network-forum
for biodiversity research
germany

FACT SHEET

June 2012

Scientific Arguments for a biodiversity richer Common Agriculture Policy (CAP)

Melampyrum arvense photo: U. Heink

DIVERSITAS GERMANY

SPONSORED BY THE

Federal Ministry
of Education
and Research

Key Messages

This compilation of scientific expertise reveals six main arguments and encouraging action points in order to fulfill the political target to green the Common Agricultural Policy (CAP) of the European Commission.

(1) A combination of Ecological Focus Areas and a goal oriented management should be aimed for and should be adapted to the local context.

(2) The connectivity of the habitats should be established and large monocultures should be avoided, instead, the landscape must become more heterogeneous.

(3) Some species groups require Ecological Focus Areas larger then 7 % (some need a suitable habitat of at least 20 % in order not to negatively affect their genetic structure).

(4) The maintenance of attractive cultural landscapes will not only improve biodiversity, but also common goods for human wellbeing (e.g. for relaxation purposes).

(5) Long crop rotation schemes and the use of diverse crop species (at least 4 – 5) are recommended and often promote biological control of insect pests.

(6) Legume plants should be particularly promoted, as they act as natural fertilizer, excellent habitat and pollen source for many species.

Network-Forum for Biodiversity Research Germany is a project by DIVERSITAS-Deutschland e.V. (www.diversitas-deutschland.de), financed by the German Federal Ministry for Education and Research. The project is mainly implemented by the Helmholtz Centre for Environmental Research in Leipzig (UFZ), the Museum of Natural History in Berlin and the University of Potsdam, as well as by the members of the advisory board of DIVERSITAS-Deutschland.

Introduction

The European Commission aims for policies that include improved ecological and sustainable components. Therefore the Commission has highlighted the importance of "Greening" the Common Agriculture Policy (CAP) in the next reform cycle starting in 2013. This is consistent with the Aichi Targets from the Strategic Plan of the Convention on Biological Diversity until 2020. Especially Aichi targets 3 (harmful subsidies), 7 (sustainable agriculture) and 15 (restoration) relate to the now suggested CAP proposal. These targets are also reflected in the European Biodiversity Strategy that was published in 2011.

Current discussions about the Commission's "Greening" proposal for the CAP reform centre around the direct payment scheme for farmers. It is suggested that in addition to a basic payment for each farm holding from the first column of the CAP, each holding will receive a payment per hectare only if fulfilling certain agricultural practices beneficial for the climate and the environment. The 3 measures foreseen are:

- maintaining an "ecological focus area" of at least 7 % of farmland (excluding permanent grassland)[1]
- crop diversification[2]
- maintaining permanent pasture

The objective of this factsheet is to inform European policy makers and other decision making stakeholders by compiling facts about relevant scientific arguments for a biodiversity richer CAP and presents examples on how the suggested measures result in high benefits for biodiversity. The focus lies on the first two suggested requirements for the payment of subsidies to European farmers: ecological focus areas and crop diversification.

The following three questions in the centre of interest are:

1. What would be the best use for the "new" ecological focus areas in order to improve the status of biodiversity and ecosystem services in agricultural landscapes of Europe?
2. Is the figure of 7 % of ecological focus area supported by conservation science?
3. What crop rotation scheme and what crop species are most beneficial for biodiversity and why?

Box 1: Background information: the Swiss situation

As part of a so far unique agricultural-environmental scheme, since 1998 farmers in Switzerland can qualify for area-related direct payments if they meet a number of environmental standards. These standards are defined by the Proof of Ecological Performance (PEP). One of the PEP-standards demands that each farmer has to manage at least 7 % of the utilised agricultural land as so-called ecological compensation areas (ECAs). To achieve the environmental goals, in ECAs the use of fertilizers and pesticides is restricted, and hay-meadows are not to be cut before 15 June. On average Switzerland now has about 10 % of ecological compensation areas, with lower values in the lowlands and higher values in marginal (mountain) regions (Kampmann et al. 2012). The Swiss agro-environment scheme has been evaluated in several studies, most of them showing positive effects on plants and various groups of insects. Even if effects of site conditions, landscape context, and regional location are accounted for, the ECA management scheme still has a significant positive effect on biodiversity and added ecological value to farmland in Switzerland.

