Review of biodiversity research results from Estonia that directly contribute to the sustainable use of biodiversity in Europe

This report is compiled using several recent works of Estonian authors, but basis mainly on findings of Kukk & Kull (1997), Mänd (2000), Sammul et al (2000), Mänd et al (2001, 2002), Kull et al (2003).

Introduction

Since most human activities decrease biodiversity, including the traditional types of nature protection which only slow down the speed of biodiversity loss, the only way to preserve biodiversity in the long run is to find ways of ecosystem management which could also increase the local species richness, without any active introduction of new species. Every species influences its environment in one way or another. This influence can lead to improved living conditions for both the actor itself and for other species, or it may be inhibiting or disastrous for both. The species may persist, whether competitive or symbiotic, if the influence is so extensive that it allows the species to use their adaptiveness to find the resources they need. Some human activities throughout history have contributed to diversity and hence to our survival, whilst others have been destructive. The few examples, however, of an human influence on nature that have enhanced the species richness of communities, all deserve more detailed study, both from a point of view of ecology and of cultural history (Kull et al 2003).

Prehistoric humans have played an important role in the genesis of semi-natural vegetation such as wooded meadows, alvars, grazed forests and all different types of meadows. Stock-breeding and primitive crop cultivation gained importance in Estonian territory in the Neolithic. Permanent crop fields were created 1000 BC. The history of semi-natural communities is a long-lasting process which started approximately 6000 years ago (Poska 2001, Veski & Poska 2004).

Understanding the mechanisms which have created these ecosystems may be helpful in coming to grips with the much more general problem of how human activity is possible without the loss of a diverse nature. Here we have a problem which has two quite different facets. One is a basic ecological problem; how is it possible for high biodiversity to persist in a certain management regime? The other is a challenge to cultural theory as it asks a similar question from the point of view of culture-nature relationships. Seemingly, these two problems can be integrated by an ecosemiotic approach, i.e, a semiotic approach to the ecosystem of culture (Kull 1998).

In Estonia a lot of fundamental research has been carried out in the field of biodiversity, but much less has been studied impacts of different policies on biodiversity. We review here results from studies on highly species rich semi-natural wooded meadows, pollinators as an indicator group, and forest management practices to increase biodiversity.

Wooded meadows: a short natural history

Until the middle of the 20th century, wooded meadows were widespread traditional semi-natural ecosystems, particularly abundant in the countries around the Baltic Sea. Wooded meadows can be defined as sparse natural stands with an annually mown herb layer. Tree canopy cover is usually in the range 10–50%. With regard to the horizontal structure of the traditional wooded meadow, only 10–20% of its surface area is not covered by a mowable herb community. Typically, deciduous trees and several shrub species are present, which are distributed in quite small irregular patches. Regular mowing (once a year) is important, but there may be some years when mowing is interrupted. Grazing on wooded meadows can vary quite a lot, usually they were lightly grazed by sheep or cattle in late summer (after mowing), but many sites were not grazed at all. Wooded meadows look like parks, but they differ from them due to their natural (not planted) vegetation and the natural unploughed soil. However, through the selective removal of trees their species composition and appearance are influenced by humans.

More than five hundred years ago, wooded meadows were quite common in many areas of Europe, including England (Schama 1995).

It is important to note that the introduction of agriculture did not change the traditional relationship to nature in this area. Although the inhabitants began field agriculture and ploughing, they did not change from being hunters-gatherers to being graziers (live stock farmers). There was always a piece of forest alongside the farm-house. The fields that were established were small, and they rarely grew much. They therefore only partially fulfilled the needs of the peasants, and many plant products were still collected from the natural plant communities. The wooded meadow therefore remained a main organiser of most of their daily life. Wooded meadows thus represented a perfect example of green management, with a very long-term and stable multifunctional use of the land. An important aspect to add is that the stability and continuation of wooded meadows was supported by their aesthetic value, a fact confirmed over and over again by old local farmers whom we questioned in our fieldwork over the last decades (Kull et al 2003).

