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Deliverable 3.2 Report on historic effect of land use changes based on organism and habitat

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- Report Deliverable D 3.2 -

COCONUT

Understanding effects of land use changes on ecosystems to halt loss of biodiversity

Contract No 044346

Report on historic effect of land use changes based on organism and habitat

Erik Öckinger & Riccardo Bommarco

Department of Ecology
Swedish University of Agricultural Sciences
Uppsala, Sweden

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Background

Habitat loss and fragmentation is known to have profound effects on species diversity. However, not all species are likely to be affected equally by these processes and little is known about factors that influence the responses of different species. From a theoretical perspective, it has been suggested that species traits, such as body size, dispersal ability, resource specificity and fecundity may influence haw species respond to habitat loss and fragmentation. In COCONUT we aim at empirically investigating the relationships between species traits and species' responses to habitat loss and fragmentation by synthesizing existing published studies and databases. We focus on some selected groups of organisms for which there is good ecological knowledge; plants, birds, bees, butterflies and moths (Lepidoptera). In this report we present the applied approach and the progress and results achieved so far.

Approach

In order to synthesize the current knowledge of species responses to habitat loss and fragmentation, especially with regard to species traits, we have adopted the synthesis workshops approach of the working groups of the NCEAS (National Center for Ecological Analysis and Synthesis) in Santa Barbara (USA). This means that people holding relevant dataset are invited to a workshop where the synthesis work is planned. Smaller working groups are formed ad specific tasks are divided among the participants. After the workshop, the decided analyses and tasks are performed individually by the participants. After some months the participants meet again to compile there results and to write a manuscript.

Workshop 1 – Effect of species traits on responses to habitat loss and fragmentation
In order to synthesize the current knowledge of species responses to habitat loss and fragmentation especially with regard to species traits, a workshop was held in Katarino, Bulgaria, 17-21 Sept 2007. People holding relevant dataset were invited. At the workshop, the synthesis work was planned. Smaller working groups were formed ad specific tasks are divided among the participants. At the workshop in Bulgaria, 9 persons from 7 countries (Bulgaria, Germany, Estonia, Finland, UK, USA and Sweden) participated.

During the workshop in Bulgaria, we decided to perform six separate synthesizing analyses:

1) Meta-analysis of the relationship between plant traits and habitat fragmentation
2) Can species traits be used as predictors of plant species sensitivity to habitat fragmentation and area?
3) Meta-analysis of the relationship between bee traits and habitat fragmentation
4) Meta-analysis of the relationship between butterfly and moth traits and habitat fragmentation
5) Analysis of density-area relationships for bees
6) Analysis of density-area relationships for butterflies and moths
7) Meta-analysis of butterfly responses to habitat fragmentation in relation to landscape matrix.

Workshop 2 – Synthesis of time lags in species responses to habitat fragmentation
A second workshop was held in Sitges, Spain 7-10 April 2008. Participants were partners involved in WP1. During the workshop, a literature review of the time lags in species responses to habitat loss and fragmentation was initiated.

Results from synthesis workshops

Databases

We have compiled meta-databases of relevant studies on the effects of fragmentation on species richness for plants, bees, birds, butterflies and moths. For a study to be suitable to include in the meta-analyses, the following criteria must be fulfilled:

a) Presence/absence records of all species in the focal group.
b) At least 7 sites were surveyed.
c) Habitat patch area was measured and there is a gradient in patch areas.
d) Some index of isolation was measured and there is a gradient in isolation.

For inclusion in the analyses of density-area relationships it is also necessary to have some estimate of species-specific abundance or population density for each site.

For bees and plants, we focused on European studies due to difficulties of accessing trait data for non-European species. In the bee meta-analysis (theme number 3 above), we used data from five separate studies of species richness in relation to habitat area and fragmentation from three countries, Finland, Germany and Sweden. These datasets will also be useful for the analysis of density-area relationships for bees (theme 5). For butterflies and moths, we have access to data from 24 separate studies from 9 European countries as well as from USA and Canada. This allows for both a cross-continental comparison and a comparison between butterflies and moths. In the plant meta-analyses, we will have access to at least 19 separate datasets from 7 European countries.

