Agriculture and Biodiversity

DEVELOPING INDICATORS FOR POLICY ANALYSIS

OECD

Agriculture and Biodiversity: Developing Indicators for Policy Analysis

Proceedings From an OECD Expert Meeting

Zurich, Switzerland, November 2001

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

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FOREWORD

Many countries have made commitments under the international Convention on Biological Diversity, agreed in 1992, which aims at conservation of biodiversity, including genetic resources, wild species and habitats. Part of this task is to quantify the linkages between human activities and biodiversity, including agriculture. This is not an easy task and few countries have systematic monitoring systems in place that track the trends in biodiversity. Also there are formidable scientific difficulties in linking changes in biodiversity associated with agriculture to specific policy measures.

To overcome some of these deficiencies the OECD is developing a set of agri-biodiversity indicators, which is part of a wider OECD activity to develop agri-environmental indicators. As part of the process to establish indicators OECD Member countries have hosted a series of Expert Meetings on specific agri-environmental issues (see www.oecd.org/agr/env/indicators.htm). This Proceedings reports on one of these Expert Meetings on agri-biodiversity indicators, hosted by the Swiss Federal Research Station for Agroecology and Agriculture, Zurich-Reckenholz, and held in Zurich-Reckenholz, November, 2001.

The Proceedings of the OECD Expert Meeting on Agri-biodiversity Indicators provides a selection of 18 of the 34 papers presented by authors from some 24 OECD Member countries, the European Commission and international organizations. The full set of meeting papers are listed in the Annex to this publication and available on the OECD website at the address above.

The Proceedings follows the order of the presentations at the meeting, covering an OECD overview of agri-biodiversity indicators, followed by papers on agricultural genetic resources, wild species, ecosytems and finally, papers linking habitats to species. The summary of the discussions that followed these presentations resulted in a set of recommendations to OECD with respect to agri-biodiversity indicators, which are included at the beginning of this publication. The summary of this publication is also available in French, German and Spanish, see the website above.

In compiling the Proceedings, no attempt was made to change the original content or message of individual papers. With the exception of formatting, the papers are reproduced here as they were submitted to the meeting. Many of the figures in these papers were prepared in colour, which can be viewed on the website above.

Acknowledgements

The OECD Secretariat wishes to thank the Swiss government authorities for hosting this OECD Expert Meeting, especially all the staff at the Swiss Federal research Station for Agroecology and Agriculture, in particular Andreas Gruening and Thomas Walter. OECD would also like to thank all the participants for their contribution to the success of the meeting, with a special thanks to those that helped as Chairs, Rapporteurs and Discussants. The following OECD Secretariat staff, under the overall guidance of Wilfrid Legg, also contributed to the meeting: planning and organisation, Kevin Parris; preparing the Proceedings for publication: Françoise Bénicourt and Laetitia Reille; and the staff of the OECD publications service.

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PREAMBLE

This report provides a selection of papers and the conclusions and recommendations reached by the experts who participated in the OECD Expert Meeting on Agri-biodiversity Indicators, held in Zurich, Switzerland, 5-8 November, 2001, under the auspices of the OECD Joint Working Party on Agriculture and Environment (JWP). At the JWP's meeting in April 2002 they agreed that the conclusions and recommendations of the experts should be made available to the wider public as a contribution to the development of agri-environmental indicators, and national and international efforts to establish agri-biodiversity indicators.

The conclusions and recommendations are those of the participants and do not necessarily reflect the views of the OECD, the JWP or its Member Countries.

The OECD undertakes analysis of agri-environmental policy issues within the JWP. As part of that work, the JWP is developing a set of agri-environmental indicators to measure the environmental performance of agriculture by:

1. providing information to policy makers and the wider public on the current state and changes in the conditions of the environment in agriculture;

2. assisting policy makers to better understand the linkages between the causes and impacts of agriculture, agricultural policy reform, trade liberalisation and environmental measures on the environment, and help to guide their responses to changes in environmental conditions; and,

3. contributing to monitoring and evaluating the effectiveness of policies addressing agri-environmental concerns and promoting sustainable agriculture and natural resource management.

The JWP has identified a number of criteria which agri-environmental indicators need to meet, including:

- *policy relevance* in addressing the key environmental issues faced by governments and other stakeholders in the agricultural sector;

- *analytical soundness* being based on sound science but recognising that their development is an evolving process;

- *measurability* in terms of data availability and cost effectiveness of data collection; and,

- *interpretation* in that the indicators should communicate essential information to policy makers and the wider public in a way that is clear and easy to understand.

In order to help establish policy relevant indicators, a number of OECD Member countries have hosted Expert Meetings on specific agri-environmental issues, in particular, to further develop two of the criteria: analytical soundness and the measurability of indicators. The Expert Meeting on Agri-biodiversity indicators, hosted by Switzerland, was one of the series of these Expert Meetings, and the full set of meeting papers and other related information (*i.e.* web links and country reports) are available on the OECD website at http://www.oecd.org/agr/env/indicators.htm

SUMMARY AND RECOMMENDATIONS

This chapter of the report provides the recommendations and summary of the discussion of the OECD Expert Meeting on Agri-biodiversity indicators, held in Zurich, Switzerland, November 2001. The main recommendations of the experts are provided in Section 1, which are further elaborated in Section 4. Background to the meeting is described in Section 2, and Section 3 provides a summary of the discussion at the meeting, supported by five Annexes.

1. Main recommendations

i) Establish agri-biodiversity indicators within a common, flexible and transparent framework that provides a hierarchy with multiple spatial and temporal scales in which to identify, structure, combine and aggregate indicators (Figure 1). The framework enables countries to identify the strengths and weaknesses in their existing compliment of indicators and takes into account an agro-ecosystem's: *diversity of elements* (*e.g.* flora and fauna); *complexity of interactions* (*i.e.* social, economic and environmental) and the *interaction with other ecosystems* (*e.g.* forests). It also recognises the *hierarchical structure* within the agro-ecosystem, including: the agro-ecosystem base (*i.e.* agricultural land; production species-crops and livestock; and production support species, *e.g.* soil biodiversity); habitat types, their structure and management; and wild species use of agro-ecosystems for different requirements (*e.g.* breeding, feeding).

ii) Member countries should provide the OECD on a regular basis, when available and where relevant, a set of agri-biodiversity indicators that monitor the effects and performance of agriculture on biodiversity (*i.e.* at the genetic, species and ecosystems levels) and which are linked to actions by farmers, the agro-food chain and governments.

iii) Integrate the agri-biodiversity indicators into policy monitoring, evaluation and in predictive scenarios to improve policy effectiveness in promoting sustainable agriculture.

iv) Invest in the scientific understanding and research of the linkages between the genetic, species and ecosystems levels related to agri-biodiversity, and the interactions between farming and biodiversity. This research should help to further develop the associated information and basic data, including in those areas not yet covered by the OECD work, notably indicators of environmental services, such as soil biodiversity, pollinators and natural pest control.

v) Continue to engage a wide range of stakeholders in developing agri-biodiversity indicators, including farmers and food industry representatives, environmental groups, government scientists and policy advisors, by drawing on and sharing their perspectives, expertise and information sources related to monitoring agri-biodiversity for policy purposes.

vi) Contribute and cooperate with other international initiatives related to developing agri-biodiversity indicators, especially those under the Convention on Biological Diversity and in FAO, by conveying the OECD work to these organisations and convening joint meetings with them for the purposes of indicator development and co-ordination, and in order to promote global consistency, similar to indicators in the socio-economic field, and also to share the OECD work with non-Member countries.

2. Background

The OECD Expert Meeting on Agri-Biodiversity Indicators (ABIs) was convened to contribute and build on the work in the OECD to develop a set of Agri-Environmental Indicators (AEIs). The meeting, hosted by the Swiss Federal Research Station for Agroecology and Agriculture, Zurich-Reckenholz, Switzerland, was attended by nearly 90 participants, drawn from 24 of the 30 OECD Member countries and involved many international organisations.

This summary and recommendations from the meeting, also includes additional information drawn from the reports of the Rapporteurs and Discussants (Annexes 1-5). All 34 papers presented at the meeting, including the list of participants, web links and country reports, are available on the OECD website at http://www.oecd.org/agr/env/indicators.htm

An oral report of the meeting was presented by the OECD Secretariat to the 7th meeting of the Subsidiary Body on Science, Technical and Technological Advice (SBSTTA, held in Montreal, Canada, November 2001) and the Conference of the Parties 6th Meeting (COP-6, held in The Hague, The Netherlands, April 2002) of the ***Convention on Biological Diversity*** (CBD) (see the CBD website at: http://www.biodiv.org/doc/meeting.asp?lg=0&wg=sbstta-07). The results from the Expert Meeting were also provided for information to the ***Pan-European Conference on Agriculture and Biodiversity***, hosted by France, in Paris, 5-7 June, 2002, and organised by the Council of Europe (COE) in cooperation with the UNEP (see the COE website at: http://nature.coe.int/conf_agri_2002/)

3. Summary

There was recognition that the overall objective of the ABIs is to monitor the effects and performance of agriculture related to biodiversity, linked to actions by farmers, the agro-food industry, and governments (Annex 1), in:

i) providing crop and livestock genetic resources, as the basis for food production, and the development of agricultural raw materials, such as renewable energy through biomass;

ii) enriching society through maintaining and enhancing the variety of wildlife habitats and wild species related to agriculture, of value for economic, scientific, recreational, aesthetic, intrinsic, landscape and other amenity purposes; and in,

iii) supporting the functioning of ecosystems and production support systems critical to agriculture, such as soil fertility protection through soil microbial activity, pollination, nutrient cycling, water filtration, and climate influence.

ABIs that can help countries and the international community to monitor progress towards achieving a sustainable agriculture need to reflect both the genetic, species and ecosystem levels in agri-biodiversity relationships and also the socio-economic interactions between farming and biodiversity, as recognised under the Convention on Biological Diversity (CBD). Annex 1 provides the classification and coverage of OECD ABIs, and their compatibility with the CBD.

Experts emphasised ABIs need to be developed within the context of the OECD's objectives for work on agri-environmental indicators, including as a:

i) source of information on the status and trends in biodiversity related to agriculture; and a,

ii) tool in policy monitoring, evaluation and in predictive scenarios, to improve policy effectiveness in promoting sustainable agriculture and management of natural resources.

The further development of ABIs should build on the solid basis already achieved by OECD (see OECD, 2001, Environmental Indicators for Agriculture — Volume 3: Methods and Results, notably the chapters on Biodiversity and Wildlife Habitats), and be selected on the basis of the OECD criteria of policy relevance, analytical soundness, measurability and ease of interpretation, and the specific guidelines for selecting agri-biodiversity indicators recommended by experts (Annexes 4 and 5). Moreover, to enhance the effectiveness of policy decision making, the indicators should be made available as soon as feasible.

The "sustainability" framework — which encompasses economic, social and environmental dimensions — can be useful to situate ABIs in their broader context. It can also help to avoid that ABIs have too narrow a focus on existing systems by recognising the possibility of change brought about by other sustainability considerations, especially economic and social factors.

The driving force-state-response model can help structure analysis of agri-biodiversity relationships. For example, *driving forces*, such as government agricultural support policies and market conditions (*e.g.* agricultural commodity and input prices) influence on pesticide use and pest management practices. This is causing the *state* of biodiversity in agriculture to change as a result of the impact of pesticide use and pesticide management on wild species, and this may in turn lead to farmer, agro-food industry and government *responses* to promote biodiversity conservation, such as through the adoption of integrated pest management and changes in government crop and pesticide input support policies and pesticide risk reduction regulations.

The importance of developing ABIs for policy monitoring, evaluation and in projection studies was emphasised, not only by experts from OECD Member countries and the EU Commission, but also by representatives of international governmental organisations (European Environment Agency, FAO, Ramsar, UNEP, and the World Bank), and non-governmental organisations representing farmers (International Federation of Agricultural Producers, IFAP), the food industry (Business and Industry Advisory Committee to the OECD, represented by Unilever), and environmental interests (Birdlife International, European Centre for Nature Conservation, World Conservation Union (IUCN), Wetlands International and the World Seed Organisation).

It was recognised that a major challenge for OECD Member and non-Member countries is to reconcile the need to expand agricultural production while meeting national and international objectives and commitments for the conservation and enhancement of biodiversity, given the projected need to increase global food production by over 20% by 2020.

Experts called on OECD Member countries to consider several issues in developing and providing indicators to:

i) reflect a comprehensive view of agriculture and its effects on biodiversity, and not just focus on protected areas and endangered species;

ii) recognise the complexity of agri-biodiversity and hence use a combination of indicators;

iii) develop existing data sets to meet the immediate needs of policy makers and, over the longer term, in recognition of the limitations in the current scientific understanding and data to measure agri-biodiversity, make further effort (in terms of scientific research and data collection) to address these limitations;

iv) establish metadata (*i.e.* descriptive notes) for ABIs that defines and describes genetic, species and ecosystems information;

v) undertake further research to improve understanding of ecosystem services related to agriculture (*e.g.* soil biodiversity, pollinators, natural pest control) and develop relevant indicators;

vi) recognise the consequences of uncertainty on changes in agri-biodiversity linkages, for example, the impact of climate change, genetic mutations and alien invasive species;

vii) provide ABIs and related data and metadata sets to the Secretariat on a regular basis as soon as feasible; and,

viii) integrate the indicators into policy monitoring, evaluation, and projection studies.

To improve interpretation of ABIs experts recommended it is necessary to take into account the:

i) spatial and temporal coverage of indicators, in particular, to take into account not only species presence, but also changes in species abundance and their distribution;

ii) overall trends rather than absolute levels across countries;

iii) baselines if established at the national level (not the OECD level) could help to improve the assessment of the performance of agriculture in achieving identified future goals and targets;

iv) causes of change on biodiversity in agriculture, both negative (*e.g.* excessive farm chemical use) and positive (*e.g.* creating field margins as wildlife corridors), in particular the effects of different farming practices and management systems; and the,

v) linkages with other agri-environmental indicators, such as farm management indicators.

It was observed that the OECD agri-biodiversity indicators are applicable to many non-Member OECD countries. The OECD work could thus provide useful synergies and input into other international efforts to develop ABIs, especially under the CBD and the FAO's work on monitoring trends in global agricultural biodiversity. Experts also noted the need for cooperation in work on ABIs, not only between OECD Member and non-Member countries, but also drawing on the expertise and databases of other international organisations, such as Birdlife International, ECNC, the EEA and its European Topic Centres, FAO, IUCN, Wetlands International and the World Bank. Even so, data drawn from other international organisations would need to be verified in terms of their validity and quality.

4. Recommendations

4.1. The Agri-Biodiversity Framework (ABF)

Experts recommended drawing together different agri-biodiversity indicators of genetic resources, habitats, and wild species within a coherent and comprehensive framework (Figure 1). The agri-biodiversity framework (ABF) provides a hierarchical framework with multiple spatial and temporal scales in which to structure and organise national (and sub-national) indicators of agri-biodiversity. The framework takes into account the socio-economic and environmental interactions in an agro-ecosystem which provide both commodities (*i.e.* food and non-food outputs) and environmental services (*e.g.* scientific, recreational, ecological).

The ABF recognises (Figure 1) the:

i) ***Diversity of elements in an agro-ecosystem***, which consists of plant and animal communities (domesticated crops and livestock, and wild species) and their environmental functioning as an ecological unit, strongly influenced, created and/or maintained by agricultural management activities within which are a diversity of different habitats. Each habitat type is defined as including both living and non-living aspects, limited to an area where a certain number of ecological factors and farm management practices are broadly homogenous and stable.

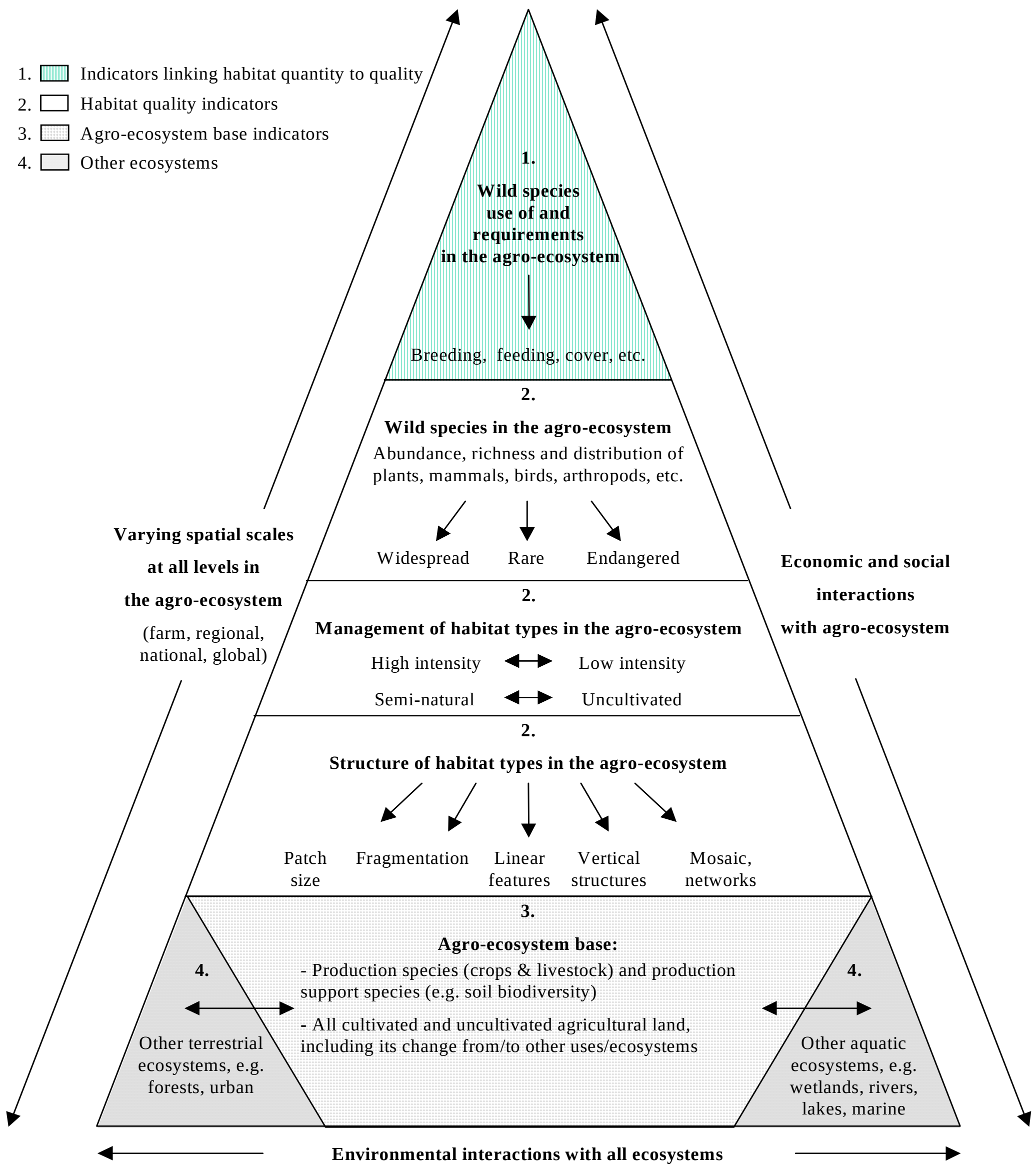
ii) ***Complexity of the interactions among the different elements in the agro-ecosystem***, in particular, between the economic (*e.g.* agricultural commodity prices and support measures), social (*e.g.* farmer education, skills, cultural values), and environmental elements (*e.g.* physical environment, biological elements) interacting on the diversity of habitat types, production species (crops and livestock) and wild species (including production supporting species) within the agro-ecosystem.

iii) ***Interaction between agro-ecosystems and other ecosystems***, both terrestrial (*e.g.* forests) and aquatic (*e.g.* wetlands), especially in terms of the effects of farming practices on other ecosystems (*e.g.* off-farm impacts from nutrient/pesticide run-off into aquatic ecosystems) and land use changes from agricultural land to other land uses (and vice versa). This can have both beneficial and harmful effects on biodiversity depending on the nature of the change in land use, such as a change from semi-natural grassland to commercial forest or a change from a tropical forest to cultivated cropland.

iv) ***Hierarchical structure of different layers within the agro-ecosystem***, including the current state and changes in the: agro-ecosystem base, including production species and production supporting species and the land use stock and changes between agriculture and other ecosystems; structure of habitats within the agro-ecosystem; management of the habitats in agro-ecosystems; wild species in the agro-ecosystem; and the use and requirements by wild species of the habitats within the agro-ecosystem (*e.g.* breeding, feeding).

v) ***Tangible and quantifiable specification of biodiversity*** (*i.e.* genetic resources, habitats and wild species) across the whole agro-ecosystem and the spatial distribution of habitats and wild species related to agriculture.

Figure 1. **OECD Agri-Biodiversity Indicators Framework**



Source: OECD Secretariat.

The ABF offers the possibility to identify and structure a range of indicators for different policy purposes and at varying spatial scales. Indicators can be used, for example, to highlight the risk of genetic erosion of domesticated crop varieties and livestock breeds (indicators of genetic resources); to track the performance of a particular policy measure aimed at reducing wetland loss to agriculture (indicators of habitat quantity); and monitor the progress of a policy measure seeking to increase the population size of rare and endangered wild species associated with agriculture (indicators of habitat quality). Also combining indicators to measure current or future trends concerning the impact on wild species of changes in agricultural land use and cover patterns, habitat structure and farm management practices and systems (indicators linking habitat quantity to quality).

The ABF is recognised by experts as potentially having a number of advantages, in particular because it:

i) establishes a structure and hierarchy in which indicators can be clearly identified, organised, combined and aggregated, providing a classification that can be used to identify the strengthens and weaknesses in the existing compliment of indicators of individual OECD countries;

ii) encompasses all agricultural land, including uncultivated habitats on agricultural land, and all species (production species, production supporting species and wild species) that use farm land or are affected by agricultural activities;

iii) provides flexibility by taking into account the varying policy priorities, agro-ecosystems and farming systems, across OECD countries, for example, from alpine pastures, rangelands, tropical plantations, to rice paddies and arable crops, and different spatial scales necessary to monitor trends in agri-biodiversity at the local, regional, national to international levels;

iv) draws on existing data sets, some of which are already well defined, such as agricultural land census data, and can help identify where data gaps exist;

v) facilitates the use of terminology that avoids value judgements or relies on imprecise definitions of different agricultural habitats by measuring habitat quality through the species use, structure and management of agricultural habitats, supported by quantitative data and clear descriptions of habitat categories and related data;

vi) recognises countries are at different stages in their development of ABIs and provides a coherent structure within which countries can begin to calculate indicators and assemble data sets that are transparent and comparable across countries;

vii) allows for the possibility that the framework could be extended and used to cover not only agro-ecosystems but other ecosystems, such as forests and mountains; and,

viii) offers the potential to integrate some of the indicators into national economic or ecological accounts, for example, changes in the stock of habitats, the habitat-species matrix and the natural capital index.

Further developing the ABF requires more attention to the following points:

i) identify baselines, targets and/or trends which countries are using or developing to assess the performance of policy measures aimed at biodiversity conservation;

ii) analyse the impact of driving forces on biodiversity in agro-ecosystems, in addition to farm management practices, such as the effects of alien invasive species, genetic mutations, changes in water table levels, and climate change on biodiversity in agro-ecosystems;

iii) explore methods that can better express spatial and temporal variations in biodiversity across a country, based on various technical methods, such as remote sensing and stratified sampling;

iv) improve both scientific understanding of the relationships between changes in agricultural genetic resources, habitat quantity, and habitat quality, and the data gaps and data quality that draw a representative picture of biodiversity, in space and time; and,

v) exchange information across OECD countries and with non-Member countries, to start a process of harmonising agro-ecosystem habitat classifications, definitions and related information and indicators (see also Annex 4 in this context).

4.2. Agri-Biodiversity Indicators (ABIs)

There are four groups of indicators within the ABF that form an integrated framework which countries are recommended to develop: ***first,*** agricultural genetic resources (4.2.1); ***second***, habitat quantity (4.2.2); ***third***, habitat quality (4.2.3); and a ***fourth*** group which combines the last two groups, habitat quantity and quality, and expresses the overall loss (gain) of biodiversity (4.2.4). Most of the indicators, highlighted in boxes below, with some small modifications are already included in the current set of OECD agri-environmental indicators, but some indicators are recommended as new additions in order to make the OECD indicator framework more comprehensive.

4.2.1. Indicators of Agricultural Crop and Livestock Genetic Resources

Experts recommended the OECD build on its current set of indicators related to agricultural crop and livestock genetic resources by providing the following indicators:

i) Total number of crop varieties/livestock breeds for the main crop/livestock categories (*e.g.* wheat, rice, cattle, pigs) that have been registered and certified for marketing, including native and non-native species and landraces.

ii) Share of crop varieties in total production for individual crops (*e.g.* wheat, rice).

iii) Share of livestock breeds in total livestock numbers for respective categories of livestock (*e.g.* cattle, pigs, poultry, sheep).

iv) Number and share of national crop varieties/livestock breeds used in agricultural production that are endangered.

v) Number of available species and accessions (samples) conserved *in situ* and *ex situ* in national programmes.

Indicators i) to iv) are already included in the current set of OECD agri-environmental indicators, although for indicator i) it is recommended 'native and non-native species and landraces' be added to the indicator definition. It is recommended that indicator v), concerning genetic resource conservation is added to the current OECD indicator set, while indicators ii) and iii) could be expressed with use of the biodiversity/evenness index (*e.g.* Shannon index) rather than as a share of major crop varieties/livestock breeds in total crop/livestock production.

In terms of ***genetic erosion*** while it may be useful to know that 90% of the national dairy herd belong to only three breeds, for example, this information does not help to address the questions of what is happening to the other 10% of dairy breeds and are their populations large enough to avoid genetic erosion? Moreover, using the dairy example, in one country the populations of the 10% of "minor" dairy breeds may be large enough to ensure their stability, but in another country a 10% share may involve a much smaller number of individuals and be too few to protect minor dairy breeds from genetic erosion. Hence, the biodiversity/eveness index (*e.g.* Shannon index) can help in solving this problem of minor livestock breeds or crop varieties, although the difficulties of individual population sizes and changes in the status of endangerment are areas for further development (Annex 2).

Experts recognised that in the ***future development of agricultural genetic diversity indicators*** OECD Member countries need to:

i) clarify definitions, in particular, through strengthening cooperation with FAO's work on agricultural genetic diversity, and to harmonise with the definitions already established by the CBD and FAO for: native and non-native species/breeds and, endangered species/breeds;

ii) quantify within species diversity and genetic difference, by using molecular markers, etc., which improves upon monitoring only numbers of varieties and breeds; and,

iii) establish a national registration process for landraces, *i.e.* identify species/types in production.

Annex 2 provides further detail on the agricultural genetic diversity indicator characteristics and areas proposed by experts for further development. Annex 3, identifies the conclusions of experts on the driving forces, state and responses to the conservation and management of agricultural genetic diversity.

4.2.2. Indicators of Habitat Quantity

These indicators provide information on the stock and flows of habitat types across all agricultural land including intensively and extensively farmed land, semi-natural areas, and uncultivated land, and changes in land use between agro-ecosystems and other ecosystems (*i.e.* terrestrial and aquatic ecosystems).

i) The current area and share (stock) of different habitat types across all agricultural land, including intensively or extensively farmed land (*e.g.* arable crops, rangeland, rice paddies), semi-natural areas (*e.g.* certain grasslands, heather moorland) and uncultivated land (*e.g.* fallow, areas of remnant native vegetation, ponds).

ii) Changes in the area and shares of habitats (flows) both within agriculture (*e.g.* less arable land, more pasture) and between different land uses (*e.g.* from agricultural use to forestry or change from wetlands to agricultural use).

All agricultural land and the full range of habitat types should be covered by these indicators, including those areas of uncultivated habitat (*e.g.* ponds, woodlands) within farming areas, while flexibility needs to be exercised in categorising habitat types in agro-ecosystems by recognising the:

i) historical time series data already developed in OECD countries; and the,

ii) diversity of agro-ecosystems and farm management systems across OECD countries.

At present two main systems of agricultural land categorisation and data time series are evident in OECD countries, including habitats defined in terms of:

i) agricultural land use and cover types, mainly drawing on data collected through regularly updated agricultural census, for example, arable land, permanent crops and managed pasture;

ii) biological and ecological characteristics, for example, mires and heathland, semi-natural grasslands, wild prairies, rangelands, and broader ecozones.

In some cases these two types of habitat data are supplemented with additional information/data to describe variations in their quality, characteristics and systems of management, increasingly complemented with sample-based surveys and remote sensing observation techniques of land cover mapping. ***To move toward consistency across OECD countries, experts recommended a set of guidelines to select habitat indicators related to agriculture***, elaborated in Annex 4, which recognise the need for countries to:

i) include all agricultural land that comprises the agro-ecosystem;

ii) provide the criteria used to select each habitat type within the agro-ecosystem;

iii) define the characteristics of each habitat type through metadata (*i.e.* descriptive notes);

iv) develop a comprehensive list of the different habitat types selected for an agro-ecosystem; and

v) identify the regularity with which data on the current area (stock) and changes (flows) in habitats across agro-ecosystems are collected and describe the methods used to collect the data.

As more information becomes available from OECD countries as to how habitats on agricultural land are classified and defined, it will be necessary for the OECD to ***establish a harmonised and comparable system of habitat classification and definitions across OECD countries***. This will require more structured and regular expert exchange between countries, and include drawing on existing cross national systems for habitat and land cover classification, such as in Europe under the EUNIS and CORINE systems (for further details of EUNIS and CORINE see the European Environment Agency website at: http://reports.eea.eu.int/topic_report_2001_06/en/Topic_6_2001.pdf .

4.2.3. Indicators of Habitat Quality

These indicators provide information on the ***quality of different habitats types*** across agro-ecosystems in terms of their:

i) structure (indirect measure of habitat quality);

ii) management (indirect measure of habitat quality); and their,

iii) use and requirement by wild species (direct measure of habitat quality).

In general, the quality of agricultural land from a biodiversity perspective is higher the greater the number of wild species and their corresponding abundance and diversity, and the greater the diversity of habitat structures and the less intensive the management of the land (this may vary according to local conditions, *e.g.* soil types, climate). While the availability of these three indicators will depend on the resources, databases and monitoring systems of a country. If no data is available on wild species, then indirect measures of habitat quality (*i.e.* structure and management) could be used instead.

Habitat Structure Indicator: Trends in the quality and quantity of habitat features and their spatial composition across agricultural land.

Indicators of habitat structure in terms of the quality and quantity of habitat features (*e.g.* extent of alpine meadows, area of field margins, area and fragmentation of remnant native vegetation patches on agricultural land) and their spatial composition across agro-ecosystems (*e.g.* patch size and patch mosaic, fragmentation of habitats, linear features and networks), are an indirect measure of habitat quality.

Taking into account the implications of different habitat structures and patterns for wild species in agro-ecosystems, further work is required to define indicators that measure:

i) ***patch size***: the size of habitat patches is important for some species;

ii) ***fragmentation***: the extent to which a given habitat type is divided into separate patches;

iii) ***linear features and networks***: for example, the length, age, quality and connectivity of hedges;

iv) ***vertical structures***: habitat structures in terms of vertical layers (*e.g.* bushes and tress), which are especially important to bird and invertebrate communities; and,

v) ***mosaic*** of different habitats in an agro-ecosystem: for example, habitat diversity, location, juxtaposition and heterogeneity of land cover, and linkages to indicators of agricultural landscape in countries where this is important.

Habitat Management Indicator: Trends in farm management practices and systems which affect biodiversity.

Changes in farming practices and management systems are a key driving force affecting habitat quality. ***Habitat management indicators***, which provide an indirect measure of habitat quality, are included under the OECD overall core set of agri-environmental indicators concerning farm management covering the effects on biodiversity from farming practices (*e.g.* timing of grass cutting, nutrient and pesticide management, stocking densities), and different farm management systems (*e.g.* integrated land management systems, organic farming).

It is important to ***clearly define different farming practices and management systems***. To avoid the difficulties and ambiguities in defining terms such as ‘intensive’, ‘extensive’, ‘traditional’ and ‘industrial’ agricultural production systems, it is necessary to know in terms of wild species impacts information on farming practices, such as the use of farm inputs (*e.g.* fertilisers, pesticides, water); livestock husbandry practices, (*e.g.* livestock stocking densities); and farming systems, such as the number of farms under environmental whole farm management plans and the area of organic farming.

Wild Species Indicator: Trends in the abundance (*i.e.* the number), richness (*i.e.* diversity) and ecologically indicative value (*i.e.* species associated with specific habitats such as prairie grazing land) of wild species using agricultural habitats or affected by farming activities.

While ***indicators of wild species*** provide a direct measure of habitat quality, they are also useful indicators in their own right to reveal the current stock and trends in wild species, including wild relatives of domesticated crop and livestock species, and widespread, rare and endangered species. Many species, particularly fauna, use a variety of farmed habitats and cannot be easily associated with a single habitat type. Because many species use a variety of farmland habitats and cannot be associated with a single habitat type, they may consequently be better indicators of agro-ecosystems. The Chough (*Phyrrocorax phyrrocorax)* is an example of this as it is a bird that moves between using different farmland habitats throughout the year. Trends in alien invasive species are also of importance to a number of OECD countries, but are currently not part of the OECD work on agri-biodiversity indicators (Annex 1).

To move toward consistency across OECD countries***, experts recognised the need for guidelines to select indicators of wild species related to agriculture***, elaborated in Annex 5, including selecting:

i) a minimum set of wild species collectively representing a wide range of habitat types across agricultural land;

ii) a range of wild species that require different types of agricultural land and from various species groups (*e.g.* birds, mammals, arthropods, plants, etc.);

iii) rare, endangered and widespread species; and, selecting;

iv) wild species relevant to policy issues at different scales from the local to global level.

In developing these guidelines it will be important to ***recognise the scientific uncertainty about the current and future links between biodiversity and agriculture***, and to also reveal the criteria used and rationale for wild species chosen within a country. To improve consistency of wild species indicators across countries, will also require in the future improved data availability and comparability, and the exchange between countries of their practice in cost effective data collection. Also the need for further examination of the function of baselines is recognised as an important issue in the future.

4.2.4. Indicators Linking Habitat Quantity to Quality

These indicators integrate habitat quantity and quality indicators to provide information on how land use and land cover changes are affecting wild species (flora and fauna) in their use and requirements of habitats in agro-ecosystems.

Habitat-Species Matrix: Changes in the area and management of all agricultural habitat types and the identification, explicitly (*i.e.* direct observations) or implicitly (*i.e.* indirect information such as expert knowledge), of the impact of these changes on wild species (flora and fauna).

Natural Capital Index: The product of the *quantity* of agricultural habitat types and their *quality* in terms of wild species abundance, richness, habitat structure and management, measured between the current state of the agro-ecosystem and a baseline state.

By ***combining indicators of habitat quantity and quality*** these two indicators allow the effects and changes in agriculture on biodiversity to be summarised more succinctly. The indicators also provide the possibility to project the implications for wild species related to future changes in agricultural land use and cover. However, both these indicators have a number of areas where methodological improvements could be made to further improve them, including the science and methods used in projection studies of agri-biodiversity which requires more work.

The *natural capital index*, has been previously discussed in OECD expert meetings/workshops related to agri-environmental indicators, including within the OECD Working Party on the Economic Aspects of Biodiversity. The index has also been developed as a contribution to the implementation of the Convention on Biological Diversity, together with other indicators described in this paper.

Annex 1. **Classification and Coverage of OECD Agri-Biodiversity Indicators and Their Compatibility with the Convention on Biological Diversity**

Convention on Biological Diversity (CBD)[1]

Biodiversity (all living organisms)		
Genetic Diversity	Species Diversity	Ecosystem Diversity

Notes:
1. The CBD is developing its work under the ecosystem approach, which it has defined as meaning "*a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit". (Article 2 of the Convention).* The CBD Conference of the Parties, at its Fifth Meeting (Nairobi, Kenya, May 2000), endorsed the description of the ecosystem approach and operational guidance and recommended the application of the principles and other guidance on the Ecosystem Approach (decision V/6). (see full text at: http://www.biodiv.org/doc/decisions/cop-05-dec-en.pdf).

OECD Agri-biodiversity Indicator Coverage and Compatibility with the CBD

	Biodiversity Related to Agriculture		
	Genetic Diversity	Species Diversity	Ecosystem Diversity
i. Commercial crops, pasture and livestock	X	X	1
ii. Habitat and wild species	2	X	X
iii. Alien invasive species	3	3	3

Notes: X denotes the areas covered by OECD ABIs.
1. There are important links between genetic diversity of certain crops and livestock and the ecosystem (*i.e.* natural conditions and production system) within which they are produced. OECD has not yet developed indicators to cover this aspect of agri-biodiversity, see also Annex 2.

2. Genetic diversity of, in particular, wild relatives of commercial crops (and to a lesser extent wild animals) provides an important resource base for improvements in crop/livestock breeding. OECD has not, yet, developed indicators to cover this aspect of agri-biodiversity. There is at present little data on genetic erosion within wild species populations, which over the long term may be more important than only species loss. This is an area of indicator development which requires consideration over the long term.

3. Work on indicators related to the impacts of alien invasive species on agricultural genetic resources, native wild species and ecosystem diversity, is being undertaken in some OECD Member countries, where the problem is especially acute (*e.g.* Australia, New Zealand, United States) but are not part of the current set of agri-environmental indicators.