In the case of Estonia, the area encompassed by natural grasslands reached its maximum at the end of the 19th or beginning of the 20th century, when wooded meadows covered 850,000 hectares (18.8% of Estonia’s surface area) (Sammul et al. 2000). According to the agricultural census of 1939, natural grasslands of various types covered altogether one-third of the surface area of Estonia, and this was considerably more than in adjacent countries.

The abandonment of wooded meadows in Estonia took place in several steps: (1) a reduction of farming during World War II; (2) the cessation of mowing by hand; (3) the cessation of mowing using horses. The first meadows to disappear were wet-wooded meadows, of which no well-preserved examples exist. A general reason for this rapid decrease was the change in agricultural management from an extensive to an intensive type (Kukk & Kull 1997).

The factors of species richness

Paradoxically, there is not a single ecosystem in the world that has been completely inventoried, i.e. of which a full species list is known. In order to make such a census of species in an ecosystem, a great deal more knowledge in field biology is required than is currently available. Therefore, it is necessary for us to restrict ourselves to data about some taxonomic groups, e.g., plants. Furthermore, we need to consider several methodical problems in species richness measurements.

Species richness is largely scale-dependent. By small-scale richness we mean the number of species found on plots of a size less than 10 square meters.

In Estonia, the number of vascular plant species in a 1 x 1 m plot does not normally exceed 20 in forests and 30 in natural meadows; in the richest alvar meadows it can be slightly over 40; and only in wooded meadows has it been found to exceed 50. The maximum (76 species in a 1 x 1 m plot) is recorded from the Laelatu wooded meadow in Estonia (Kukk & Kull 1997).

What are the factors determining the species richness in wooded meadows? The wooded meadows which have the highest richness in their plant communities, have been found to be similar in the following characteristics:

they are very old, regular mowing has taken place sometimes for several centuries;
soil is neutral, calcium-rich;
grazing has not taken place and if so, not intensively;
their territory has been large (tens of hectares, as a minimum);
they include some moist or wet patches;
the tree layer is species-rich;
the local species pool is large.

A large species pool requires a diversity of niches on a small territory – i.e. nearby sites with conditions of shade and light, moisture and dryness, rich and poor soil nutritiousness. This corresponds exactly to the conditions found in wooded meadows. The richest community patches were usually found in sites of lower productivity and with a relatively open canopy (Kull et al 2003). The number of bryophyte species in a 1 x 1 m meadow plot is usually between 4 and 10 in the Laelatu wooded meadow. In a contrast to vascular plants, less rare bryophyte species are growing on these meadows (Ingerpuu et al. 1998). The total number of species in a terrestrial ecosystem is roughly proportional to the number of plant species, however, this correlation is not very strong. Still, according to our estimations, the diversity of bird, mammal and reptile species is higher in a wooded meadow, if compared with either a forest or an open meadow site in otherwise similar conditions. A case study about the species diversity of terrestrial molluscs and carabid beetles gave similar results (Talvi 1995).

Protection, restoration and the contemporary management of wooded meadows

The existing ways and experience in keeping and protecting wooded meadows may give some hints for understanding the possibilities of preserving biodiversity, also in more general terms. Biodiversity of the meadow ecosystems is connected to human use and it declines significantly if this use ceases. Since these plant communities are products of long-term interaction between man and environment, the possible man-induced threats are two-fold. Active threats include drainage, fertilisation, ploughing, etc. However, the passive threat of stopping traditional uses like grazing or mowing is just as serious. Any conservation of these communities must therefore include active management in the form of support to traditional uses like grazing or mowing.

Ecosemiotic remarks

Wooded meadow analogues exist also in other ecosystems where human intervention can often facilitate the preservation of biodiversity:

(1) Traditional non-intensive fishery in lakes, rivers or marine ecosystems with a long-term regular harvesting of fish populations (or other water organisms) focusing on the more abundant species. This reduces the competition level in the water community, and keeps the species diversity permanently high.
(2) So-called ecological forestry. This means forest management that does not involve clear-cutting or forest planting and where mainly the dominant species are regularly harvested.
(3) Low-intensity (extensive) pasturing that keeps the pastures mosaic and where many sites on the pasture are rarely visited by the animals.