For each of the selected organism groups, a database of species traits is needed for the analyses. For two of the groups, plants and bees, such databases exist, while for birds and Lepidoptera, databases need to be compiled. For plants, there exist a number of relevant databases containing species traits, for example the Biolflor database (http://www.ufz.de/biolflor/index.jsp) containing all German species, and the Ecological Flora of the British islands (http://www.york.ac.uk/res/ecoflora/cfm/ecofl/index.cfm). For bees, we are using the database of traits of European bee species compiled within the EU-FP6 project ALARM and held at the University of Reading. For Lepidoptera, we have compiled a database of selected traits from various published sources, cover the majority of butterflies form temperate Europe as well as several North American butterfly and moth species and north European moth species.

Synthesis topics

1) Meta-analysis of the relationship between plant traits and habitat fragmentation

The work, coordinated by Regina Lindborg and Meelis Pärtel is still in progress. A manuscript will be submitted to a scientific journal in 2009:

Lindborg R. et al Are there general relationships between plant traits and sensitivity to fragmentation? - a meta-analysis .

2) Can species traits be used as predictors of plant species sensitivity to habitat fragmentation and area?

The work, coordinated by Risto Heikkinen and Ingolf Kühn is still in progress. A manuscript will be submitted to a scientific journal in 2009:

Heikkinen R. et al. Plant traits modify response to habitat fragmentation .

3) Meta-analysis of the relationship between bee traits and habitat fragmentation
The analysis revealed a strong a positive species-area relationship for bees. The relationship, however, was modified by species traits. Large specialist bees were most strongly negatively affected large generalist bees were least strongly affected by habitat loss. Social bees were negatively affected by habitat loss irrespective of body size.

A manuscript is ready and will be submitted in the summer 2009:
Bommarco, R., Biesmeijer, J.J., Meyer, B., Potts, S.G., Pöyry, J., Roberts, S.P.M., Steffan-Dewenter, I. & Öckinger, E. Dispersal capacity and diet breadth modify the response of wild bees to habitat loss

4) Meta-analysis of the relationship between butterfly and moth traits and habitat fragmentation
The effect of habitat loss on butterflies, but not on moths, is modified by life-history traits. Resource specialist butterflies show the strongest response to habitat loss, and large generalist species have the weakest response.

A manuscript will be submitted during the summer 2009:
Öckinger E., O. Schweiger, Th.O. Crist, D.M. Debinski, J. Krauss, M. Kuussaari, J.D. Petersen, J. Pöyry, J. Settele, K.S. Summerville & R. Bommarco. Life-history traits predict species responses to habitat area and isolation – A cross-continental synthesis.

5) Analysis of density-area relationships for bees
The work, coordinated by Riccardo Bommarco is still in progress. A manuscript will be submitted to a scientific journal in 2009:
Bommarco R. et al. Shifts in density of wild bees in fragmented landscapes.

8) Analysis of density-area relationships for butterflies and moths
The slope of the density-area relationship for butterflies change as predicted with wing span and habitat preference. Large species have a negative slope, similar for both generalist species and habitat specialists, and the slope matches quantitative predictions based on the scaling of migration rates. Small habitat specialists have a slope that is less negative than the slope of large specialist species, whereas the slope does not change with size for generalist species. The results suggest that the variability in response among butterfly species to patch size could be explained by accounting for body size and habitat preferences among species.

A manuscript has been submitted to *Ecography*:
Hambäck, P., Bergman, K.-O., Bommarco, R., Krauss, J., Kuussaari, M., Pöyry, J. & Öckinger, E. Allometric density responses in butterflies: The response to small and large patches by small and large species

9) Meta-analysis of butterfly responses to habitat fragmentation in relation to landscape matrix.
We re-analysed geographical data to calculate the proportions of forest and arable land in the surroundings of 481 grassland patches from 11 independent datasets in 5 European countries. The strength of the relationship between path area and butterfly species richness increased with increasing cover of arable land in the landscape "matrix".