Annex 2. **Agricultural Genetic Resources: Indicator Characteristics**

Indicators proposed:	Indicator Characteristics					
	Refers to diversity level at which indicator can provide useful information: Genetic (G) Species (S)	Applicability of indicator to different farming systems	Availability and quality of information	Reliability of information	Value from point of view of:	
					Science	Policy
1. Number of crop varieties and livestock breeds in use	S	All	Good	Good	Low	Good
2. Share of crop varieties in total production (for each crop)	G	All	Good (most countries)	Good	Good	Good
3. Share of breeds in livestock numbers	G	All	Good (most countries)	Good	Good	Good
4. Number of crop varieties and livestock breeds endangered	S	Stronger pressure in intensive systems	Relatively good	Depends on definition	High	High
5. Number of species and accessions conserved - *in situ* and *ex situ*	G S	All (*ex situ* only)	Relatively good	Good	Good to Low	High

Annex 2 (continued). **Agricultural Genetic Resources: Areas for Further Development of Indicators**

Indicators proposed	Possible areas for further development	Complementary information needed
1. Number of crop varieties and livestock breeds in use	- Per country, per area (and which area-arable land, grassland, etc….) - Number of varieties/breeds x diversity among varieties/breeds	- Number of crops in use - Number of breeds in use
2. Share of crop varieties in total production (for each crop)	Biodiversity/eveness index (*e.g.* Shannon index). For crops and livestock these indicators need to be developed to address the questions of what is happening to other minor varieties/breeds and are their populations large enough to avoid genetic erosion? Also in one country the populations of "minor" varieties/breeds may be large enough to ensure their stability, but in another country minor populations may involve a much smaller number of individuals and be too few to avoid genetic erosion. While the biodiversity/eveness index can help solve the problem of minor varieties/breeds, the difficulties of individual population sizes and changes in status of endangerment are areas for further development.	Number of crop varieties covering x…y % production
3. Share of breeds in livestock numbers		Number of breeds
4. Number of crop varieties and livestock breeds endangered	- How endangered: -- use in production -- use in conservation - What type of danger (effective population size): -- extinction -- genetic erosion	- Life time of cultivars - Number of breeding companies - FAO Early Warning System on Plant Genetic Resources For Agriculture (PGRFA)
5. Number of species and accessions conserved *in situ* and *ex situ*	- Per country, per area for landraces - Number of accessions and diversity among accessions - Unique accession collections and possible duplicates - *In situ* : -- on farm -- ecosystem (wild relatives)	-Available - Evaluation/character data - Core collections -FAO indicators

Annex 3. **Driving Forces, State, and Responses Related to Agricultural Genetic Diversity**

The expert meeting discussed the general driving forces, state and responses to the conservation and management of agricultural genetic resources and recognised a number of commonalities across most OECD countries, described below.

1. Driving Forces and Processes Affecting Agricultural Genetic Resources

- Impact of artificial insemination on the maintenance of diversity for animal genetic resources.
- Upgrading of indigenous (native) populations with non-domestic (non-native) genetic material.
- Role of farming at different scales and the influence of home gardens on conservation efforts.
- Intensification of agro-ecosystems and the conversion to agricultural use of some ecosystems (*e.g.* wetlands).
- General concern for cross pollinated crop species, where there is concern for the potential of a lack of seed or fruit set due to the loss of effective pollinators and their populations.

2. State of Agricultural Genetic Resources

- Each country should be responsible for maintaining their own plant/animal genetic resource programmes and for delivery of information (passport, characterisation, diversity indicators) on their own crop and livestock genetic resources.
- The number of registered cultivars within national programmes have been increasing across all OECD countries and throughout the rest of the world.
- Genetic erosion is taking place at an accelerated level with the number of landraces and endangered breeds being particularly affected. The effective population size for threatened plants or animals remains a contentious issue in need of scientific input as differences in estimates exist among species from a theoretical population genetic level and at a practical level.
- Recently registered, modern cultivars are much more genetically similar than those registered 10-20 years ago. Less genetic diversity exists in the modern cultivars making them potentially more susceptible to biotic and abiotic stresses. However, detailed scientific data in this area is lacking.
- Across OECD countries there is heterogeneity of natural conditions for farming and different production systems resulting in a diversity of different demands for livestock and crop genetic resources. Description of agro-ecosystems and farm management systems in which genetic resources are cultivated/reared are required.

3. Responses To Conserve Agricultural Genetic Diversity

- Most national genetic resource programmes continue to suffer from lack of adequate financial resources to meet their mandates.

- Evaluation, documentation, and monitoring are essential elements of all national programmes.

- Collections and *in situ* and *ex situ* conservation are complementary for effective conservation of national resources, but rarely exist in harmony. Efforts tend to be fragmentary. *In situ* conservation has long been the conservation method of choice for wild species and ecosystems, while *ex situ* approaches have generally been preferred by plant breeders and other scientist concerned with plant genetic resources for food and agriculture.

- Necessary and effective systems for seed multiplication are required to distribute the benefits of modern plant breeding and registered cultivars.

- Raise awareness of the cultural value of genetic resources linked to ethnobotany. Ethnobotany involves knowledge that develops in a particular area and accumulates over time through being handed down from generation to generation. Better linkages are required between ethnobotanists and plant conservationists, as both can lead to the same result.

- Define thresholds and targets for agricultural genetic conservation across countries to target current and future needs.

Annex 4. **Broad Guidelines for Categorising, Defining and Selecting Habitat Types in Agro-Ecosystems**

To move toward consistency across OECD countries, experts recognised the need for guidelines as to how habitat types in agro-ecosystems are classified, including the criteria used in their selection and the characteristics that provide their definition. These guidelines provide the basis of a system to harmonise a system of habitat classification and definitions for agro-ecosystems across OECD countries. The key guidelines for countries to take into account include:

1. Include all agricultural land that comprise the agro-ecosystem, and not just the protected areas in agro-ecosystems or those areas that are subject to specific conditions and restraints in terms of how they are managed for farming purposes.

2. Provide the criteria used to select each habitat type within the agro-ecosystem, in particular, clearly establishing whether the criteria are based largely on how the land is managed (*e.g.* the intensity of input use and animal stocking rates), or if mainly ecological/biological criteria are used to classify different habitats (*e.g.* wetlands, heathlands, wild prairie) or some combination of both ecological/biological and management criteria are employed (*e.g.* semi-natural grassland).

3. Define the characteristics of each habitat type through metadata (*i.e.* annotated descriptive notes), such as the intensity of input use for a given habitat type, the animal stocking density, and the time of the year when the grass is mown.

4. Develop a comprehensive list of the different habitats types selected for an agro-ecosystem, supported by appropriate metadata and other relevant information.

5. Identify the regularity with which data on the current area (stock) and changes (flows) in habitats across agro-ecosystems are collected, and describe the methods used to collect the data (*e.g.* census, sampling, remote sensing).

Annex 5. **Proposed Guidelines for Selecting Indicators of Wild Species Related To Agriculture**

To move toward consistency across OECD countries, experts recognised the need for guidelines to select indicators of wild species related to agriculture, as outlined below.

1. **Select a minimum set of wild species collectively representing a wide range of habitat types across agricultural land.**

Species indicators should be capable of reflecting changes across all agricultural habitats, as well as particular biodiversity rich habitats. The minimum coverage of wild species should include plants, birds, mammals and at least one invertebrate group. The wild species selected should be well known to biologists, preferably with a stable taxonomy, and with a good knowledge of their habitat preferences, including an understanding of the use and requirements wild species make of habitats in agro-ecosystems, for example, for breeding, feeding, and cover.

2. **Select a range of wild species that require different types of agricultural land and from various species groups.**

A range of species should be chosen with a variety of requirements, to ensure that the indicators are capable of reflecting changes in different agricultural habitats and across different species groups (*e.g.* birds, mammals, arthropods, plants, etc). Indicators based on single species, with particular requirements, are unlikely to detect all of the changes affecting agricultural habitats. For example, farmland birds have a variety of requirements in terms of nesting sites, winter and summer food, and thus, different species are affected by various agricultural changes.

3. **Select rare, endangered and widespread species.**

Biodiversity conservation is concerned not only with rare and endangered species, but also with trends in widespread species in the agro-ecosystem. Indicators based on rare/endangered species are likely to reflect progress in conserving priority species and habitats, while indicators of widespread species are likely to be more representative of trends in the health of biodiversity in the wider countryside.

4. **Select wild species relevant to policy issues at different scales from the local to global level.**

Indicators need to reflect the effects on species of agricultural policy and practice at the national and international level, as well as being able to measure the impact of specific agri-environment policies, at local and regional levels. The choice of species, and the scale at which indicators are developed, need to be appropriate for the policy issues being considered. For example, it may be appropriate to use indicators based on populations of breeding wading birds to evaluate the performance of a particular wetland agri-environment scheme, but this may not be a good indicator of national trends in wild species in agriculture, which would require inclusion of species more representative of more widespread agricultural habitats.

In developing these guidelines it will be important to:

i. Recognise the scientific uncertainty about current and future biodiversity issues in agriculture.

Current understanding of trends in wild species, and the reasons for these trends, is incomplete. Furthermore, it is difficult to predict future trends, and the choice of species indicators needs to be flexible to reflect this uncertainty. For example, the United Kingdom wild birds indicator is based on data collected since 1970, before it was known that farmland birds would decline, but has since proved to be a valuable agri-environmental policy tool (the UK bird indicator is included in the national set of sustainable development headline indicators, see http://www.sustainable-development.gov.uk/indicators/index.htm)

ii. Reveal the criteria used and rationale for the wild species chosen within a country

Debate about the development and interpretation of wild species indicators will be greatly facilitated if countries publish information about the criteria they have used in developing indicators and the rationale for their choice of species. Regular publication and discussion of the indicators themselves will also help in this respect.

OECD AGRI-BIODIVERSITY INDICATORS: BACKGROUND PAPER

Kevin Parris[1]

"New indicators of progress are needed to monitor the economy, wherein the natural world and human well-being, not just economic production, are awarded full measure." Edward. O. Wilson (Biologist), *Consilience - The Unity of Knowledge*, p.326, Little Brown and Company, United States, 1998.

"….it would be especially useful to develop better data quantifying the losses of natural capital we currently are experiencing." Kenneth Arrow (Nobel Laureate Economist), *et al*, *Are We Consuming Too Much?*, p.19, 9 July, 2001 Draft from the United States Hewlett Foundation Research Initiative on the Environment, the Economy and Sustainable Welfare, unpublished.

1. What is Agri-biodiversity?

The effects of agriculture on biodiversity are of considerable importance because farming is the human activity occupying the largest share of the total land area for many OECD countries. Even for countries where the share of agriculture in the total land area is smaller, agriculture can help by increasing the diversity of habitat types. The expansion of agricultural production and intensive use of inputs over recent decades in OECD countries is considered a major contributor to the loss of biodiversity. At the same time certain agricultural ecosystems can serve to maintain biodiversity, which may create conditions to favour species-rich communities, but that might be endangered by fallowing or changing to a different land use, such as forestry. Agricultural food and fibre production is also dependent on many biological services. This can include, for example, the provision of genes for development of improved crop varieties and livestock breeds, crop pollination and soil fertility provided by micro-organisms.

The importance of biodiversity for agriculture involves:

- facilitating the functioning of ecosystems and life-support systems, such as nutrient cycling, protection and enrichment of soils, pollination, regulation of temperature and local climates, and watershed filtration;

1. Policies And Environment Division, Agriculture Directorate, OECD. The author wishes to thank Wilfrid Legg for his comments and assistance in preparing this paper. Any remaining errors in the paper are the responsibility of the author, and the views expressed do not necessarily reflect those of the OECD or its Member countries. For further information regarding the OECD work on agri-environmental indicators send an Email to Kevin Parris at Kevin.Parris@oecd.org or visit the OECD website at: http://www.oecd.org/agr/env/indicators.htm

- providing the source of most of the world's food and fibre products, including the basis for crop and livestock genetic resources, their improvement, and the development of new resources; and,

- offering a range of scientific, health/medicinal, cultural, aesthetic, recreational and other intangible (and non-monetary values) and services from biodiversity richness and abundance.

Biodiversity, as it relates to agriculture, can be considered in terms of three levels, drawing on the Convention on Biological Diversity (CBD) definition of biodiversity:

- *genetic diversity* ("within species"): the diversity of genes within domesticated plants and livestock species and wild relatives;

- *species diversity* ("between species"): the number and population of wild species (flora and fauna) affected by agriculture, including soil biota and the effects of non-native species on agriculture and biodiversity;

- *ecosystem diversity* ("of ecosystems"): the ecosystems formed by populations of species relevant to agriculture or species communities dependent on agricultural habitats.

The survival of these 3 levels of diversity is interdependent, as genetic diversity fosters the survival of species, enabling it to adapt to changing ecosystem conditions. A loss of species or the introduction of non-native species, can disturb the ecosystem and alter resilience to further changes.

Genetic diversity provides the means for agriculture to improve crop and livestock yields through: selective plant and animal breeding of 'landraces' over many generations drawing on genetic resources from wild relatives; using 'hybrid' breeding methods for the selection of specific desirable traits; and most recently using biotechnology, involving genetic modification, cloning, and other such technologies.

Wild species diversity and its relationship with agriculture is important in a number of different ways, including:

- *Species supporting agricultural production systems*, the so called "life-support-system", that is crypto-biota, including soil micro-organisms, worms, pest controlling species and pollinators.

- *Species related to agricultural activities*, covering a) wild species using agricultural land as habitat ranging from marginal use to complete dependence on agro-ecosystems, and b) wild species that use other habitats but are affected by farming activities, such as the impact of farm chemical run-off on marine life in coastal waters.

- *Non-native species* that can threaten agricultural production and agro-ecosystems, such as invasion of weeds and pests that are alien to indigenous biodiversity.

Ecosystem diversity and its relation to agriculture is manifest through:

- changes in farming practices and systems;

- changes in land use between agricultural and other land uses; and the

- interaction between agriculture and adjacent ecosystems.

2. What is the Need for Agri-biodiversity Assessment?

The preservation and enhancement of biodiversity poses a major challenge for agricultural policy decision makers, as world population and demand for food increase. It is estimated that, with current population trends, food production will have to increase over 20% by the year 2020 just to maintain the existing levels of food consumption and without any significant expansion of agricultural area.

A challenge for policy makers in many OECD countries is to match the apparent imbalance between the demand for, and supply of, biodiversity on agricultural land. That is to say there is an increasing public demand for biodiversity conservation linked to rising disposable incomes, more leisure time and other factors, such as the increasing awareness of the value of ecosystem services, for example crop pollinators and soil micro-flora and fauna. However, farmers tend to undersupply (or can damage) biodiversity associated with agricultural activities, as they are usually unable to charge for its provision and may be unwilling to bear the cost of biodiversity conservation. Even so, for many farmers the maintenance and enhancement of biodiversity can also be an important aspiration in common with non-farming interests.

The essence of this policy challenge concerning biodiversity conservation associated with agriculture, is that there is no ‘right' or ‘correct' level for its supply (Bromley, 1997). Figure 1 depicts biodiversity as a continuum from destroyed or damaged biodiversity to natural or pristine biodiversity. The experts' view regarding an absolute minimum level of biodiversity in a particular agricultural region is defined by B^*, while B_S represents the level of biodiversity that currently exists. For naturalists and other non-farming interests they advocate greater biodiversity conversation to increase biodiversity to the level B_N. While farmers may not wish to destroy or damage biodiversity, they would prefer not to be prevented from providing less biodiversity, defined by B_F, in the absence of any legal restrictions and/or remuneration. It is between the points B_F and B_N that the political process will refer to resolve its disagreements between farmers and the public, through various policy measures described briefly below.

Most agricultural policy affects, directly or indirectly, biodiversity. For a growing number of OECD countries, protecting and enhancing biodiversity is becoming an important part of their domestic and international agri-environmental policy objectives and actions. These policy actions are in response to a growing public concern over the increasing pressure and harmful impacts on ecosystems brought about through a variety of causes, including agricultural activity. There is also the perceived threat that damage to biodiversity could be highly detrimental to human welfare over the long term, although the consequences are complex and poorly understood.

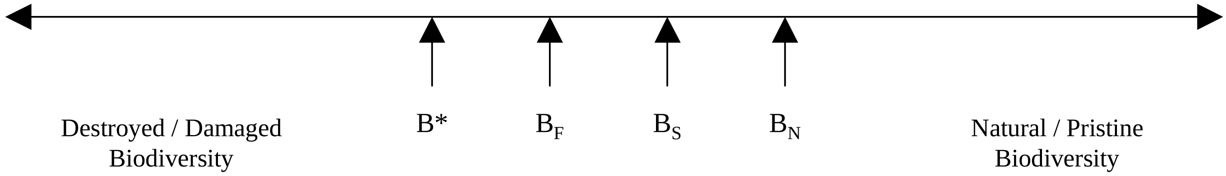
In practice, implicitly or explicitly, government policy towards biodiversity involves balancing the trade-offs between socio-economic values (*e.g.* increasing agricultural production) and biodiversity conservation. Up to present the main focus of policy actions in the area of biodiversity has been to protect and conserve endangered species and habitats. Measures adopted by OECD countries for agricultural biodiversity conservation can be categorised into three main types:

- *Economic incentives*, such as through area payments and management agreements based on individual agreements between farmers and regional/national authorities, where payments are provided in compensation for restrictions on certain farming practices for biodiversity conservation.

- *Regulatory measures*, which may set certain minimum standards on a whole agricultural area and can designate certain areas of ‘high’ biodiversity value as national parks or reserves, and impose restrictions on certain management practices for farmers in these areas or protect specific biodiversity elements, such as wetlands.

- *Community and voluntary based systems*, which set out to devolve the responsibility and management of natural resources, the environment and biodiversity to farm families, rural communities and local governments.

Figure 1. **The policy space for biodiversity associated with agriculture**



Notes:

B*: expert’s view of absolute minimum level of biodiversity in a particular agricultural region.

B_F: level of biodiversity most farmers consider appropriate in the absence of any restrictions / remuneration.

B_S: level of biodiversity that currently exists.

B_N: biodiversity desired by naturalists and other non-farming interests.

Source: Adapted from Bromley (1997).

Many countries commonly use a mix of these policy approaches in addressing the biodiversity conservation objective in agriculture. It is apparent, however, that a number of countries are beginning to move toward a more holistic policy approach, by developing national biodiversity strategy plans under the CBD process, which usually incorporate the agricultural sector as a key player in biodiversity conservation. These strategy plans set out the relevant policy objectives and targets for managing and sustaining biodiversity. They also provide a starting point for establishing policy relevant biodiversity indicators to measure the performance of national policies and help monitor progress in fulfilling international obligations.

At the international level a range of agreements and conventions are also important in the context of agriculture and biodiversity, most notably the International Convention on Biological Diversity (CBD) agreed at the UN Conference on Environment and Development at Rio in 1992. Recognition has been given by the CBD to the significance of biodiversity for agriculture. This has led the FAO to request member countries to negotiate, through the FAO inter-governmental Commission on Genetic Resources for Food and Agriculture (CGRFA), the revision of the international undertaking on plant genetic resources in agriculture in harmony with the CBD. In addition, in January 2000 within the overall context of the CBD, the Biosafety Protocol was agreed by 130 nations. This was the first major international agreement to control trade in genetically modified organisms (GMOs), covering food, animal feed and seeds.

Other related international conventions include, for example, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES, 1973), the Convention on Wetlands (Ramsar Convention, 1971), the Convention on Migratory Species of Wild Animals (Bonn, 1983), the North American Waterfowl Management Plan, and the Canada-United States Migratory Birds Convention (1995). The Commission for Environmental Cooperation, created by *Canada*, *Mexico* and the *United States* to examine the environmental provisions of the North America Free Trade Agreement, has begun to develop a strategy for improving biodiversity, including the role of agriculture.

3. How Can Agri-biodiversity Indicators Serve as a Tool for Policy Makers?

OECD Agriculture and Environment ministers have emphasised the importance of analysing agri-environmental policies supported by indicators. Most recently at the May 2001 meeting of OECD Environment Ministers, they adopted the *OECD Environmental Strategy for the First Decade of the 21st Century* (www.oecd.org/env/min/2001/products/EnvStrategy.pdf), which noted the need to "further develop and use the core set of OECD agri-environmental indicators, and provide information on the adoption of sustainable agricultural management practices by 2003". The general objectives of the work on measuring the environmental performance of agriculture through indicators are to:

- provide information and improve understanding of changes in environmental conditions in agriculture; and,
- use policy relevant and feasible indicators to help in analysis of policy impacts on the environment in agriculture and in future looking scenarios, to improve policy effectiveness in promoting sustainable agriculture.

Many governments are beginning to invest in agribiodiversity indicators as tools to aid policy making in a systematic way, to help answer a broad range of questions, including:

- What is the impact on biodiversity of reducing subsidies to the agriculture sector?
- What are the impacts on biodiversity of alternative agricultural policy instruments, such as direct payments versus market price support?
- What are the impacts on biodiversity of extending current agricultural policies into the future?
- What are the economic implications for the agriculture sector of meeting the commitments of international trade and environmental agreements, such as those under the World Trade Organisation (WTO) Uruguay Agreement and the Convention on Biological Diversity?

The use of indicators as an aid to policy decision-making in the agri-biodiversity context is a relatively recent phenomenon and still a developing field, however, indicators are perceived to have considerable potential as policy tools. Most policy makers concerned with agri-biodiversity issues at the national level, are confronted with fragmented information and it is accordingly difficult to harness the information in a way that effectively contributes to policy decision making.

While indicators are being introduced into the policy-making process, they are being included in an *ad hoc* way in response to short-term policy pressures. Many of these pressures arise from new legislation and initiatives, which have introduced requirements to undertake evaluations and meet specific targets in respect of domestic agri-biodiversity schemes and international environmental agreements, such as the CBD.

The OECD is using AEIs, including those relevant to biodiversity, to support policy monitoring and evaluation across a range of recent OECD studies and activities, as outlined below:

- *Agricultural Policies in OECD Countries Monitoring and Evaluation Report*, an annual report which includes information and data on the effects of agriculture on the environment (OECD, 2001*b*).

- *Agri-environmental related policy studies*, an irregular series of reports which examine different agri-environmental related policy issues, summarised in OECD (2001*c*). For further information on related agri-environmental studies see the website: http://www.oecd.org/agr/policy/ag-env/index.htm

- *Review of Agricultural Policies*, are country policy reviews of non-member OECD countries, such as the recent reviews of Romania (OECD, 2000*d*) and Slovenia (OECD, 2000*e*), which have used the AEIs in the sections covering agri-environmental issues.

- *Environmental Performance Review* country series examine the environmental performance of OECD countries and some non-OECD countries, including in certain reviews a special feature on agriculture drawing on the AEIs, for example, Denmark (OECD, 1999*b*).

- *Economic Working Papers,* with special focus in some papers on sustainable development, including reference to agriculture, see for example Finland (OECD, 2000*c*) and Norway (OECD, 1999*c*).

- *Agricultural and Environmental Outlook Reports,* these include a special section in the *OECD Agricultural Outlook 2001-2006* report on “The Long-Term Outlook for Agriculture and the Environment”, and chapters on agriculture and biodiversity in *the OECD Environmental Outlook* 2001 report examining environmental trends to the year 2020 (for further information on the OECD Environmental Outlook see the web–site: http://www.oecd.org//env/outlook/outlook.htm).

- *Sustainable development*, is a major horizontal activity for the OECD, examining the broader economic, social and environmental dimensions of sustainable development, including reference to issues related to sustainable agriculture, natural resources and indicators (see OECD, 2001*d*; and the OECD sustainable development web-site for further information: http://www.oecd.org/subject/sustdev).

4. Which Characteristics are Important for Policy Relevant Agri-biodiversity Indicators?

In building on the experience of preparing the OECD (2001) report — *Environmental Indicators for Agriculture Volume 3: Methods and Results* — there is broad agreement across Member countries to:

- ***use criteria*** to determine the policy relevance of indicators and assess their quality in terms of analytical soundness, measurability and ease of interpretation;

- ***situate the indicators within the sustainable agriculture framework***, focusing on the environmental dimension, in particular the relationship between the use by agriculture of natural resources (soil/land, water, air/atmosphere, plant/animal resources) and farm inputs (nutrients, pesticides and energy), and their impact on eco-efficiency in agriculture and environmental outcomes;

- ***recognise that environmental conditions and issues differ spatially*** within and across countries, while taking this into account by better expressing the national average indicator to reveal sub-national variation; and,

- ***set priorities in terms of what is feasible to achieve*** over the current three year JWP Mandate to the beginning of 2004 and within the scope of the resources available for work on indicators both in the OECD Secretariat and Member countries.

4.1. Criteria to Select Indicators and Assess Indicator Quality

OECD has identified a number of general criteria which agri-environmental indicators need to meet, including the requirements that they are:

1. **Policy relevant:** deal with an environmental issue that is important across the OECD Membership, and/or relevant to multilateral environmental agreements (such as the Convention on Biological Diversity), while is comprehensive in capturing the key issues and links between agricultural activities, natural resource and farm input use and environmental outcomes.

2. **Analytically sound**: theoretically well founded in technical and analytical terms; based on international standards and international consensus about their validity and comparability; able to reveal the impact of agricultural activities on the environment; and can be used as a tool in policy monitoring and evaluation, including future projection scenarios.

3. **Measurable**: possible to measure the indicator on the basis of data available now or in the near future subject to assured scientific validity of measurement procedures; and the data is adequately documented, of known quality, updated at regular intervals in accordance with reliable procedures, and collected at reasonable cost.

4. **Easily interpreted**: variations in the direction of change of the indicator over time should be clearly understood by policy decision makers, other stakeholders and the wider public, in terms of an improvement or deterioration in environmental performance at the local, regional, national and international level as appropriate.

   A number of general points related to these criteria should also be taken into account in the choice and quality control of indicators, as follows:

- It is necessary to recognise that no indicator will meet every attribute of all four criteria.

- The availability of long term and consistently defined time series of indicators are vital for sound policy monitoring, evaluation, and decision making.

- Work completed on indicators and data sets available in other international organisations should wherever possible be used and synthesised into the OECD AEI set to avoid duplication of effort. Establishing international consensus on the indicator set should involve developing guidelines as, for example, established under RAMSAR (for Wetlands) and IUCN (for endangered species). This would help to facilitate the meaningful comparisons of indicators across countries, by establishing standardised indicator definitions and methodologies.

- Trends and ranges in indicators are important for comparative purposes across countries rather than absolute levels for many indicators, especially as local site specific conditions vary considerably within and across countries.

- The use of indicators need to be qualified because work is at an early stage of development, and that agri-environmental linkages are the result of complex interactions not yet fully understood. In this context caution is required in using indicators in isolation, and options for establishing an integrated approach (or indicator clusters) to indicator development needs to be explored.

4.2. Framework in which to develop indicators

In providing a framework in which a cohesive and balanced set of AEIs can be identified, selected and further developed, the OECD Driving Force-State-Response framework provides a useful model in highlighting the linkages between indicators (see OECD, 1999). OECD is also exploring the use of the 'sustainability' framework, which provides a way of examining the linkages between the economic, social and environmental dimensions of sustainable development in terms of stocks and flows of capital (see Pearce, 1999). For sustainable agriculture this capital stock includes *natural capital* (*e.g.* soil/land, water, air/atmosphere, and plant and animal resources, *i.e.* biodiversity), *man-made or physical capital* (*e.g.* farm machinery and inputs such as fertilisers, pesticides, and energy), and *human capital* (*i.e.* farmer education, knowledge and management skills). At this stage of OECD work it is the environmental dimension of sustainable agriculture which is of critical importance. Some of the key elements that are important in moving toward an environmentally sustainable agriculture are to:

- use efficiently the *flow* of natural resources (*e.g.* water) and farm inputs (*e.g.* nutrients and pesticides) through agricultural systems to enhance agriculture's environmental (*e.g.* reduce damage to biodiversity) and economic performance (*e.g.* raising agricultural productivity);

- conserve *stocks* of natural resources used or affected by agricultural activities (*e.g.* soils, plant and animal resources *i.e.* biodiversity).

- minimise *flows* of harmful materials (*e.g.* nutrients, pesticides, soil sediments, ammonia, and greenhouse gas emissions) from agriculture into the environment, especially water bodies (*i.e.* rivers, lakes, groundwater, and coastal waters), the air/atmosphere, and human and animal food chains.

- improve the management of the *stocks* and *flows* of natural resources and farm inputs associated with agriculture to help enhance environmental performance and agricultural productive efficiency.

Establishing the AEIs within the sustainability framework, with focus on the environmental dimension of sustainable agriculture, has a number of advantages by:

- Recognising the overarching policy goal for most OECD countries of moving toward sustainable agriculture in the broader context of sustainable development.

- Helping to provide a basis to analyse the issue of eco-efficiency in agriculture, and also to better understand the causal links between farm management and conservation practices and environmental outcomes (*i.e.* relationships between man-made, human and natural capital).

- Facilitating at a later stage of the work, the positioning of the environmental dimension in relation to the economic and social dimensions of sustainable agriculture, and allowing consideration of the various linkages and trade-offs between these three dimensions, and between agriculture and other economic activities in the broader context of sustainable development.

  With emphasis on the environmental dimension of sustainable agriculture it is important to be clear as to what this should cover to help focus the future direction of work on indicators. In this regard most countries agree that the main environmental resources (*natural capital*) that should be included cover soil/land, water, air/atmosphere, and plant and animal resources (*i.e.* biodiversity). In addition, it is necessary to consider the farm inputs (*man-made capital*) that agriculture uses in conjunction with natural resources in its production activities, notably nutrients, pesticides, and energy. The management (*human capital*) of these farm inputs has a significant bearing on the environmental outcomes from agricultural activities.

4.3. Spatial Coverage of Indicators

A key challenge is to integrate information on the status of, and changes in, agriculture's impact on the environment to assist policy decision making at different spatial levels, and which is also understandable to other stakeholders and the wider public. Many countries have already established a hierarchy of national, regional and local levels of policy objectives, monitoring and indicators.

The *spatial coverage* of OECD indicators has so far been mainly confined to revealing the state and trends at the national level, although the regional dispersion around the national average trend is a longer term goal as more data becomes available. For many of the agribiodiversity indicators, these can be applied at different scales ranging from the farm to the national level, although data collection by OECD have only, so far, been at the national scale. Even so, nearly all national level indicators are often calculated by aggregating regional information to estimate a national average value.

4.4. Setting Indicator Priorities in Terms of What is Feasible

In set priorities to further develop agri-biodiversity indicators, it will be important that countries can draw upon data that is currently (or will soon become available), collected at the national scale, so that the development of OECD indicators will not be too resource intensive and costly to collect. There is also need to recognise that the methods by which information is collected and indicators are developed will vary between countries according to the relative costs and benefits with different approaches.

5. What has OECD Achieved in Developing a Set of Agri-biodiversity Indicators?

While the set of indicators to monitor biodiversity are potentially very large, a smaller and policy relevant set are being established by OECD, structured within the general framework of genetic, species, and ecosystem diversity (see Figure 2). Together the indicators establish the initial steps in providing a coherent picture of biodiversity in relation to agriculture. It is the impact of agriculture on biodiversity which is the emphasis here, and not the effects on agriculture of biodiversity and related ecosystem services (OECD is also developing an indicator concerning the impacts of non-native species on agriculture and agro-ecosystems, not examined here, but see OECD, 2001. Also for a full list of OECD AEIs see Annex Box 1).

Figure 2. **Coverage of biodiversity indicators in relation to agriculture**

Biodiversity level		**Indicators**
Genetic	Variety	Domesticated crop varieties and livestock breeds
Species	Quality	Wild species abundance, richness, and non-native species
Ecosystem	Quantity	Habitat area

Source: OECD (2001).

6. What are the Future Challenges to Advance Work on Agri-biodiversity Indicators?

Some of the key challenges to further advance work on agri-biodiversity indicators are briefly outlined below, particularly, drawing on those areas identified in Expert Papers.

1. To eliminate some of the methodological and data impediments requires a step-by-step approach in developing agri-biodiversity indicators. This implies initially developing indicators at a fairly rudimentary level and moving toward more rigorous indicators as understanding of issues improves, methodological problems are overcome, and more basic data becomes available. Experts from all countries observe that biodiversity is a scientifically complex area, where the understanding of the relationship between agriculture and biodiversity is still in an early phase of development and requires further research of the basic conceptual issues concerning the complex and multidimensional nature of biodiversity.

2. Work on agri-biodiversity indicators will benefit in the future from further co-operation internationally, not only with different international governmental organisations such as the Convention on Biological Diversity, CITES, RAMSAR, FAO, UNEP and the World Bank, but also the many Non-Governmental Organisations that have a wealth of experience and information in the area, such as BirdLife International, the European Centre for Nature Conservation, IUCN, Wetlands International, and the World Resources Institute. However, considerable research has been undertaken on the effects of agriculture on biodiversity, while there are now a range of databases established or being developed that are of relevance to the area.

3. A recurrent impediment to further developing biodiversity indicators, expressed by all experts is the current poor availability, consistency, currency and quality of data (see for example, Mac, p.8; and Walcott, p.10; from experts). It is critical for countries to enhance monitoring activities and develop the supporting science (Mac, p.8).

4. Developing a set of international generic principles and guidelines for countries to follow in developing agri-biodiversity indicators would help to promote the development of a more coherent, consistent and comparable set of indicators (Heath, p.5; Feehan, p.6; Mac, p.5; Sprague, p.12). This process would also help in the development of standardised international biodiversity data sets, and consider that there is potential to make progress on achieving this.

5. Developing linkages between biodiversity and other agri-environmental indicators can help contribute to a better understanding of underlying cause and effect relationships, and enhance their usefulness for policy makers (see Garcia-Cidad, p.8-9; Heath, p.23; Smith, p.10; and Stott, p.9). In this context farm management practices are viewed as a key element in farming's impact on habitat and wildlife, which many experts have observed (see for example, Mac, p.8-9; Smith, p.13; and Walter, p.3).

6. Many countries are in the process of developing criteria and thresholds to interpret biodiversity indicators, and in many cases the only practical baseline will be the first year from the beginning of when programmes are monitored. A number of baseline options can be considered for biodiversity, but setting such a baseline is a complex and often a relatively arbitrary process. However, given the difficulties in determining suitable baselines across OECD countries, it may be more useful for policy makers to measure progress towards agreed targets. This is an issue discussed across nearly all expert papers, but see for example, Birdlife, p.4; Brink, p.4,12; Dijk, p.3-4; Feehan, p.5; Garcia-Cidad, p.13-14;Geronimo, p.3; Simoncini, p.6; Smith, p.4-5,7; Sprague, p.2; Stott, p.3; and Walcott, p.10.

7. There are a number of agri-biodiversity issues, and related indicators, that will need further research in future. In particular, these concern the issue of ecosystem services provided to agriculture, especially through pollinators and soil micro flora and fauna; and also the impact of climate change on biodiversity in agriculture. Further examination of the ecological footprint concept is also raised as a possibility by some experts (see Heath, p.3; and Smith, p.11-12).

8. Research on the economic value of biodiversity is of considerable importance to policy makers and society in assessing the costs and benefits of biodiversity conservation, and in helping determine which policies might best achieve biodiversity goals in agriculture, as recognised in the CBD. While there is work underway in this area, further studies are required to estimate the economic benefits of biodiversity, and the costs and benefits of the trade-offs between increased agricultural production and biodiversity loss. Biodiversity has an economic value to society operating at many different levels, but mainly in terms of biodiversity's use value, such as providing a life supporting system to agricultural production; and non-use values, for example, the knowledge of the continued existence of a particular species which others might enjoy or benefit (OECD, 1999*d*). Placing a monetary value on biodiversity is especially difficult as in many instances no markets exist for biodiversity, and also market prices fail to properly reflect the many non-market benefits of biodiversity.

Annex Box 1. **Complete list of OECD Agri-environmental Indicators**[1]

I. AGRICULTURE IN THE BROADER ECONOMIC, SOCIAL AND ENVIRONMENTAL CONTEXT		
1 Contextual Information and Indicators		**2 Farm Financial Resources**
• *Agricultural GDP* • *Agricultural output* • *Farm employment* • *Farmer age/gender distribution* • *Farmer education* • *Number of farms* • *Agricultural support*	• *Land use* – Stock of agricultural land – Change in agricultural land – Agricultural land use	• *Farm income* • *Agri-environmental expenditure* – Public and private agri-environmental expenditure – Expenditure on agri-environmental
II. FARM MANAGEMENT AND THE ENVIRONMENT		
1. Farm Management		
• *Whole farm management* – Environmental whole farm management plans – Organic farming	• *Nutrient management* – Nutrient management plans – Soil tests	• *Soil and land management* – Soil cover – Land management practices
	• *Pest management* – Use of non-chemical pest control – Use of integrated pest management	• *Irrigation and water management* – Irrigation technology
III. USE OF FARM INPUTS AND NATURAL RESOURCES		
1 Nutrient Use	**2 Pesticide Use and Risks**	**3 Water Use**
• *Nitrogen balance* • *Nitrogen efficiency*	• *Pesticide use* • *Pesticide risk*	• *Water use intensity* • *Water use efficiency* – Water use technical efficiency – Water use economic efficiency • *Water stress*
IV. ENVIRONMENTAL IMPACTS OF AGRICULTURE		
1 Soil Quality	**3 Land Conservation**	**4 Greenhouse Gases**
• *Risk of soil erosion by water* • *Risk of soil erosion by wind*	• *Water retaining capacity* • *Off-farm sediment flow (soil retaining capacity)*	• *Gross agricultural greenhouse gas*
2 Water Quality		
• *Water quality risk indicator* • *Water quality state indicator*		
5 Biodiversity	**6 Wildlife Habitats**	**7 Landscape**
• *Genetic diversity* • *Species diversity* – Wild species – Non-native species	• *Intensively-farmed agricultural habitats* • *Semi-natural agricultural habitats* • *Uncultivated natural habitats* • *Habitat matrix*	• *Structure of landscapes* – Environmental features and land use patterns – Man-made objects (cultural features)
• *Eco-system diversity* (see Wildlife Habitats)		• *Landscape management* • *Landscape costs and benefits*

Note: 1. This list includes all the agri-environmental indicators covered in the Report quoted below.
Source: OECD (2001) *Environmental Indicators for Agriculture Volume 3: Methods and Results*, Paris, France.

REFERENCES

Neave, P., E. Neave, T. Weins and T. Riche (2000), “Availability of Wildlife Habitat on Farmland”, Chapter 15, in T. McRae, C.A.S. Smith and L.J. Gregorich (eds.), *Environmental Sustainability of Canadian Agriculture: Report of the Agri-Environmental Indicator Project*, Agriculture and Agri-Food Canada (AAFC), Ottawa, Ontario, Canada. Available at: http://www.agr.ca/policy/environment/publications/list.html

Neave, P. and E. Neave (1998), *Agroecosystem Biodiversity Indicator — Habitat Component: Review and Assessment of Concepts and Indicators of Wildlife and Habitat Availability in the Agricultural Landscape — Concept Paper*, Report No. 26, Agri-Environmental Indicator Project, Agriculture and Agri-Food Canada, Regina, Canada.

OECD (2001*a*), *Environmental Indicators for Agriculture Volume 3: Methods and Results*, Publications Service, Paris, France. The *Executive Summary* of this report is available from the OECD agri-environmental indicators web site at: http://www.oecd.org/agr/env/indicators.htm (see “Publications”).

OECD (2001*b*), *Agricultural Policies in OECD Countries: Monitoring and Evaluation 2001*, Paris, France.

OECD (2001*c*), *Improving Environmental Performance of Agriculture Policy Options and Market Approaches*, Paris, France.

OECD (2001*d*), *Sustainable Development Critical Issues*, Paris, France.

OECD (2000*a*), *Review of Agricultural Policies: Romania*, Paris, France.

OECD (2000*b*), *Review of Agricultural Policies: Republic of Slovenia*, Paris, France.

OECD (2000*c*), *Enhancing Environmentally Sustainable Growth in Finland*, Economics Department Working Papers No. 229, General Distribution document [ECO/WKP(2000)2], Paris, France. Available at: http://www.oecd.org/ [Documentation > 2000 > Reference Components > ECO]

OECD (1999*a*), *Environmental Indicators for Agriculture, Volume 2: Issues and Design — The York Workshop*, Paris, France.