[1] landscape features and biotopes, such as floodplains, field margins, hedges, trees, fallow land, buffer strips, afforested areas

[2] farmers must cultivate at least three crops on his arable land with a minimum of 5 % and not more than 70 % of the land

1. What would be the best use for the "new" ecological focus areas in order to improve the status of biodiversity and ecosystem services in agricultural landscapes of Europe?

At present, the European Biodiversity strategy already calls for a positive contribution of agriculture in order to preserve biodiversity. By reducing key pressures on EU biodiversity (target 3) by 2020 and that ecosystems and their services are maintained and enhanced by establishing green infrastructure and restoring at least 15 % of degraded ecosystems (target 2).

However, from a scientific point of view, there is not a simple or single answer to the question of what would be the best use for the new ecological focus areas. Rather, the answers usually depend on the research focus of each scientist. For example what is good for one species might not be beneficial for another. Furthermore, the landscape context plays an important role. This means that in landscapes which already consist of highly structured mosaics of different landscape elements, additional elements might not bring a significant increase in biodiversity. Therefore management will be more effective if applied in simple, species-poor landscapes. As large-scale biodiversity is not determined by any one local management, a management across landscapes and regions is needed (Tscharntke et al. 2005, Tscharntke et al. 2012) and ecological focus areas in less as well as in highly productive regions will most likely yield the highest benefits for biodiversity. Ecological focus areas will also support the Green Infrastructure, a major European approach to ensure the conservation of key biodiversity components. In that way, agricultural systems could not only ensure the survival of animal (see examples 1I and 1II) and plant species, but also the diversity of their genes (by avoiding inbreeding) and the conservation of entire habitats that both mobile as well as sessile species so strongly depend upon (see example 1 III).

Example I: Bee requirements

Bees can be found in different habitats (Steffan-Dewenter et al. 2002). Yet, in order to support bee populations the best use for new ecological focus areas would be on a mixture of different kinds of semi-natural habitats, including hedges and orchards for nesting sites of above ground nesting bees, flowering stripes, extensively managed grassland for continuous food supply and disturbed areas for ground nesting bees (Winfree et al. 2007).

Example II: Nesting requirements for Corn Bunting

The Corn Bunting (*Emberiza calandra*), a farmland bird, nests both in extensively managed crop provisions and conventional intensively managed barley crops. However, results of a study showed that extensively managed cereal crops were strongly selected by breeding females and supported a high proportion of the breeding population. Females that used extensively managed crops for first nesting attempts were almost four times more likely to re-nest than females nesting in conventional crops. The latter rarely produced a second nest and, when they did, usually switched nesting habitat. A re-nesting model demonstrated that differential re-nesting rates led to 26 % higher annual productivity per female in extensively managed cereal crops. Therefore the authors of the study recommend the provision of unharvested, extensively managed cereal crops as an agri-environment option for Corn Buntings where intensively managed cereal crops are the main nesting habitat (Setchfield et al. 2012).

Example III: Floodplains: A European biodiversity hotspot[3,4,5]

Floodplains in Europe are considered as hotspots for biodiversity. There is almost no other ecosystem type that offers such a remarkable variety of goods and services to humans like rivers and their floodplains (e.g. flood prevention, ground water reservoir, filter for sediment and dissolved nutrients and pollutants, living carbon storage, recreational area or the natural habitats). Floodplains can provide these ecosystem services only if their ecological integrity is sustained. However, about three-quarters of active floodplains are used for agriculture (Brunotte et al. 2009). Currently under the influence of increasing biomass production for the increasing biofuel market, there is a high pressure of land use transition in riverine landscapes, from grasslands into intensive agricultural areas. Floodplains will greatly benefit from the establishment of ecological focus areas. Therefore agro-environmental schemes should exclude arable land use in floodplains and small structuring landscape elements like hedges, solitary trees or oxbow lakes, should be promoted.