In all these examples, humans use some of the natural biotic production without removing any of the selected species entirely, and without adding new species in large quantities. The soil is not turned over, and the flow of waters is not redirected. This is a management of natural communities as they are: it does not remove any plant or animal community from the area, but it uses pieces of the community in a mosaic way, and reduces the number of some of the dominant populations thereby diminishing the competition intensity of the community. Thus, many species are given a niche that may allow them to survive.

When comparing the principal ways of human-nature relationships with regard to the spatial aspects, we can distinguish between three types:

(1) the spatial separation of large civilised and wild areas, according to the idea of wilderness;
(2) the total overlapping of nature and culture, as in the countryside (in the case of intensive management), parks, or gardens;
(3) the maximum spatial mosaic of nature and culture, as in wooded meadows, and other semi-natural ecosystems.

Originally, wooded meadows were an integral part of the world of people, who lived as settled hunters and fishermen with some few domestic animals. In using the different products of the diverse ecosystem which surrounded them, they contributed to the factors which preserved the high species richness.

Now, for contemporary Western people, primeval nature and natural plant communities only exist outside of their everyday world – their *Umwelt* (in the sense of Uexküll 1982) – despite the existence of indigenous communities in some places. For current cultures, these wilderness areas serve the function of museums. Visiting these places means that people learn how it *was*, and see examples of previous, ancient times – something rare. For most people, natural species – as small populations in wilderness areas – do not play any real functional role in their everyday cultural life, either in a utilitaristic or in an ecosystemic (recycling) sense. That nature, which surrounds the majority of contemporary people in the civilised world, consists mainly of non-indigenous cultural forms, where the local flora and fauna are represented for the most part through weeds and parasites. Even if a garden seems to be well-designed with a high concentration of developed species, the overall number of species in such an ecosystem is much lower than in a natural community, particularly due to reduced soil and insect fauna, and microbiota.

An alternative or additional possibility would be to live as a *part* of local nature, thus requiring a different type of communication with other species. This *living together* with local flora and fauna would allow us to use them to some extent, and allow them to carry on the eternal round-dance of our common nature. All this is possible if we surround ourselves with ecosystems consisting of local, indigenous biota. This is the basic idea of the wooded meadow (Kull et al 2003).

Bumblebees in the agricultural landscape of Estonia

Bumblebees are valuable pollinators of crops as well as native plants but their populations have declined in many parts of western Europe during recent decades. Their decline has been greatest in intensively managed agricultural areas and associated with the decline in suitable forage plants. This study compared the abundance and diversity of forage plants and bumblebees in agricultural and semi-natural habitats in Estonia, where land management for agriculture is less intensive than in western Europe.

No significant difference in the abundance of either flowering forage plants or bumblebees between agricultural and semi-natural habitats was found. However, the number of bumblebee species observed in agricultural areas was significantly smaller than the number in adjacent semi-natural areas.

The smaller proportion of preferred forage plants in the agricultural habitat was a possible reason for its reduced bumblebee species richness. For example, in the agricultural habitat, the annual and biennial plants tended to be more common and the hemiparasitic *Melampyrum* *nemorosum* significantly less common, among the flowers visited by bumblebees, than in the semi-natural habitat. The proportion of stable micro-habitats, which are not subjected to ploughing and root disturbance and therefore allow establishment of highly preferred forage plants, rather than the overall quantity of any kinds of refuge areas between cultivated lands, may be critical for the species richness of bumblebee communities in agro-ecosystems.