OECD (1999*b*), *Environmental Performance Reviews: Denmark*, Paris, France.

OECD (1999*c*), *Sustainable Economic Growth: Natural Resources and the Environment in Norway*, Economics Department Working Papers No. 218, General Distribution paper [ECO/WKP(99)10], Paris France. Available at: http://www.oecd.org/ [Documentation > 1999 > Reference Components > ECO]

OECD (1999*d*), *Handbook of Incentive Measures for Biodiversity — Design and Implementation*, Paris, France.

BIOLOGICAL DIVERSITY OF LIVESTOCK AND CROPS: USEFUL CLASSIFICATION AND APPROPRIATE AGRI-ENVIRONMENTAL INDICATORS

Frank Wetterich[1]

1. Introduction

On behalf of the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, the Institute of Organic Agriculture is working as part of a R+D-project on agri-environmental indicators, responsible for the categories biodiversity, wildlife habitats and landscape. Primarily, we are instructed to implement the OECD indicators and to put them in concrete terms (OECD, 2001). Furthermore, we shall check their suitability for national environmental reporting systems and for international reporting duties such as within the scope of the Convention on Biological Diversity (CBD). If generally appropriate, the indicators should be further developed, modified or completed.

2. Classification of Biological Diversity for Purposes of Indication and Monitoring

The CBD (1992) concerns all living organisms, distinguishing biological diversity between the genetic, species and ecosystem level (Figure 1). In contrast, the OECD proposal assigns the genetic level only to livestock and crops and the species level to wildlife fauna and flora. However, crop species diversity is at least as relevant as the diversity of varieties. Additionally, the division in biodiversity at the one hand and habitats at the other hand seems to be artificial and should be suspended (Figure 1). Therefore we propose an approach where we divide biological diversity into the three thematic domains of livestock/crops, wildlife and the aspect of non-native (alien invasive) species. Each of these domains should be captured by appropriate indicators at all levels according to the CBD which are relevant ("X" marked in Figure 1). That way, our approach is completely compatible with the CBD.

3. Appropriate Agri-Environmental Indicators of Livestock and Crop Biodiversity

The OECD indicators capture the number of registered livestock breeds and crop varieties, the share of key breeds/varieties and the number of endangered breeds/varieties. This reduction to a few state indicators makes the issue easily comprehensible, but it meets only partly the demands of the

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Figure 1. **Biological diversity as classified within the approaches of the CBD, the OECD and compared with the approach presented here**

Convention on Biological Diversity (CBD):

Biodiversity (→ all living organisms, wild and domesticated)		
Genetic Diversity	Species Diversity	Ecosystem Diversity

OECD Agri-Environmental Indicators:

Biodiversity			**Wildlife Habitats**
Non-native Species	Genetic Diversity (→ livestock, crops)	Species Diversity (→ wildlife species)	(→ wildlife species)

Classification of agri-environmental indicators suggested in this work:

	Biodiversity		
	Genetic Diversity	Species Diversity	Ecosystem Diversity
1. Livestock and crops	X	X	(X)
2. Wildlife	X	X	X
3. Non-native species	(X)	X	-

Source: CBD, 1992; OECD, 2001; author.

subject. As the number and shares of breeds and varieties capture only a part of genetic diversity, important driving forces impacting genetic diversity should be added to the set of indicators.

Furthermore, crop species diversity as an essential aspect of agrobiological diversity is not considered at all in the OECD set. The number of endangered varieties is a desirable indicator, but at least in Germany up to now, endangered varieties are neither defined nor registered. That is why this indicator cannot be implemented yet. Livestock species diversity can perhaps be neglected, particularly in industrialized countries, because rare species of livestock are in most cases non-native, “exotic” species (*e.g.* alpaca in Germany), for whom the “host” countries see no responsibility to preserve them. Frequently, rare species are kept by non-farmers only for leisure purposes. The loss of animal genetic resources is linked closely to the extinction of domesticated animal breeds. In Germany however, due to the activity of a private initiative and more recently also due to public subsidies, the extinction of breeds over the last 150 years has ended. In the short- and medium-term, further losses of originally domestic breeds are not likely to happen. Therefore, actual changes in the number of registered breeds are based on the introduction of non-native breeds, often only for leisure purposes. For instance the case of an introduction of four female Tajikistanian goats and their registration in 1999 may increase the genetic diversity in Germany in a marginal way. However it is normally no contribution to the conservation of global genetic resources. Despite this, the four introduced goat individuals lead to an OECD-indicator increasing by 4%. That’s why the number of registered breeds in the way this indicator is used by the OECD is not a very significant parameter for biodiversity. An alternative might be to differentiate between native breeds — with a high national responsibility for conservation - and non-native breeds with, in general, a low responsibility.

An overview of the OECD indicators and our own suggestions of modification and expansion is given in Table 1. The respective proposed indicators are subsequently presented in Sections 3.1 and 3.2. The required data to implement these indicators are widely available, at least within the EU.

Table 1. **Overview of the OECD livestock and crop biodiversity indicators (*in italics*) and our own proposal of modification and expansion (with numbers)**

Livestock biodiversity	Crop biodiversity
	1. Number of crop species in agricultural use (new)
	2. Crop species ratio / diversity index (new)
Number of registered livestock breeds	*Number of registered crop varieties*
→ 1. Number of key livestock breeds (native endangered, native not endangered, non-native)	→ 3. Number of key crop varieties (domestic, non-domestic)
Share of key livestock breeds in livestock numbers	*Share of key crop varieties in marketed production*
→ 2. Share of the three major livestock breeds (additional information: native, non-native breeds)	→ 4. Share of the three major crop varieties in seed production area / diversity index
Number of endangered national livestock breeds	*Number of endangered national crop varieties*
→ 3. Native breeds' population size and status of endangerment (see also 1.)	→ in Germany not feasible yet
4. Application of high-selective breeding methods (new)	5. Share of genetically heterogeneous and homogeneous varieties (new)
	6. Share of varieties with and without ‚evolutionary potential' (new)
5. Number of breeder's associations (new)	7. Number of breeders per crop (new)

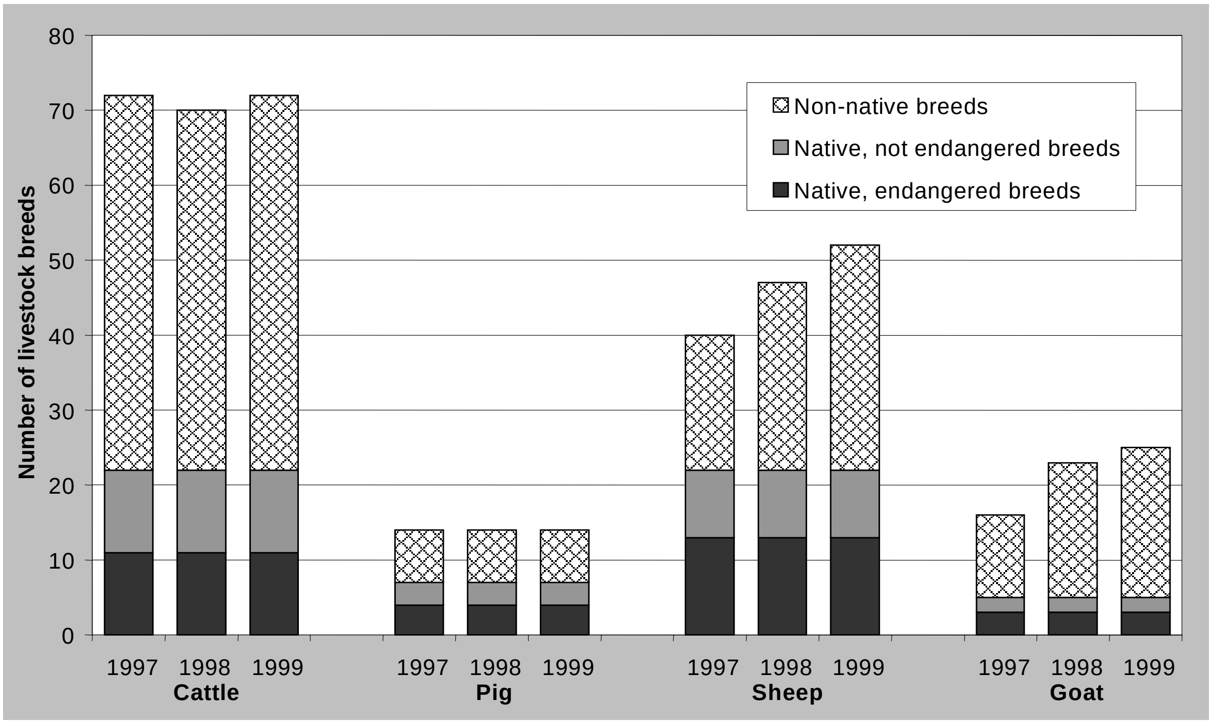
Source: OECD, 2001; author.

3.1. Appropriate indicators of livestock biodiversity

3.1.1. Number of key livestock breeds

Figure 2 shows the modified OECD-indicator with the number of native and non-native breeds registered in the German herd-books for the main livestock species cattle, pigs, sheep and goats. The native breeds are classified whether they are endangered according to the red list of endangered domestic animals (GEH, 2001).

Figure 2. **Number of key cattle, pig, sheep and goat breeds registered in the German herd-books**



Source: Calculated of the data from IGR, 2001; GEH, 2001.

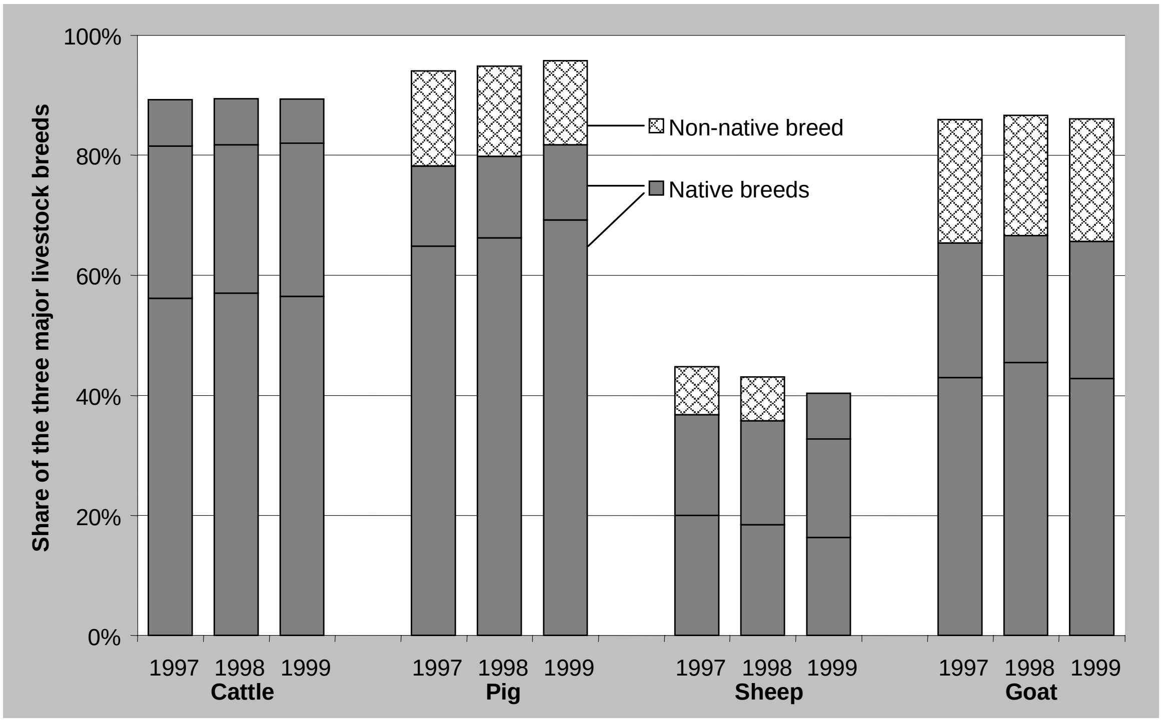
The figure reveals, that the number of native breeds remained constant for the considered period, while several "exotic" non-native breeds were introduced and newly registered. So genetic diversity does not really seem to have been enhanced, but more distributed around the globe.

3.1.2. Share of the three major livestock breeds

The share of major livestock breeds in total livestock numbers is another indicator proposed by the OECD. We suggest to enhance the information value of this parameter by pointing out the individual three major breeds and whether they are native or not. Figure 3 reveals, that in Germany a positive trend can be detected for the sheep populations.

The informative capability of this indicator is limited insofar as the major and the more fragile part of the national genetic diversity is not present within the three common (sometimes even non-native) breeds, but in the whole rest of native breeds. However, the relevant indicator is not the share of these breeds in total livestock, but the size and stability of their populations. Therefore, we propose to complete the OECD set by the following indicators.

Figure 3. **Share of the three major cattle, pig, sheep and goat breeds in Germany, pointed out, whether they are native or not**



Source: Calculated of the data from IGR, 2001.

3.1.3. Native breed's population size and status of endangerment

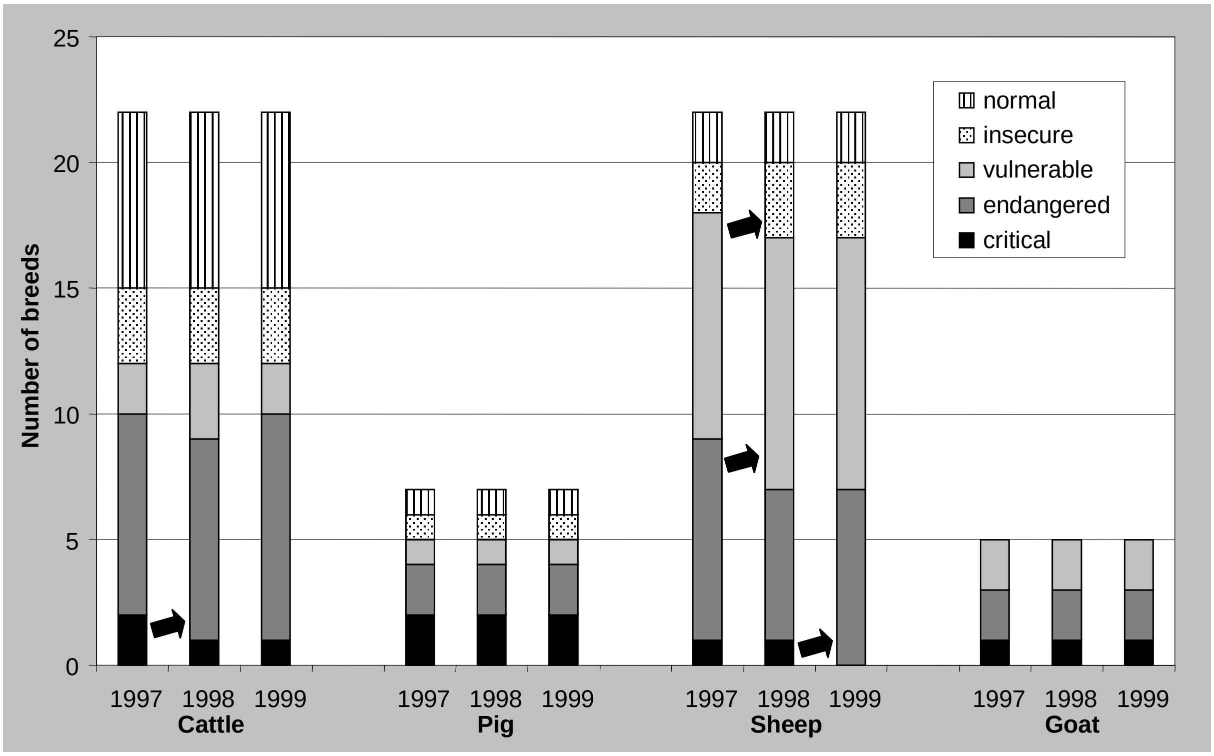
Native breeds, for whom a country carries major responsibility, should be held on a stable population size, preventing extinction and limiting genetic drift. Depending on the actual population size, it is possible to classify the breeds roughly into different status' of endangerment (Table 2). So changes in a population's situation can be traced in a more sensitive way than by using the informations of the red list of endangered livestock breeds (GEH, 2001). Figure 4 shows the development of the population sizes of the German native breeds with respect to their status of endangerment.

Table 2. **Classification of livestock populations**

Status of endangerment	**Population size**	
• Critical	< 100	breeding females
• Endangered	100 – 1,000	breeding females
• Vulnerable	1,000 – 5,000	breeding females
• Insecure	5,000 – 10,000	breeding females
• Normal	> 10,000	breeding females

Source: Bodó, 1992

Figure 4. **Trends in the status of endangerment of native lifestock breeds according to their population size**



Source: Calculated of the data from IGR, 2001; Bodó, 1992.

Positive trends in the considered period can be detected for cattle and mainly for the sheep breeds, where meanwhile some small populations have been stabilized.

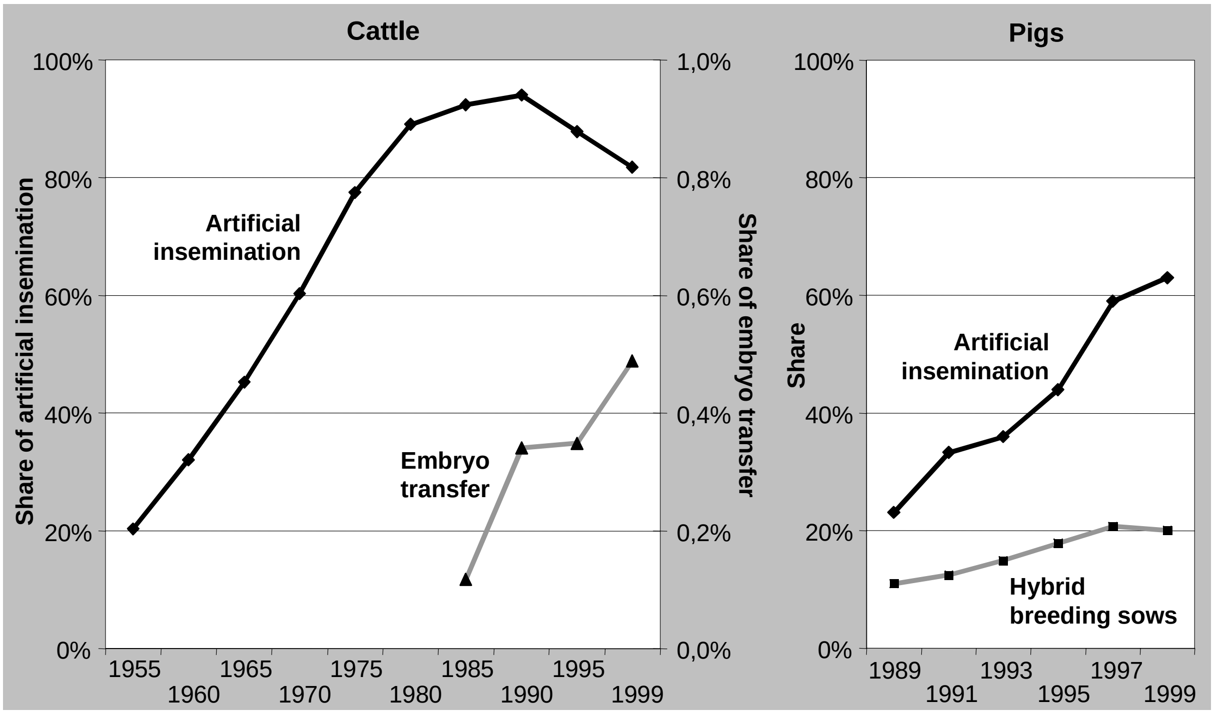
3.1.4. Application of high-selective breeding methods

The indicators presented above are based on the assumption, that the genetic diversity is equally distributed over all individuals so that the diversity within a breed is more or less directly correlated with the population size. However, it is not considered, that modern breeding methods have uniformed — that is reduced — the genetic equipment of the animals especially within the major, high performance breeds (Sambraus, 1986). Already in 1979, Simon & Schulte-Coerne stated, that the main reasons for the "success" of animal breeding are at the same time the fundamental causes for the uniformisation, endangering and loss of domestic animal breeds and populations. Artificial insemination, multiple ovulation and embryo transfer are applied for reproducing the few very top performing individuals only (Kalm, 1991, 1997). Therefore a corresponding number of other animals are excluded from breeding. The dimension of this situation be-comes clear when well-known scientists estimate the population-genetically relevant so-called "effective populations size" of the German Holstein-Fresians at a range of 50 (!), although the total population has 1.5 million registered herd-book cows.

Hybrid breeding and — in the future — cloning are methods to produce genetically homogenous and high performing livestock material. Impacts on the genetic pool are expected when traditional pure breeding gets replaced by these modern breeding methods. Concerning cattle breeding, artificial insemination and embryo transfer are more or less regularly applied while hybrid breeding is used beside the artificial insemination mainly for pigs (and poultry) (Figure 5).

Up to now, in Germany, sheep and goats are usually reproducing naturally, so that no corresponding negative impact on genetic diversity has to be expected.

Figure 5. **Application rate of artificial insemination, embryotransfer and hybrid breeding for cattle and pigs (different periods)**

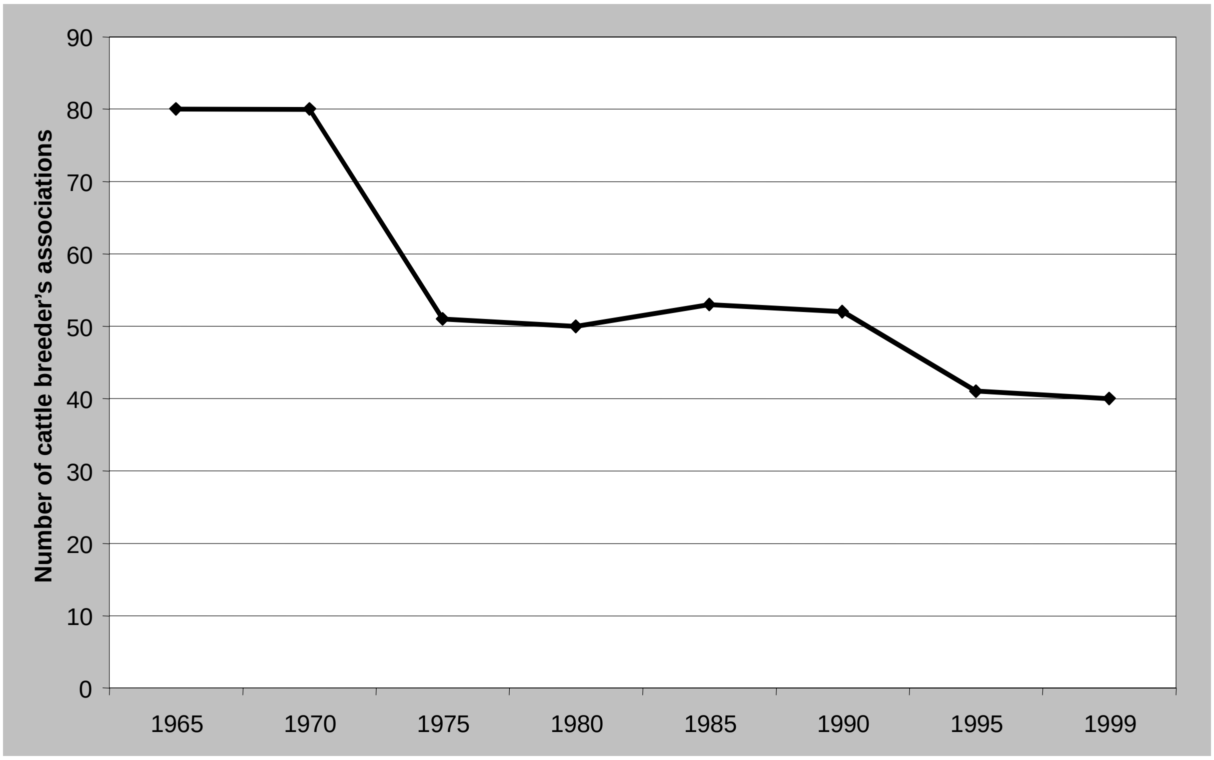


Source: Calculated of the data from ADR, ZDS and StBA, several years each.

3.1.5. Number of breeder's associations

The number of officially accredited breeder's associations is roughly correlated with the number of independent breeding populations. The decrease in the number of breeder's associations as shown in Figure 6 is usually based on mergers. This happens particularly with the objective to merge the previously more or less separate populations in order to increase the selection intensity in the subsequently enlarged population. A higher selection intensity implies an increasing exclusion of individuals from reproduction, coupled with an increasing risk of genetic erosion (Simon & Schulte-Coerne, 1979; Sambraus, 1986).

Figure 6. **Number of cattle breeder's associations in Germany**



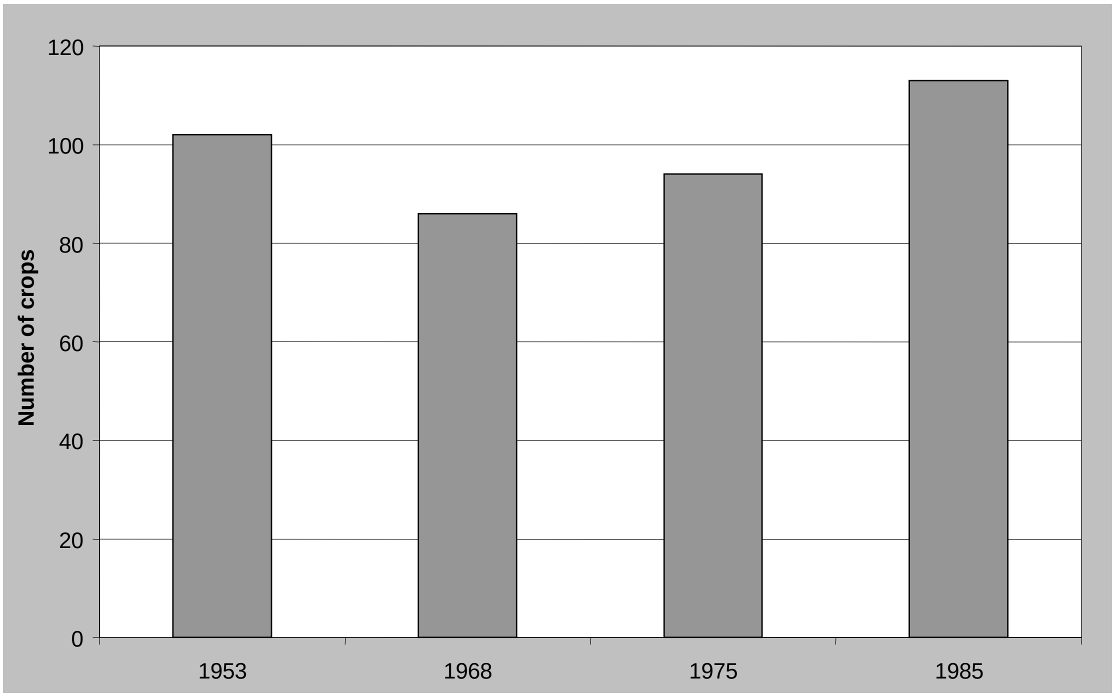
Source: ADR, 2000.

3.2. Appropriate indicators of crop biodiversity

3.2.1. Number of crop species in agricultural use

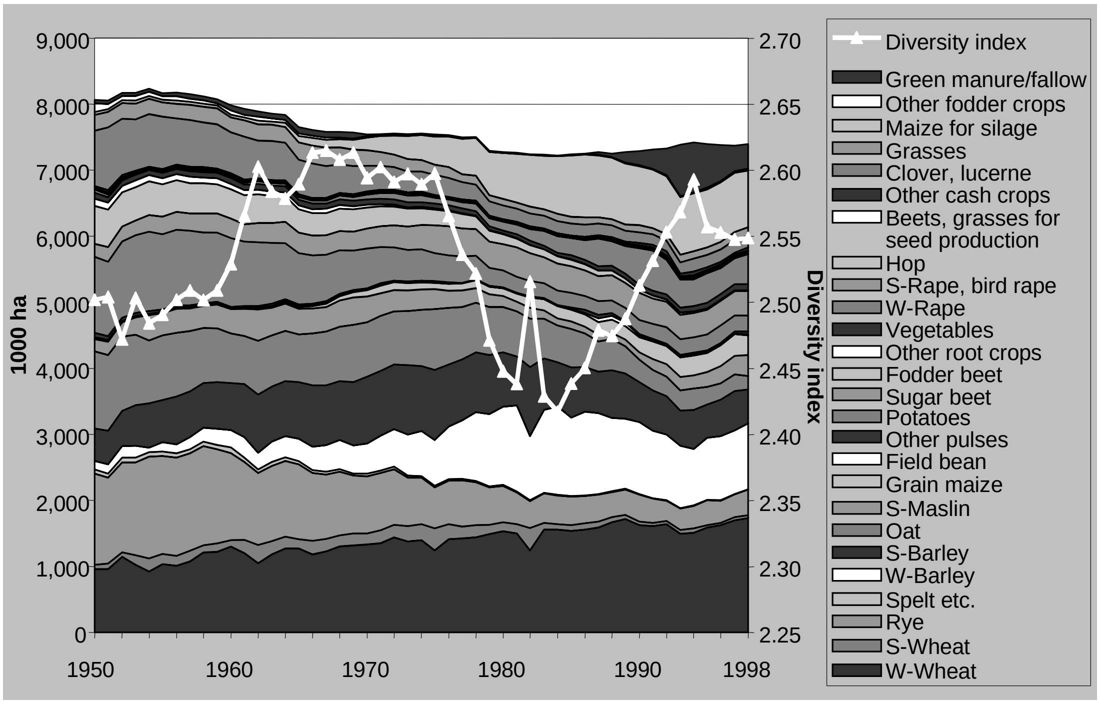
For a qualified and comprehensive set of indicators, crop diversity on the agricultural land has to be captured, which means the number of grown crop species as well as trends in crop ratio have to be assessed. Unfortunately, the number of grown crops cannot be quantified exactly, because only the main crops are covered by the statistics. A rough impression of the development in crop numbers can be derived from the species directory related to the German seed trade act, containing all agricultural and horticultural crops, assessed as economically relevant. Figure 7 shows the changes of the species directory since 1953. Further evaluation should document, whether formerly native crops declined and new "exotic" crops increased. The supposed decline of old native crops which were previously uniquely cultivated in Germany is coupled with the irreversible loss of genes. In contrast, many of the new crops can only be grown under glass and are not reproduced in Germany at all, so that there is no relevant German responsibility for conserving their genetic diversity.

Figure 7. **Number of crops registered in the different amendments of the species directory related to the German seed trade act (without ornamental plants)**



Source: BGBl, 1953, 1968, 1975, 1985.

Figure 8. **Crop area and (Shannon-Weaver) diversity index of cultivation in (West-) Germany**



Source: StBA, 2001; authors' calculation.

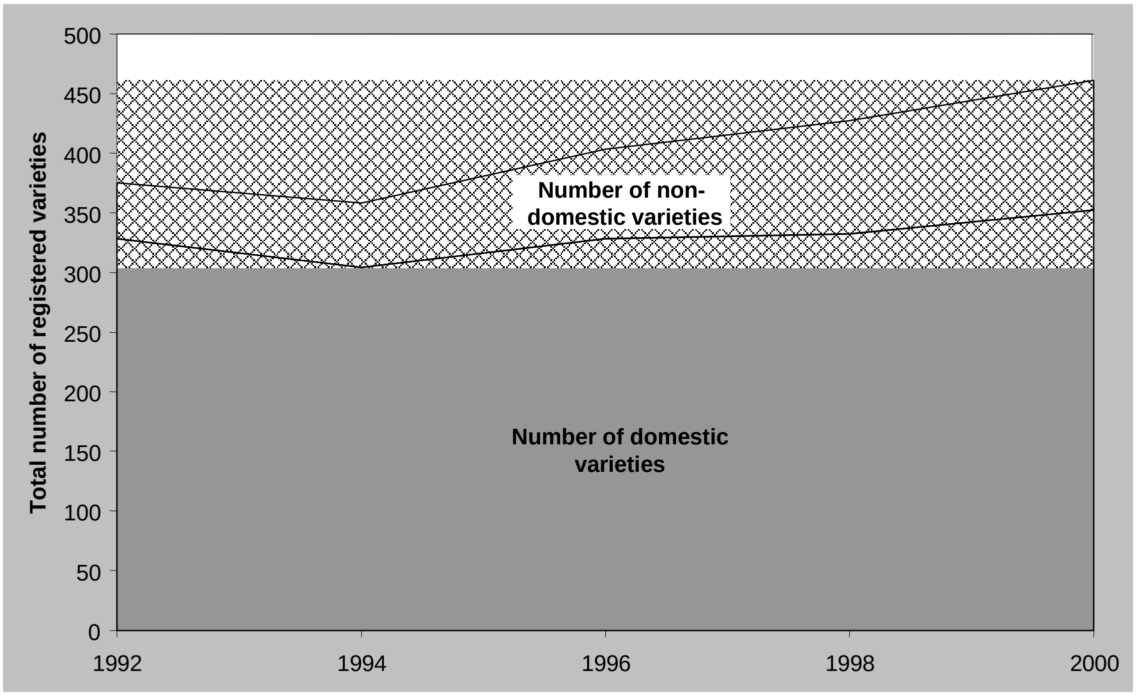
3.2.2. Changes in crop ratio

The number of crops is one aspect of diversity, the share of the individual crops is another. The cultivation areas for those agricultural crops for which data are available, are given in Figure 8. As the data for such a number of crops can hardly be overlooked, the presentation of a diversity index (*e.g.* Shannon-Weaver Index) seems to be a useful alternative, which is also presented in Figure 8.

3.2.3. Number of registered crop varieties

The number of registered crop varieties is an indicator corresponding to the OECD proposal. In times of globalization, there are trends of a worldwide distribution of high performance varieties, which seem to increase the national diversity while at the same time global genetic diversity may perhaps decline. Therefore, we propose the varieties classified as either representing the domestic biodiversity and enhancing global diversity or whether they are traded internationally, so that the country does not seem to be responsible for conserving this genetic material. For pragmatic reasons, the varieties registered by the German Federal Office of Plant Varieties (Bundessortenamt) are distinguished in ‚domestic‘ varieties, whose breeders are located in Germany, and ‚non-domestic‘ varieties whose breeders are situated abroad. An evaluation of maize and cereal crops for the period of 1992 to 2000 shows a slightly rising number of domestic varieties while the number of non-domestic, internationally traded varieties is more than doubling (Figure 9). That means, diversity in Germany seems to be increasing while the German contribution to the global biodiversity remains nearly constant. The investigation should be expanded to other crops including vegetables.

Figure 9. **Number of domestic and non-domestic varieties registered at the German Federal Office of Plant Varieties (maize and cereal crops only)**



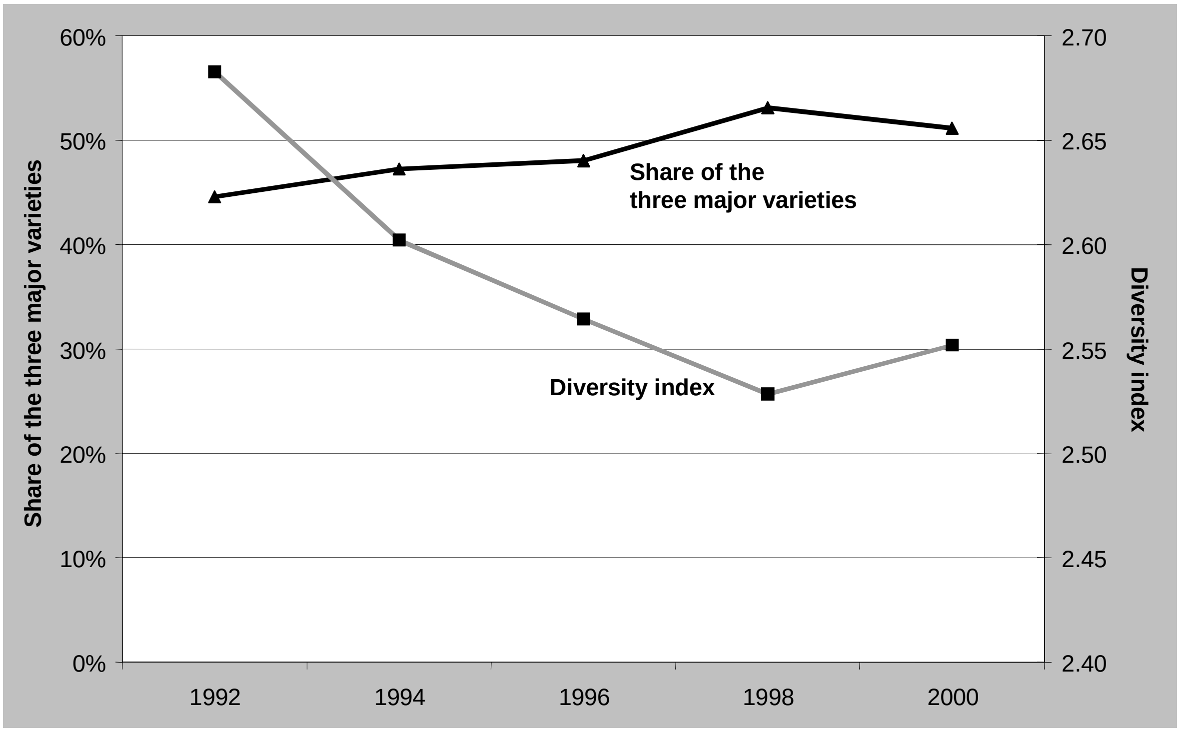
Source: Calculated of the data from BSA, several years a).

3.2.4. Share of major crop varieties / diversity index

The number of registered varieties represents only the potential diversity, which does not correspond with the real diversity on the fields, where often only a few high performance varieties dominate the cultivation. The OECD suggests the share of *e.g.* the three major (=”key”) varieties for each crop in total marketed production to be used as an indicator. As there is no variety-specific information on the production quantity available, the information on seed multiplication areas can serve as a data source, but restricted to those crops mainly multiplied at home in Germany. However, regarding diversity, the cultivation of the varieties beside the three major crops is very important. Because this large number cannot be overlooked anymore, the application of a diversity index, *e.g.* the Shannon-Weaver-Index, is a useful method. Figure 10 reveals a rather decreasing diversity on the fields, although the number of registered, potentially available varieties is increasing (Figure 9).