Bottom line

A combination of ecological focus areas and a goal oriented management (Berger & Pfeffer 2011) should be aimed for. There has to be a variety of management strategies and habitat types supported and adapted to the local context.

Examples of management strategies include:
- temporary flooding of floodplains,
- extensive cultivation of pasture and extensive meadows,
- establishment and maintenance of field margins and buffer strips around water bodies,
- planting and pruning of hedges.

Furthermore mowing regimes and dates have to be diverse to avoid large areas being mown at the same time (within a few days or less than two weeks) and to include large enough areas mown late in the year (around August, but also areas that are mown much earlier, e.g. spring time) in order to create a mosaic that e.g. birds like the hoopoe (*Upupa epops*) and the Northern lapwing (*Vanellus vanellus)* can benefit from (Mühlethaler & Schaad 2010, Meisser et al. in prep, Müller et al. 2009). A further measurement can be the removal of topsoil in order to reduce availability of nutrients (which are artificially high in most of today's agricultural ecosystems) and extensive use (Müller et al. 2009, Schaub et al. 2008, Spaar et al. 2011, Weisshaupt 2012).

A variety of vegetation types and structural elements for ecological focus areas is desirable and should be a mix of permanent elements (grassy, woody) and of more flexible ones (such as temporary ponds). Suggested high-biodiversity biotopes include hedgerows with buffer strips, orchards, dry grassland, forest margins, young and old fallows with naturally developed vegetation[6], field margin strips, unmown legume-grass strips, sown blossom strips, wetlands, ponds and kettleholes.

---

[3] National assessment of ecosystem functions and services in German floodplains https://www.ufz.de/index.php?en=17551)

[4] Status report on German floodplains (http://www.bfn.de/0324_floodplains+M52087573ab0.html)

[5] Tockner K, Stanford JA (2002) Riverine flood plains: present state and future trends. *Environmental Conservation*, 20, 308-330.

[6] Have been shown to be beneficial for various arthropods (Aviron et al. 2008).

Box 2: Agriculture-related ecosystem services

Agroecosystems are vital for supplying ecosystem services to human society (MA 2005) and include services such as:

- pollination
- natural pest regulation
- provision of water
- decomposition
- provision of fertile soil
- provision of genetic diversity
- climate and air regulations
- cultural services (e.g. local people`s sense of place, social relations, cultural heritage)
- rural tourism and recreation

2. Is the figure of 7 % of ecological focus area supported by conservation science?

Thresholds and minimum areas depend on the component of biodiversity in focus of protection. In other words, a bird of prey would need a different area in comparison to a plant or a soil mite. Particular target species are however not specified in the suggested measures of "Greening the CAP". Furthermore, not only the combination of different land uses, but also the physical layout of the land use is important for the survival of species. Therefore it might be very important whether the 7 % area, within a given region, is highly aggregated or dispersed in space. No regulations or ideas on that do yet exist in the suggested CAP scheme.

Some scientists argue that scientifically proofed figures cannot to be given, because they are species specific and need advanced modelling often not yet available. However the majority of scientists that contributed to this factsheet do agree that, if 7 % ecological focus areas become reality, it will lead to a substantial improvement of biodiversity in agricultural landscapes.

Example I: The bee perspective

Loss and fragmentation of semi-natural habitats are the main drivers of pollinator declines (Ricketts et al. 2008; Potts et al. 2009) as this development prevents continuous nesting sites and food supply for bees (Corbet 2000). Thus not only the percentage of semi-natural habitats matters, but also their connectivity as most pollinators are affected by the distance to the next semi-natural habitat. Semi-natural habitats only at one or few locations of a landscape might not be sufficient and they should be found even if patchy, spread all over a landscape. In addition, semi-natural habitats are needed, e.g. for landscapes with small fields and therefore many field edges with potential flowering resources, 7 % ecological focus areas might be enough. In areas with larger fields, a higher percentage of connected habitats is needed. Landscapes must become more heterogeneous to prevent bee communities being negatively affected by land use intensity (Winfree et al. 2008).