A manuscript has been submitted to *Ecology*:
Öckinger, E., Bergman, K.-O., Franzén, M., Kadlec, T., Krauss, J., Kuussaari, M., Pöyry, J., Smith, H.G., Steffan-Dewenter, I. & Bommarco, R. Matrix quality influences the response of species richness to habitat fragmentation

10) Review of time lags in species responses to habitat fragmentation
A literature review on this topic was performed by partners involved in WP1 and coordinated by Mikko Kuussaari, SYKE. In this review we show that time-delayed extinctions is a challenge for biodiversity conservation, as these extinction debts are often unrecognized because of missing long-term monitoring data and missing high quality empirical studies on different taxa and ecosystems. We further suggest that the development of new analytical methods is necessary to better quantify extinction debt and protect biodiversity.

The review has bee accepted for publication in *Trends in Ecology and Evolution* and is expected to be published during 2009:
Kuussaari, M., Bommarco, R., Heikkinen, R. K., Helm, A., Krauss, J., Lindborg, R., Öckinger, E., Pärtel, M., Pino, J., Rodà, F., Stefanescu, C., Teder, T., Zobel, M., Steffan-Dewenter, I. (in press): Extinction debt: a challenge for biodiversity conservation. Trends in Ecology & Evolution.

See also deliverable D 1.2.

General conclusions and output

Effects of habitat loss and fragmentation on butterflies and moths

We have demonstrated effects of habitat fragmentation on butterflies and moths across a wide range of habitats, landscape types and biogeographic regions. The relationship between habitat area and population density is positive for moths but negative for butterflies and more negative for large than for small species. The effect of fragmentation on species richness is modified both by life history traits such as resource specialization and body size, but also on the quality of the landscape matrix.

References

Hambäck P.A., Summerville K.S., Steffan-Dewenter I., Krauss J., Englund G., and Crist T.O. (2007). Habitat specialization, body size, and family identity explain lepidopteran density–area relationships in a cross-continental comparison. PNAS 104: 8368-8373.

Kuussaari, M., Bommarco, R., Heikkinen, R. K., Helm, A., Krauss, J., Lindborg, R., Öckinger, E., Pärtel, M., Pino, J., Rodà, F., Stefanescu, C., Teder, T., Zobel, M., Steffan-Dewenter, I. (2009). Extinction debt: a challenge for biodiversity conservation. Trends in Ecology & Evolution. *in press*

Dover, J. & Settele J. (2009). The influences of landscape structure on butterfly distribution and movement: a review. Journal of Insect Conservation. 13:3-27.

Pöyry, J., Paukkunen, J., Heliölä, J. & Kuussaari, M. (2009) Relative contributions of local and regional factors to species richness and total density of butterflies and moths in semi-natural grasslands. Oecologia 160:577-587.

Öckinger, E., Dannestam, Å. & Smith, H.G. The importance of fragmentation and habitat quality of urban grasslands for butterfly diversity. Landscape and Urban Planning, *in press.*

Krauss, J., Bommarco, R., Steffan-Dewenter, I. (2008): Extinction debt of vascular plants and butterflies in five European countries. XXIII International Congress of Entomology, Durban South Africa. Abstract No: 1025

Brückmann, S., Krauss, J., Steffan-Dewenter, I. (2008): Impact of local and surrounding landscape predictors on butterfly diversity in semi-natural grasslands. Future of Butterflies in Europe II, Wageningen, Netherlands. Page 43

Brückmann, S., Krauss, J., Steffan-Dewenter, I. (2008): Habitat connectivity affects butterfly diversity and community composition in calcareous grasslands. Verhandlungen der Gesellschaft für Ökologie 38:234.