Similar to the animal breeds, the trends in numbers and shares of varieties are only partly correlating with the actual genetic diversity, for which a real widespread measurement (*e.g.* of genetic distances) is not foreseeable for the medium-term. Therefore, different breeding methods and the resulting variety categories can serve as an indicator for the impact of breeding on genetic diversity besides creating a lot of marketable products called “variety”. For example, 30 to 40 wheat subspecies (taxonomic varieties) were cultivated a hundred years ago in Germany, while today, the plenty of (legally formal) varieties are based only on two of these former subspecies. Therefore, a substantial loss of genes may be covered by a high number of varieties, because many varieties are very closely related to each other. That’s why we suggest to amend the OECD set of indicators by the following indicators.

Figure 10. **Weighted mean share of the three major varieties in total seed production area per crop and weighted average of the (Shannon-Weaver) diversity index of seed production areas per crop in Germany (cereal crops only)**

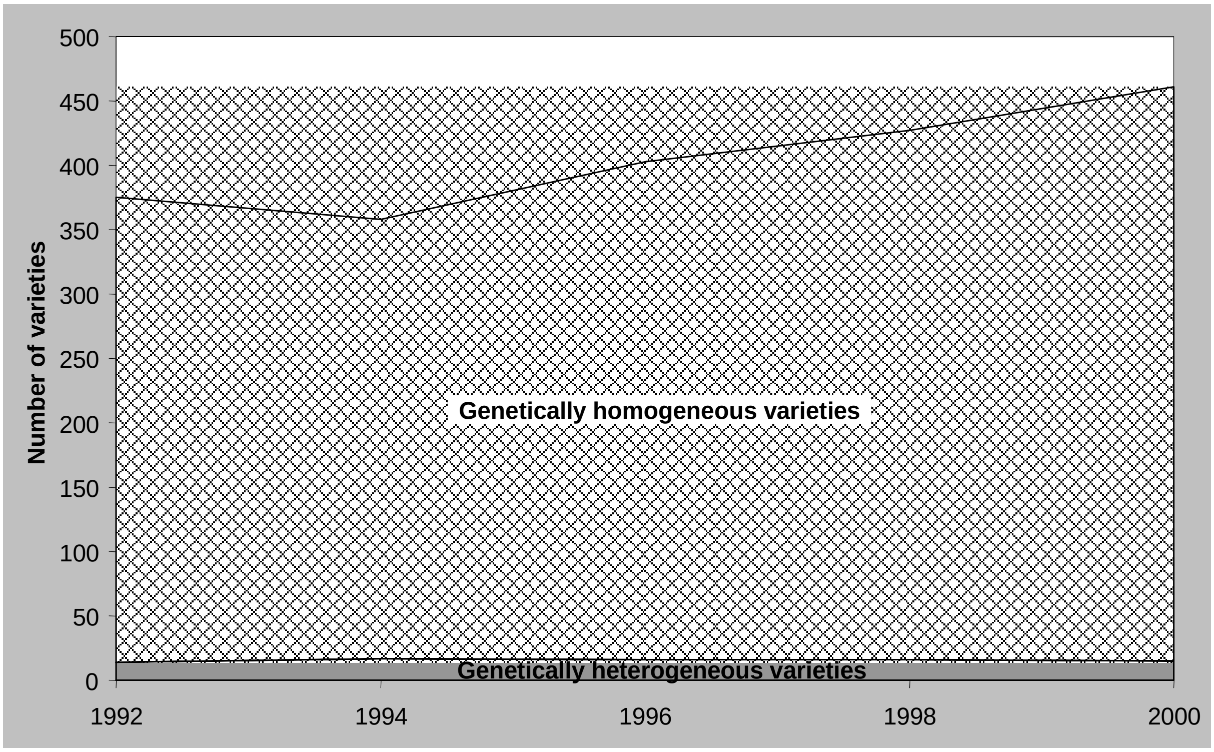


Source: Calculated of the data from BSA, several years b).

3.2.5. *Share of genetically heterogeneous and homogeneous varieties*

According to different population-biological characteristics and different methods applicated in breeding, there are big differences in how far a variety leads to a higher or lower genetical diversity within a field's population. Therefore, population varieties of allogamic crops like rye and old local varieties are composed of a multitude of genetically different plant individuals. On the other hand, modern line and hybrid breeding results in varieties, which consist of more or less genetically identical individuals. So it is possible to classify the registered varieties by the way they contribute to the genetic diversity in the field (Figure 11). In Germany, all registered varieties of self-pollinating cereal crops must be classified as genetically homogeneous line varieties. Genetically heterogeneous population varieties are existing for the allogamic rye, but also there, hybrids are dominating today. For maize, only one local variety is still registered, all others are hybrids. This indicator would be also very interesting for vegetables, as there are still many local varieties cultivated.

Figure 11. **Genetically heterogenous and homogenous registered varieties in Germany (maize and cereal crops)**



Source: Calculated of the data from BSA, several years a).

3.2.6. *Share of varieties with and without, evolutionary potential*

While the indicator above captures a spatial dimension of genetic diversity on the fields, there is also a temporal dimension, when farmers save parts of their own harvest for sowing in the next period ("farmers privilege"). When this procedure is being pursued for several times, the seeds adapt to site-specific conditions, that means evolutionary processes can evolve and new diversity is created in the medium- and long-term. Unfortunately there are no official statistics on these practices. So in a first step, an indicator could be drawn capturing the suitability of varieties for saving and sowing the own seeds again, that means a kind of “evolutionary potential” of a variety, not considered if this potential is used or not (Figure 12). In general, all traditional varieties can be assigned to this evolutionary potential. In contrast, for population-biological reasons hybrids are not suited for using the next generation. Genetically modified varieties must not be reproduced, because of technology user agreements, based on the patent law. This indicator may be of very high relevance in less industrialized countries.

3.2.7. Number of breeders per crop

Usually, plant breeding is based on the breeder’s own genetic pool of the relevant crop. That’s why in general the genetic diversity within a crop is higher, the more breeders are working on a crop, each with his own genetic pool. Different varieties of one breeder are often based on the same pool. That’s one reason for the close relationship between many varieties. A high amount of separate breeding programmes counteracts this relationships, though potentially enhancing genetic diversity. Although cooperations between breeding enterprises are increasing, the mean number of breeders per crop may serve as an appropriate and feasible indicator for the width of the actual breeding basis, the genetic pools (Figure 13).

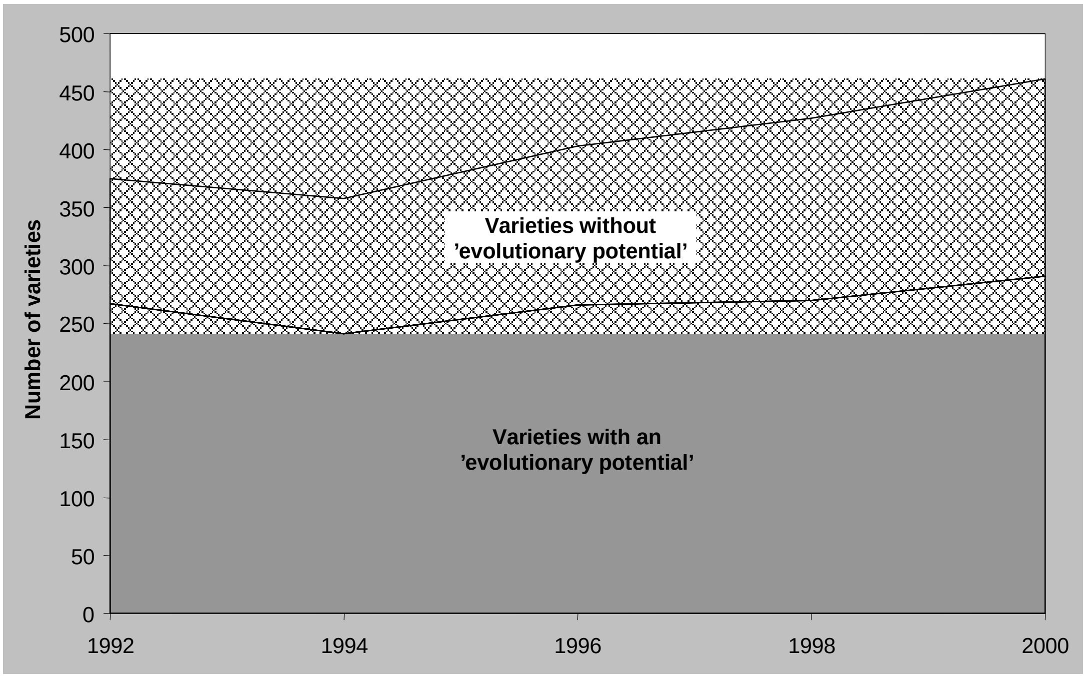
4. Conclusion and Outlook

The livestock and crop biodiversity indicators presented above are regarded to give a more comprehensive insight to the processes influencing agrobiological diversity than the basic OECD indicators. A final judgement on the quantity of genetic erosion (or growth?) of livestock and crops is only possible when widespread measurements of genetic diversity (distances) are implemented. In the former livestock chapter we focussed mainly on cattle, pigs, sheep and goats for which data are widely available. However, we also suggest to include *e.g.* poultry in the indicators. Unfortunately, the availability of data is weak. In contrast, crop diversity could be easily expanded to oil, root and fodder crops, fruit and particularly vegetables, partly except for the share of key crop varieties for crops mainly reproduced abroad.

Acknowledgement

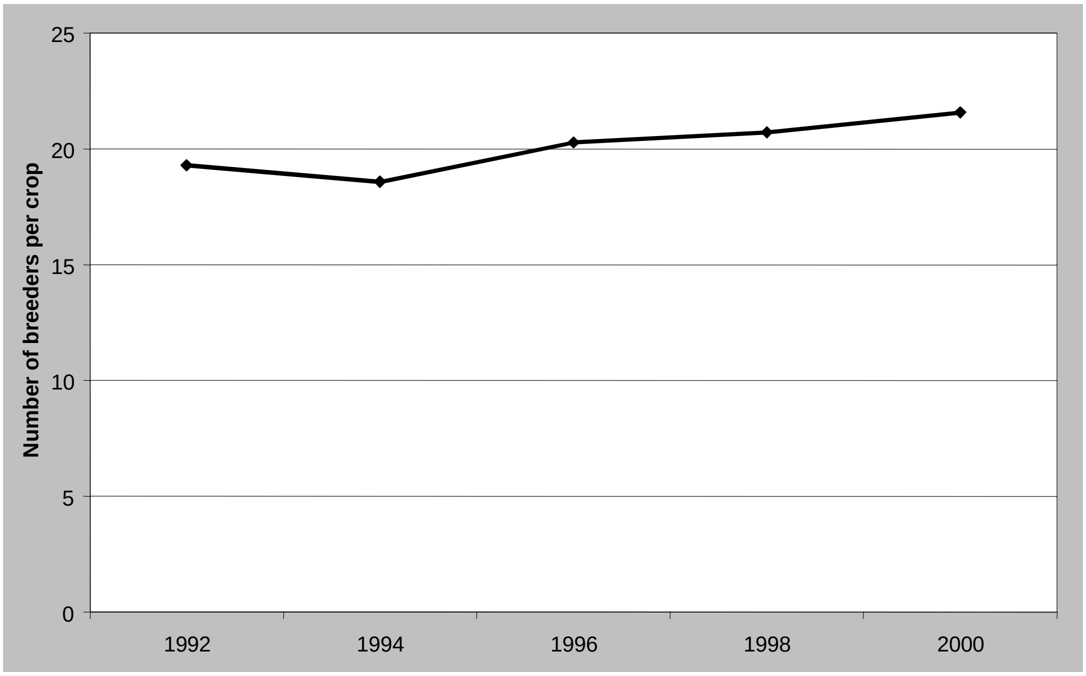
This study was financed by the German Federal Environmental Agency on behalf of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. It was particularly supported by the German Information Centre for Genetic Resources and the Federal Office of Plant Varieties. We gratefully acknowledge their support and express our gratitude to several anonymous experts assisting our work.

Figure 12. **Number of registered varieties with and without ‚evolutionary potential‘ (see text) (Germany, maize and cereal crops)**



Source: Calculated of the data from BSA, several years a).

Figure 13. **Average number of breeding enterprises per crop (breeding enterprises, which have registered at least one maize or cereal crop variety in Germany)**



Source: Calculated of the data from BSA, several years a).

REFERENCES

Arbeitsgemeinschaft Deutscher Rinderzüchter (ADR) (several years), *Rinderzucht in der Bundesrepublik Deutschland.* Annual report. Bonn.

Bodó, I. (1992), "The minimum number of preserved populations." In: *The management of global animal genetic resources* (J. Hodges, ed.): 91-104. Rome: FAO animal production and health paper 104.

Bundesgesetzblatt (BGBl), Teil I (1953), Verordnung über das Artenverzeichnis vom 30. Oktober 1953. 1487-1490.

Bundesgesetzblatt (BGBl), Teil I (1968), Artenverzeichnis. Anlage zum Gesetz über den Verkehr mit Saatgut (Saatgutverkehrsgesetz) vom 20. Mai 1968. 460-462.Verordnung über das Artenverzeichnis vom 30. Oktober 1953. 460-462.

Bundesgesetzblatt (BGBl), Teil I (1975), Verordnung über das Artenverzeichnis zum Saatgutverkehrsgesetz vom 2. Juli 1975. 1649-1653.

Bundesgesetzblatt (BGBl), Teil I (1985), Verordnung über das Artenverzeichnis zum Saatgutverkehrsgesetz vom 27 August 1985. 1762-1764c.

Bundessortenamt (BSA) (several years *a*), "Sortenregister." *Blatt für Sortenwesen* (4).

Bundessortenamt (BSA) (several years *b*), "Saatgutvermehrungsflächen in Deutschland." *Blatt für Sortenwesen* (10).

Convention on Biological Diversity (CBD) (1992), Convention text. <http://www.biodiv.org/doc/legal/cbd-en.pdf>.

Gesellschaft zur Erhaltung alter und gefährdeter Haustierrassen (GEH) (2001), Rote Liste der bedrohten Nutztierrassen in Deutschland. <http://www.genres.de/tgr/geh-allg/rotelist.htm>.

Information Centre for Genetic Resources (IGR) (2001), Central Documentation for Animal Genetic Resources in Germany. Personal information and <http://www.genres.de/tgrdeu>. Bonn.

Kalm, E. (1991), "Zuchtfortschritt durch Biotechnologie — Züchterisch-ökonomische Aspekte." *Deutsche Schwarzbunte* **15**(1): 26-29.

Kalm, E. (1997), "Zukunftstechnologien in der Rinderzucht." *Züchtungskunde* **69**(6): 478-487.

OECD (2001), *Environmental Indicators for Agriculture — Volume 3: Methods and Results*. Paris: OECD Publications.

Sambraus, H. H. (1986), Bedrohte Nutztierrassen in den deutschsprachigen Ländern." *Tierärztliche Praxis* **14**: 297-307.

Simon, D. L., Schulte-Coerne, H (1979), "Verlust genetischer Alternativen in der Tierzucht — notwendige Konsequenzen." *Züchtungskunde* **51**(5): 332-342.

Statistisches Bundesamt (StBA) (several years), *Viehbestand und tierische Erzeugung*. Wiesbaden: Fachserie 3, Reihe 4.

Statistisches Bundesamt (StBA) (2001), Time series service. Time series 1740001 - 1740049. http://www-zr.statistik-bund.de/zeitreih

Zentralverband der Deutschen Schweineproduktion (ZDS) (several years), *Schweineproduktion in Deutschland.* Annual report. Bonn.

DEVELOPING BIODIVERSITY INDICATORS FOR LIVESTOCK IN GREECE

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Introduction

Animal production policies in Greece do recognize the varying and often conflicting claims of rural development, tourism, industry and urbanization. Differences in climate, topography and soil lead to a great diversity in the agricultural potential of the different regions of the country. In most cases, the official recommendations as well as the governmental encouragement and efforts have tended so far, to introduce high yielding strains and breeds. As a consequence, the indigenous cattle breeds have either been completely replaced by high yielding, but very demanding, animal populations or they are in the process of being rapidly replaced through massive upgrading by imported types that respond better to improved feeding and management and intensive production conditions. On the better lands, intensive or semi-intensive ruminant (*e.g.* dairying and intensive fattening) and non-ruminant (poultry, pigs) production has been integrated with the other agricultural sectors, whereas on the poorer lands extensive suckling cows and small ruminant production, forestry and tourism developed complementary to answer the existing needs.

The management of the Animal Genetic Resources and the conservation of unique breeds and strains that are threatened by extinction are encouraged financially and technically by the Ministry of Agriculture. The activities concerning characterization, conservation, collection and utilization of the farm animal genetic resources of the country are undertaken in collaboration with the Agricultural Universities. Sufficient numbers of purebred indigenous sheep breeds are maintained in nucleus form in Agricultural Stations of the National Agricultural Research Foundation (N.AG.RE.F.), for research and as a source of genes for future use.

Characterization and present situation of livestock species and breeds

The water buffalo used to be an integral part of the biodiversity of many Greek wetland ecosystems, enriched their landscape and provided invaluable services and products to the rural people living close to wetlands, and to the economy in general. Buffaloes total population in Greece before

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the 1950's was over 100 000 animals. Presently, it is found only in four wetland sites in Macedonian and Thrace. According to our investigations, the Greek buffalo population numbered a total of about 900 animals in 2000. Even this small population is threatened with immediate extinction because of the rapidly changing rural socio-economic conditions and the expansion of cultivated fields into wet meadows.

For many decades, the mutually constituted bovine nucleus of the country has been undergoing a population change with the introduction from abroad of improved and purebred cows and bulls. However, the real alteration took place after World War II, with the extensive application of the artificial insemination, using sperm of pure breeds, mainly Brown Swiss, aiming at upgrading the indigenous bovine populations. As a consequence, the cattle in Greece were genetically stratified as follows: indigenous breeds and crossbred animals (used mainly for meat production) and purebreds of foreign origin (dairy type animals). Following this trend, the number of cattle has decreased from 1 131 000 animals in 1965 to 608 000 in 1993. In 2000 the number of dairy cows is estimated at 216 000 heads, from which 94.0% are Holstein-Friesian. Only 28.6% of these dairy cows are recorded (Georgoudis and Baltas, 1998).

In Greece, there are two types of indigenous cattle that are in danger to become extinct, the *Steppe breed*, with two types, *Sykia and Katerini*, and the *Shorthorn (Brachyceros) breed*. Dairy cattle in Greece are kept in environments, which range from the upper medium to high level of inputs. The local cattle breeds and the crossbreds are kept mainly in semi-mountainous and mountainous areas, under poor feeding (poor, dry pastures) and management conditions (Georgoudis *et al.,* 2000).

Small ruminants husbandry is the most important branch of the Greek animal production. In Greece about 9.244 million sheep and 5.900 million goats, which correspond to 50% of the total goat population of the European Union, are raised (Loukeri, 1996). The majority of sheep and goats are raised in the mountainous and marginal regions of the country, having a substantial economic, social and ecological role by keeping the remaining inhabitants in the villages and contributing to the conservation of the environment (Boyazoglu, 1999).

Sheep population in Greece is characterized by certain specific situations, as well as breed structure and husbandry methods. The evolution and distribution of the different sheep types and breeds in Greece are the result of developments and changes that took place over the past thirty years. The uncontrolled crossbreeding between the different breeds and the unplanned extension of artificial insemination played a major role in the disappearance of certain smaller breeds and the diminishing number of the purebred mountain populations. The major segment of the sheep population belongs to the Zackel type, which is found all over the country and is characterized by the long tail and the coarse wool. A second segment of breeds belong to the Ruda type, with finer and more uniform wool and are found mainly in Macedonia, Thrace and on some Aegean islands. A third category consists of the so-called semi-fat-tailed type, found on East Aegean islands. Although all of the above breeds can be broadly classified as dual-purpose sheep (milk and meat), in the second and third category belong breeds combining high prolificacy and milk yield (Boyazoglu, 1991; Hatziminaoglou *et al.*, 1985; Ligda *et al*., 1997; Zervas *et al.*, 1991).

The 90% of the present goat population in Greece numbers belong to various indigenous types. These local breeds represent about 4.5 million heads in 200 000 flocks. The local goat is to be found over the entire country and derives its name from the particular region. Big interest is being attracted to the Skopelos goat, originated from the homonymous island. A small percentage of the population consists of purebred imported goat breeds such as Malta, Zaanen, Toggenburg and Damascus breeds and their crosses with the local (Hatziminaoglu *et al.*,1995).

Overall input level of the production environment

Very extensive husbandry systems are applied to the local breeds, which play a major role in the rural economy of the difficult mountainous and semi-mountainous and mountainous regions of the country. Seventy eight per cent of sheep and 90% of goats are raised under low input production system. These species, which are naturally adapted to the optimal use of poor and marginal regions under difficult grazing conditions, play a major role in the rural economy of these regions (Loukeri, 1996). The total population of ewes and goats in the country is milked and about 90% of this milk is transformed into good to high quality cheeses. The average prices of ewes' and goats' milk are higher than that of cows' milk. The relative values are 40-70% and 35-50% higher than the price of cows' milk for ewes' and goats' milk, respectively. On average 60% of the total income comes from milk production and 40% from lamb or kid meat production, which in Greece traditionally are slaughtered in a liveweight not higher than 14 kg. Taking into account the above parameters, the breeding objective was defined as the improvement of milk production and having the lamb/kid as by-product (Ligda *et al.*, 1999)

The sheep population in Greece is characterised by a great variability in husbandry practices. Sixty per cent of all flocks contains 1-50 ewes indicating that sheep raising is of complementary importance to other agricultural production branches.

The main production systems are:

- the extensive system with transhumance, which is applied to the mountain breeds Boutsiko and Sfakia;

- the extensive or semi-intensive system without transhumance, which involves occasionally the Boutsiko and Sfakia breeds, the plain breeds, Karagouniko, Serres and Frisarta and occasionally the island breeds Chios, Lesvos, Zakynthos and Kefallinias; and,

- the intensive system which mainly concerns the Chios, Lesvos, Zakynthos and Kefallinias breeds and occasionally the Karagouniko, Serres and Frisarta breeds (Hatziminaoglou *et al.*, 1985).

Current and proposed indicators

OECD proposed the following three indicators relevant to animal genetic resources (Environmental Indicators for Agriculture Vol. 3, 2001),

1. For the main livestock categories the total number of livestock breeds that have been registered and certified for marketing.

2. The share of key livestock breeds in respective categories of livestock numbers.

3. The number of national livestock breeds that are endangered.

According to a nation-wide survey initiated by the Ministry of Agriculture and conducted during the years 1998 to 2000 by experts of the Agricultural Universities and the Ministry, for the determination of the actual demographic distribution and the characterisation of the farm animal genetic resources of the country, the situation regarding the three proposed indicators is shown in Figures 1, 2.1, 2.2, 2.3, 2.4 and 3. It has to be noticed that the system used in Greece to classify genetic diversity and assess the breeds of livestock is based on the number of the female breeding animals registered by the relevant authorities according to the relevant EU regulations.

Indicator number one is describing the current situation and comparing the figures of past years, giving a clear picture of the actual trend in a county or region, where higher numbers of existing breeds are demonstrating in general a richer biodiversity. A peculiarity concerning Greece but also other countries with similar conditions is the high number of crossbred populations that are, in general, classified as native but not attributed to a specific breed. These crossbreds constitute a high percentage of the total cattle and sheep populations as stated in the previous chapter, but this situation is not reflected in the indicator. As a consequence, this indicator is most relevant for situations where the total population in a livestock category is the total of the number of animals in each of the existing breeds. Obviously, a clear picture of the biodiversity can be acquired only in relation to the other two indicators, giving the distribution of the actual numbers of the breeds in each category.

Indicator number two should be calculated on the basis of the key livestock breeds, which is a rather subjective criterion. For this reason, Figures 2.1 and 2.2 are presenting instead of the key breeds, the share of all breeds in the respective livestock categories. The crossbred animals are excluded again, a situation that refers to the same problems as mentioned for the first indicator. Obviously, the domination of one breed (as it is the case for the cattle population) or some breeds (as it is the case for the sheep population) indicates an erosion of the biodiversity, without taken into consideration the availability of different environments and production systems in the country. The in depth study of the existing populations is the appropriate tool to investigate the in breed variation which is a clear indicator of the biodiversity status in the relevant livestock category.

Indicator number three is calculated as the total of the endangered breeds in each category. Two important points must be noticed regarding this approach, namely the definition of the status of endangerment and the possibility to rank the breeds according to their endangerment in the same category. As a result of the mentioned nation-wide survey in Greece, the situation regarding the breeds threatened by extinction is as follows:

A. Two cattle and five sheep breeds are listed under the “critical” status.

B. The total of the buffalo population, four sheep and one pig breeds are listed under the “endangered” status.

C. Eight sheep and one goat breed are listed under the “vulnerable” status.

D. One cattle, ten sheep breeds and the total of Greek goat population are being listed as normal.

A number of the above breeds is supported in the frame regulation 1257/99, which is a continuation of the 2078/92. As the definition of the endangerment status in relation to the possible financial support was not accepted by the whole scientific community, new criteria have been developed and proposed by the EAAP Working Group on Animal Genetic Resources.

Figure 1. **Total number of breeds for the main livestock categories in Greece**

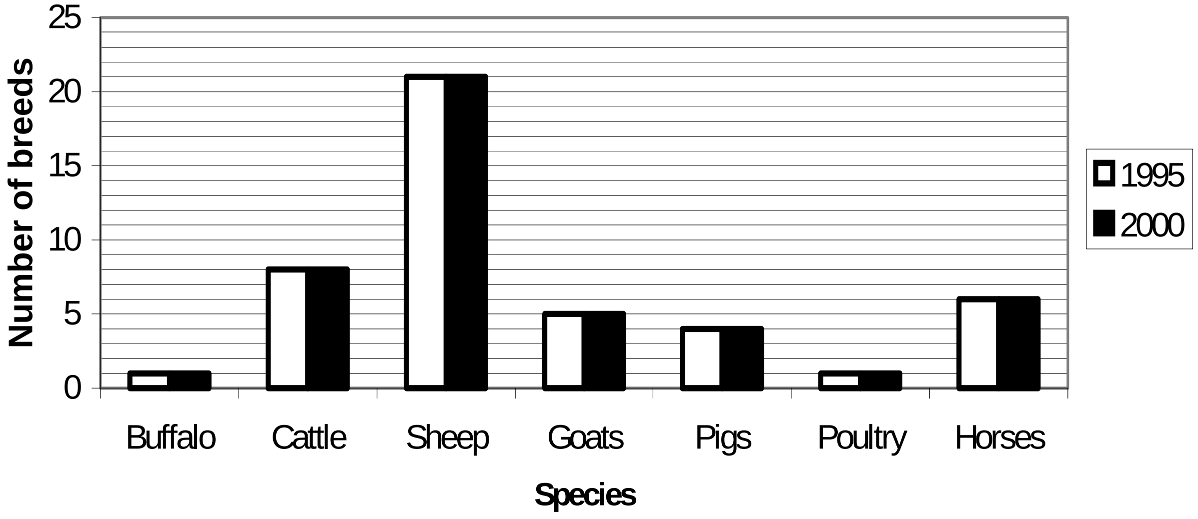


Figure 2.1. **Share of breeds in the total cattle population in Greece**

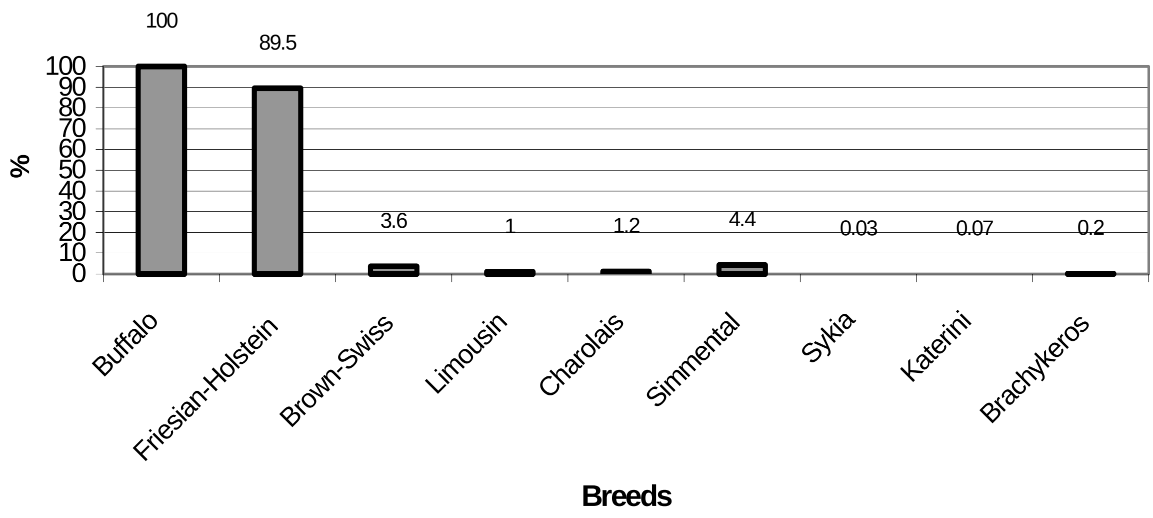


Figure 2.2. **Share of breeds in the total sheep population in Greece**

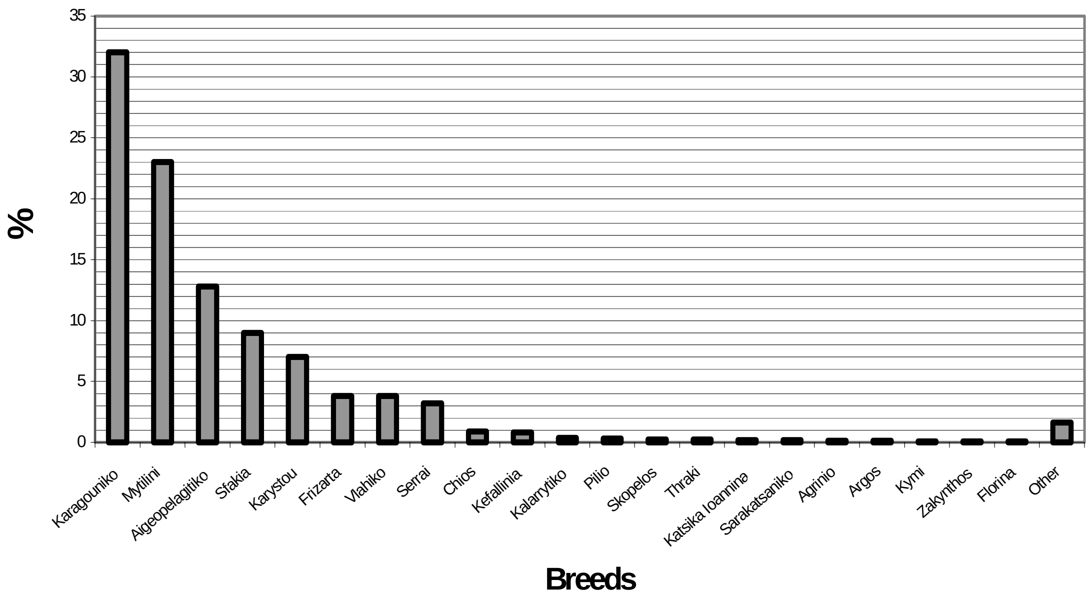


Figure 2.3. **Share of breeds in the total horses production in Greece**

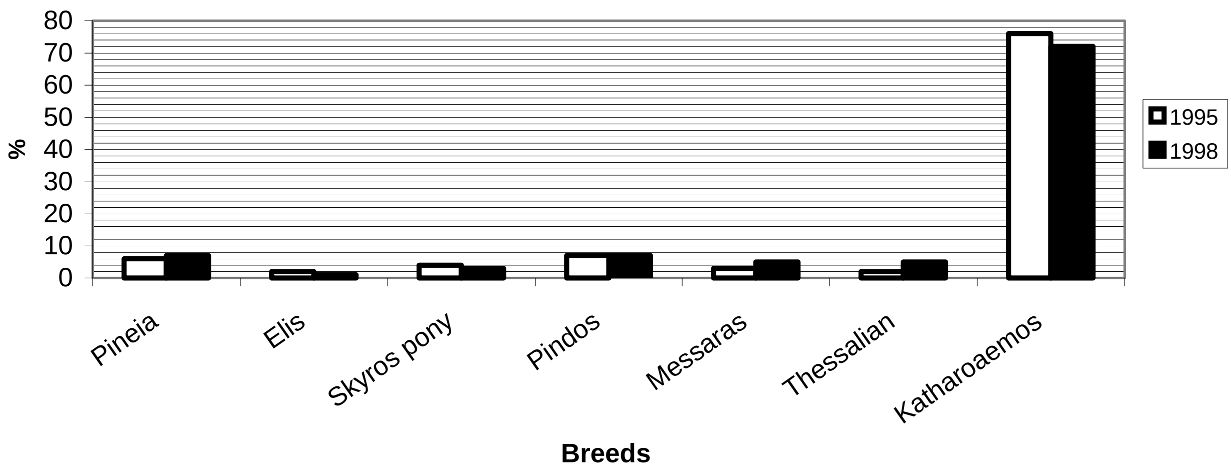
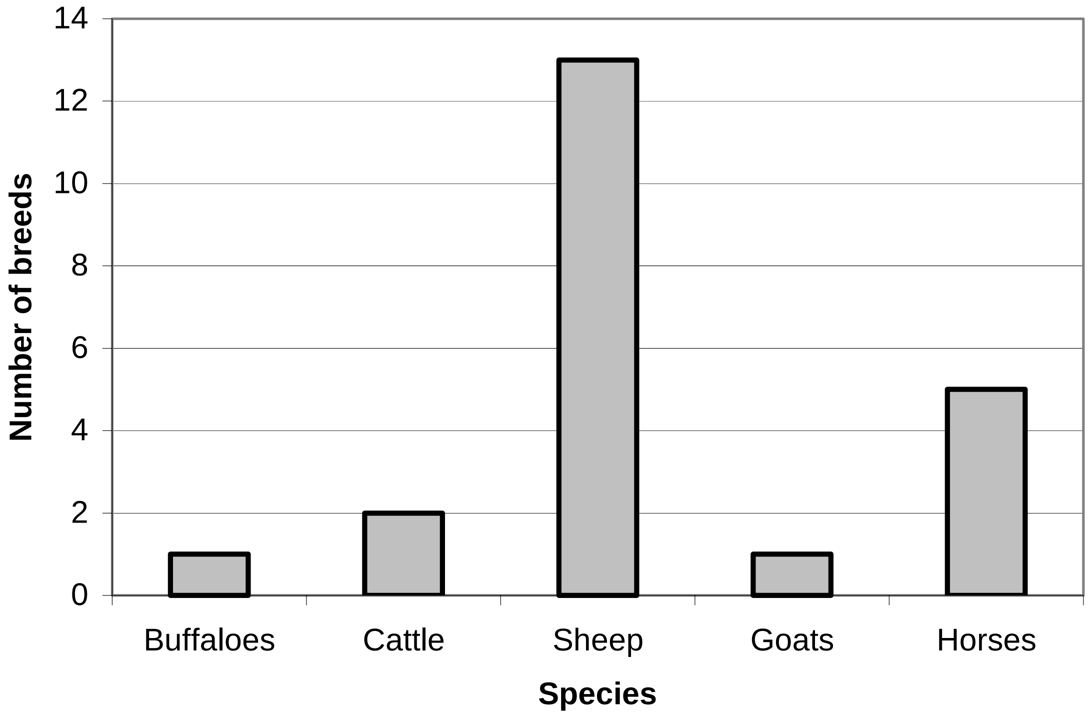


Figure 3. **Number of endangered livestock breeds for the main livestock categories in Greece**



In general, the indicators proposed by OECD have the advantages to be rather simple in their construction and calculation procedure but they do not go in depth in analyzing the current biodiversity status. Another drawback is their appropriateness only for countries with well-described breeds supported by breeders' organizations, without significant crossbred populations.

These indicators are based on figures which are attributed to the genetic level of the livestock breeds, leaving out the environment, which is a major part of the total biological diversity. Taking into account the populations constituting the livestock diversity in a country, especially in the high industrialized ones, where modern breeding programs are operating successfully since several decades, it seems that the above indicators do not cover the existing biodiversity as a whole. From the other side, it is known that livestock breeds are the result of a long selection process on several production traits associated with specific environmental conditions. Moreover, it is to emphasize that the production system in which a breed is adapted and exploited, is still playing a major role regarding its prospects of surviving covering current and/or future needs.

Both of the above attributes, namely the location and the production system of a breed, can compose together or separately indicator(s) for the biological diversity of livestock in a country or region.

The proposed indicators,

- location of the herds/flocks;
- number of existing types of production systems.

can be obtained using the following characteristics of the Geographical Information Systems (GIS) which make them capable to describe the biodiversity.

1. Description of the AnGR which exist in a particular area

The subject concerns the populations and breeds of farm animals, which are kept in a specific area. This area can be specified by various ways, such as a county, a village or just as a location with its place-name or by their geographic co-ordinates. Thus, a GIS can show the distribution of an autochthonous breed population in a specific area and also give more detailed information, such as the owner/breeder (name, address, age), herd data (number of the animals, sex, age), morphological and performance data, etc.

2. Classification of geographic areas with livestock, according to certain criteria

With a GIS, geographic areas where farm animals are kept can be classified taking into consideration certain criteria, as, for instance, the altitude, the distance from the sea, the vicinity with water resources (lakes, rivers), the yearly distribution of temperatures and rainfalls, the density of human population etc.

3. Determination of changes, which have taken place within a time period in a specific area

This topic concerns the changes, which occurred in a specific geographic area between two given dates, and especially the changes that can be combined with the alterations of the local farm animals' breeds or populations.

4. Finding associations of available information with specific spatial data concerning AnGR

In this issue, the queries, which might be posed to the GIS, could be referred to eventual relations between the decreasing rate of the numbers of the autochthonous breeds or populations and the spreading of the artificial insemination, in different geographical areas and in different periods of time.