Despite the relatively high diversity and mosaic pattern of the agricultural landscape in Estonia compared with many West-European countries, the species richness of bumblebees is significantly reduced even here, in comparison with that in the semi-natural landscape. This study supports the hypothesis that species composition of forage plants rather than the abundance of suitable flowers or the number of potential forage species is the main cause for this reduction (Mänd 2000, Mänd et al 1998, 1999, 2000, 2002a,b).

Diversity of bumble bees on ecological and conventional farms

The impact of ecological land cultivation on the abundance and species richness of nonparasitic bumblebees was studied. For these purposes twelve pairs of farms (ecological and conventional) were selected in different areas of Estonia. The transects passed through fields of leguminous crops, field boundaries and wasteland in correlation with the land use of each farm.

The diversity and abundance of bumblebees on the conventional farms was significantly smaller than on the ecological farms. However, no significant difference was found in the abundance of flowering plants between ecological and conventional farms. Smaller numbers of bumble bees in the fields on conventional farms can, possibly, be explained by the cultivation practice peculiarities and using of pesticides of these fields, as there was no statistical difference in the abundance of bumble bees in the natural grasslands of ecological and conventional farms (Mänd et al 2001a,b).

Diversity of bumblebee diet on ecological and conventional farms

The heterogeneity (the Shannon-Wiener diversity index) of the plant species composition used by the most abundant bumble bee species were significantly higher in the ecological farms compared with the conventional farms. The only exception was *Bombus terrestris.* The diet diversity was the highest for the short-tongued *B. lapidarius* and for *B. lucorum* but it was also high for the medium-tongued *B. pascuorum*. These species were the most abundant and collected nectar and pollen from a large variety of flowering plants in both farm types. For the long-tongued *B. hortorum,* the diversity value was low both on the ecological and on the conventional farms. Our study showed that food generalists as *B. lapidarius*, *B. lucorum* and *B. pascuorum* have advantages in using variable resources during the season, whereas long-tongued bumble bees are most vulnerable due to their restricted diet. These bumble bees are required to perform pollinator service that cannot be replaced by short-tongued species or honeybees (Mänd et al 2002, Koskor et al 2006).

Landscape structure and bumble-bee communities

This study tested the relationship between data sets of landscape elements and bumblebee communities from nine agricultural areas in Estonia. The species composition and abundance of bumblebees was to a great degree determined by landscape structure. The most important landscape features correlating with the distribution of the bumblebee species were the ecotone length between cultivated land and forests, and the size of the area covered with mixed forests and wetlands (Mänd et al 2001).

Monitoring of the Estonian Agri-Environmental Programme at landscape level

We tested the possibilities to apply bumblebees as the biodiversity indicators in monitoring and evaluation of Estonian agri-environmental program. The need for agri-environmental indicators has arisen during the last years. To evaluate the real outcome of agri-environmental policies we need a good set of environmental indicators. Consequently, some proxy measure is required to indicate progress towards the desired outcome. Results showed that there was a highly significant co-structure of the data sets of landscape elements and bumblebee communities. Considering, that the purpose of many agri-environmental measures is to create more ecotones and higher biodiversity in agricultural landscape, "bumble bee approach" could be used as a biodiversity indicator at landscape level (Sepp et al 1998, 2004).

Forests

In Estonia considerable human impact on forests dates back to about 1000 years, and where industrial timber harvesting with its devastating consequences for the forest biota has lasted for about 200 years. In Estonia, general restoration of the forest cover is irrelevant (nearly half of the territory is covered by forest) but for the year 2010 ten percent of the forest should be strictly protected to protect old-growth stands (Lõhmus et al. 2004). Diversification of stand structure, restoration of disturbance regimes, and restoration of waterbodies and water regime is needed (Lõhmus 2005, Lõhmus et al 2005, Lõhmus 2005a,b; Lõhmus and Lõhmus 2005).

Conclusions

Human impact is not only negative. Permanent mild (sustainable) management of indigenous ecosystems may create valuable diversity and helps to sustain it.
Wide-spread organic farming will enable biodiversity survival and long-term continuation of ecosystem services in agro-ecosystems.

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