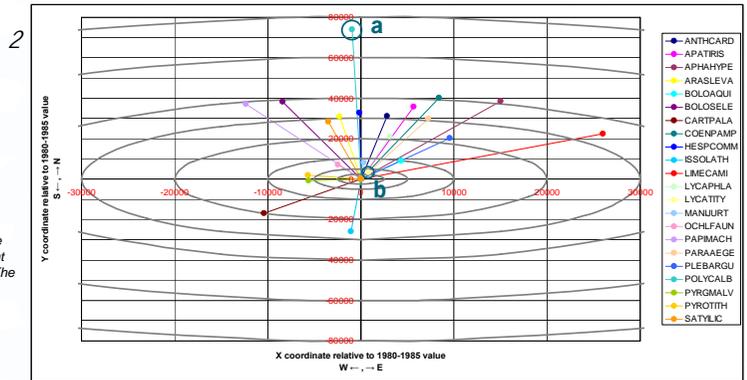

POLYCALB
Polygonia c-album, Comma butterfly

1980-1981   1982-1989   1990-1997   1998-2005

LYCATITY
Lycaena tityrus, Sooty copper

Photos: Ruut Wegman

Figure 3: Census data for 4 periods: 1980-1981, 1982-1989, 1990-1997, and 1998-2005 (red dots); green indicates suitable habitat; a: Polygonia c-album (Comma butterfly) shows a fast shift to the north; b: Lycaena tityrus (Sooty copper) shows hardly any shift. See Figure 2 for northing and easting relative to other species.

Interpretation by metapopulation models

Since the majority of the butterfly species show poleward shifts, it is attempted to implement a **process-based approach**, using a **stochastic patch occupancy model** (SPOM). SPOMs are both biologically specified and can be relatively easily parameterized with snapshot data (observations of patches in a network being occupied or empty for a single year; Hanski 1994). Given the current occupancy states of all patches in a patch network, SPOMs predict for each patch the probability that it will be occupied at any time in the future (Etienne et al. 1999).

The occupancy probabilities depend on the chances of local extinction and colonization. In this study, it is hypothesized that the local extinction and colonization chances depend on the characteristics **patch area**, **connectivity,** and **temperature**.

Figure 4: Schematic representation of the process-based approach with a stochastic patch occupancy model, where the chances of local extinction and colonization depend on patch area, connectivity, and temperature. E=local extinction chance; E(Ai)=extinction chance for patch i with area A; C=local colonization chance; C(di,j)=colonization chance for patch i with distance d to patch j; T=temperature
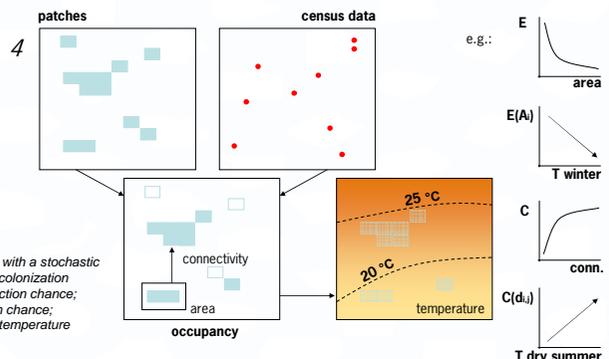
References:

Etienne, R. S., Ter Braak, C. J. F. & Vos, C. C. 2004 Application of Stochastic Patch Occupancy Models to Real Metapopulations. In *Ecology, Genetics and Evolution of Metapopulations* (ed. I. Hanski & O. E. Gaggiotti): Elsevier Academic Press.

Hanski, I. 1994 A Practical Model of Metapopulation Dynamics. *Journal of Animal Ecology* 63, 151-162.

IPCC. 2007 Climate change 2007: Impacts, Adaptation and Vulnerability; Working Group II Contribution to the Intergovernmental Panel on Climate Change; Fouth Assessment Report.

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

Parmesan, C., Ryrholm, N., Stefanescu, C., Hill, J. K., Thomas, C. D., Descimon, H., Huntley, B., Kaila, L., Kullberg, J., Tammaru, T., Tennent, W. J., Thomas, J. A. & Warren, M. 1999 Poleward shifts in geographical ranges of butterfly species associated with regional warming. *Nature* 399, 579-583.

Warren, M. S., Hill, J. K., Thomas, J. A., Asher, J., Fox, R., Huntley, B., Roy, D. B., Telfer, M. G., Jeffcoate, S., Harding, P., Jeffcoate, G., Willis, S. G., Greatorex-Davies, J. N., Moss, D. & Thomas, C. D. 2001 Rapid responses of British butterflies to opposing forces of climate and habitat change. *Nature* 414, 65-69.