5. Forecasting of anticipated changes of the status of the AnGR in a specific area

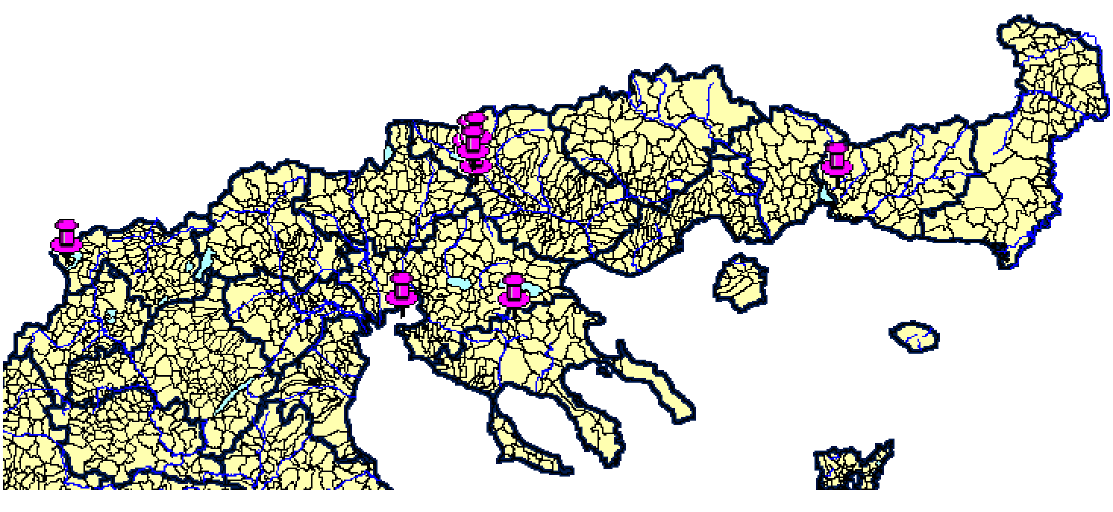
In this case, the investigation concerns the changes, which may happen in a specific area, when alternative eventual events that will take place are considered, with questions of the type "what is going to happen if" set in a simulated process.

The main parameters to be considered as inputs from the GIS to the proposed indicator(s) are: the average distance between the herds/flocks, the area which is covered by the relevant populations (herds/flocks or grazing animals) and the number and the area covered by the existing different production systems.

The input of the described data in a GIS and their appropriate processing can provide useful results for assessing the biodiversity and the danger of a breed to be extinct. An example is the distribution of the Greek Buffalo population shown in Map 1. From the five locations shown on the map only one has more than one Buffalo farms. Consequently, even if the population poses a wide distribution, it is obvious that the danger of extinction rises significantly when the number of animals in the main location will decline.

The Greek Focal Point for Animal Genetic Resources uses GIS since 1997 for the implementation of the census of the autochthonous breeds, which is carried out in collaboration with the Ministry of Agriculture and other Institutions. The system has been used for mapping the locations where crossbred populations and the last enclaves of the purebred autochthonous cattle breeds are kept. The mapping of the remaining native sheep, goat and horse breeds and the appropriate processing of the collected data will follow in the near future (Georgoudis *et al.*, 1999).

Map 1. **Distribution of the Greek Buffalo population (~ 1 000 animals)**



Each pin represents a buffalo farm

REFERENCES

Boyazoglu, J.G. (1991), Milk breeds of sheep. In *Genetic Resources of Pig, Sheep and Goat,* Maijala, K. (ed.). Elsevier Science Publishers B.V., Amsterdam, Chapter 13, p. 243-255.

Boyazoglu, J.G. (1999), Livestock production systems and local animal genetic resources with special reference to the Mediterranean region. VII Congress of the Mediterranean Federation for Ruminant Health and Production. Santarem, Portugal.

Georgoudis, A., and A. Baltas (1998), The development and maintenance of animal recording systems in Greece. A case study. Animal Genetic Resources Information, No. 23: 27-40.

Georgoudis, A., E. Komninou and E. Karkavelia (1999), The Implementation of Geographic Information Systems (GIS) in the Management of AnGR. Proceedings of the Workshop on the Development of Programmes for Co-operation on Animal Genetic Resources Management in the countries of Southeastern Europe. June 19-22, Thessaloniki, Greece.

Georgoudis, A., Ch. Ligda, K. Fragos, A. Baltas and J. Boyazoglu (2000), The role of dual purpose breeds in the evolution of the cattle milk production sector in Greece. International Symposium, Prospects for a sustainable dairy sector in the mediterranean. October 26-28, Hammamet, Tunis.

Hatziminaoglou J., N. Zervas and J.G. Boyazoglu (1985), Sheep and Goat in Greece (in Greek and English). Special publication of the University of Thessaloniki, p. 25.

Hatziminaoglou J., N. Zervas and J.G. Boyazoglu (1995), Goat production systems in the Mediterranean area: the case of Greece. EAAP publication No. 71:82-109.

Ligda, Ch., A. Baltas, A. Georgoudis, J. Hatziminaoglou and J. Boyazoglu (1997), The organization of sheep and goat breeding in Greece. Sheep and Goat Husbandry in the Central and Eastern European Countries. International Workshop. 29.11-3.12 1997. Hungary

Ligda, Ch., A. Georgoudis and G. Gabriilidis (1999), Definition of the breeding objective of the Greek dairy prolific ewes. Meeting of the Subnetwork on Animal Resources, FAO CIHEAM network on Cooperative Research on Sheep and Goats, 18-20 November, Zaragosa, Spain.

Loukeri, A. (1996), The greek sheep and goat husbandry in the frame of European Union and GATT. Animal Science Review, Special edition, 18:13-19 (in greek).

Zervas N., J. Hatjiminaoglou, J. Boyazoglu and A. Georgoudis (1991), Production Potential and Breeding Schemes of some Mediterranean Dairy Sheep Breeds. FAO, Animal Genetic Resources Information No. 8, Rome, p. 11-27.

PLANT GENETIC RESOURCES AND AGRI-BIODIVERSITY IN THE CZECH REPUBLIC

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Plants create the basis for life on the Earth. Even when existence of more than 300 000 species of higher plants has been estimated, only about 7 000 species were cultivated by humans and about 30 plant species are of crucial importance for man's nutrition and provide 95% of dietary energy or protein. This tiny part of the existing biodiversity in species, however, has an extraordinary importance and involves huge intraspecific genetic diversity. This diversity is a unique and irreplaceable source for further genetic improvement of crops and for increasing the diversity of crops and cultivars in agriculture.

The genetic diversity of agricultural crops is represented by bred (registered or restricted) cultivars, landraces and other genetic stock (breeders lines, experimental lines) as well as by wild relatives of cultivated plants. All these materials form a gene pool of agricultural crops, which is used for improvement of important characters, broadening of a genetic base of cultivars and also as a source of new diversity for agriculture (alternative use of crops, utilization of neglected crops, broadening the spectra of crops grown).

Today, the existing genetic diversity is often seriously endangered. In nature, biodiversity has been reduced due to the industrial development, climatic changes and agricultural practices. The biodiversity of crops in agricultural systems has also been decreased. During last century — and especially during the last 50 years — the diversity of local and well-adapted landraces has been replaced by a much narrower spectrum of bred cultivars that are often genetically rather similar. Often valuable original resources of many crops were lost.

In Czech Republic, a large-scale farming, which has arisen as a result of collectivization in agriculture in the time of communist rule, resulted in significant loss of biodiversity. Broad choice of local cultivars and landraces has been decreased in many crops and the relatively narrow spectra of crops and cultivars are grown in present agricultural practice. Some local genetic resources were lost, however, many of them were saved and some can be still found in remote areas. Still exists rich diversity in ecotypes of grasses, fodder legumes and other dicots, which can be found in some regions of the country and selected valuable genotypes can be utilized to increase the diversity of meadows and pastureland or provide new forms of fodder crops. Also some valuable landraces of fruit trees (especially apples, cherries, plums and pears) can be found in some regions of the country. Large-scale farming has disadvantaged growing of some minor crops used for specific purposes (minor crops, catch crops, alternative crops), which were less suitable for new technologies and did not provide high yields. However, these crops often have positive effect on soil fertility (improvement of soil characters, increase of organic matter), protect soil against the erosion and they contribute to the crop

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diversity in agricultural practice, which is an important precondition for sustainable development in agriculture.

Biodiversity plays also an important role in landscaping and maintenance of countryside. For this use the local species and genotypes should be preferably utilized because of their adaptation to the local and regional conditions, and their tradition and cultural value. Therefore, local and traditional species and clones of trees and bushes should be assessed from this point of view and selected materials can be evaluated as possible components in landscaping.

Research and utilization of plant genetic resources has a long tradition in this country. Various research and breeding stations have been gathering cultivars since the beginning of the 20th century. The range of 6 000 cultivars gathered in former Czechoslovakia in 1951 was increased to 45 500 accessions in 1988. Due to revisions of the collections and due to splitting off the former Czechoslovakia, the total number of accessions decreased in the early 1990$^{th.}$. However, the present state of Czech collections reached 51 000 accessions without duplications in 2001.

Collecting activities had been carried out by some Czech institutes since 1930s, but systematic collecting of landraces and wild relatives of agricultural crops on our territory begun in the 1960th and continues with different intensity till the present time. A continuous effort was devoted to conservation of collections. First a system of regeneration using sowing of accessions in several years' cycles has been implemented and since 1976, long-term storage under controlled conditions has started. Gene Bank in RICP Praha had been completed in 1988 with total storage capacity for 100 000 accessions. Genetic resources studies were oriented on evaluation of the most important biological characters, with respect to the effective utilization of genetic resources in breeding and agricultural practice.

Problems in plant genetic resource study and conservation appeared in the early 1990th in connection with cuts in budget for agricultural research, privatization (or the abolishment) of two institutes holding collections, and also due to the division of former Czechoslovakia. These problems have been overcome by the decision of the Ministry of Agriculture of the Czech Republic in 1993 when the "National Programme on Plant Genetic Resources Conservation and Utilization" has been launched. During few years of existence the Programme concentrated all activities on crop genetic resources within this country. The system allowed effective coordination and rationalization of all activities. Also international cooperation has been extended significantly during this period. In this way Czech Republic has joined the countries with safe and effective system of work on plant genetic resources, which meets international standards.

The political changes in Czech Republic in the 1990th lead to the new trends in agriculture, as well. Even when large- scale farming is still a prevailing form of husbandry, family farms and ecologically- oriented farmers and companies started their activities, too. Official agricultural politics accepts also the sharing of responsibilities for countryside maintenance as an important task for agriculture. In addition, an increasing public awareness on biodiversity importance and clean environment stimulates demand on new quality products and interest of farmers in growing neglected crops or landraces and broadening diversity in farming systems.

National Programme on Plant Genetic Resources

National Programme on Plant Genetic Resources Conservation and Utilization deals with gathering (including collecting missions), documentation, characterization, evaluation and conservation of plant genetic resources and provides also services to users. Presently, 11 institutions in the Czech Republic are involved in this project, among them two state research institutes, one agricultural university and eight private companies. The project coordinates the Gene Bank in RICP Praha, expertise and consultations are provided by the Czech Board on Plant Genetic Resources.

The institutions holding collections are responsible for maintenance and increase of collections (in co-operation with the gene bank), characterization, documentation, evaluation and regeneration of genetic resources. In vegetatively propagated species, the institutes holding collections are in the position of a gene bank and they are responsible for a long-term conservation of plant genetic resources, too. The Gene Bank in RICP Praha provides long-term storage of seed samples for all seed-propagated species as well as services of the National Information System on Plant Genetic Resources (EVIGEZ) for all co-operating institutions. Institutes and companies have close partnerships with users within the country and also abroad.

Relatively large collections are gathered in cereals, especially wheat (10 542 accessions and another 1 449 accessions of primitive and wild *Triticeae*), barley (4 487 accessions) and oat (1 979 accessions). Extensive collections are available in vegetables (8 820 accessions), grasses (2 036 accessions), fodder legumes (2 057), fruit plants (2 897 accessions, among them 1 102 apples). Also collections of flax (1 991 accessions), potatoes (1 697 accessions) and hop (303 accessions) belong to important ones in Europe.

Documentation of Plant Genetic Resources

National Information System on Plant Genetic Resources (EVIGEZ) consists of three parts: passport, characterization/evaluation, and storage data. The passport part includes the main characteristics of the genetic resource: accession number, taxonomy, accession name, country of origin, status of sample, year of arrival to collection, breeder and donor institutions etc. Altogether, 33 passport descriptors contain also information on wild material received from collecting missions. Since 1998, passport data base EVIGEZ is on-line searchable on URL http://www.vurv.cz/genetic/resources/.

In the characterization and evaluation part, the results of evaluation of all important characters can be included. In contrary to the passport descriptors, which are used universally, characterization and evaluation descriptors are crop-specific. All characterization and evaluation data are coded in a scale 1-9, according to the national descriptor lists (which are available for all important crops in this country).

Storage files describe the accession number, acquisition number, a code for the location of seed sample in the store, germination ability, seed moisture and amount of seeds in a container. The storage date of each sample is entered as well. It is also documented how much, when and to whom the seeds have been distributed.

Increase of collections, collecting missions

The aim of gathering and increasing plant genetic resources collections is to secure existing biodiversity and build up a wide base of genetic diversity to meet demands of present and future users. Primary attention is paid to materials of local origin, which include domestically bred cultivars, old local cultivars, landraces and wild relatives. The sources of new accessions are new cultivars from domestic breeders, foreign cultivars from areas with similar conditions of climate and soil, samples exchanged with other gene banks and finally samples collected by collecting missions. In some cases, it is necessary to reintroduce lost original genetic resources from gene banks abroad.

An annual increase of all Czech collections reached 2 000-2 800 samples in last years (2 230 accessions in 2000), the most important sources of new materials are collecting missions and exchange of materials with partner gene banks and other institutes abroad. In 2000, there were 732 samples obtained through international exchange and another 536 samples were provided by local donors. Collecting missions contributed by 1 107 new samples (among them 420 samples were collected on the Czech territory). Collecting missions are an important tool to increase collections by new original diversity and save resources, which could be endangered in nature or in agricultural practice. Collecting on the Czech territory extended previous efforts especially since 1993, when project "Gathering, Collection and Conservation of Wild Genetic Resources and Landraces in Czech Republic" has been launched. Project "The Mapping, Collecting and Conserving of Threatened Landraces and Wild Plants Related to Cultivated Crops in the Czech Republic and Bordering European Region" (1996-2000) was a continuation of former activities. As a result, valuable resources were found and saved as well as the inventory, distribution maps and computer documentation were developed.

Characterisation, evaluation and utilisation of plant genetic resources

Recently, more attention has been paid to increase the effective utilization of genetic resources. Good characterization and evaluation of genetic resources under conditions similar to those of their origin can provide breeders with valuable information on effective utilization of genetic resources for the breeding programmes. Characterization of genetic resources is aimed at morphological characters, electrophoretic protein spectra or/and suitable molecular techniques of DNA fingerprinting. The evaluation consists of data on plant growth and development, characteristics of plant stand, analysis of yield elements, responses to biotic and abiotic stresses and qualitative characteristics of the products. Importance of characters for breeding is a significant indicator for their systematic evaluation. Evaluation in field trials is usually carried out for 2-3 years (in vegetatively propagated species annually) and it is completed by laboratory tests (*e.g.* quality, specific resistance).

In a number of cases, genetic resources supplied to breeders have been used in the development of new cultivars or breeding materials. Acknowledged co-authorship of collection curators in released cultivars indicates close and successful cooperation between breeders and researchers. Some selected materials (especially in neglected crops, minor crops or newly cultivated species) are evaluated and recommended for utilization in agricultural practice to increase the agri-biodiversity.

Annually, 2-3 thousands samples of genetic resources and relevant information on them are distributed to users. In 2000 there were 1 665 samples provided to the local users (mostly breeders, researchers) and 747 samples were sent abroad.

Genetic Resources Conservation

The collections of vegetatively propagated species are in most crops maintained in field collections (fruit-tree or hop gardens, vineyards etc.) or in tissue culture (potatoes). All seed - propagated collections are multiplied and regenerated by institutes (companies) holding such collections, long-term maintenance of seed samples is provided by the Czech Gene Bank in the Research Institute of Crop Production, Praha. Hence only 70% accessions of seed- propagated collections are presently stored in the gene bank, there are still 10 400 accessions to be regenerated in the near future. Prevailing species in the gene bank are cereals (18 084 accessions) and legumes (2 532 accessions). Altogether 31 thousands accessions are presently stored in the Gene Bank.

These seed samples, which meet demanded standards are dried to 4-8% moisture content, filled into glass containers with vapor-proof cover and placed into moving shelves in cooling chambers. Containers are stored under -18°C (base collection, in selected species active collection as well) and under -5°C (active collection), seed viability as well as seed supply are regularly monitored during long- term storage. Regeneration of accession is initiated when seed parameters drops down below standard level. All information on seed samples in the gene bank is recorded and maintained in the information system EVIGEZ.

Cryo-conservation and some other perspective techniques of conservation are being developed. Research project " Methods and Utilization of Cryopreservation of Field and Garden Crops" (1996-2000) was aimed at development and introduction of cryo -methods for maintenance of vegetatively propagated species, (mostly meristems in "*in vitro*" culture). Lately additional research projects on "Cryo-conservation of selected fruit trees" (1999-2001) and "New conservation method of genetic resources of fruit trees" (2001-2004) have been launched. Also advanced seed storage technologies are being developed in the framework of the research projects "Seed viability changes caused by seed aging and storage conditions; improvement of gene bank techniques" (1999-2001) and "Maintenance of biological value of seeds in some species with low seed longevity using combination of effects of physical factors" (2001-2004) for application in the gene bank.

Conservation "on farm" is under development and should be applied on valuable selected local landraces of fruit trees (mainly apples, pears, cherries, and some other species) and few local landraces of neglected crops (millet, buckwheat, emmer wheat, einkorn wheat, spelt wheat). Also "*in situ*" conservation in few valuable selected localities is planned, on the base of systematic mapping of the Czech territory. Ecotypes of grasses and fodder crops as well as some fruit trees will be the target materials. In some cases these genetic resources are located in protected areas and "*in situ"* conservation is actually provided by existing national authorities (*e.g.* in the national parks Sumava or Krkonose).

Enrichment of crop diversity by local ecotypes and landraces

In accordance with the Convention on Biodiversity the Czech Ministry of Agriculture supports studies on biodiversity, which are carried out within the research programme "Biodiversity Utilization in Agriculture". Also few other research projects supported by the Czech Grant Agency contribute to the knowledge on local valuable landraces and ecotypes and their possible utilization. Some farmers (especially organic farms) and some companies dealing with processing of agricultural products are involved in these activities, as well. Among others following tasks are solved by above mentioned activities :

- Enrichment of biodiversity of meadows and pasturelands.
- Mapping and utilization of landraces and old local cultivars of fruit trees.
- Utilization of catch crops in agricultural systems.
- Study and utilization of neglected crops.

Biodiversity of meadows and pastureland

Efforts were aimed at monitoring, study and utilization of local landraces and ecotypes to enrich the diversity in species. Local adapted ecotypes were preferably used, especially in protected areas, rich natural localities and in less favorable areas for agriculture (LFA).

Due to systematic collecting of ecotypes of grasses and dicots, which started on the Czech territory since 1987 and extended previous occasional collecting activities, there were over 1 700 samples of grasses and dicots collected and conserved during this time. Some of these materials were utilized in the projects aimed at the increase of biodiversity. Selected 51 original ecotypes of grasses and dicots were tested in biological and economical characters (including seed production) and evaluated as possible components in species rich meadow mixtures. Convenient ecotypes were multiplied and provided for restoring biological diversity of grasslands, especially in Protected Landscape Areas (PLA Bile Karpaty). Valuable ecotypes of 37 species originating from this localities were multiplied and re-introduced to the regions of their origin. Seed multiplication was carried out on 2.4 ha and regional mixtures were composed on the base of botanical expertise using original composition of meadows and pastureland as a target status. Over 100 ha of species rich grasslands were newly established using multiplied seed (*e.g.* localities Stitna, Slavkov, Nivnice, Sterkovny, Ostrozska Nova Ves), as well as several small farms in Moravia).

Multiplication of wild grass species for increasing grassland biodiversity

Multiplication of sufficient amount of seeds of wild grass species and their use for regeneration of native, species rich meadow swards has also been used as a possible way of increasing the biodiversity in landscape. Thirteen grass species have been tested at the Grassland Research Station in Zubri to estimate the seed production potential in field conditions. Modified technologies for fodder grasses were used during establishment and treatments of multiplication plots. On the base of five years' results the species were divided into the groups shown in Tables 1 and 2.

Table 1. **Species convenient for multiplication in field conditions with high and steady seed production**

Name	Latin name	Seed rate ($kg.ha^{-1}$)	Notes
Giant fescue	*Festuca gigantea* (L.) Vill.	25	very late, 3 harvest years only, seed falling, low uniformity of ripening
Fescue	*Festuca rupicola* Heuff.	18	
Yorkshire fog	*Holcus lanatus* L.	12	
Upright Brome	*Bromopsis erecta* (Huds.) Fourr. (syn.: *Bromus erectus* Huds.)	30	
Smooth Brome	*Bromopsis inermis* (Leyss.) Holub (syn.: *Bromus inermis* Leyss.)	20	

Table 2. **Species with middle, lower or variable seed production, fitting to the multiplication in field conditions**

Name	Latin name	Seed rate ($kg.ha^{-1}$)	Notes
Narrow-leaved Meadow- grass	*Poa angustifolia* L.	15	low seed productivity
Hairy Oat-grass	*Helictotrichon pubescens* (Huds.) Pilger	30	
June grass	*Koeleria pyramidata* (Lam.) Beauv.	13	
Sweet Vernal-grass	*Anthoxanthum odoratum* L.	12	seed falling, low uniformity in ripening
Common Quaking-grass	*Briza media* L.	15	

Wavy hair-grass *(Avenella flexuosa* (L.) Drejer), heath-grass (*Danthonia decumbens* (L.) DC. in Lam. et DC.) and chalk false-brome *(Brachypodium pinnatum* (L.) Beauv) were considered as unconvenient for the multiplication in field conditions, mainly due to very low seed productivity and/or vitality.

Species-rich mixtures for restoring meadows

The different composition of floral mixture containing about 80% of wild species, mostly herbs, resulted in significant difference in the price when compared to the standard mixture of *Bromus*, *Arrhenatherum* and *Trisetum* containing 85% of commonly traded seed components and 15% of herbs. All tested variants developed high-density swards without weeds. Higher level of nutrients resulted in prevailing grass species in the swards and the higher green matter production. Even when the lower sowing rate of the floral mixtures were used (when decreased to one half, that is 15 $kg.ha^{-1}$, sometimes even to 10 kg ha^{-1}) the expenses were still much higher when compared to the standard commercial variants.

The herbs rate is clearly prevailing in plots of floral mixtures in the first and second vegetation period compared to the another variants. But in the third vegetation year the herbs rate is fully comparable with *Bromus, Arrhenatherum and Trisetum* mixtures. Therefore, renovation mixtures containing common species (about 80-85%) and herbs in amount about 15% could be considered as ecologically acceptable and economically convenient.

Wild species of grasses and herbs for strip seeding into grassland

Strip re-seeding of native species into the grassland is the technology by which demanded species may be introduced into the grassland. The final effect of strip seeding depends on the seeding establishment, which is affected by the weather conditions and by the chosen species resisting to the dry period in the year of establishment. Strip seeding of species with low field germination and poor growing activity after the sowing had often to be repeated during good weather conditions, especially in early spring under sufficient precipitations.

Only well-developed swards in reseeding strips with wild species can significantly affect the final green matter production. Rapid growth, competition ability and persistence are the most important characters for developing re-seeded components in meadow swards.

Among the suitable wild grass species as components for the strip seeding *Holcus lanatus*, *Bromus erectus*, *Bromus inermis* and particularly *Festuca rupicola* can be recommended.

Utilization of fodder legumes and other forage crops

Beside grasses also use of forage crops and other species in farming and landscaping has been studied in last five years. Forage crops can play an important role not only in fertile growing regions but predominantly also in marginal areas, in areas damaged by industrial activities, in flowering meadows, when creating a biological balance in extreme conditions of orchards and vineyards and also by increasing an ecological stability on hunting grounds and consequently by reducing damages caused by browsing game to crop stands and forests. Combined with other plant species they can contribute to the restoration of rich plant communities on the localities in protected landscape areas and nature reserves.

Cultivars of many fodder crops were often bred from local ecotypes, which had been usually collected in localities near former breeding stations. Some of the cultivars of such origin are still released for growing in Czech Republic. Brief review of such landraces is given in following summary:

Species	Landrace
Melilotus albus Medic.	Krajova
Lotus corniculatus L.	Malejovsky
Anthyllis vulneraria L.	Trebicsky
Onobrychis viciifolia Scop.	Visnovsky vicesecny
Trifolium repens L.	Viglassky
Trifolium pratense L.	Chlumecky, Jicinsky
Daucus carota L. *(fodder)*	Taborska zluta

Beside old released landraces, newly collected ecotypes are tested and best promising materials are used in breeding or directly examined as candidate cultivars. In addition to main fodder species (alfalfa, red clover and Dutch clover) also neglected species and some wild species are collected and studied to extend the spectra of fodder species and meet specific demands arising *e.g.* from needs to increase the diversity of dicots in meadows and pasture land, to meet needs on fodder crops for specific conditions or purposes. Some of these species are also used as components to mixtures which are used for maintenance of "set aside" arable lands.

Neglected fodder species (where local cultivars are still available) were evaluated and their utilization was recommended for use as convenient components in mixtures with grasses and /or other legumes. Following species and cultivars were recommended for growing: *Onobrychis viciifolia* cv. Visnovsky vicesecny, *Trifolium incarnatum* cv. Kardinal, *Anthyllis vulneraria* cv. Trebicsky, *Trifolium hybridum* cv. Taborsky, *Lotus corniculatus* cvs. Lotar and Malejovsky and *Melilotus albus* cvs. Krajova and Adela.

Some fodder crops were grown historically on the territory of the Czech Republic but the cultivars disappeared after the World War II. and the crops have to be newly introduced in the last decade. In this way the new cultivars of following species have been released:

Carthamus tinctorius L. cv. Sabina is grown on about 3 000 ha, usually as oil crop, but also as fodder or catch crop.

Medicago lupulina L. can be used as a fodder crop, catch crop or a component in mixtures with grasses and other legumes. New cultivar Ecola can compete with alfalfa in biomass quality and due its self-reproduction it is a valuable component in mixtures (occupying lower layer in mixtures).

Kribice (*Secale cereale* var. *multicaule)* was traditionally grown in northeast Moravia (Valassko) for pasture and for baking bread with special flavor. This form of rye was usually sown in June; it was used for grazing in autumn and for grain harvest in the next year. The rescued materials are multiplied and tested. Results indicate that kribice could be used as a fodder crop (in pure stand or in mixture with legumes) and provide grain harvest in consequent year. Also utilization of this crop for green maturing and as a fodder for game in forests was successfully tested.

Among grasses, *Phalaris canariensis* L. cv. Judita (released in 2000) is being reintroduced as fodder crop (for growing in monoculture or in a mixture with annual legumes) and its seeds can be used for feeding (*e.g.* they are popular with birds´ breeders).

In addition to traditional forage species, some new species were evaluated and selected among native wild plants, with the aim to introduce new crop diversity and some of them were released as cultivars. In this group *Coronilla varia* L. cv. Eroza can be used as fodder crop as well as a cover plant preventing erosion. Among grasses, *Bromus secalinus* L. (which is on the list of endangered species) has been examined and recommended as annual fodder crop or in mixtures with annual legumes. Also *Astragalus cicer* L. has been tested and recommended as a component to pasture mixtures and for protection against soil erosion.

An important task is to increase and maintain the biodiversity in protected areas. Therefore, mutual cooperation of agricultural research institutes (especially Research Institute of Fodder Crops Ltd., Troubsko near Brno and OSEVA PRO, Ltd., Grassland Research Station, Zubri) has been initiated. The partners in cooperation are Protected Landscape Areas Bile Karpaty, Moravian Karst and the National Park Podyji. Botanical explorations were performed and evaluations of botanical composition have been carried out in selected areas. The aim of these studies is to recommend measures for management improvements. Seed samples of some fodder plant species are collected in the National Park Podyji and geobotanical survey is carried out on the base of permission for botanical exploration given by Administration of the National Park. The collected seed samples are regenerated and used for creation of regional meadow mixtures for restoration of some areas in the National Park.

Some newly introduced species were tested for a possible use in marginal areas as industrial or energetic crops and for land reclamation in areas damaged by industrial activities. The experiments were aimed at selection of convenient species and ecotypes, development of growing technologies and verification of their value for practical utilization in marginal areas and extreme conditions (coal mining areas, extremely dry conditions of the Southern Moravia). With respect to the diversity of possible growing conditions a broad spectrum of annual and perennial species is being tested.

Monitoring and utilization of landraces and old local cultivars of fruit trees

The territory of Czech Republic is rich in landraces and local cultivars of fruit trees, especially apples, pears, cherries and plums. These original resources have an important role in the breeding and they are still grown in some areas. They can be often used as sources of resistance to diseases (*e.g.* resistance to *Erwinia amylovora* has been found in one local cultivar of pear ’Libovicka maslovka’. Also adaptation to the local condition of climate is an important character utilized in breeding, especially in breeding cultivars for marginal growing areas. Some landraces have been recommended for growing on ecological farms (*e.g.* apple landrace ’Chodske’ due to its resistance to fungi diseases and tolerance to less convenient climatic conditions).

Since 1994 several collecting missions have been undertaken on the territories of the National Parks (NP) and Protected Landscape Regions (PLR) in the Czech Republic (namely NP Sumava, NP Krkonose, PLR Orlicke hory., PLR Beskydy, NP Podyji and PLR Jeseniky) as well as in western part of the mountains Krusne hory and Doupovske vrchy. The distribution of fruit woody plants was found to be larger in the lower altitudes of the Sumava Mts., in the vicinity of former or existing villages and along melioration gullies, mainly along the Schwarzenberg Channel. Solitary trees and former alleys were predominating. In the most cases we have found wild forms of cherries, apple and pear trees. In NP Krkonose the collecting was mainly oriented to interesting frost-resistant individuals. Altogether 39 items were chosen for in situ conservation. Bird cherries (*Prunus avium* L.) from the altitudes of 800 to 1 000 m formed the major part. They were characterized by a good health and were not damaged by frost; their age was estimated ranging between 100 and 200 years. From the pomological point of view the region of the mountains Orlicke hory is poor for original landraces. Nearly all old fruit trees were cut down during the last 50 years. Nevertheless, we succeeded to discover several original apple landraces (’Vinne’, ’Kralicke’, ’Studnicne’, ’Medove’ and ’Louzne’). The western part of the mountains Krusne hory is relatively rich in the fruit trees, especially in apple and pear trees. The regional cultivar collection includes cultivars planted after 1st World War. Surprisingly, there is a very often appearance of apple and especially pear seedlings which do not occur in the other localities. Two seedlings of pears with red fruits and good economic traits were found.

The region of the mountains Krusne hory is relatively rich in historical fruit plantations, especially in apples and pears. The cultivar spectrum includes accessions planted after the World War I. A very often occurrence of apple, and even more pear seedlings is surprising and it was not noticed in other West Bohemian localities. In the region of the Mts. Krusne hory 26 apple landraces and obsolete cultivars were recorded as well as 10 landraces and cultivars of pears. Altogether 25 sites were visited, shortly described and localized by GPS. Available cultivars/landraces were determined and their characters and health state were recorded.

The notes taken and monitoring data serve for the mapping initiative of Czech native historical genetic resources and for decision-making and proposals for *in situ* or on farm conservation. Selected landraces were recommended for growing in extensive conditions.

Utilization of alternative crops in farming system as a source of organic matter, as catch crops and for the increase of biodiversity

Twenty-seven commonly grown as well as non-traditional plant species were tested in field experiments (Research Institute of Fodder Plants, Troubsko near Brno) in different conditions as catch crops. Experiments were sown in August, after the harvest of the main crop. Following characteristics were estimated: over-ground biomass, root biomass, root/shoot ratio and rate of biomass decomposition in soil. The yield of next crop in rotation, the influence of catch crops and subsequent crops on soil structure and the nitrogen content were also investigated as well as the influence of catch crops on humus content and quality. Cultivars of *Sinapis alba* L , *Malva verticilata* L., *Phacelia tanacetifolia* Benth. and several other species were selected for further evaluation.

In another series of experiments (Research Institute of Crop Production, Praha), 239 cultivars and ecotypes of 12 species (*Sinapis alba* L., *Brassica nigra* (L.) Koch , *Brassica carinat* A. Braun, *Brassica juncea* (L.) Czern., *Camelina* sativa (L.) Crantz, *Crambe abyssinica* Hochst.ex R.E.Fr. , *Brassica rapa* L., *Eruca sativa* Miller, *Phacelia tanacetifolia* Benth., *Setaria italica* (L.) Beauv., *Panicum miliaceum* L. and *Fagopyrum esculentum* Moench) were evaluated and promising genetic resources were chosen for field tests. In the subsequent experiments several economically important characters were evaluated in 24 selected cultivars (ecotypes) of 11 species. Also the growth of biomass (dry matter) during first seven weeks of vegetation and its dynamics was measured as well as the protein content in above ground biomass. The data were analyzed and potential "catch effect" of particular crops by keeping soil nitrogen has been estimated.

Higher mean seed yields were found in *Sinapis alba* L. (2,34 t/ha) and *Setaria italica* (L.) Beauv (2.22 t/ha). Seed production over 2t/ha provided also buckwheat (*Fagopyrum esculentum* Moench) and krambe (*Crambe abyssinica* Hochst.ex R.E.Fr.). Dry biomass production during first weeks of vegetation has been strongly influenced by climate and soil conditions (years and sites). Under different conditions white mustard (*Sinapis alba* L.) produced high dry biomass within the seven- week period (0.5-0.7 kg/m^2). Also *Phacelia tanacetifolia* Benth, *Setaria italica* (L.) Beauv and *Brassica carinata* A. Braun provided relatively high dry matter production (over 0.5 kg/m^2) in most environments. Especially in *Sinapis alba* L. and, *Setaria italica* (L.) Beauv significant accumulation of nitrogen in dry matter can be expected (about 140-150 kg N/ha in the best cultivars under convenient conditions when they are used as catch crops for green manuring). The highest catch effect was estimated in cv. Nakielska (*Sinapis alba* L.) and in ecotype SET 621/91 of *Setaria italica* (L.) Beauv. These preliminary results should be verified in large-scale experiments and in agricultural practice. In this way, alternative crops can contribute to the wider diversity of crops in agricultural systems but they can also help to maintain the soil fertility and prevent the leakage of nitrogen to the ground waters.

Evaluation and utilization of neglected crops on arable land

Wheat, barley, ray, oats and lately also triticale are most important cereals in the Czech Republic. However, historically there were grown on the Czech territory other important crops — pseudocereals and cereals, mainly buckwheat, millet and some neglected wheat species (spelt wheat, emmer wheat and einkorn wheat). Even when most of local landraces were lost in last century still some valuable local materials exist, which should be conserved (some of them preferably in “on farm” conservation) and effectively utilized for increasing agri-biodiversity in field cropping systems. All above-mentioned species provide specific quality products, which can be utilized in human nutrition. All these species belong also to the crops with relatively lower demands on fertilizers and pesticides which can be successfully grown in low- input systems and less favourable areas. These important characters, stressed by specific nutritious value, predestinate them as convenient crops for organic agriculture and stuff for bio-food production.

The oldest records of buckwheat on the territory of the Czech Republic go back to the 12th century. It was the most favourite food in the 16th and 17th century, then the growing decreased due to expansion of bakery products and potato popularity. The maximum falling-off of interest in buckwheat was during last century. Later, the irreversible loss of local varieties took place, and therefore the domestic materials contribute only by a small part to the present collection.

At present time the growing area of buckwheat is not officially registered, estimations are about 2 000 ha. in conventional systems and about 1 000 ha in organic systems; altogether 3 000 ha of buckwheat is grown (0.12% of total crop area). The interest in buckwheat growing has arisen in the last decade, mainly in organic systems of agriculture, where the interest in buckwheat is continuously increasing.

There are 136 accessions of buckwheat maintained in the Czech collection. On the base of evaluation, several promising populations were chosen and tested for utilization in practical growing. Beside agronomics characters also rutin content has been tested as well as a complex nutritive value and significant variability within varieties in quality characters was determined. The experimental results on growing practices in ecological conditions and their comparison with conventional ones were important for the development of organic buckwheat production.

Two buckwheat cultivars are registered and recommended for growing in Czech Republic — ’Pyra’ (selection from local population) and bred cultivar — ’Jana’; but also some Polish cvs. are grown. Landrace from former Czechoslovakia ’Vychodoslovenska’ (which was grown on the Czech territory, as well) is considered as valuable material for “on farm” conservation.

Also millet has been grown in the Middle Europe for centuries but in modern agriculture its growing has been strongly reduced to present areas of about 400 ha (with presently small, but fast increasing share of organic farming). Czech collection of millet genetic resources reached 171 accessions, but only few local landraces were maintained. Local cultivar Hanacka mana and bred cultivar Unicum are recommended for growing. Landrace ’Slovenske cervene’ (grown historically also in Czechia) is considered as convenient valuable material for “on farm” conservation.

Wheat is considered to be one of the most important crops for human nutrition. Wheat species *Triticum aestivum* L. and *T. durum* Desf. are widely grown round the world. In addition to these major species, some another ones have special properties and characters important for their potential utilisation as crops. Collection of wheat genetic resources at the Czech Gene Bank contains at present 10 481 accessions. Among them there are 104 emmer (*T. dicoccum* Schűbl.), 74 spelt (*T. spelta* L.) and 38 einkorn (*T. monococcum* L.) obsolete cultivars and landraces of these hulled wheat species. Standard evaluation of the accessions takes place regularly and also detailed evaluation of valuable cultivars has been done in the last decade.

Spelt wheat belongs to old cultivated crops with specific characters. Percentage of glumes in harvested spikelets was about 25%, TKW was 4 857 g with high protein content (close to 18%) and good bread making properties of spelt flour were certified. Growing areas are continuously increasing during last decade and reached over 500 ha in the last year. Two cultivars are available, cv. Franckenkorn and lately local cultivar 'Rubiota', which was selected as the best material among local landraces. Several other landraces could be recommended for "on farm" conservation, mainly due to their superior quality characters.

Glum proportion in emmer wheat (*T. diccocum* Schűbl.*)* spikelet harvest was 25-27%, TKW was lower then in spelt and reached 35-37 g. Yield of naked kernels was 2.2-2.5 t/ha and crude protein content reached the level nearly by one third higher than in bread wheat and it was close to 20%. On the other hand lower SDS sedimentation values show worse suitability for breadmaking.

Proportion of glumes in einkorn (*T. monoccocum* L.) spikelets was higher (28%) and kernels are relatively small (TKW was 27-29 g). Yield of de-hulled kernels in einkorn accessions was nearly the same as in emmer (2.5 t/ha in 1999 and 2.1 t/ha in 2000). Einkorn also did not differ from emmer in crude protein content (20.7 resp. 18.6%). Einkorn similarly as emmer seems to be more suitable for other utilisation (porridges, műsli etc.) than for breadmaking.

Hulled wheat species are more resistant to unsuitable growing conditions. For instance, it was very hot and dry period in spring 2000 at Praha -Ruzyně locality. Under such conditions some emmer and einkorn accessions overcame check bread wheat cultivar in crude protein production per hectare. Recently organic farmers in the Czech Republic are interested in addition to other crops also in growing of neglected wheat species as spelt, emmer and einkorn. In both, emmer and einkorn wheat, there are presently no registered cultivars. However, most of local populations (landraces) were maintained and some valuable materials were found in both species, which can be recommended for "on farm" conservation as well as practical utilization. Their quality parameters and agronomic characters allow to recommend them for growing in limited extent in low- input systems, especially in organic farming.