Example II: Genetic diversity of cricket and the 20% threshold

Studying genetic diversity - one key aspect of biodiversity - Lange et al. (2010) found out that once the amount of suitable woody habitat dropped below a threshold of 20 %, the genetic structure of even the widespread and abundant bush cricket species *Pholidoptera griseoaptera* is negatively affected. Though this study might represent a species-specific result, a similar threshold was also established for dispersal success, population persistence, species distribution and community composition in simulation approaches (e.g., Fahrig 1997; With & King 1999a, b) and other empirical studies (Wiens et al. 1997; Tscharntke et al. 2002; With et al. 2002; Schmidt & Roland 2006).

Example III: Needs of Farmland birds

Most typical farmland species on arable land need at least 10-12 % of set-asides areas. This was at first proclaimed by Fischer (2006) for Corn Bunting, and also results of studies on Quail (Herrmann & Dassow 2006) and Partridge (Herrmann & Fuchs 2006) support this threshold (published in Flade et al. 2006). The 10 %-threshold for Corn Bunting (and somehow similar for Yellowhammer) is also supported by the data of the German Common Birds Census (DDA-Monitoringprogramm). However results of a study by Hoffmann et al. 2012 show that most farmland bird species have their optimum at 12-35 % proportion of set-aside areas in their territory and almost no species tolerates proportions of more than 12 % maize crop. Other structures like hedgerows, kettlehole ponds etc. are additionally needed to support the full farmland biodiversity (Flade pers. comm.).

Box 3: Aesthetic Ecosystem services and stress recovery of humans

Beyond its traditional functions agricultural land also offers aesthetic values and are important for recreational purposes and therefore human well-being. As agriculture subsidies consist of public monies they should be used for public interests. The so called cultural services (MA 2005) should be provided and maintained.

Junge et al. (2011) investigated the preferences of non-farmers and farmers for nine landscape photo-montaged scenarios in the Swiss lowlands. Results amongst non-farmers rated a landscape with a mixed land-use type and 30% ECAs highest, whereas farmers rated a landscape dominated by arable crops and 10% ECAs highest. Overall the results indicate that heterogeneous landscapes (mixed land use, high proportion of ECAs) influence scenic beauty positively.

A recent yet unpublished study investigated the influence of plant species-richness on stress recovery of humans. With increasing plant species richness, relaxation increased. However, a poppy monoculture had the largest effect on relaxation (unpublished data, pers. comm. Lindemann-Matthies).

In another Swiss study on the attitude towards field margins for biodiversity conservation participants were asked to rate the attractiveness of improved field margins (IFMs) of different species richness and composition that were presented to them. Study participants responded very positively to species-rich vegetation. The more species-rich an IFM was perceived to be, the more it appealed to them. Study participants strongly approved the establishment of improved field margins (Junge et al. 2009).

Bottom line

The connectivity of the habitats is important and large monocultures shall be avoided. Instead, the landscape must become more heterogeneous. If a suitable habitat is below a 20 % the genetic structure of even widespread species might be negatively affected. Farmland birds need 10-12 % of set-aside areas, but seem to flourish best between 12-35 % of set-aside areas in their territory.The maintenance of attractive cultural landscapes will not only improve biodiversity itself, but also common goods, which agriculture can and should provide for human wellbeing.

3. What crop rotation scheme and what crop species are most beneficial for biodiversity and why?

Crop diversity has been shown to foster agriculture-associated species diversity (Billeter et al. 2008). As a rule of thumb, the longer the crop rotation and the more diverse the crops within the rotation the higher the biodiversity effect (Tscharntke pers. comm.). The schemes would have to be adapted to the respective agronomic potential of a region and the farming systems in order to avoid nation wide homogenization of agriculture (Dauber pers. comm.). In general, crop rotations with at least 4, better 5 crops should be implemented; interchanging winter and summer crops as well as interchanging broad leaf crops and cereals. An exception could be on very poor soils, where only a few arable crops can be cultivated. Scientists (who contributed to this factsheet) have ranked biodiversity beneficial crops (from very good to bad): grass-legume mixtures; summer cereals; winter cereals[7]; rape; potatoes, beets; maize.