Bommarco R., E. Öckinger & A. Helm. (2009) Life history traits in insects and habitat fragmentation. Chapter in Atlas of Biodiversity Risk *in press*

Öckinger E., Bergman K-O, Franzén M., Kadlec T., Krauss J., Kuussaari M., Pöyry J., Smith H.G., Steffan-Dewenter I., & Bommarco R. Matrix quality influences the response of species richness to habitat *Submitted to Ecology.*

Hambäck P.A., Bergman K-O, Bommarco R., Krauss J., Kuussaari M., Pöyry J. & Öckinger E. Allometric density responses in butterflies: The response to small and large patches by small and large species. *Submitted to Ecography.*

Brückmann, S.V., Krauss, J. & Steffan-Dewenter, I. Butterfly and plant specialists suffer from reduced connectivity in fragmented landscapes. *Submitted to Journal of Applied Ecology.*

Ekroos, J., Heliölä, J. & Kuussaari, M. Homogenization of lepidopteran communities in intensively cultivated agricultural landscapes. *Submitted to Ecology Letters.*

Öckinger E., O. Schweiger, Th.O. Crist, D.M. Debinski, J. Krauss, M. Kuussaari, J.D. Petersen, J. Pöyry, J. Settele, K.S. Summerville & R. Bommarco. Life-history traits predict species responses to habitat area and isolation – A cross-continental synthesis. In preparation.

Krauss J. et al. Extinction debt in European grassland plants and butterflies. In preparation.

Effects of habitat loss and fragmentation on bees

We have demonstrated strong negative effects of habitat loss for bees. The strength of the negative effect, however, depends on life history traits such as niche breadth, mobility and sociality.

References

Krauss, J., Alfert, T., Steffan-Dewenter, I. (2009). Habitat area but not habitat age determines wild bee richness in limestone quarries. Journal of Applied Ecology 46: 194-202.

Bommarco R., E. Öckinger & A. Helm. (2009) Life history traits in insects and habitat fragmentation. Chapter in Atlas of Biodiversity Risk *in press*

Bommarco R., J.C. Biesmeijer, B. Meyer, S.G. Potts, J. Pöyry, S.P.M. Roberts, I. Steffan-Dewenter, E. Öckinger. Dispersal capacity and diet breadth modify the response of wild bees to habitat loss *Submitted to Ecology Letters.*

Schweiger O., J.C. Biesmeijer, R. Bommarco, Th. Hickler,Ph.E. Hulme, S. Klotz, I. Kuehn, M. Moora, A. Nielsen, R. Ohlemueller, Th. Petanidou, S.G. Potts, P. Pyšek, J. Stout, M.T. Sykes, Th. Tscheulin, M. Vilà, G-R. Walther, *C*. Westphal, M. Winter, M. Zobel & J. Settele. Multiple stressors on biotic interactions: climate change and alien species affect pollination in concert. *Submitted to Biological Reviews.*

Bommarco R. et al. Importance of scale and species traits in determining bee diversity patterns.

Bommarco R. et al. Shifts in density of wild bees in fragmented landscapes.

Effects of habitat loss and fragmentation on plants

Fragmentation effects on plants differ considerably between studies. One explanation for this can be that landscape history affects current species distributions. Our review shows that current plant distributions often, but not always, are strongly influenced by landscape history. Another reason for the variability between studies can be that species respond differently depending on their life-history traits.

References

Raatikainen, K.M., Heikkinen, R.K., Luoto M. (2009). Relative importance of habitat area, connectivity, management and local factors for vascular plants: spring ephemerals in boreal semi-natural grasslands. Biodiversity Conservation 18:1067-1085.

Kuussaari, M., Bommarco, R., Heikkinen, R. K., Helm, A., Krauss, J., Lindborg, R., Öckinger, E., Pärtel, M., Pino, J., Rodà, F., Stefanescu, C., Teder, T., Zobel, M., Steffan-Dewenter, I. (2009). Extinction debt: a challenge for biodiversity conservation. Trends in Ecology & Evolution. *in press*

Krauss, J., Bommarco, R., Steffan-Dewenter, I. (2008): Extinction debt of vascular plants and butterflies in five European countries. XXIII International Congress of Entomology, Durban South Africa. Abstract No: 1025

Krauss, J. & Steffan-Dewenter, I. (2008): Is time delayed extinction a major threat for grassland butterflies and vascular plants? Verhandlungen der Gesellschaft für Ökologie 38:235.

Heikkinen R. et al. Plant traits modify response to habitat fragmentation. In preparation

Lindborg R. et al Are there general relationships between plant traits and sensitivity to fragmentation? - a meta-analysis. In preparation