Crop diversity in agriculture and indicators of biological diversity

Crop diversity (diversity within crops as well as within grown cultivars of a crop) is one of important means influencing a range of biological, economical and social outcomes of agricultural systems. On the other hand an optimal structure of crops and cultivars is to some extent determined by regional natural conditions (climate, soil) and also by traditions, market demands etc. Even when crop diversity in agricultural systems does not determine the biodiversity directly, it is obviously one of factors with significant impact on many biodiversity indicators and the biodiversity as a whole. Therefore, some indicators describing the crop diversity in farming systems should be involved as a means for biodiversity measurement, as well. Because of linkage of crop diversity to natural (regional) conditions, these conditions should be taken in account when constructing relevant indicators. Specific approach will probably be useful for different groups of crops, namely:

- crops on arable land;
- meadows and pasture;
- orchards and other perennial cultures.

In our opinion following parameters should be considered when creating and selecting indicators of biodiversity based on the crop diversity in farming systems:

- number of crops in crop rotation(s), (farming system);
- share of crops in rotation (farming system) convenient for low input systems;
- proportion of “neglected” or “minor” crops;
- incidence of local cultivars and landraces in growing systems.

Because all crop diversity parameters are closely related to the intensity of production, it should be also discussed whether indicators based on agro-ecosystems should be related to this intensity (for instance to LFA and other regions separately).

Acknowledgements

The above overview has been compiled on the base of information provided by researchers dealing with plant genetic resources and crop diversity studies in the Czech Republic. We thank to following colleagues who contributed to the particular chapters:

Vojtech Holubec and Vojtech Skaloud, Research Institute of Crop Production, Prague- Ruzyne.
Jan Pelikan, Iva Zapletalova, Research Institute for Fodder Crops Ltd., Troubsko near Brno.
Frantisek Paprstejn, Research Institut for Pomology Ltd., Holovousy.
Pavel Sramek, Magda Sevcikova, Grassland Resarch Station Zubri, OSEVA PRO, Ltd.

REFERENCES

Dotlacil, L., Stolc, K.J. (1998), National Programme on Plant Genetic Resources Conservation and Utilization in The Czech Republic. Geneticke zdrojec. 71, VURV Praha, 78 pp. ISBN 80-238-3207-7.

Dotlacil, L., Stolc, K. J., Stehno, Z., Faberova, I. (1998), The National Programme on Plant Genetic Resources Conservation and Utilisation in the Czech Republic. IN*: Implementation of the Global Plan of Action in Europe — Conservation and Sustainable Utilisation of Plant Genetic Resources for Food and Agriculture, Proceedings of the European Symposium, 30 June-3 July 1998, Braunschweig Germany*. IPGRI Rome pp. 350-354.

FAO (1998), The state of the world’s plant genetic resources for food and agriculture. FAO, Rome, 1998, 510 p.

FAO (1996), Global Plan of Action for the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture. FAO, Rome, 63 pp.

FAO (1996), The state of the world’s plant genetic resources for food and agriculture. FAO, Rome, 336 p.

Stehno, Z., Dotlacil, L., Faberova, I. (1999), Genetic Erosion Issues — Plant Genetic Resources in the Czech Republic in: *Proceedings of the Technical Meeting on the Methodology of the FAO World Information and Early Warning system on Plant genetic resources*, RICP, Prague, 21-23 June 1999, p. 56-60.

WILD FLORA AND FAUNA IN IRISH AGRO-ECOSYSTEMS: A PRACTICAL PERSPECTIVE ON INDICATOR SELECTION

Jane Feehan[1]

Introduction

Agriculture and Biodiversity

Until recently, agricultural land was not regarded as important for wildlife. Conservation activities had developed to focus almost entirely on protected sites. However, an appreciation is emerging of the importance to biodiversity of farming activities. Many of the 'wildest' areas of Europe are in fact farmland, and farming has been the major influence in creating many valuable landscapes, habitats and wildlife communities across the continent. Such habitats and their associated wildlife communities are sustainable only through the continuation of farming (McCracken and Bignal, 1998, Bignal, 1998).

With more than half of the total area of Europe being used for agriculture, the implications of agricultural practices have critical importance for European landscapes and biodiversity. In Ireland, over 75% of land use is agricultural, and the majority of this consists of grassland. Therefore, the link between agriculture and biodiversity is particularly strong in Ireland. Indeed, the first national report on the implementation of the UN Convention on Biological Diversity (CBD) in Ireland acknowledged that agriculture is the single biggest influence on biodiversity in Ireland (Dept of Arts, Heritage, Gaeltacht and the Islands, 1998).

Agri-Environment and Biodiversity Conservation

Agri-environment schemes are a significant tool in biodiversity conservation (Ovenden e*t al*. 1998). The linking of biodiversity and agri-environment objectives is an important step towards achieving a more sustainable agriculture.

The agri-environment regulation, Council Regulation No. (EEC) 2078/92, provides for programmes to encourage farmers to carry out environmentally beneficial activities on their land. Farmers receive payments in recognition of the costs and income losses incurred in providing this environmental service. All EU Member States are required to apply agri-environment measures throughout their territories, according to environmental needs and potential. Two broad types of environmental objective are evident (Fay, 1998):

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- To reduce the negative pressures of farming on the environment, in particular on water quality, soil and biodiversity;

- To promote farm practices necessary for the maintenance and enhancement of biodiversity and landscape, including the avoidance of degradation and fire risk from under-use.

Agri-environment has a particularly significant role to play in countries such as Ireland which have an exceptionally high proportion of agricultural land.

Agri-Environment in Ireland: The Rural Environment Protection Scheme (REPS)

The Rural Environment Protection Scheme (REPS) is Ireland's agri-environmental scheme, introduced in 1994 in response to EC Regulation 2078/92. The REPS is a voluntary, horizontal (countrywide) scheme: farmers from any part of the country can apply, which contrasts with the programmes in certain other Member States which have adopted a 'zonal' approach, focusing on certain areas. Farmers who wish to join the scheme must do so for five years, and must apply the scheme's measures to the entirety of their farm. An agri-environment plan is then drawn up for the farm by an approved planner. Over 35% of Ireland's farmers have joined the scheme, covering an area of more than 1.5 million hectares.

The scheme consists of 11 measures, and a further 6 'Supplementary Measures'. Measures relate to waste management, grassland management, protection of watercourses, retention of wildlife habitats, maintenance of field boundaries, restrictions on the use of herbicides, pesticides and fertilisers near hedgerows, lakes and streams, protection of archaeological features, visual appearance of the farm, production of tillage crops in a prescribed fashion, attendance at a training course and the keeping of appropriate records.

Several REPS measures are of particular relevance to the biodiversity of wild flora and fauna living on farms. They are as follows (Department of Agriculture and Food, 1999):

Measure 3 — Protect and maintain watercourses and wells

Under this measure, streamside vegetation must be fenced off and allowed to develop.

Measure 4 — Retain wildlife habitats

This measure is intended to facilitate the retention of habitats listed in the measure, and to 'curtail commercial farming practices on these areas in the interests of wildlife'.

Measure 5 — Maintain farm and field boundaries

This measure specifies guidelines for hedgerow maintenance and protection.

Measure 6 — Cease using herbicides, pesticides and fertilisers in and around hedgerows, ponds and streams

A spray limit of 1.5 m of the aforementioned features is specified.

Measure 9 — Tillage crop production

One of the requirements of this measure is that an uncultivated strip of at least 1.5 m be retained at the margin of the field.

The importance of monitoring and evaluation

Monitoring and evaluation is important for several reasons, including the following.

- The world's living resources are being depleted all the time. If sustainable development is to be a realistic objective, we need to monitor change in those living resources as a basis for modelling strategies of such sustainable development.

- Without monitoring changes in natural communities, in the status of species and habitats, we have little on which to base good policies and practices. In evaluation and refinement of a policy or scheme, there is no substitute for a system of ongoing monitoring, with baseline data to provide a basis for comparison.

- The quality of water, air and soil can be monitored using indicator species and indicator communities far more successfully than by chemical monitoring alone.

- Long-term ecological studies are rarely conducted, and biological monitoring programmes have an important role to play in developing our understanding of natural long-term processes of ecosystems, and in providing essential baseline data.

Although the REPS is subject to several 'point assessments' examining aspects of its ecological impact, there is no system of ongoing monitoring in place. Furthermore, there is a failure to define specific targets. Without targets and quantified objectives it is difficult to relate the results of evaluation back to the scheme. There is concern that the failure of most EU Member States to define performance targets for their agri-environmental schemes, may mean that performance against objectives will not be properly assessed. The REPS and its sister programmes elsewhere are innovative schemes which will need to be appraised and modified if they are to realise their full potential (Hamell, 1999). Monitoring and the definition of quantified targets are fundamental to effective appraisal. Agri-environment schemes must earn their keep: benefits yielded must be self-evident and quantifiable, or their future becomes uncertain.

Agri-biodiversity species indicators have the potential to make an important contribution to the monitoring and assessment of the impacts of agricultural practices on wild flora and fauna on agricultural land. Such indicators have a role to play in the establishment of appropriate policies and in providing an early warning system for the deterioration of key communities and habitats.

In contrast with the UK, which has a highly advanced monitoring infrastructure in the form of the UK Breeding Birds Survey and the Butterfly Monitoring Scheme, Ireland's nature monitoring infrastructure is relatively undeveloped. Ireland does not as yet have the resources in place for large-scale ecological monitoring.

The selection and establishment of baseline data

> "Setting baselines is a complex and often an arbitrary process, with many alternative baselines possible" (OECD, 2001).

> "Care will be required in relating species reductions or increases to agriculture, where other external factors, such as changes in weather etc., may have an effect. Baselines from which to interpret changes in biodiversity are indispensable for valuing the state and trends in biodiversity. The choice, however, is complex" (OECD, 1999).

A prerequisite to effective monitoring and evaluation is the presence of a basis for comparison, a benchmark against which trends can be measured, or an agreed target level to be aimed for. Without baseline data to provide this basis for comparison, a set of monitoring data are merely a list of observations, rather than a tool for policy assessment and evaluation. Furthermore, baseline data are an integral element in the development of indicators: "Defining baselines is an important step in calibrating, comparing and interpreting indicators of biodiversity" (OECD, 2001).

Considerable confusion has arisen over what is meant by 'baseline'. It is quite common for a baseline to be described on the basis of a one-off survey, which really only provides a snapshot of current conditions. Ecosystems are dynamic and it is essential to take account of their inherent spatial and temporal variation if any attempts are to be made to attribute subsequent changes in ecosystem parameters to specific stresses or actions (Treweek, 1999). Many systems have 'moving baselines' which may not be adequately characterised by a short run of data alone. A true baseline study is necessarily based on comprehensive monitoring. Moreover, the baseline must be set according to the same methodology employed in subsequent monitoring, necessitating the establishment of a standard protocol.

Standard protocols have been established for monitoring certain groups. For example, in Northern Ireland the Centre for Environmental Data and Recording (CEDaR), established by the Ulster Museum in 1995, serves as a local records centre and produces atlases on certain key groups (*e.g.* The Ground Beetles of Northern Ireland. Atlases of the Northern Ireland Flora and Fauna No. 1. Anderson *et al.*, 2000). CEDaR is responsive to the local conditions and needs of the environmental recording community. Also in Northern Ireland, the Environmentally Sensitive Areas (ESA) Scheme has been monitored since the early 1990s by systematic flora surveys and the collection of ground predators by standardised pitfall trapping in Scheme areas. This ongoing monitoring has generated a valuable, detailed database of flora and Carabidae (ground beetle) fauna distributions and populations around Northern Ireland. It is likely that a Biological Record Centre will be established in Ireland in response to the forthcoming Biodiversity Action Plan, and it is hoped that this Centre will be modelled on the precedent set by CEDaR.

Another example of the establishment of a standard monitoring protocol is the development by the four Nordic countries of co-ordinated, standardised monitoring guidelines for terrestrial species and habitat diversity (From and Söderman, 1997). These valuable guidelines cover a wide range of groups — lichens, bumblebees, bats — as well as those groups such as birds and higher plants which normally receive greatest attention. In the UK, the well-established Butterfly Monitoring Scheme and the national Breeding Bird Survey have been carried out using consistent methods over a long period of time, providing both a valuable baseline for evaluating subsequent changes, and a ready-made framework for indicator selection and monitoring.

The Environmental Indicators for Agriculture document (OECD, 2001) states that many alternative baselines are possible with respect to wild species. These include setting the baseline at the time of the CBD's agreement in 1992, determining a baseline that represents the 'natural state', or establishing a baseline prior to the intensive use of inputs in agriculture, which for many OECD countries is around the 1950s. Because of the need to establish a baseline according to the same, standardised methodology used to conduct monitoring thereafter, ensuring that the baseline provides a meaningful basis for comparison, these three options will rarely be practical or possible. In all three cases, there are many other factors which can not be controlled for, and which prevent a direct comparison from being made with current levels of biodiversity.

An alternative is to set the baseline at the onset of the new wave of monitoring for which this OECD work is laying the foundations. In Ireland there are no long-term datasets that can be called upon to provide baseline data or from which potential indicator species can be selected. Therefore, the baseline should be defined as the situation at the onset of monitoring. Although this does not co-incide with the instigation of the CBD, or with the inception of the REPS in 1994, it is at least reliable and defined according to a standardised methodology. What the indicators are indicating will be clear. Deterioration or improvement will be related to known conditions.

Developing a baseline *de novo* is a challenge for Ireland and those other countries with little or no tradition of nature monitoring from which to draw. This, however, is accompanied by the advantage that the design of effective and appropriate monitoring strategies will not be 'data led'. There will not be the obligation to give undue emphasis to certain groups for the sake of continuity and convenience, rather than scientific justification and rigorous evaluation of their potential as indicators. For example, birds are frequently picked out to serve as indicators primarily because they are such a well-known, thoroughly-monitored group rather than for their indicator value *per se*: their selection is often 'data led'. In regions where there is no such outstandingly well-studied group, other more objective criteria can come to the fore in indicator group selection. These criteria are discussed below.

The selection of VECs (Valued Ecosystem Components) and indicator species

> "Indicators of wildlife species diversity related to agriculture: Appropriate key species indicators for each agro-ecosystem". "The choice of species (possibly surrogate species, taxonomic groups or Red List endangered species) would be left to individual countries" (OECD, 1999).
>
> "Indicators for species diversity cover trends in population distributions and numbers of a) wild species dependent and/or affected by agriculture, and b) non-native species threatening agricultural production" (OECD, 2001).

Effective biodiversity indicators of necessity have high spatial resolution: they are of little value without reference to the spatial context. As described above, "appropriate indicators for each agro-ecosystem" will be needed: a species that is a useful indicator in one particular area will be absent from other areas, or so common as to be insensitive to management change and habitat fluctuations. The diversity of landscapes and habitats within a region, not to mention the diversity of soil types within one farm, mean that national level quantification is highly problematic (OECD, 1999). Clearly, it is not possible to employ the same species indicators in different countries and ecosystems.

As the recent Environmental Indicators for Agriculture document (OECD, 2001) details, different countries have different approaches to assessing and monitoring wild species populations. There is wide variation in availability of data and in the level of biodiversity research. Moreover, most OECD countries do not have a specific monitoring system to track wild species populations and numbers on agricultural land (OECD, 2001). However, despite the diversity of approaches that have been taken in different countries, and despite the fact that different species indicators must be defined in different ecosystems and habitats, it is imperative that some level of standardisation be achieved between countries with regard to the monitoring of wild species agri-biodiversity. There are certain guidelines that should be adhered to if indicators are to be defined according to sound criteria.

The need for an objective and transparent approach to indicator selection

The species richness of agricultural areas may rank in the order of tens of thousands of species. The need to restrict the range of surveyed components has resulted in the development of focusing procedures to select suitable 'valued ecosystem components' (VECs) to provide the focal point for ecological impact assessment. Focusing procedures are not always formalised, and this aspect of impact assessment is fraught with difficulties. Ideally, VECs are selected according to criteria that are objective, consistent, transparent and defensible. VECs encompass habitat and ecosystem characteristics as well as individual species of interest. It is the wild species indicators that emerge from these focusing procedures that are examined in this paper.

Here the procedures according to which wild species which are potentially useful as VECs, and indeed as indicators, are selected will be considered.

OECD countries have applied different approaches to describe and assess the state and trends in population distribution and numbers of wild species associated with agriculture. Wide variation in the availability of data, differing stages of scientific research and varying policy priorities make the development of a consistent method of calculation extremely difficult. Amidst this patchy availability of data, there is a danger that VECs or ecological indicator species may be selected by two processes that rarely rely on scientific criteria (Pearson, 1994). First, rare taxa often become indicators by default. Public pressure may focus on the taxon itself, rather than what it purports to indicate, for example habitat degradation, ecosystem decline and species distribution patterns. Second, some taxa have been defined as indicators solely because they are well-studied and familiar, the taxonomic favourite of the in-house ecologists. Expedience alone is insufficient justification for the selection of an indicator taxon: if indicators are to be meaningful, their selection must be more rigorous and transparent.

Key criteria for the selection of indicator taxa

A number of useful criteria that can be used to objectively test the claim that a given taxon is an ideal indicator or VEC are discussed below (after Pearson, 1994, Brown, 1991). These criteria are:

- 'Surrogate value': patterns of biodiversity reflected in other related and unrelated taxa.
- Higher taxa broadly distributed geographically and over a breadth of habitat types, lower taxa specialised and sensitive to habitat change.
- Well-known and stable taxonomy, well-known natural history.

- Readily surveyed and manipulated.
- Potential economic importance.

'Surrogate value': patterns of biodiversity reflected in other related and unrelated taxa

Selected species should, by their presence alone, reveal useful information about the habitat and the species assemblage with which they are associated. A taxon which consistently occurs in association with certain other species (an 'umbrella species') is potentially useful in indicator development. Such 'surrogate taxa' may serve as useful proxies of biodiversity quality (OECD 1999, another reference). A guild is a group of species that exploit the same class of resources in a similar way, and the selection of 'guild indicator species' is a useful approach because it allows the assessment of habitat resources as well as species population. For endangered species, there is a risk that indirect monitoring using a guild indicator or surrogate species may jeopardise status, and so such species should be monitored directly.

Higher taxa broadly distributed geographically and over a breadth of habitat types, lower taxa specialised and sensitive to habitat change

Species (lower taxa) which are known to be susceptible to habitat change and which are highly responsive to defined impacts may serve as a useful 'early warning' for a wider community. Comparisons can more readily be made between studies conducted in different locations if the higher taxa (genera, families) are broadly distributed geographically and over a breadth of habitat types (Pearson, 1994).

Well-known and stable taxonomy, well-known natural history

Taxonomic stability and reliability is a prerequisite for any indicator taxon: identification must be relatively straightforward, not requiring a high level of expertise. Clearly, the natural history of the taxon must be well researched in advance in order to maintain a sense of ecological context at all times. Extensive natural history knowledge is necessary for the adoption of for example the 'guild indicator' approach: a considerable amount of information is needed to establish the presence of guilds in an area and to estimate the significance of difference between guild members. The concept can only be used for species that have been well studied and for which detailed autecological information is available (Treweek, 1999).

Readily surveyed and manipulated

In the event, the most mundane and practical reasons can lead to the selection of a particular group for targeted sampling. An otherwise ideal indicator taxon may require a highly labour-intensive sampling strategy for which the resources may not be available. Butterfly and dragonfly surveys, for example, require many repeated visits to the same sites in the same weather conditions. Groups that are sampled using sweep-netting (*e.g.* Heteroptera, see example below) can only be surveyed when vegetation is dry. This is a problem in a wet country like Ireland. Pitfall trapping does not present this particular difficulty.

Species selected as indicators should be those for which follow-up monitoring is a realistic option. One-off surveys alone are of little predictive value and do not contribute to the overall knowledge base. Selected species will need to be readily surveyed in a standardisable manner on an ongoing basis. The importance of standardising techniques cannot be over-emphasised (Stork and Davies, 1996). Where consistent, standardised survey methods are used there is considerably more scope for comparative analysis.

Potential economic importance

Evidence that populations of certain species are of economic importance can help to convince scientists and politicians that it is worth dedicating local personnel and resources to the study of those species. This is particularly the case in developing countries where pure of basic science is frequently considered a luxury (Pearson, 1994).

Monitoring studies evaluate changes in habitats or ecosystems over time, such as habitat degeneration. In this case, high priority for potential indicators is placed on sensitivity to environmental change. Priority assigned to indicator criteria will vary depending on whether it is a monitoring study or an inventory study that is being undertaken. Pearson's (1994) suggested prioritisation for monitoring studies is as follows:

1. Economic potential.
2. Occurs over a broad geographical range.
3. Patterns of response reflected in other taxa — 'surrogate value'.
4. Biology and natural history well-known, taxonomy stable.
5. Easily observed and manipulated.
6. Specialisation to habitat.

An example of indicator taxon selection is the study by Di Giulio *et al.*, (2001), on the enhancement of insect diversity in agricultural grasslands. The true bugs (Heteroptera) were chosen as an indicator group for insect diversity on the basis of the following criteria:

- They are an ecologically very diverse group, including phytophagous saprophagous and predatory species.

- Some species are generalists while others are specialists.

- Both larval and adult stages live in the same habitat and respond sensitively to environmental changes.

- Previous studies have shown that the richness of the bug fauna correlates strongly with total insect diversity.

- Despite their ecological diversity, the Heteroptera is a manageable group in terms of the numbers of species occurring in grasslands.

Assessing the impact of the REPS on plant and invertebrate species diversity on farmland: an example of agri-biodiversity monitoring and indicator selection

In order to illustrate the kind of fieldwork that agri-biodiversity monitoring necessitates, an outline of my research methodology is given below. The fieldwork protocol reflects in a practical way some of the constraints that differentiate between theory and practice. This research is being undertaken as part of a Ph.D. funded by Teagasc, the Irish agriculture and food development authority.

The study assesses the impact of the REPS on plant and invertebrate species. Measures relating to the management of field margins, watercourse margins and hedgerows (measures 3, 6 and 9) were examined. Two farming systems, drystock grassland and tillage, were studied. These were selected in order to reflect the generality of REPS farms: the majority of REPS farms are grassland, with tillage being the second highest farm management type in the Scheme. Special Areas of Conservation (SACs) were avoided, as were areas of particularly high nature-value, again in order to conserve the relevance of the study to the ordinary farmland that comprises the majority of farmland within REPS.

Focusing procedures were employed to select groups for sampling, and a standardised protocol for the evaluation of these groups was established. Habitat types and indicator species for those habitats are now being identified from the data. These indicator species will be hilighted thereafter because they are disproportionately informative, and are useful as 'cases in point' in describing the effects that the scheme is having. This approach is modelled on the monitoring methodology employed in Northern Ireland in the ongoing ESA (Environmentally Sensitive Area) scheme evaluation (Anderson *et al*., 2000).

Methods

Indicator group selection

Two taxa, plants and Carabidae or ground beetles, were selected for sampling. Both groups fulfil many of the criteria for indicator group selection discussed earlier.

Higher plants are the mainstay of many monitoring and assessment studies: they are the primary producers and most habitats are characterised according to floral composition. Plant diversity can act as a surrogate for the diversity of other taxa because many species in a community are specifically adapted to the presence of host plant species (Begon *et al*., 1996, Spellerberg, 1995). Plants were surveyed using quadrats in field margins. A hierarchical sampling design enhanced sensitivity to community change.

The Carabidae were selected as an invertebrate indicator group. Broadly distributed geographically and across a wide range of habitats, the group features several guilds including herbivores, predators and scavengers. Some species are widely-distributed generalists while others feature highly specific habitat requirements; their potential contribution to the assessment of environmental threat and pollution must be regarded as significant (Forsythe, 1996, Anderson *et al*., 2000). Carabids were surveyed using pitfall traps. This standardisable, widely-used technique yields large amounts of data per unit effort compared to other invertebrate sampling methods such as butterfly surveying, which is highly labour-intensive. Pitfall trapping is biased towards the most active surface-movers, rather than the most abundant, and other techniques such as sweep-netting and D-vac sampling may avoid this bias (Southwood and Henderson, 2000). These, however, require perfectly dry conditions and collect many juveniles, which are difficult to identify.

Fieldwork

Fieldwork was carried out during 1999 and 2000. 60 farms in three counties were surveyed, 30 of which were REPS farms and 30 non-REPS farms. During 1999, cattle-grazed grassland in Laois and Offaly was surveyed, and during 2000 tillage land in Wexford was surveyed (Table 1). Farms were selected by random selection from a list of suitable farms. Only REPS farms which had been in the scheme for at least four years were selected. This was necessary to optimise the likelihood of detecting any impact that the scheme may be having.

Table 1. **Breakdown of the 60 farms surveyed during the study**

County	Farm type	REPS farms	Non-REPS farms	Year sampled	Total
Laois	Grassland	7	7	1999	14
Offaly	Grassland	8	8	1999	16
Wexford	Tillage	15	15	2000	30

Plants

On each farm two hedgerows, their associated field margins and one watercourse margin were surveyed. Each of these components was, wherever possible, selected randomly. Field and watercourse margins were surveyed using a nested quadrat system incorporating both percentage cover and species presence data (Cameron *et al*., 1997). Recording at a range of scales in this way maximises the likelihood of detecting changes in the abundance of a wide range of species (Critchley 1997). The boundary area 1.5 m from the hedge or the watercourse was surveyed separately from the next 1.5 m band out from that, thereby enabling assessment of the impact on plant diversity of measures designed to eliminate inputs in field margins and alongside watercourses.

Carabidae (Ground Beetles)

Carabids were recorded using pitfall traps. Trapping was done in early June and late August. On each trapping occasion two pitfall traps 10 m apart were set in each of the two plant-surveyed field margins, yielding a total of 8 traps per farm. Traps were left in place for two weeks. Beetles were identified to species using Lindroth (1996) and Forsythe (1996).

Environmental variables

The environmental variables that were recorded from each site included hedge height, gappiness, approximate age of the hedge, aspect, an outline of the management history of the field, age of watercourse fence and proximity to large non-farmland habitats such as forests, bogland or lakes. Soil samples were taken from all the plant relevée sites, both from the inside 1.5 m strip and the outside 1.5 m strip. Basic nutrient analysis was carried out on the samples. A brief questionnaire was administered to ascertain details about management of the surveyed fields, to ask farmers what they thought of the scheme and — in the case of REPS farmers — to investigate the changes that the scheme has necessitated on their particular farm.

Data analysis: statistical methods used to select indicator species from a dataset

Two-Way Indicator Species Analysis (TWINSPAN) is a widely-used analytical technique for examining species assemblages and pinpointing species which indicate the presence of assemblages of interest (Kent and Coker, 1992). The analysis involves the construction of ordered two-way species/sites tables. This is done at a series of levels, where the data are divided into paired groups. The groups are further subdivided until the operator perceives that the end groups correspond with the different communities observed. To each division, and to each of the final assemblages, at least one indicator species is assigned.

In the ground beetle dataset, one of these ‘final assemblages’ is a group of species that are characteristic of well-established woodland. The presence of these species in hedgerows can be interpreted as an indication that the hedgerow is likely to be particularly ancient. The indicator species that is assigned to this assemblage is *Cychrus caraboides*, a large distinctive beetle with characteristically elongated mouthparts that are adapted for consuming snails. It is, in other words, very easily identified by a non-expert. In the plant dataset, common cleavers (*Galium aparine*) and nettles (*Urtica dioica*) have been identified as indicators of soils that are particularly rich in nutrients such as phosphorous.

In the monitoring of the Northern Ireland ESAs, the two species *Carabus nitens* and *Nebria salina* were found to be particularly characteristic of the community that favours open conditions in upland heaths including mountain summits. These two species are therefore indicators of that particular ecosystem.

Relating indicators to changes in agricultural practices

> "For policy makers, it is very important to be clear about the precise linkage of any indicator to agricultural practices. A number of indicators have been developed which are not very sector-specific, in the sense that agriculture's contribution to the harm and/or benefit of the environment cannot be separated from other economic sectors. This makes it difficult to interpret the agricultural policy implications of the indicators" (OECD, 1999).

Relating indicators to changes in agricultural practices is very important if they are to be policy-relevant. In my work, this linkage is achieved by carrying out fieldwork which related directly to specific measures within the Scheme, and carrying out the same procedures on areas which are not subject to those measures.

For example, REPS tillage farmers are asked to leave an uncultivated margin of at least 1.5 m in all tilled fields, and to eliminate chemical inputs in this margin area. The width of these uncultivated margins on 15 REPS and 15 non-REPS farms was measured (in order to assess compliance), and REPS margins were found to be significantly wider. Plant surveys and invertebrate surveys were then carried out in these margins in order to evaluate whether this impacted on flora and fauna in the margins: relating policy to ecology. A second measure requires the fencing of watercourse margins where livestock are present, and a similar approach was adopted in order to assess the success of this measure in meeting its objective of benefiting riparian flora and fauna.

Conclusions

1. Species indicators have high spatial variation: one habitat's indicator species will not be another habitat's indicator species. However, the same guidelines and criteria should be used to select these indicators across different ecosystems and indeed nations. A common approach should be adopted across OECD countries.

2. Baseline data are fundamental to any monitoring strategy. The most recent Environmental Indicators for Agriculture document (OECD, 2001) cites several possible baselines. These include setting the baseline at the time of the CBD's agreement in 1992, determining a baseline that represents the 'natural state', or establishing a baseline prior to the intensive use of inputs in agriculture. However, baseline data must be collected according to the same methodology employed in ensuing monitoring. Thus, the most reliable basis for comparison will usually simply be the situation at the onset of monitoring.

3. The steps towards species indicator selection (focusing procedures) can be summarised as:

   - Theoretical criteria including 'surrogate value' as discussed in the 1999 Environmental Indicators for Agriculture document (OECD, 1999), where patterns of diversity are reflected in other taxa. Other criteria, discussed here, include the wide distribution of higher taxa, specialisation and sensitivity to habitat change of lower taxa (species), well-known and stable taxonomy and thoroughly researched natural history.

   - Practical considerations concerning fieldwork methodology. For example, target groups must be easily handled and identified, and survey methods must be standardisable between different regions.

   - The selection of indicator species from data, using statistical tools such as Twinspan (Two-Way Indicator Species Analysis).

4. Amidst patchy availability of data, there is a danger that ecological indicator species may be selected by two processes that rarely rely on scientific criteria. First, rare taxa often become indicators by default. Second, some taxa have been defined as indicators solely because they are well-studied and familiar. Expedience alone is insufficient justification for the selection of an indicator taxon: if indicators are to be meaningful, their selection must be more rigorous and transparent.

5. Ireland, like many other countries, is a relatively blank canvas in terms of baseline data availability, monitoring development and species indicator selection. This means that indicator development can proceed in an unbiased manner, not 'data-led' but rather 'problem-led'.

REFERENCES

Anderson, R., D. McFerran, and A. Cameron (2000), *The Ground Beetles of Northern Ireland (Coleoptera — Carabidae). Atlases of the Northern Ireland Flora and Fauna Vol. 1*. Belfast: The Ulster Museum/National Museums and Galleries of Northern Ireland.

Begon, M., J.L. Harper and C.R. Townsend (1996), *Ecology — Individuals, Populations and Communities*. Oxford: Blackwell Science.

Bignal, E.M. (1998), Using an ecological understanding of farmland to reconcile nature conservation requirements, EU agriculture policy and world trade agreements. *Journal of Applied Ecology* 35: 949-954.

Brown, K.S. (1991), Conservation of neotropical environments: insects as indicators. In: *The Conservation of Insects and their Habitats* (eds. N.M. Collins and J.A. Thomas). London: Academic Press.

Cameron, A., C.A. Millsopp and J.H. McAdam (1997), Biological Monitoring of Grasslands in the West Fermanagh and Erne Lakeland Environmentally Sensitive Area. In Sheldrick, R.D. (ed.) *Grassland Management in the 'environmentally sensitive areas': proceedings of the British Grassland Society Conference held at the University of Lancaster, 23-25 September 1997.* Reading, British Grassland Society.

Critchley, C.N.R. (1997), Monitoring methods. In Sheldrick, R.D. (ed.) *Grassland Management in the 'environmentally sensitive areas': proceedings of the British Grassland Society Conference held at the University of Lancaster, 23-25 September 1997*. Reading: British Grassland Society.

Department of Agriculture and Food (1999), *Rural Environment Protection Scheme. Agri-Environmental Specifications, revised 1 January 1999.* Dublin: Government of Ireland Publications.

Dept of Arts, Heritage, Gaeltacht and the Islands (1998), *First Report on the Implementation of the UN Convention on Biological Diversity in Ireland.* Dublin: Government of Ireland Publications.

Di Giulio, M., P.J. Edwards and E. Meister (2001), Enhancing insect diversity in agricultural grasslands: the roles of management and landscape structure. *Journal of Applied Ecology* 38: 310-320.

Fay, F. (1998), European Commission's Report on the Application of the Agri-Environment Regulation, COM (87) 620. In Teagasc (1998) *REPS Conference Proceedings — Protecting Ireland's National Heritage.* Dublin: Teagasc publications.

Forsythe, R.G. (1996), *Common Ground Beetles. Naturalists' Handbooks 8.*

From, S. and G. Söderman (eds.) (1997), *Nature Monitoring Scheme. Guidelines to Monitor Terrestrial Biodiversity in the Nordic Countries*. Copenhagen: The Nordic Council of Ministers.

Hamell, M. (1999), Environmental Protection Requirements for Agriculture — Perspective for the New Millennium. In Teagasc (1999) *REPS Conference Proceedings.* Dublin: Teagasc publications.

Kent, M. and P. Coker (1992), *Vegetation Description and Analysis: a Practical Approach.* Chichester: John Wiley and Sons.

Lindroth, C.H. (1996), *Handbooks for the Identification of British Insects Vol. IV Part 2: Coleoptera — Family Carabidae.* London: Royal Entomological Society of London.

McCracken, D.I. and Bignal, E.M. (1998), Applying the results of ecological studies to land-use policies and practices. *Journal of Applied Ecology*, 35: 961-967.

OECD (1999), *Environmental Indicators for Agriculture — Volume 2: Issues and Design*. Proceedings of the OECD Workshop on Measuring the Environmental Impacts of Agriculture (K. Parris, ed.). Paris: OECD Publications.

OECD (2001), Environmental Indicators for Agriculture — Volume 3: Methods and Results. Paris: OECD Publications.

Ovenden, G.N., A.R.H. Swash and D. Smallshire (1998), Agri-environment schemes and their contribution to the conservation of biodiversity in England. *Journal of Applied Ecology*, 35: 955-960.

Pearson, D.L. (1994), Selecting indicator taxa for the quantitative assessment of biodiversity. Philosophical Transactions of the Royal Society of London B 345: 75-79.

Southwood, T.R.E. and P.A. Henderson (2000), *Ecological Methods (Third Edition)*. Oxford: Blackwell Science.

Spellerberg, I.F. (1995), *Monitoring Ecological Change.* Cambridge University Press.

Stork, N. and J. Davies (1996), Biodiversity inventories. In: Biodiversity inventories. In: *Biodiversity Assessment. A Guide to Good Practice.* London: HMSO.

Treweek, J. (1999), *Ecological impact assessment*. Oxford: Blackwell Science.

AN AGRICULTURAL HABITAT INDICATOR FOR WILDLIFE IN KOREA

Jin-Han Kim, Byung-Ho Yoo, Changman Won, Jin-Young Park and Jeong-Yeon Yi[1]

Introduction

As a well known from many sources the popular definition, "biodiversity" may be considered as "the total variety of life on earth, which includes all genes, species and ecosystems and the ecological processes of which they are part". Biodiversity, thus, is the basic resources for ecological services and for sustaining the Earth's life support system.

Basic unit should be taken species, because the species plays an important and unique role in ecosystem. Ecosystem diversity relates to the variety between and within ecosystems types and agricultural practice area has a broad range of ecosystem types ranging from the Mountain grassy meadows to intensive rice paddy and different kinds of wetlands found in those areas. Ecosystems are very complex systems in which many different organisms and species interact**.** Certain species (species group) changes in accordance with the habitat conditions. It is important to inventory these sensitive species because they themselves can become the important indicators. Among the living organism, birds are regarded as important indicators because:

- are valuable in their own right;
- are sensitive indicators of biological richness and environmental condition. And also integrate and accumulate environmental stresses over time because they are usually high level in the food chain and have relatively long life-spans. Thus birds can be used as indicators of unexpected environmental problems, when declining numbers and breeding success of birds such as the White-tailed Eagle *Haliaeetus albicilla*, Osprey *Pandion haliaetus*, Golden Eagle *Aquila chrysaetos* and Black Kite *Milvus migrans*;
- are vital for ecological functions in the natural environment;
- have a direct and indirect economic and cultural value to people;
- are well known organisms. Because the biology, ecology, behavior, and evolutionary histories of many birds have been extensively studied, scientists have a foundation to ask the most pertinent questions, base hypotheses, to obtain answers, and to cultivate solutions. This background knowledge reduces risk of misinterpretation, allowing scientists to use birds, sensitive to stresses in predictable ways, as a proxy measure of environmental change. Furthermore, this background knowledge yields cost-effective research, since studies using other groups of animals often requires several years of basic data gathering before monitoring can begin;

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- provide a useful means to improve our scientific knowledge and understanding of the environment;
- are beautiful and inspirational, and a source of happiness and pleasure for many people;
- are very useful for promoting conservation awareness.

Birds are international resource, because every year an estimated 50 billion birds make migratory journeys, along a network of routes that encompasses the whole world. Sometimes travelling tens of thousands of kilometres, crossing continents and oceans, migratory birds have become so well adapted to this task that they can traverse the largest deserts and seas, the highest mountains and expanses of ice. The record for distance covered in a single year belongs to the Arctic Tern (*Sterna paradisaea*) and is of the order of 50 000 km, with songbirds not far behind with journeys of 20 000 to 30 000 km. Waders migrating from Siberia, Russia via Korea, China and Japan to Tasmania, Australia hold records for non-stop flight, over distances that probably somewhat exceed 7 000 km. Seabirds wing their way over all the world's oceans and seas.

Agriculture in Korea

Korea and Japan is the only East-Asian OECD countries. The characteristic agriculture system of both countries is the composition of rice paddy. In Korea, the rice paddy area is 1 149 thousand hectares which form 60.8% of total arable land area, 1 889 thousand hectares (Table 1). The arable land area per farming family is 1.37 hectares, this figures are relatively small scale. Many of the rice paddies are patched and surrounded by forest or mountains, and have played an ecological roles for two thousand years.