Example I: Legumes[8] – fertilizer, habitat and pollen source

Even in intensified field crops, only 50 % of crop nitrogen uptake comes from fertilizers, while the remainder is from mineralized soil organic matter (Robertson & Swinton 2005). Legume plants are naturally fixing atmospheric nitrogen. Legume-grass leys as part of the crop rotation system provide excellent habitat for many species groups. To improve the density and reproduction of farmland birds (e.g. corn bunting, sky lark, whinchat), a 4-years or 8-years rotation with 25-33 % leys (grass-leguminoses-mixtures) or summer cereals is recommended (Flade et al. 2006 and Hoffmann et al. 2012). But also Brown Hares showed a strong preference for legume-grass leys during the whole year (Fuchs 2010). Furthermore fields with legume-grass leys were essential for reproductive success in Grasshoppers (Saltatoria) and for some butterfly species (Lepidoptera) which were provided with excellent food resources during blossom time (Gottwald 2010). Therefore legumes are important not just because of the positive effects on soil fertility, but also because of their importance for pollinating insects. Legumes might be suitable to loosen up the often tight crop rotations, for reducing the inputs (fertilizer) and are therefore beneficial for biotic and abiotic soil life.

Example II: Promotion of biological control

Planting a diversity of crop plants, designed with multiple food and non-food functions in mind (e.g. polycultures instead of monocultures), often promotes biological control of insect pests (Tscharntke et al. 2005), including control of viruses transmitted by insects, and contributes to risk avoidance in a changing environment (Matson *et al.* 1997; Vandermeer *et al.* 2002). Most pests are in fact not controlled by pesticides but natural enemies. DeBach and Rosen stated in 1991 that about 99 % of all potential pests are already under biological control. Cereal aphid predation by a rich community of ground-living natural enemies resulted in a yield increase estimated to be 23 % (Östman et al .2003). Generally, from a nature conservation point of view, the polyculture concept is highly recommended and its potential economic benefits have also become more and more evident during the recent years. For example, in a polyculture the entire plant community can use resources such as water, nutrients and light more efficiently. In combination with its lower susceptibility to pests, polycultures may turn out to be not only ecologically but also economically favourable compared to monocultures.

[7] Besides the change in summer crops, winter cereals are essential for the segetal flora (field weed companies), because most species germinate in autumn (Schneider et al. 1994, Gottwald 2010). Summer crops only allow for a much poorer segetal flora.

[8] e.g. clover, peas, beans, lentils, lupins, soy, peanuts.

Bottom line

A long crop rotation schemes and use of diverse crop species (at least 4 – 5) is recommended. Legume plants shall be particularly promoted, as they act as natural fertilizer, excellent habitat and pollen source for many species. Furthermore, a diverse crop rotation scheme often promotes biological control of insect pests (Tscharntke et al. 2005). Good agronomic practice allows for 1-3 years of grassland as part of a crop rotation.

Box 4: Underestimation of the importance of endangered species

Characteristic European landscapes inhabit high percentages of synanthropic species including many endangered flagship species such as the white stork and hares. In Germany alone the 350 species of arable weeds (mainly annual plants) include 38 % red list species. In the future these rare species may turn out to be more important for ecosystem functioning than few abundant species (Tscharntke et al. 2005).

Conclusion

Agroecosystems do not only provide us humans with food and provide a habitat for species, but are also vital to supply ecosystem services (MA 2005, Plieninger et al 2012) (see Box 2 and 3) that all species on Earth depend upon.

Yet these complex landscapes are in total at risk due to landscape-wide agricultural intensification. Therefore agricultural landscapes must be a heterogeneous mosaic of well connected habitats, to be able to support a high biodiversity (Bengtsson et al. 2003). In order to achieve this, 7 % ecological focus area in conventional farming will perhaps not be sufficient, if compared with population densities attained in common organic farming systems as target values. Even though 7 % might increase biodiversity in agro-systems, a minimum of 10 % for ecological focus areas plus 5 % arable land managed for the preservation of the segetal flora is needed. Furthermore a diversity of different crop species with a long crop rotation is required and can help to promote biological pest control. A good mixture of crop species and the support of the use of legume plants as natural fertilizers is recommended.