Table 1. **The importance of rice paddy in agriculture of Korea**

Major Indexes / Year	1990	1995	1998	1999	2000
Total land area *	9,926	9,927	9,941	9,943	9,946
Arable land area *	2,109	1,985	1,910	1,899	1,889
-composition rate	21.2%	20.0%	19.2%	19.1%	19.0%
Rice paddy area *	1,345	1,206	1,157	1,153	1,149
Crop field area *	764	779	753	746	740
Percentage of Rice paddy area in Arable land area	63.8%	60.8%	60.6%	60.7%	60.8%
Arable land area per family **	1.19	1.32	1.35	1.37	1.37

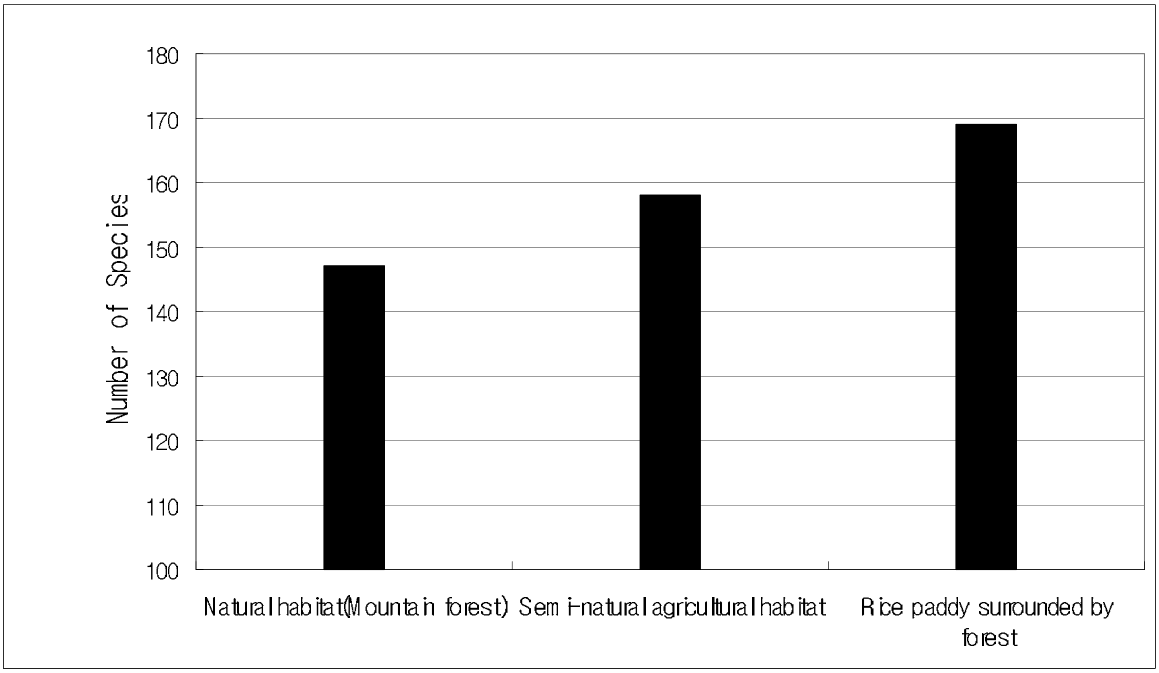
* : units are 1,000 hectares.
** : units are one hectares.
Source: Ministry of agriculture and forestry. http://www.maf.go.kr/html/pds/pds01_01.htm

Number of bird species in three agricultural categories

To compare the differences between agricultural habitat types, 405 wildlife survey plots (30 hectare scale) were divided into natural habitats (mountain forest), semi-natural agricultural habitats and agricultural habitats (rice paddy surrounded by forest). From 405 survey plots, 128 plots were classified as natural habitats, 127 plots were classified as semi-natural agricultural habitats and 92 plots were classified as agricultural habitats. The total number of bird species surveyed from January to December in 2000 was 169 species in rice paddies surrounded by forest, 158 species in semi-natural agricultural habitats and 147 species in mountain forests (Figure 1). The high avian species diversity in the habitats of rice paddy surrounded by forest can be explained by the role of forest patches and edge effects on the avian community, furthermore the rice paddy plays important role as a good wetland habitat for some kinds of waterbirds which do not occur in the mountain forest habitats. And also the water channels and reservoirs set up for farming purpose support some waterbirds as a kind of wetlands.

The dominant species in rice paddies surrounded by forest were Tree sparrow, Roufous-necked turtle dove, House swallow, Spot-billed duck, magpie and Great egret. In semi-natural agricultural habitats, dominant species were Crow tit, Roufous-necked turtle dove, Great tit, Azure-winged magpie, Brown-eared Bulbul, Tree sparrow and Magpie. In natural habitats, the dominant species were Crow tit, Long-tailed tit, Roufous-necked turtle dove, Azure-winged magpie, Great tit, Brown-eared Bulbul, Jay and Yellow breasted bunting. The dominant species between natural and semi-natural habitats have similarities. mountain forests. The high avian species diversity in the habitats of rice paddy surrounded by forest can be explained by the role of forest patches and edge effects on the avian community, furthermore the rice paddy plays important role as a good wetland habitat for some kinds of waterbirds which do not occur in the mountain forest habitats. And also the water channels and reservoirs set up for farming purpose support some

Figure 1. **Numbers of bird species in three agricultural categories**



Number of mammal species in three agricultural categories

In the same study plots, mammal species were surveyed from July to October. But the results were reverse to those of bird (Table 2). In October, 8 species and 55 individuals were surveyed in rice paddies surrounded by forest, 14 species and 244 individuals in semi-natural agricultural habitats and 19 species and 283 individuals were surveyed in mountain forests. One of the reason of the high mammal species diversity in the habitats of mountain forest may be the abundance of hides, on the other hand the rice paddy is lack of hide.

Table 2. **Numbers of mammal species in three agricultural categories**

Month / Habitat	July	August	September	October
Natural habitats(Mountain forest)	16 species 268 ind.	17 species 265 ind.	16 species 267 ind.	19 species 283 ind.
Semi-natural agricultural habitats	13 species 228 ind.	14 species 224 ind.	15 species 236 ind.	14 species 244 ind.
Agricultural habitats (rice paddy surrounded by forest)	6 species 20 ind.	5 species 26 ind.	7 species 38 ind.	8 species 55 ind.

Population dynamics of avian index species of farmland

One of the representative avian species in Korea is Tree sparrow *Passer montanus*. Their density was low till 1970's and after then their density was increased to 467.6 individuals per one hundred hectare in 1988. In this period, housing renovation movement was taken place as a part of rural development. This cause the deficiency of suitable nesting places for sparrow, formerly they can easily nest in the thatched houses. With this effect and the spread of chemicals, pesticides and herbicides cause the decrease to 176.2 individuals per one hundred hectare in 1998 (Figure 2).

Habitat selection of birds in farmland especially rice paddy

Egrets

These species use rice paddy mainly for foraging ground after rice plantation from when the water control begin (Table 3). Thus in Korea, most egret breeding colonies located near big scaled rice paddy.

Waders

Most waders are passage migrant. Some species use rice paddy for stop-over site and very few species use for nesting place. But most species use tidal flat for their habitat.

Cranes, dabbling Ducks and Geese

Migrate from northern breeding area and wintering mainly feed on rice residues on the rice paddy.

Crakes and Rails Rallidae

These species use rice paddy as breeding, foraging and resting site. Intensive agricultural practices lead the dramatical decrease of these species.

Birds of prey

These species use rice paddy running after ducks and small rodent, their food resources.

Also rice paddy serve as a good foraging ground for Crows, Rofous turtle dove and Pheasant in winter and autumn.

Figure 2. **The population dynamics of Tree sparrow in rural areas in Korea**

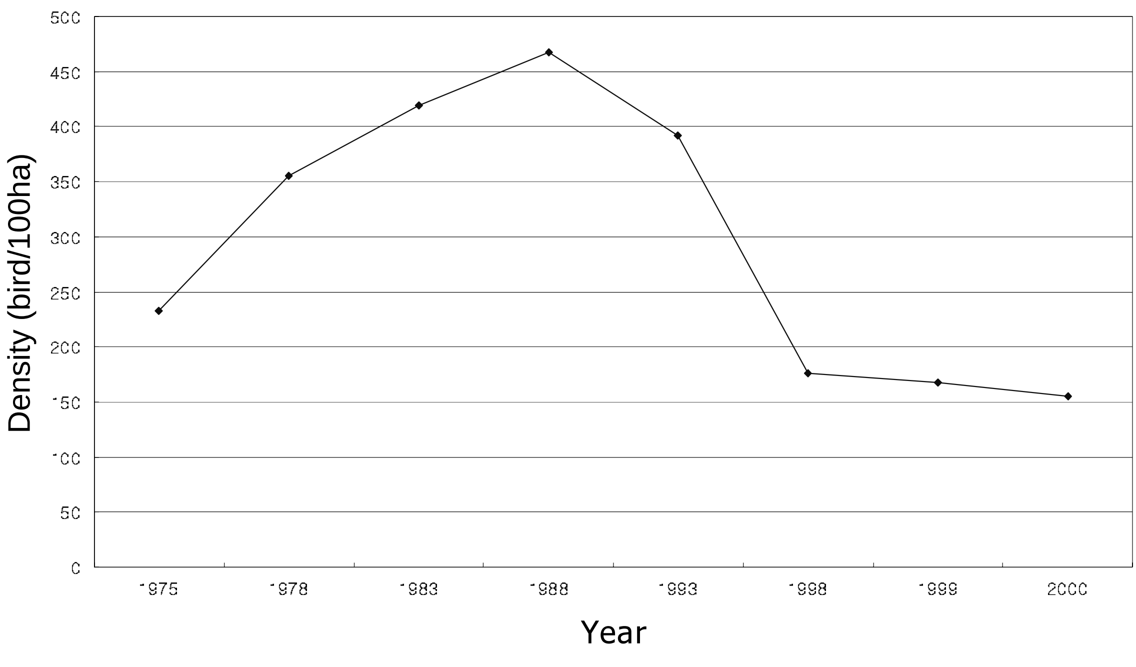


Table 3. **The habitat utilizations of rice paddy by different bird taxa in Korea**

Taxon	Breeding	Foraging	Resting	Remarks
Egrets		○	○	Summer visitor
Ducks and Geese		○	○	Winter visitor
Waders		○	○	Passage migrant
Cranes		○		Winter visitor
Crakes	○	○	○	Summer visitor
Gulls		○	○	Resident
Birds of prey		○	○	Winter and Summer visitor
Passerriformes	○	○	○	Resident and migrant
Crows		○		Winter visitor

To identify the habitat selection of Egrets, we investigate their feeding sites. Great egret *Egretta alba modesta* use reservoirs most (32.4%) for their feeding site, rice paddies (27.6%) and water channels (25.5%). Little egret *Egretta garzetta* use rice paddy most (43.8%) and next is water channels (23.4%). On the other hand, Intermediate egret *Egretta intermedia* and Cattle egret *Bubucus ibis* were surveyed to use only rice paddy for foraging (Table 4).

Table 4. **The feeding site selection of Egrets**

Species		River	Stream	Rice paddy	Channel	Reservoir	Total
Great Egret	%	2.1	12.4	27.6	25.5	32.4	100
	Observed ind.	3	18	40	37	47	145
Little egret	%	14.1	14.1	43.8	23.4	4.7	100
	Observed ind.	9	9	28	15	3	64
Intermediate	%	-	-	100	-	-	100
Egret	Observed ind.	-	-	15	-	-	15
Cattle egret	%	-	-	100	-	-	21
	Observed ind.	-	-	21	-	-	-
Grey Heron	%	16.7	1.6	13.5	25.5	42.7	100
	Observed ind.	32	3	26	49	82	192

Impact of green house on Hooded cranes wintering population

About 200-300 The Hooded cranes(*Grus monacha*) had wintered at Dasan-myun, Goryeong county, Kyungsangbuk province and Dalsung-dong Daegu. And furthermore this area is one of three possible flyways of Hooded cranes from breeding ground in far eastern Russia to the main wintering ground in Izumi Japan. So at least three thousand Hooded cranes are believed to use this area for their annual route and some populations use this area as a stopover area and wintering ground. This area possess seven thousand hectares scaled rice paddy along Nakdong river. In this rice paddy, the grain of rice residues were the primary food for Hooded cranes during the wintering period and for passage migrants during spring northern migration period. Hooded cranes ate more than 98% of rice grains in paddy fields and ate less than 1% plants tubers and vegetables in upland fields (Cho and Won, 1998). The mean density of crop residues(mainly unhulled rice grains) decreased from 3.52 g dry wt/m^2 in October to 2.08 g dry wt/m^2 in March after the departure of the Hooded cranes($p<0.05$). The amount of rice grain residues are sufficient for the wintering hundred Hooded cranes based on crane-use days.

The increase of green houses affect negatively to the Hooded cranes wintering population. The area of green houses increased to 48.1% than 1993. In 1997 the percentage of green houses rose to 650 hectare and this resulted no more wintering cranes (Table 5).

Table 5. **The impacts of green houses to the Hooded cranes wintering population**

Year	Area of rice paddy(ha)	Crop field (ha)	Area of Green houses (ha)	Number of Wintering Hooded Cranes
1988	- *	-	-	214
1989	-	-	-	253
1990	-	-	-	315
1993	7 035.2	2 930.2	498.1	-
1994	7 013.5	2 906.5	579.6	175
1995	6 830.1	2 774.0	599.8	-
1996	6 813.4	2 766.6	596.9	110
1997	6 789.3	2 753.0	650.8	0
1998	6 743.0	2 730.1	690.7	0
1999	-	-	737.8	0

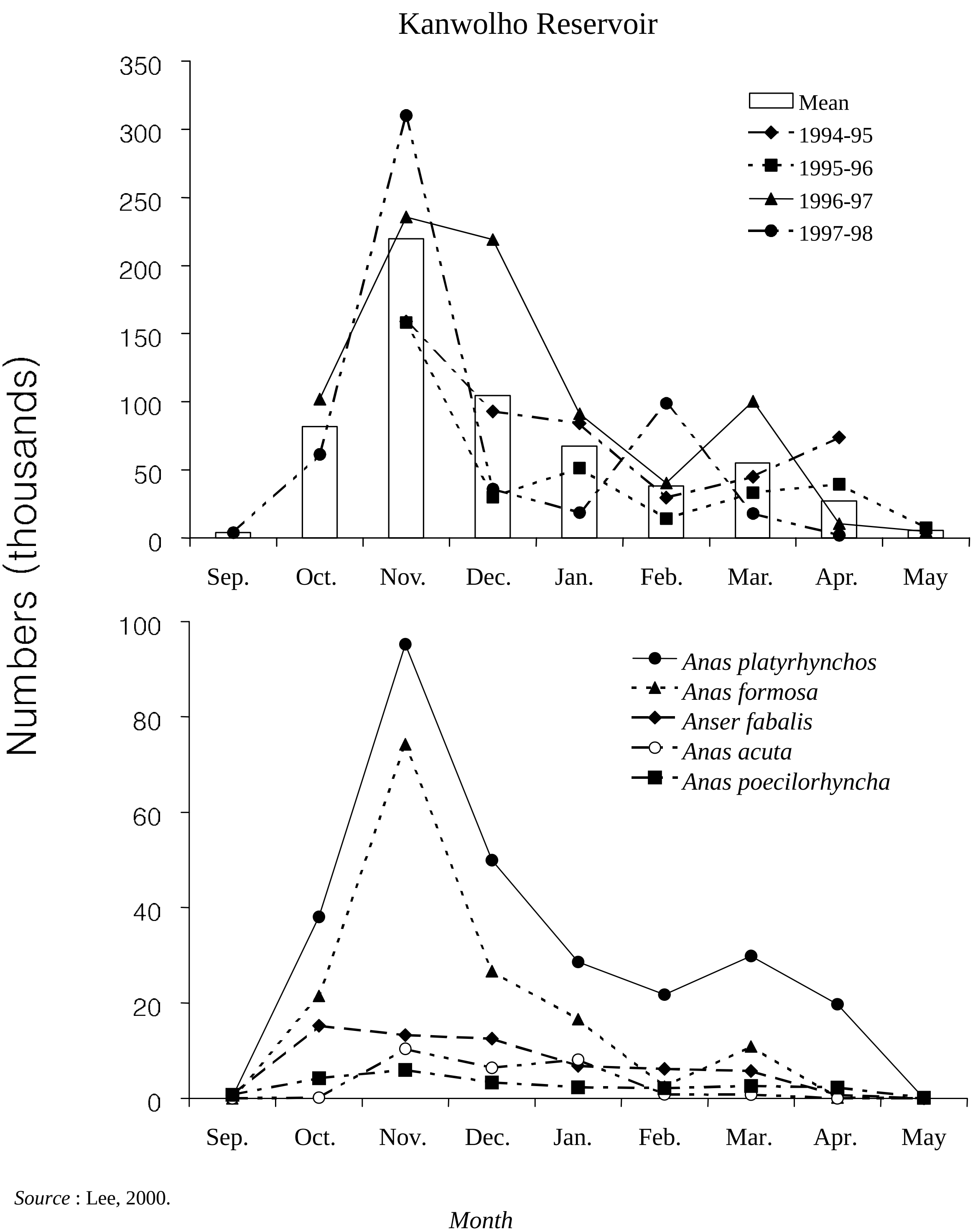
* : not available.

Impact of ploughing on wintering waterfowl community

During wintering season many waterfowls use rice paddy for food and for shelter mainly escapes from their roosting site by human interferences. Some Farmers began to plough the rice paddy for next year, but this agricultural practice affect the movement of waterfowl community.

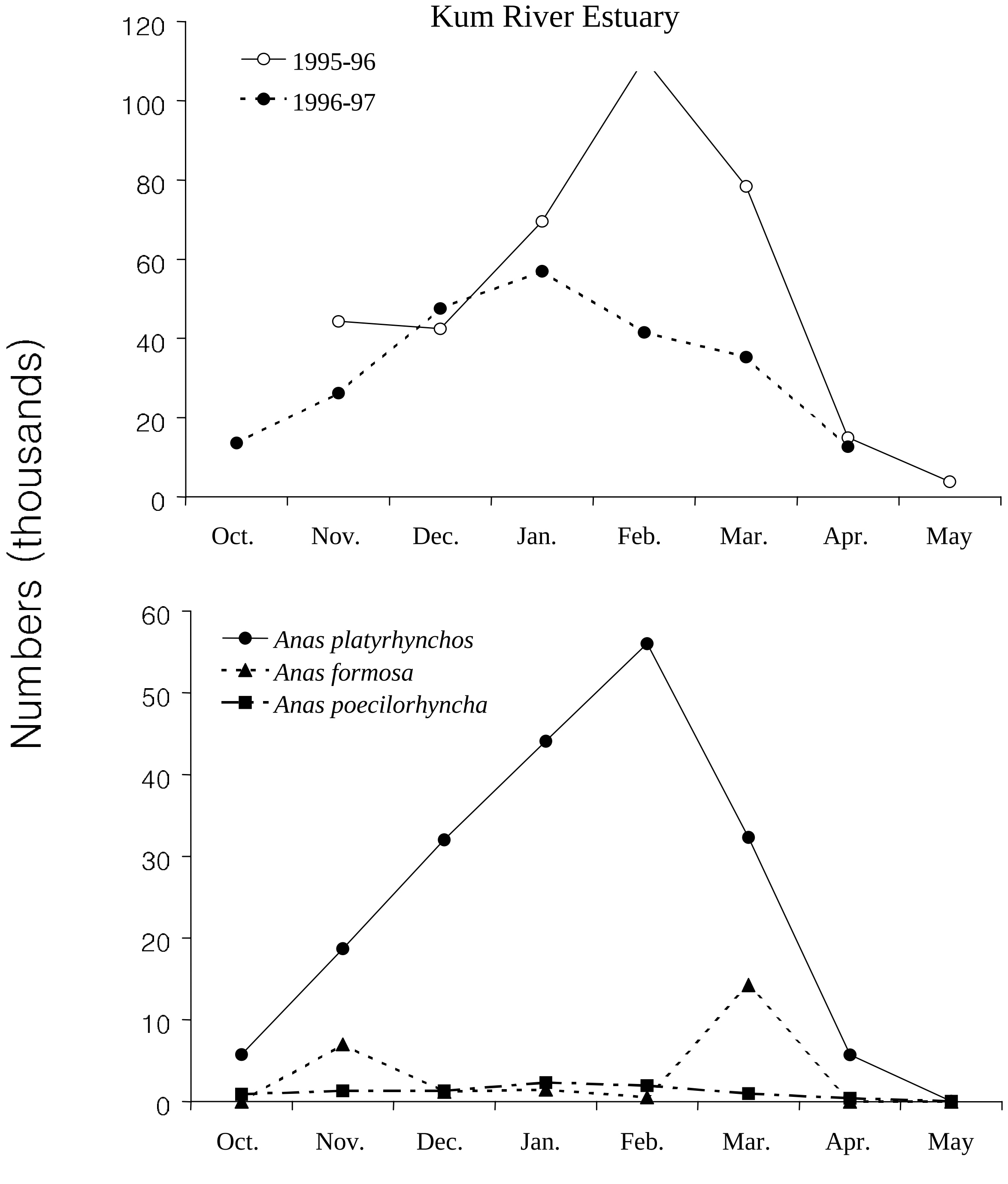
In the vicinity of Kanwol reservoir (Seosan reclaimed area A) there are big rice paddy which ran by private company. Normally from November the farmers began to set fire on the rice paddy for easy ploughing and they finished ploughing by December or January. Ploughing decreased the availability of food resources especially for ducks. The density of Mallards *Anas platyrhynchos* and Baikal teal *Anas formosa*, the dominant species in this area decreased from December rapidly (Figure 3). While the Kum river area, where ploughing began from March, the density of ducks increased till February (Figure 4).

Figure 3. **Numbers of waterbirds and the dominant species on Kanwolho Reservoir of Chonsu Bay during 4 years from Nov. 1994 to Apr. 1998. Numbers of the dominant species were averaged on the data of 4 years**



Source : Lee, 2000.

Figure 4. **Numbers of waterbirds and the dominant species on the estuary of Kum River, Korea, from Nov. 1995 to Apr. 1997. Numbers of the dominant species were averaged on the data of 2 years**

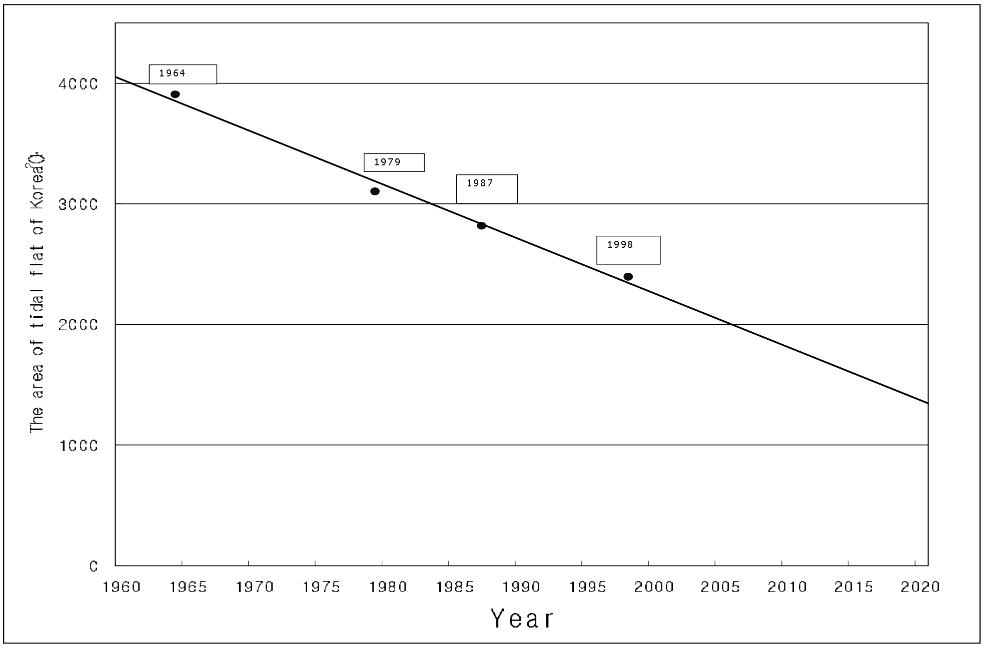


Source: Lee, 2000.

Habitat loss by land reclamation for intensive agricultural use

One of the main cause of threats to wetlands and biodiversity in Korea is reclamation. In the west coast of Korea, most places are disturbed by human interference. In the 1960's the main purpose of reclamation was to meet the needs of agriculture production, particularly rice. From the 1970's reclamation pressure was also a result of industrialization, urbanization and waste deposit needs — all occurring on a large scale (Figure 5). Reclamation of tidal flats crucially affects marine ecosystems, bentic invertebrates, fish and shorebirds population. Many land reclamation projects either completed or currently being carried out revealed many anticipating problems, such as pollution from sewage, ecosystem function failure and economic impacts to the aquatic-products industry. Recognizing the seriousness of the loss of wetlands and their biodiversity caused by the land reclamation, the government enacted the Coastal Management Act in 1997 to stipulate the provisions for establishing an integrated coastal management mechanism which can comprehensively coordinate policies with regard to conservation, utilization and development of coastal wetlands. Currently, action plan on the integrated coastal management prepared by the Ministry of Environment and Ministry of Maritime Affairs and Fishery.

Figure 5. **The decrease of tidal flat in Korea**



Conclusion

The high species diversity recorded in the agricultural fields (rice paddy) illustrate the importance of these areas as feeding and breeding grounds for wildlife. But in other instances croplands might act as barriers to dispersal of certain species, thereby limiting them to habitats provided by the corridors of forest edges and other habitats.

Agricultural installations such as green houses affect negatively to the avian diversity and habitat utilization. Ploughing time is very essential for migratory birds since they use the limited resources in mass flocks and in a relatively short period. Next step of study might be focused on the sustainable and adequate agricultural practice details and management system.

In another point of view, we may consider the flyways of migratory birds as well as rare and endangered species in developing the Agri-environment index. Some areas estimated as normal habitats but actually have been supported large numbers of rare and endangered species.

REFERENCES

Cho, S.R. and P.O. Won (1990), Wintering ecology of Hooded crane *Grus monacha* Temminck in Korea. Bulletin of the Institute of Ornithology, Kyung Hee Univ. 3.

Fleharty, E. D. and K. W. Navo (1983), Irrigated cornfields as habitat for small mammals in the sandsage prairie region of western Kansas. Journal of Mammalogy, 64:367-379.

Kim, Jin-Han (1998), Ecology and management of migratory birds in Korea-with special reference to waterbird migration on the west coast in Korea. Doctoral thesis. KyungHee University. p. 98.

Lee, Kisup (2000), Current status and population fluctuations of waterbirds on the west coast of Korea.. Doctoral thesis. KyungHee University. p. 211.

Ministry of agriculture and forestry. http://www.maf.go.kr/html/pds/pds01_01.htm

Navo, K. W. and W. D. Fleharty (1983), Small mammals of winter wheat and grain sorghum croplands in West-Central Kansas. Prairie Naturalists, 15:159-172

Schamberger, M. (1988), Monitoring wildlife habitat a critique of approaches. Statistical Journal of the United Nations ECE 5:303-313.

Short, H. L. (1982), Development and use of a habitat structure model for natural resource management. Transactions North American Wildlife and Natural Resources Conference 47:57-72.

Short, H. L. (1988), A habitat structure model for natural resource management. J. Environmental Management 27:289-305.

USING BIRD DATA TO DEVELOP BIODIVERSITY INDICATORS FOR AGRICULTURE

Melanie Heath and Matthew Rayment[1]

Birds as indicators

The wealth and quality of data on birds, relative to other taxa, may be used to develop the thinking and lead the way in the development and application of biodiversity indicators at local, national, regional and global levels. It is important therefore that bird data are being put to best use in the development and application of such indicators. How effectively we are conserving the world's birds is a means of assessing how successful we are in conserving ecosystem functions and biodiversity as a whole.

Birds are good indicators of spatial biodiversity and sustainability, because:

- they are high in the food chain, thus integrating changes at other levels;
- they occupy a broad range of ecosystems and have varied natural histories;
- a wealth of data has been (or can be) collected by volunteers and professionals, and bird population sizes and trends, and conservation status, are often well known relative to other taxa;
- they are meaningful to a wide audience including the public.

There is therefore increasing interest in the use of ornithological data to indicate the effects of environmental change on biodiversity. Bird indicators are likely to form an important component of sets of indicators for biodiversity and habitats. Habitat indicators can be used to assess wider, "macro" level changes, while indicators for birds and other taxa can also be used to identify more subtle changes in biodiversity within habitats. By highlighting these changes, bird indicators can point to the need for more detailed research to identify the causes of change in populations of different species.

Further research into biodiversity change will help to establish whether birds are always the best group to use as indicators, and the extent to which indicators need to incorporate other taxa. At present, however, bird conservation data appear to offer the most promising opportunities for developing wild species indicators in agriculture.

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Birds and agriculture

Changes in agricultural habitats are of concern in that they affect the overall level of biodiversity, including the populations of widespread and common species, as well as threatening rarer species.

Biodiversity has suffered severe declines in many OECD countries as a result of expansion and intensification of agricultural production. BirdLife International believes that reversing these declines, and achieving progress towards sustainable agriculture, currently represents one of the greatest environmental challenges facing policy makers in OECD countries. Indicators have a key role to play in assessing progress towards sustainable agriculture, and in evaluating the effectiveness of agri-environment policies.

Impacts of agriculture on birds include:

1. Changes in agricultural habitats as a result of agricultural development and intensification. Agriculture represents the dominant rural land use in many OECD countries, and many species have adapted to rely on farmed habitats. Increases in agricultural productivity have modified these habitats. Some of the trends of particular concern to BirdLife include:

- Specialisation of agriculture, and loss of mixed farming through conversion of arable to pasture and vice-versa;

- Intensification of arable production, with increased use of pesticides and fertilisers, with resultant impacts on agricultural habitats and food chains, and changes in cropping patterns;

- Intensification of livestock production, with increased fertiliser use depleting grassland biodiversity, and increased stocking rates effecting vegetation change;

- Loss of unfarmed features such as hedgerows, woodlands and ponds;

- Drainage of wetlands, marshes and pastures;

- Irrigation of dry agricultural habitats;

- Loss of traditional agricultural habitats such as hay meadows and orchards through conversion to more intensive systems.

In recent years, there have been efforts to reverse some of these changes — *e.g.* by re-creating features and habitats, and promoting organic farming.

2. Agricultural abandonment. This is a problem in many OECD countries, especially where farming finds it difficult to compete in an increasingly global market. Abandonment often threatens traditional farming systems that may be rich in wildlife.

3. Impacts of agriculture on other habitats. These include pollution *e.g.* eutrophication of watercourses, and conversion of semi-natural habitats such as wetlands and forests. Conversion of other habitats is a major issue at a global level.

Principles of indicator development

Qualities of environmental indicators

Biodiversity indicators should help policy makers to identify priorities for policy action, and help to monitor and communicate the impact of policy. More specifically indicators should have the qualities listed in Box 1.

Box 1. **The qualities of biodiversity indicators**

Indicators should have the following qualities (Bibby 1999):

- Quantitative — they should be formally measured;
- Simplifying information — the complexity of biodiversity knowledge has to be conveyed briefly if it is to have impact;
- User driven — the stakeholders involved will have to commit to plans and targets being monitored and will often collect the relevant data;
- Policy relevant — indicators should give signals to policy makers about their impact and effectiveness;
- Scientifically credible — methods should be sound and hold statistical validity;
- Easily understood — non expert policy makers and public should understand and have a sense of ownership and judge the success of policy-making;
- Realistic to collect — in terms of manpower and cost efficiency;
- Susceptible to analysis — it should be possible to disaggregate data to investigate possible causes of trends.

In addition, indicators should:

- address all of the key issues of policy relevance, *e.g.* populations of species within agriculture, impact of agriculture on other species, effects on both widespread and threatened species;
- be representative of wider trends — single species trends may be informative, but there is a danger that they are unrepresentative and misleading. It is preferable to use a wider group of species;
- present time series data to reveal medium term trends;
- utilise available data, without being excessively data-driven. There is a need to strike an appropriate balance between using what data we have, and improving monitoring systems to develop data for use in future indicators.

Ideally, indicators should also be included to measure a country's footprint outside its own boundaries. For example, agricultural policies in OECD countries can have a profound impact on biodiversity and the environment outside the OECD, by affecting patterns of trade and agricultural development.

Importantly, while indicators are valuable policy development and communication tools, they are not a substitute for the detailed knowledge needed to assess the causes of changes or to formulate strategies or plans in response.

Indicators should be scientifically valid but should be meaningful to a wide audience including the general public. BirdLife supports the development of headline indicators, which are a useful communication tool, as well as larger sets of more detailed indicators for use in policy analysis.

- An ideal wildlife indicator should therefore be simple, show annual trends, be sensitive to environmental change, integrate data from many species, be representative, use data that are already available or feasible to collect and be capable of being disaggregated by policy sectors.

BirdLife believes that trends in wild species are a good indicator of agricultural practices and the effectiveness of agri-environment policy. Tackling wild species change usually requires targeted and well-designed agri-environment schemes to be implemented, and thorough monitoring systems to be put in place. Trends in wildlife are a tangible and measurable outcome of these schemes. Species indicators are also important in assessing overall trends in biodiversity on farmland, as a result of wider changes in agricultural policy and practice.

Targets and indicators

Indicators do not make much sense without reference points against which the significance of change can be assessed. This includes the baseline, or starting point against which change can be measured. Indicators can also use thresholds to assess changes in species status (*e.g.* measuring changes in status from secure to threatened).

Indicators are designed to quantify and communicate these biodiversity trends and patterns in a simple way. Targets and indicators need to be linked. For example, the UK Government's 'Quality of Life' indicators include a wildlife indicator based on the population trends of breeding birds summarising the status of nearly 140 breeding species over the last 30 years. In the Biodiversity Action Plan, the Government has set targets for the most threatened and declining species. For example the species showing severe downward trends have targets set against them requiring a halt in decline and a return to 1990 levels by 2008.

The taxonomy of indicators

OECD indicator work has identified different frameworks for classifying indicators, including:

- The Driving Force-State-Response framework. This is particularly useful for considering the impacts of agricultural practices (driving forces) on the state of the environment, and considering policy responses to these;

- The “Sustainability” framework, which considers the trade-offs between different types of capital (natural, social, man-made and human capital; Pearce, 1998).

The Driving Force-State-Response framework is useful for the development and assessment of agri-environment indicators. For example, for biodiversity, it is essential to develop indicators to assess trends in wildlife populations (the state), as well as understanding the driving forces that affect farmland wildlife (*e.g.* pesticide use, water use, grassland management, length of hedgerows), and responses (*e.g.* agri-environment schemes, farm biodiversity plans).

While further progress is needed to develop indicators for the state of biodiversity in agriculture, many of the indicators developed already by the OECD have relevance for biodiversity conservation in agriculture in OECD countries, as driving force or response indicators. The Driving Force-State-Response framework is a useful for categorising these indicators.

The sustainability framework is also useful in addressing the conservation of biodiversity in agriculture. Wild species can be considered to constitute part of the stock of natural capital, and indicators therefore help to assess whether this capital stock is changing and why this might be the case.

Indicators at different spatial scales

Indicators can be developed at a range of scales. Ideally, data collected at local scale can be aggregated to provide national, regional and global data. The strengths of BirdLife's science programmes are very much based on large networks of many thousands of people gathering and compiling data at local and national levels. Common and agreed standards are applied to these data so they may be easily combined and synthesised at different geographical scales. This allows national and regional or global level indicators to be developed from data collected at a local level. These data allow cause-effect links to be investigated at a local or national scale.

Review of OECD progress to date

The OECD is to be congratulated on its work on developing agri-environment indicators. The OECD work programme has helped to provide a coherent framework and methodology for indicator development, and to promote a consistent approach between member countries.

- The OECD indicators highlight many of the issues of concern to BirdLife, by including indicators of the state of biodiversity, wildlife and habitats; many of the driving forces that affect habitats and species; and some of the responses to these effects.

BirdLife acknowledges the difficulty of developing indicators for biodiversity and wildlife habitats that are applicable across OECD countries. These difficulties arise from differences in land use, species presence, conservation issues and priorities, and the relative importance of farmed and other habitats. In the light of these difficulties, we welcome the considerable progress made by the OECD in recent years.

Biodiversity Indicators

The OECD indicators report (OECD, 2001) presents a useful discussion of the issues surrounding the development of indicators for wild species, as well as numerous examples of how wild species indicators have been developed and used in OECD countries. The report rightly identifies the difficulties in developing wild species indicators that can be used across OECD countries, and notes that limited progress has been made in this area.

At least two possible approaches to developing biodiversity indicators can be identified:

- "Standardised" approaches, which seek to obtain and apply data in a standardised way across OECD countries. This has the advantage of promoting comparability and consistency in the development and use of indicators. It suffers from data problems, however, because of the variability of biodiversity monitoring between countries. As a result, there is a danger that resulting indicators will represent the "lowest common denominator" of available data, potentially reducing their usefulness and policy relevance. Nevertheless, some organisations, including BirdLife, collect international wildlife data in a standardised way, and we believe that there is potential to make progress in this area.

- "Country-led" approaches. The OECD report notes that many member countries have made considerable progress in developing wild species indicators at a country level. By grouping these indicators, the OECD is able to report trends in wild species diversity and abundance in several (but not yet all) OECD countries. Allowing member countries flexibility in developing and reporting wild species indicators helps to overcome some of the problems associated with data availability and differences in priorities and issues. Producing a set of generic principles and guidelines for member countries to follow in developing and submitting these indicators would help to promote the development of a more coherent, consistent and comparable set of wildlife indicators.

Habitat Matrix

This approach involves combining data on changes in the extent of different agricultural habitats with information on the species dependent on those habitats. This has some value in assessing the likely effects of changes in agricultural habitats on wild species. Bird conservation data could be used to develop matrices covering different agricultural habitats. This might include lists of species dependent on each habitat type, identifying which of these are threatened species.

However, as noted in the OECD report, great care needs to be taken in interpreting habitat matrices, since:

- Wild species abundance depends on the quality as well as the extent of farmed habitats. Developments in agriculture have had profound impacts on farmed habitats in many OECD countries, but these may not be identified by habitat indicators that focus on quantity rather than quality of habitats. For example, the substantial declines in farmland birds and other wildlife within agricultural habitats in Europe would be unlikely to be identified by the habitat matrix approach;

- It is important to consider the types of species dependent on different habitats, and their conservation status, as well as their number, in order to avoid undervaluing rarer species occurring in species poor habitats;

- Issues about spatial patterning of habitats, connectedness and fragmentation should be considered;

- Changes in agricultural landscapes and habitats over time may also pose difficulties for the matrix approach.