A functional biodiversity will be able to secure the provision of ecosystem services for human wellbeing for now and for future generations.

Contact:

Rosmarie Katrin Neumann (rosmarie-katrin.neumann@ufz.de) and the NeFo-Team - Elisabeth Marquard, Carsten Neßhöver, Axel Paulsch, Sebastian Tilch, Katrin Vohland

NeFo appreciates contributions made by:

Raffael Aye, Gert Berger, Theresa Biermann, Jens Dauber, Sarah Effertz, Martin Flade, Sarah Fuchs, Frank Gottwald, Arne Hegemann, Felix Herzog, Philippe Jeanneret, Ralf Joest, Björn Kristian Klatt, Jan-Dieter Ludwigs, Stefan Möckel, Ernst-August Nuppenau, Guy Pe'er, Manfred Probst, Mathias Scholz, Karin Stein-Bachinger, Johannes Timaeus, Rebecca Thier-Lange, Teja Tscharntke, Volkmar Wolters

References

Bengtsson, J., Angelstam, P., Elmquvist, T., Emanuelsson, U., Forbes, C., Ihse, M. *et al. (*2003*).* Reserves, resilience and dynamic landscapes. Ambio, 32, 389–396.

Berger, G. and H. Pfeffer (2011). Naturschutzbrachen im Ackerbau. Anlage und optimierte Bewirtschaftung kleinflächiger Lebensräume für die biologische Vielfalt – Praxishandbuch-. Natur & Text, Rangsdorf: 160 S.

Billeter, R., Liira, J., Bailey, D., et al. (2008). Indicators for biodiversity in agricultural landscapes: a pan-European study. Journal of Applied Ecology 45, 141-150.

Brunotte, E., Dister, E. Günther-Diringer, D. Koenzen U. & Mehl, D. (2009): Flussauen in Deutschland - Erfassung und Bewertung des Auenzustandes. – Naturschutz und Biologische Vielfalt 87.

Corbet S.A. (2000): Conserving compartments in pollination webs. Conservation Biology 14, 1229-1231.

Debach P and D Rosen 1991 (second edition) Biological control by natural enemies Cambridge University Press, Cambridge, UK.

Fahrig L (1997) Relative effects of habitat loss and fragmentation on population extinction. Journal of Wildlife Management 61, 603-610.

Flade, M., H. Plachter, R. Schmidt & A. Werner 2006: Nature Conservation in Agricultural Ecosystems. Quelle & Meyer, Wiebelsheim.

Fuchs, S. (2010): Feldhase, Feldvögel. In: Stein-Bachinger, K., Fuchs, S., Gottwald, F., Helmecke, A., Grimm, E., Zander, P., Schuler, J., Bachinger, J. & Gottschall, R. (2010): Naturschutzfachliche Optimierung des Ökologischen Landbaus ‚Naturschutzhof Brodowin'. Ergebnisse des E+E-Projektes ‚Naturschutzhof Brodowin'. - Naturschutz und biologische Vielfalt 90: 149 - 157.

Gottwald, F. (2010): Heuschrecken, Tagfalter, Segetalflora. In: Stein-Bachinger, K., Fuchs, S., Gottwald, F., Helmecke, A., Grimm, E., Zander, P., Schuler, J., Bachinger, J. & Gottschall, R. (2010): Naturschutzfachliche Optimierung des Ökologischen Landbaus ‚Naturschutzhof Brodowin'. Ergebnisse des E+E-Projektes ‚Naturschutzhof Brodowin'. - Naturschutz und biologische Vielfalt 90: .

Hoffmann, J., G. Berger, I. Wiegand, U. Wittchen, H. Pfeffer, J. Kiesel & F. Ehlert 2012: Bewertung und Verbesserung der Biodiversität leistungsfähiger Nutzungssysteme in Ackerbaugebieten unter Nutzung von Indikatorvogelarten. Berichte aus dem Julius-Kühn-Institut 163: 1-214.

Junge, X., Jacot, K.A., Bosshard, A., Lindemann-Matthies, P. 2009. Swiss people's attitudes towards field margins for biodiversity conservation. Journal of Nature Conservation 17: 150-159.

Junge, X., Lindemann-Matthies, P., Hunziker, M., Schüpbach, B. 2011. Aesthetic preferences for different agricultural landscapes in the Swiss lowlands - a comparison between non-farmers and farmers. Biological Conservation 5: 1430-1440.

Kampmann D., A. Lüscher, W Konold, F Herzog.(2012). Agri-environment scheme protects diversity of mountain grassland species, Land Use Policy, Volume 29, Issue 3, Pages 569-576.

Lange R., Durka W., Holzhauer SIJ et al. (2010) Differential threshold effects of habitat fragmentation on gene flow in two widespread species of bush crickets. Molecular Ecology 19, 4936-4948.

MA (Millennium Ecosystem Assessment). (2005). Ecosystems and human well-being: synthesis. Island Press, Washington, DC.

Matson, P.A., Parton, W.J., Power, A.G. & Swift, M.J. (1997). Agricultural intensification and ecosystem properties. Science, 277, 504–509.

Meisser C., Brahier A., Lardelli R, Schudel H, Kestenholz M. (in prep): Plan d'action Cevêche d'Athéna Suisse. Programme de conservation des oiseaux en Suisse. Office fédéral de l'environnement OFEV, Station ornithologique suisse, Association Suisse pour la Protection des Oiseaux ASPO/BirdLife Suisse ; Berne, Sempach et Zürich. L'environnement pratique

Mühlethaler E., Schaad M. 2010: Aktionsplan Wiedehopf Schweiz. Artenförderung Vögel Schweiz. Bundesamt für Umwelt, Schweizerische Vogelwarte, Schweizer Vogelschutz SVS/BirdLife Schweiz, Bern, Sempach und Zürich. Umwelt-Vollzug Nr. 1030: 65 S.

Müller, W, Glauser, C, Sattler, T. & L. Schifferli (2009). Wirkung von Massnahmen für den Kiebitz *Vanellus vanellus* in der Schweiz und Empfehlungen für die Artenförderung.

Östman, Ö., Ekbom, B. & Bengtsson, J. (2003). Yield increase attributable to aphid predation by ground-living polyphagous natural enemies in spring barley in Sweden. Ecol. Econ., 45, 149–158.

Plieninger T, Schleyer C, Schaich H, Ohnesorge B, Gerdes H, Hernández-Morcillo M, Bieling C (2012) Mainstreaming ecosystem services through reformed European agricultural policies. Conservation Letters, doi: 10.1111/j.1755-263X.2012.00240.x

Potts S., Biesmeijer JC, Kremen C, Neumann P, Schweiger O, Kunin WE (2009): Global pollinator declines: trends, impacts and drivers. Trends in Ecology and Evolution 25, 345-353.

Ricketts T.H., Regetz J., Steffan-Dewenter I., Cunningham S., Kremen C., Bogdanski A., Gemmill-Herren B., Greenleaf S.S., Klein A.M., Mayfield M.M., Morandin L.A., Oechieng A., Viana B.F. (2008): Landscape effects on crop pollination services: are there general patterns? Ecology Letters 11, 499-415.

Robertson, G.P. & Swinton, S.M. (2005). Reconciling agricultural productivity and environmental integrity: a grand challenge for agriculture. Front. Ecol. Environ., 3, 38–46.

Schaub, M., N. Zbinden, N. Martinez, M. Maurer, A. Ioset, R. Spaar, N. Weisshaupt & R. Arlettaz (2008): Vögel brauchen lückige Vegetation zur Nahrungssuche. Faktenblatt. Schweizerische Vogelwarte, Sempach.

Schmidt B.C., Roland J. (2006) Moth diversity in a fragmented habitat: importance of functional groups and landscape scale in the boreal forest. Annuals of the Entomological Society of America 99, 1110-1120.

Schneider, Ch., Sukopp, U., & Sukopp, H. (1994): Biologisch-ökologische Grundlagen des Schutzes gefährdeter Segetalpflanzen. - Schriftenreihe für Vegetationskunde 26, 356 S. Bundesamt für Naturschutz, Bonn-Bad Godesberg, 356 S.

Setchfield, R. P., Mucklow, C., Davey, A., Bradter, U. and Anderson, G. Q. A. (2012), An agri-environment option boosts productivity of Corn Buntings Emberiza calandra in the UK. Ibis, 154: 235–247.

Spaar, R, R. Ayé, N. Zbinden & U. Rehsteiner (Hrsg.) (2011): Elemente für Artenförderungsprogramme Vögel Schweiz – Update 2011. Koordinationsstelle des Rahmenprogramms «Artenförderung Vögel Schweiz». Schweizer Vogelschutz SVS/BirdLife Schweiz und Schweizerische Vogelwarte, Zürich und Sempach.

Steffan-Dewenter I., Münzenberg U., Buerger C., Thies C., Tscharnte T. (2002): Scale dependent effects of landscape context on three pollinator guilds. Ecology 83, 1421-1432.

Tscharntke, T., Klein, A. M., Kruess, A., Steffan-Dewenter, I. and Thies, C. (2005), Landscape perspectives on agricultural intensification and biodiversity – ecosystem service management. Ecology Letters, 8: 857–874. doi: 10.1111/j.1461-0248.2005.00782.x

Tscharntke T, Steffan-Dewenter I, Kruess A, Thies C (2002) Contribution of small habitat fragments to conservation of insect communities of grassland-cropland landscapes. Ecological Applications 12, 354-363.

Tscharntke, T., Tylianakis, J. M., Rand, T. A., Didham, R. K., Fahrig, L., Batáry, P., Bengtsson, J., Clough, Y., Crist, T. O., Dormann, C. F., Ewers, R. M., Fründ, J., Holt, R. D., Holzschuh, A., Klein, A. M., Kleijn, D., Kremen, C., Landis, D. A., Laurance, W., Lindenmayer, D., Scherber, C., Sodhi, N., Steffan-Dewenter, I., Thies, C., van der Putten, W. H. and Westphal, C. (2012), Landscape moderation of biodiversity patterns and processes - eight hypotheses. Biological Reviews.

Vandermeer, J., Lawrence, D., Symstad, A. & Hobbie, S. (2002). Effects of biodiversity on ecosystem functioning in managed ecosystems. In: Biodiversity and Ecosystem Functioning (eds Loreau, M., Naeem, S. & Inchausti, P.). Oxford University Press, Oxford, UK, pp. 157–168.

Weisshaupt, D. (2012). Artenreiche Kulturlandschaft Zürcher Unterland und Wehntal. Förderprogramm Gartenrotschwanz. Jber. 2011. Schweizer Vogelschutz SVS/BirdLife Schweiz, Zürich. 10S.

Wiens J.A., Schooley R.L., Weeks R.D. (1997) Patchy landscapes and animal movements: do beetles percolate? Oikos 78, 257-264.

Winfree R., Griswold T., Kremen, C. (2007): Effect of human disturbance on bee communities in a forested ecosystem. Conservation Biology 21, 213-223.

Winfree R., Williams N., Gaines H., Ascher J., Kremen C. (2008): Wild bee pollinators provide the majority of crop visitation across land-use gradients in New Jersey and Pennsylvania, USA. Journal of Applied Ecology 45, 793-802.

With K.A., King A.W. (1999a) Dispersal success on fractal landscapes: a consequence of lacunarity thresholds. Landscape Ecology 14, 73-82.

With KA., King AW. (1999b) Extinction thresholds for species in fractal landscapes. Conservation Biology 13, 314-326.

With K.A., Pavuk D.M., Worchuck J.L., Oates R.K., Fisher J.L. (2002) Threshold effects of landscape structure on biological control in agroecosystems. Ecological Applications 12, 52-65.