Therefore, while it is useful to have indicators that assess changes in the extent and quality of agricultural habitats, and the species that depend on them, the habitat matrix approach should not be seen as a substitute for indicators covering trends in populations of wild species.

Many of the factors affecting habitat quality (irrigation, chemical use, extent of landscape features etc.) are covered by other OECD agri-environment indicators. This highlights the importance of considering the links between habitat and wildlife indicators and the wider indicator set, rather than considering them in isolation.

BirdLife's approach to indicator development

BirdLife International is a global partnership of 60 organisations in over 100 countries concerned with the conservation of birds, habitats and biodiversity. Research and monitoring to assess the status and conservation needs of birds and their habitats are central to BirdLife's approach to priority-setting, and are used to inform policy makers at a national and international level. BirdLife is increasingly concerned about the effects of agriculture on birds and their habitats, and seeks to promote policies that encourage sustainable agriculture.

This section attempts to show how the data gathered through BirdLife's programme may be useful to the indicator development and implementation work of the OECD.

Indicator development and monitoring programmes

BirdLife regularly reports on the status of birds and the sites and habitats important for them.

These data are published in a wide-range of global, regional and national publications, inventories, reports and scientific papers and many data are available on the web. These programmes identify priorities that underpin and set the direction for conservation and management. Extensive networks of professional and amateur naturalists and ornithologists are central to these programmes of work.

Common standards and methodology are important elements of the science work with information gathered being robust and sustainable. Scientific criteria, standard guidelines and databases have been established to maximize the scientific credibility and compatibility of datasets nationally, regionally and globally. Sharing expertise on data collection and maintenance through training and workshops are also important aspects of the programme. Data are peer reviewed and validated. The methodology and standardisation that have been applied when gathering these data allow their effective application to indicator-based reporting as monitoring programmes generate time-series data.

BirdLife is currently building on its priority-setting and assessment work through the development of monitoring programmes, indicators and indicator-based reporting. This encompasses three main strands:

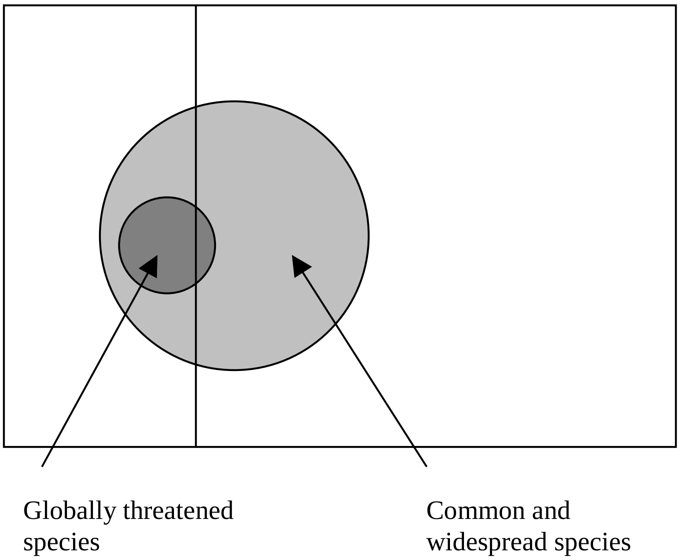
- Important Bird Areas (IBAs) — to track changes in the conservation status of core areas for birds

- Widespread and common species — to track changes in the population sizes of widespread and common birds in the wider landscape

- Rare and restricted range species — to track and report on changes in the conservation status of globally threatened birds. These may require species specific monitoring schemes or be covered through monitoring IBAs — some species may be covered through broader scale monitoring of widespread species.

Each approach is essential for the effective conservation of a large number of species, and while different, the programmes are complementary and independent (Figure 1).

Figure 1. **Monitoring of bird species at sites and in the wider landscape**



Indicators for each of these programmes provide important information on the status of bird populations, the pressures placed upon them, either directly or on the habitats and sites upon which they depend, and the effectiveness of policy and conservation responses. Table 1 describes these areas of work and outlines monitoring and indicator activities in each programme.

Plans are advanced to bring together these three strands of work into a Pan-European Bird Monitoring Strategy as described in Box 2.

Table 1. **Key elements of BirdLife's assessment, monitoring and indicator activities**

Component	Major BirdLife Programme	Status of assessments	Assessments, monitoring and indicator activities
Sites	Important Bird Areas *A global network of internationally important sites for birds*	*Europe* – 3 619 sites identified *Americas* – 226 sites in Mexico, c.50% of states covered in US, 597 sites in Canada. *Africa* – 1 250 sites identified *Asia* – list in preparation for 2002 Middle East – 391 sites identified Pacific – programme starting	- Regional inventories - National inventories - Monitoring programmes - Indicator development initiated - Caretaker networks/support groups
Rare and restricted-range species	Globally Threatened Species *Species at risk of global extinction*	1 186 species (in year 2000). Published 1988, 1994 and 2000.	- Annual updates - Complete re-assessment of global threat status every 4 years - Monitoring of species - Action Plans - Recommended actions - Evaluation of targets - Indicator development
Common and widespread species	Species of conservation concern *Species of concern because of declining populations, small populations or highly localized.* *(can include some globally threatened species)*	To date regional assessment only complete for Europe. 278 Species of European Conservation Concern identified (SPECs) of which 195 have an unfavourable conservation status in Europe (1970-1990)	- National monitoring schemes - National indices (*e.g.* UK) - Development of pan-European indices - Support to new national schemes. - Habitats for Birds in Europe - Farmland bird monitoring schemes (in some countries)

Box 2. **The development of a Pan-European Bird Monitoring Strategy**

Goal

To develop good quality Pan-European monitoring and assessment of the state of birds and their critical sites in Europe, the pressures acting upon them and the actions being taken to conserve them

Objectives

- To research and define a set of core indicators and targets.
- To strengthen, streamline and expand monitoring schemes and people networks.
- To ensure efficient storage, analysis and reporting of data on core indicators.

The Pan-European Bird Monitoring Strategy will be built through a participatory process of:

- linking people and organisations to work towards a shared goal;
- using existing expertise and resources as fully as possible, including building on and investing in existing programmes;
- dividing strategy tasks and responsibilities according to wishes, expertise and capabilities;
- sharing skills, experience and information so as to develop overall capacity;
- providing open access to data to enable better informed decision-making.

It will monitor:

- Important Bird Areas — to track changes in the conservation status of core areas for birds.
- Threatened species — to track changes in the conservation status of threatened birds.
- Common species — to track changes in the population sizes of common birds.

Table 2 summarises the numbers of globally threatened species, IBAs and the existence of national monitoring schemes functioning in each OECD country. Each of these programmes is described in more detail in the following sections, and the types of indicators being developed are outlined.

Policy relevance of indicator and monitoring programmes

Developing links and collaboration with broader monitoring initiatives and end-users is extremely important. The data generated from these programmes aim to fulfil the monitoring requirements and obligations of key directives and conventions such as the Convention on Biological Diversity, Ramsar Convention, Bonn Convention, Africa Eurasia Waterbird Agreement (AEWA) and the OECD International Development Strategy. In Europe these also relate to a number of European Union initiatives such as the Birds and Habitats Directives, the 6th Environmental Action Programme, the Biodiversity Strategy and the Strategy for Sustainable Development as well as the Pan-European Biodiversity and Landscape Strategy.

Table 2. **Summary of status of IBA, threatened species and common species work in OECD countries**

Country	Important Bird Areas[1]	Threatened species[2] (no. in any season?)	National common species monitoring programmes[3]
Australia	Follow-up work planned to Australia Bird Atlas	21 species	
Austria	Published: 1989, 1995 (national), 2000. 55 sites (53)	4 species	
Belgium	Published: 1989, 2000. 48 sites (39)	3 species	
Canada	Published on www 2001 (597 sites)	6 species	Migration monitoring Programme
Cezch Republic	Published: 1989, 1992 (national), 2000. 16 sites (13)	4 species	National scheme
Denmark	Published: 1989, 2000. 127 sites (69)	1 species	National scheme
Finland	Published: 1989, 2000. 96 sites (15)	3 species	National scheme
France	Published: 1989, 1994 (national) 2000. 277 sites (209)	5 species	
Germany	Published: 1989, 2000. 285 sites (175)	4 species	National scheme
Greece	Published: 1989, 1994 (national) 2000. 196 sites (177)	7 species	
Hungary	Published: 1989, 1992 (national), 1998 (national), 2000. 43 sites (37)	7 species	National scheme started 1998
Iceland	Published: 1989, 2000. 61 sites (44)		
Ireland	Published: 1989, 1995 (national), 2000. 140 sites (78)	1 species	Countryside Bird Survey (started 1998)
Italy	Published: 1989, 1991 (national) 2000, 2000 (national). 192 sites (163)	7 species	National scheme recently started
Japan	Initial list to be completed end 2001	27 species	
Korea	Initial list to be completed end 2001	27 species	
Luxembourg	Published: 1989, 2000. 9 sites (9)	1 species	
Mexico	Inventory published 2000 (226 sites)	28 species	
The Netherlands	Published: 1989, 2000. 106 sites (60)	3 species	National scheme
New Zealand	Under discussion	9 species	
Norway	Published: 1989, 2000. 52 sites (16)	2 species	National scheme
Poland	Published: 1989, 1994 (national), 2000. 77 sites (64)	4 species	National scheme (started 2000)
Portugal	Published: 1989, 2000. 60 sites (41)	5 species	
Slovak Republic	Published: 1989, 1992 (national) 2000. 32 sites (28)	5 species	
Spain	Published: 1989, 1992 (national), 1998 (national), 2000. 391 sites (311)	10 species	National scheme (started 1996)
Sweden	Published: 1989, 2000. 63 sites (36)	2 species	National scheme
Switzerland	Published: 1989, 2000. 31 sites (28)	2 species	National scheme
Turkey	Published: 1989, 1989 (national), 1997 (national) 2000. 97 sites (66)	11 species	
United Kingdom	Published: 1989, 1992 (national), 2000. 295 sites (174)	2 species	National scheme
United States	Complete for c. 50% of states	33 species	Breeding bird survey

1. Numbers relate to total number of IBAs in country and number with agricultural land-use *e.g.* Spain 391 IBAs (311 with agricultural land-use).
2. The number of Globally Threatened Species (Critical, Endangered or Vulnerable) using agricultural habitats in each country.
3. Where known presence of systematic national monitoring scheme for breeding birds listed (not complete and needs further review).

Many different organisations and programmes are developing biodiversity indicators and collaboration in this field is increasing. The European Biodiversity Monitoring and Indicator Framework (EBMI-F) is one example. The Framework was initiated as part of the Pan-European Biodiversity and Landscape Strategy, in order to promote and facilitate collaboration on monitoring and indicators to report trends in Europe's biodiversity, using the objectives of the Convention on Biological Diversity as guidance. This framework is being developed by the European Environment Agency and European Centre for Nature Conservation with input from BirdLife, CONNECT, NINA, UNEP-WCMC and Wetlands International.

These indicator sets will aim to characterise the trends and their causes to policy-makers and the wider public. Improved understanding of the impact that society and the economy have on biodiversity will help guide the development of more sustainable and targeted policies.

Using Important Bird Area data to develop indicators

Definition of Important Bird Areas

The BirdLife Partnership has initiated an Important Bird Area Programme to identify and protect a network of critical sites for the conservation of the world's birds. Important Bird Areas (IBAs) are sites of international importance for the conservation of birds, identified at a local level using a set of globally standardised scientific criteria based on the site's international importance for:

- Globally threatened bird species.
- Congregatory bird species.
- Assemblages of restricted-range bird species.
- Assemblages of biome-restricted bird species.

The programme initially comprises site identification using these criteria, followed by programmes of monitoring, policy development, advocacy for international and national legislation, public awareness and education, and practical conservation action and protection for a network of internationally important sites.

Since 1981, the BirdLife International Partnership has identified over 3 619 IBAs in 51 European countries/autonomous regions (Heath and Evans 2000), 1 250 in 58 Africa countries and associated islands (Fishpool and Evans, 2001), and 391 sites within the 14 nation states of the Middle East (Evans 1994). Regional inventories of Important Bird Areas for Europe, the Middle East and Africa have all been published and widely distributed to government agencies, NGOs, the corporate sector, and others responsible for, or with an interest in, the conservation of species, sites and habitats. In addition, over 40 national IBA inventories have been published in the appropriate local language for nations in Europe, Asia, Africa, the Americas and the Middle East (Table 2).

Important Bird Area data are stored and analysed in an IBA module of BirdLife International's World Bird Database, enabling the data to be synthesised and presented in a variety of ways for a variety of audiences. The database also provides electronic links to non-BirdLife information and links to Geographical Information Systems for presentation purposes. For Europe alone the database currently includes information on bird populations at IBAs (>100 000 records), habitat type and extent at IBAs (>12 000), impacts (>12 000), protection status and management plans.

Large networks of ornithologists, birdwatchers and conservation experts are involved in the collation of data on IBAs. The BirdLife Partnership is at the core of this network, coordinating much of the work nationally and with substantial collaboration with governmental and non-governmental organisations and experts. Most partners have an IBA coordinator (or team), responsible for delivering this programme within the country concerned. Networks of local contacts (IBA Caretakers) form the foundation of community based networks active in the protection, management and monitoring of IBAs in several countries.

The importance of IBAs is increasingly recognised by authorities at a national level and globally. For example, the World Bank (in their Critical Natural Habitat Operational Policy) and the Global Environment Facility's Operational Strategy both refer specifically to IBAs as objective, internationally-recognised sites of biological importance for conservation and sustainable development.

The relevance of agricultural activity to Important Bird Areas

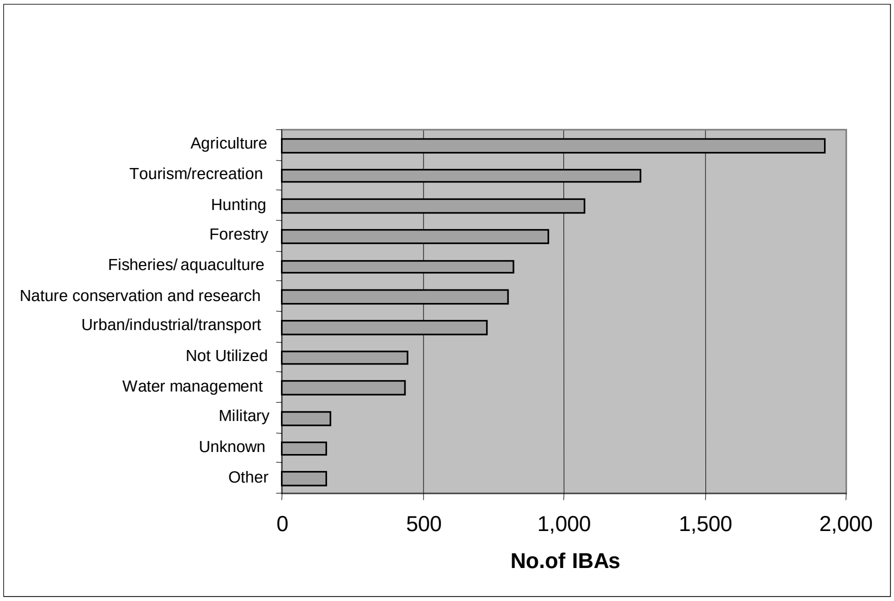
A great variety and often high intensity of land-uses are recorded within IBAs, reflecting the high human use of habitats in general. Across Europe, land-use activities have been recorded in 95% of IBAs, and in only 15% of these is part or all of the individual IBA area classified as 'not utilized'. As a result the conservation of habitats and birds within this key network of internationally important sites is very much dependent on the land-use practices, policies and programmes that affect these sites. Figure 2 shows that agricultural activity is the most frequent form of land-use recorded in IBAs in OECD countries in Europe. Such habitats, especially when extensively or traditionally managed, support important populations of many bird species. There are 2 837 IBAs in OECD countries in Europe, and, in 68% of these (1 923 sites), agriculture is a land use. Therefore the nature and management of agricultural activity in these sites is critical to the biodiversity contained within them.

Agricultural intensification and expansion is one of the most serious factors impacting on IBAs. In total, 51% of the IBAs where agriculture is a land-use in OECD countries in Europe are considered threatened by these. In 19 of the 23 OECD countries in Europe, more than 30% of the IBAs with agricultural landuse are threatened by agricultural intensification (Figure 3).

One of the indirect effects of agricultural intensification is that remaining marginal land becomes less profitable to farm. Many bird species that have adapted to farmland require methods of non-intensive habitat management for their continued survival in such habitats. The abandonment of such practices is considered a threat to 418 IBAs in OECD countries in Europe where agriculture is a land-use. This particularly affects IBAs in many parts of central and Eastern Europe (Figure 3), as well as the Mediterranean region and Baltic States. In 15 of the OECD countries in Europe, more than 20% of IBAs with agricultural land-use are impacted by abandonment and reduction in land management.

Similar analysis will be possible for other OECD countries.

Figure 2. **The number of IBAs in OECD countries affected by particular land-uses**



Source: BirdLife International World Bird Database.

Indicators and the IBA Programme

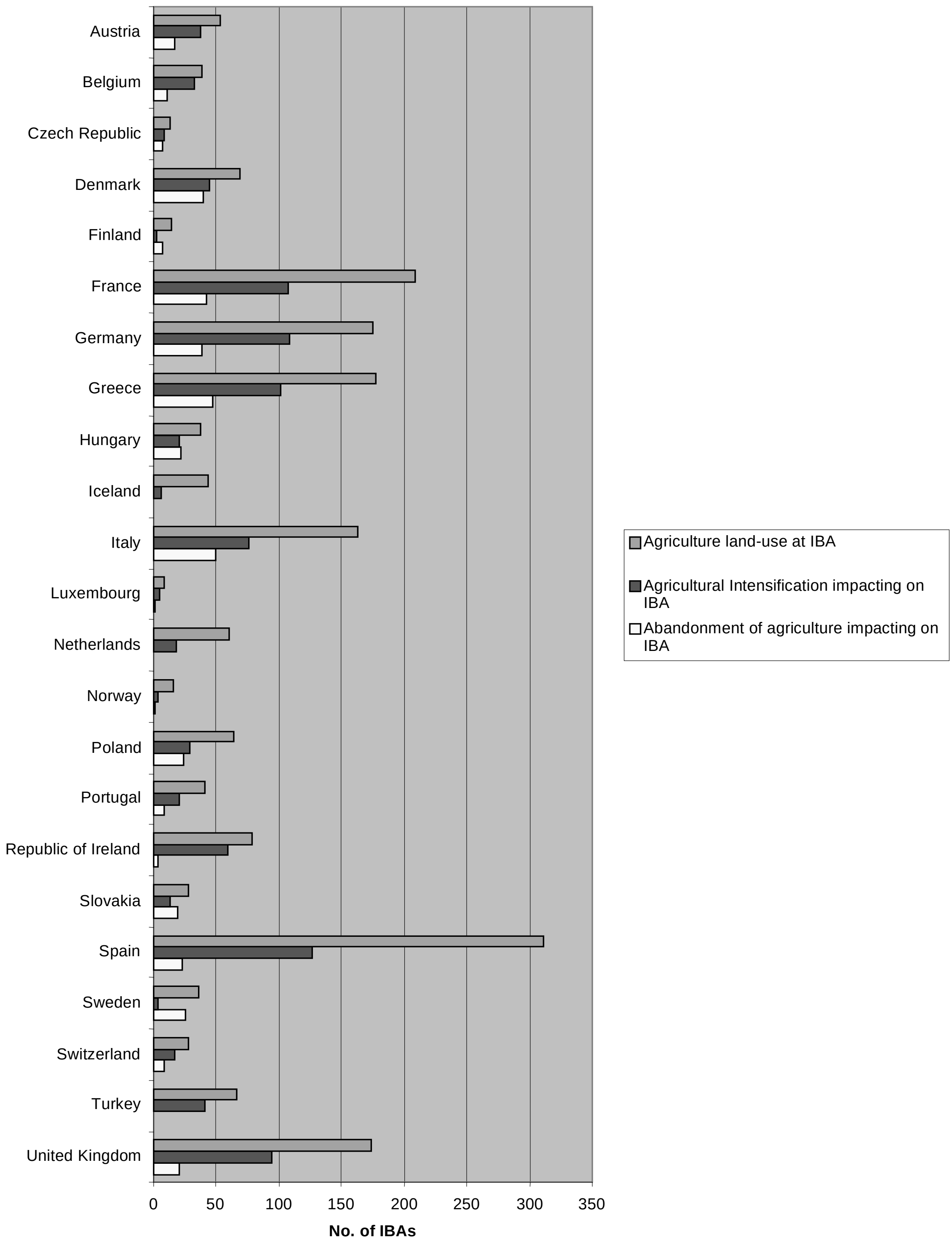
The figures presented above have been compiled from data gathered at each of the IBAs in OECD countries in Europe. Through a standard approach, it is possible to combine such data at national, regional and global levels and report on trends of considerable relevance to the agricultural sector. Indicators that may be drawn from this programme include:

- Proportion of IBAs in country with agricultural land-use.
- Number of IBAs in OECD countries with agricultural land-use.
- Area of IBAs in OECD countries with agricultural land-use.
- Trends in wild species populations at IBAs with agricultural land-use.

With continued monitoring, the programme will generate key time-series data on bird population trends and the impacts and pressures they face.

BirdLife is building and implementing a comprehensive pan-European IBA monitoring programme. Workshops have been held within the European and African Partnerships to initiate the development of IBA monitoring strategies and papers are being prepared. For Europe, central to this are six proposed core indicators (Figure 4). They have been chosen to allow monitoring of the state of IBAs and their key bird species, pressures acting upon them and responses taken to conserve them. Monitoring this network is achievable on a regular basis, *i.e.* some annual, some every 4 years. For example, a comparison of data on the protection status of IBAs in Europe in 1989 and 2000 for Ramsar and Special Protected Area designations indicate an increase from 22% to 29% and 30% to 54% respectively in the proportion of sites protected by these designations.

Figure 3. **IBAs in OECD countries in Europe**



Source: BirdLife International World Bird Database.

Figure 4. **Core indicators on the status of Important Bird Areas and the bird populations they support**

Indicator type	Indicator	Description
State	Habitat	Change in cover of habitat types (those relevant to agriculture include highly improved re-seeded grassland, arable land, perennial crops/orchards/groves, ruderal land, steppe/dry calcareous grassland, meosphile grassland etc.)
	Key bird populations	Trends in population sizes of: - globally threatened species using agricultural habitats - significant populations of Species of European Conservation Concern using agricultural habitats - significant populations of species listed on Annex 1 of the EU Birds Directive using agricultural habitats - waterbirds on wetlands impacted by agriculture e.g. irrigation, pollution - other common and widespread species
	Land-use	Change in cover of land-use types
Pressure	Impacts	Change in impact (importance score — high, medium, low) of 25 classes of impact to IBAs including agricultural intensification/ expansion, abandonment/reduction in land management, groundwater abstraction, shifting agriculture etc.
Response	Protection status	Change in overlap with national and international protected areas.
	Management plan	Change presence of management plan. Potential to extend to include implementation of actions in plan related to agricultural practices.

Source: Under development by BirdLife European Partnership.

Policy relevance of data

Site networks are addressed under various international agreements, such as the Ramsar network (under the Ramsar Convention), the Natura 2000 network (under the EC Birds and Habitats Directives) and the Emerald Network (under the Bern Convention). For example in Europe 2 083 IBAs meet the Ramsar criteria and should therefore be considered for designation under this convention (BirdLife, 2001). Similarly, 2 342 IBAs lie within the 15 countries of the European Union and a further 412 fall within the 10 accession countries. These sites comply with the criteria for identifying Special Protection Areas and therefore should fully overlap with the SPA network designated under the Birds Directive. The monitoring of the status of IBAs will therefore provide important information to test the effectiveness of EC nature conservation policy. In addition, in many cases a site will have multiple designations, each with their separate formal monitoring and surveillance requirements (*e.g.* in Europe Natura 2000 system, the Ramsar Convention and the Emerald Network). The IBA programme offers a well advanced platform from which an integrated system could be developed.

Using common and widespread species data to develop indicators

Background on common and widespread species

There have been widespread changes in land use in many OECD countries over the last 50 years. Site based conservation measures (including protected areas) have undoubtedly a very important role to play in biodiversity conservation. However there is growing recognition that biodiversity cannot be solely maintained through the conservation of sites. Maintaining biodiversity internationally means conserving the wider environment. Therefore, to maintain the abundance and distribution of species we also need to monitor and report on what is happening to more common and widespread species to ensure wise management of the environment as a whole through the integration of conservation objectives into all aspects of land-use activity and policy.

State of work on widespread species in each OECD country

A complete review of the state of national schemes for bird monitoring in all OECD countries has not been possible for this paper. However, a recent review of 80 bird monitoring schemes across Europe (Marchant *et al.*, 1997) (commissioned by the Royal Society for the Protection of Birds) shows that national schemes for monitoring common birds are established in 17 countries in Europe, 14 of which are within OECD countries (see Table 2). The great bulk of fieldwork for these surveys is undertaken by skilled volunteer ornithologists, co-ordinated by a small number of professionals working for national monitoring organisations, conservation agencies or universities

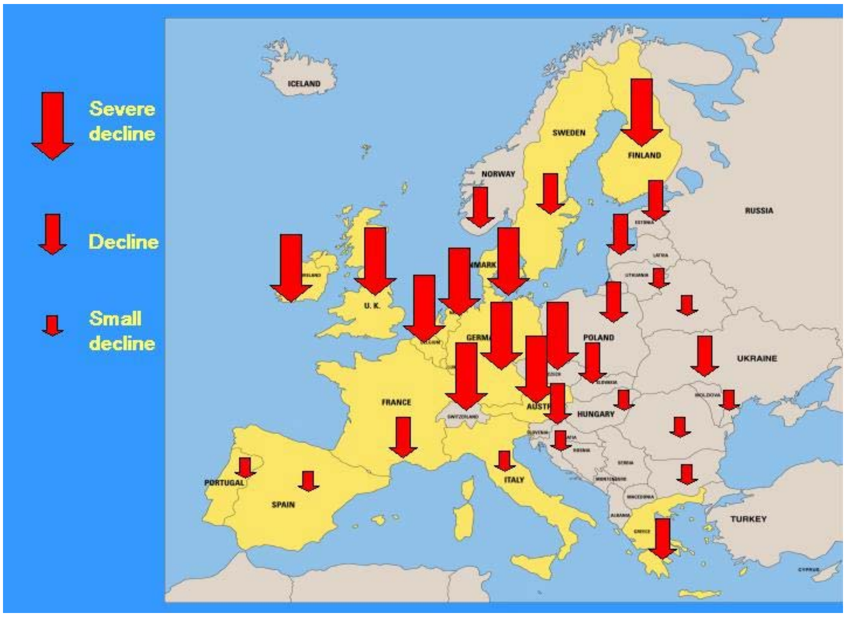
Between 1990 and 1994, BirdLife carried out a complete assessment of the conservation status of Europe’s birds through the Dispersed Species Project. In order to assess status reliably and comprehensively it was necessary to obtain detailed population information on all species, in each European Country, for both breeding and mid-winter populations. To do this there was broad collaboration with ornithologists throughout Europe, utilising the BirdLife International network in conjunction with the European Ornithological Atlas Project. These data were published in 1994 (Tucker and Heath, 1994) and about one third have since been updated and published (BirdLife/European Bird Census Council, 2001).

Relevance of agricultural activities to widespread species

BirdLife used population and trend data to assess the conservation status of all bird species in Europe for the 1970-1990 period . A decline of 20% over 20 years is defined as the minimum for a significant decline, and 50% over 20 years as the minimum level of rapid decline. Results show widespread reductions of bird populations across many species and countries. Most striking has been the reduction of once common and widespread species, especially in Western Europe and primarily attributable to agricultural intensification. Lowland farmland provides breeding or wintering habitat for nearly 120 bird Species of European Conservation Concern, the largest number of such species supported by any habitat.

Further recent analysis of these data has modelled population and range changes in terms of a number of indices of agricultural intensity (data taken from the FAOSTAT database of the UN Food and Agriculture Organization) (Donald *et al.*, 2000). This shows that population declines and range contractions were significantly greater in countries with more intensive agriculture and significantly higher in the European Union than in former communist countries (Figure 5). Cereal yield alone

Figure 5. **Farmland bird declines in Europe (1970-1990)**



Source: Donald *et al.*, (2001) based on data for 40 farmland species from BirdLife/EBCC European Bird Database.

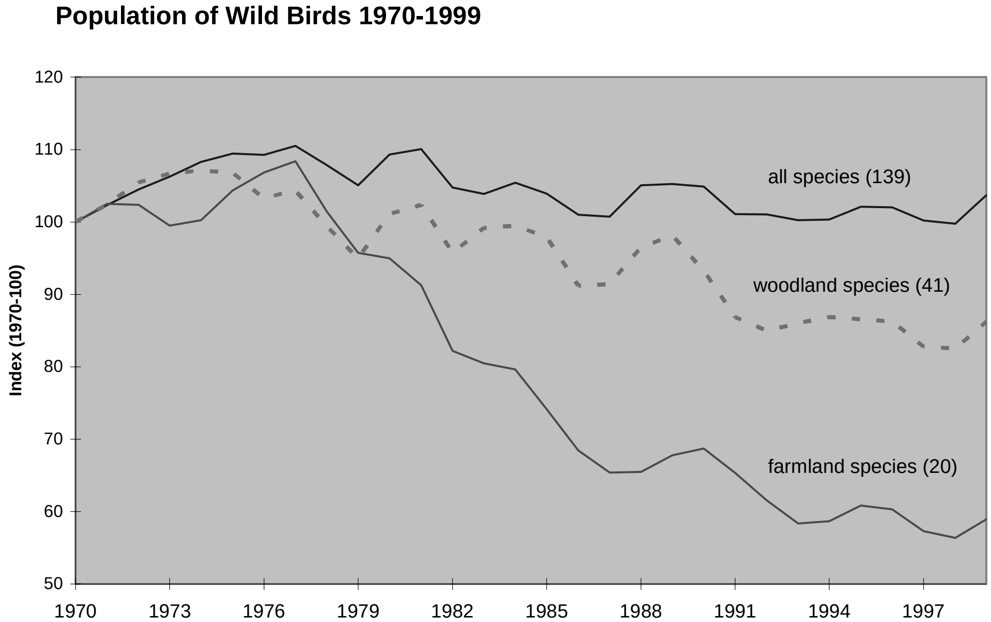
explained over 30% of the variation in population trends. These results suggest that recent trends in agriculture have had deleterious and measurable affects on widespread and common bird populations on a continental scale.

Indicators and widespread species

Long running bird monitoring schemes for breeding landbirds is in the UK have been pivotal in demonstrating severe declines amongst farmland birds and their association with intensive agriculture. Using data from the Common Bird Census and Breeding Bird Survey the UK BirdLife partner, the RSPB, has developed an indicator of wild bird populations in the UK in conjunction with the British Trust for Ornithology and the Department for the Environment, Food and Rural Affairs.

A version of this mean index, representing the 139 commoner native bird species has been adopted by the UK Government as one of its 15 headline indicators, the so called Quality of Life Indicators, out of a set of 150 core indicators of sustainable development (Anon 1998, 1999). This indicator shows that on average farmland birds are in sharp decline (Figure 6). These declines in farmland bird populations have been mirrored by declines in populations of many specialised invertebrate and plants, mostly driven by similar changes in land-use. The UK Government is committed to publishing annual updates headline indicator. The goal is to reverse long-term trends: the Department for the Environment, Food and Rural Affairs has pledged to reverse the decline of farmland birds by 2020, using the headline indicator to measure their progress.

Figure 6. **The UK Government's Quality of Life Indicator: populations of common wild breeding birds**[1]



1. On average, the numbers of common birds have been stable in the UK, but, on average, woodland and farmland species have declined. These composite indices reduce trends for several species into a single average trend line.
Source: RSPB, BTO, DETR.

Methodology used in the UK is based on an average index across all species (Gregory *et al.*, submitted). This approach treats all species equally, regardless of conservation status. There is therefore no subjectivity in the choice of species to be included or the relative importance they may have because it covers all species for which data are available. However, since all species are weighted equally, rare or vulnerable species are treated equally with common or even pest species. Indicator information needs careful thought and interpretation and disaggregating the trends is an important step to understanding the underlying problems (Gregory *et al.*, submitted).

The adoption of wild bird indicators in the UK illustrates the potential to use birds as indicators of sustainability. This index may also work in other data rich countries and it would be beneficial to explore this as a model.

In order for such an index to be developed, effective national monitoring schemes need to be in place. In Europe BirdLife is currently developing a programme focusing on monitoring common species, which will form sensitive indicators of the state of habitats in the wider environment. Integration of data from different national programmes across Europe will result in pan-European indices of bird trends. The programme has the following objectives:

- set in place common bird monitoring across Europe;
- generate national bird indices in a standardized manner;
- bring together national bird indices into a single European dataset;

- generate European indices for individual species;

- generate European composite indices for groups of species.

A great deal of work has already been completed to integrate monitoring information. Preliminary work by Statistics Netherlands and the European Bird Census Council, funded by RSPB, has shown how breeding data from different countries can be brought together into pan-European indices for individual species (van Strien and Pannekoek, 1998). These could be further developed to produce pan-European indicators for farmland birds (van Strien *et al.*, in press).

Alternative approaches may be to concentrate efforts on monitoring species indicative of wildlife-friendly agriculture. BirdLife Switzerland and the Swiss Ornithological Institute at Sempach are working on management indicator species as part of a scheme to improve the 'ecological performance' of farms. Farmers are required to set aside 7% of their land for ecological compensation such as low intensity-use meadows, hedgerows, fruit tress wildflower strips etc. in order to receive public money. This will involve the monitoring of priority farmland species. In some regions it has already been shown that populations of several farmland species have increased due to ecological compensation areas (report in press).

In Denmark, population indices of widespread farmland birds have been used as agri-environment indicators since 1988. Data come from the nationwide point count programme where approximately 60 routes (1 200 points) are placed in farmland (chiefly arable). Farmland population indices are calculated for several species, seven of which have been selected as indicators. This list includes granivorous as well as insectivorous species, long-distance migrants, short-distance migrants and sedentary species. Farmland population indices of the seven species are averaged to yield a "farmland bird index". Most years the index, or indices, are published in the official publication "Natur og miljø; udvalgte indikatorer" ("Nature and Environment; Selected Indicators") from the Ministry of Environment and Energy. Until now, the farmland part of the point count programme has been financed by the Ministry.

In the Netherlands three separate indices have been developed, termed the AMOEBA approach (Ten Brink, 1991) the Red List Index and the Ecological Capital Index (van Strien, 1997, 1999). The Ecological Capital Index (ECI) combines the quality and quantity of habitat into a single figure. Quality is taken to be the density of a number of habitat-specific species, and quantity is the area of that habitat. One of the difficulties with this approach is that it concentrates two fundamentally different but related processes; the loss of habitat area and the loss of biodiversity inhabiting that habitat. One could have the situation where the area of habitat declined rapidly but the biodiversity of the remaining patches was unaltered, or a situation where the habitat area remained constant but the biodiversity declined rapidly — yet both might have the same ECI (Gregory *et al.*, submitted). There are also difficulties in the choice of the reference period and the selection of habitat-specific species. Further editions of the ECI are likely to take a broader group of species thus increasing similarity with the UK index (Gregory *et al.*, submitted).

Also of relevance to developing indicators for common species is the International Waterfowl Census (IWC), covering Africa, Asia and Europe. The IWC is a standardised international scheme for annual monitoring of wintering waterbird populations and is coordinated by Wetlands International.

Using globally threatened species data to develop indicators

Background on globally threatened species

For over 20 years, BirdLife has published information on globally threatened bird species in Red Data Books and checklists, such that birds are recognized as the best-documented group of all species. BirdLife is the official Listing Authority for birds for the IUCN Red List and works closely with the IUCN/SSC Specialist Groups and a worldwide network of experts in this capacity.

The risk of extinction for all animal and plant species is evaluated against a comprehensive global standard developed by the IUCN Species Survival Commission. This standard sets thresholds by which species are identified as globally threatened, based on population and/or range sizes, and rates of decrease in these. This objectivity enables resources to be targeted at the most important sites, species and habitats for action.

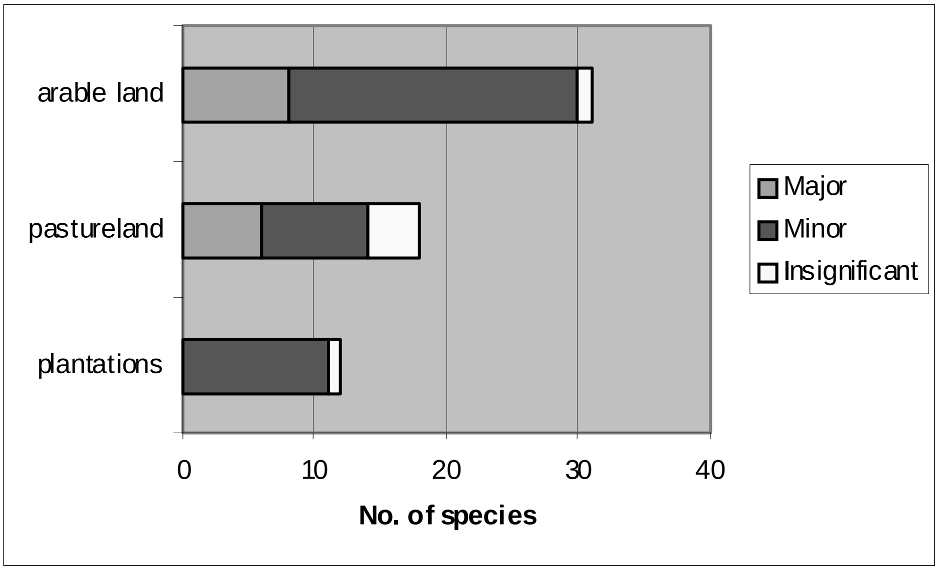
In 2000, BirdLife published the third global checklist of threatened birds (BirdLife, 2000). This reveals that one in eight (or c.12%) of all bird species have a real risk of becoming extinct in the next 100 years. This is a total of 1 186 species. Most worryingly, 182 are Critical, meaning that they have only a 50% chance of surviving over the next 10 years or three generations. A further 321 are Endangered and 680 are Vulnerable. A further 727 (Near Threatened) species are close to qualifying as threatened.

Relevance of agricultural activities to globally threatened species

There are 235 globally threatened species (classed as Critical, Endangered or Vulnerable) in OECD countries. Analysis shows that 54 of these (<25%) use agricultural habitats (Figure 7). For many of these species, agricultural habitat is considered to be of minor or insignificant importance. It is unlikely that these species can survive without adjacent unmodified habitats for breeding and or/feeding. However, for some species agricultural habitat is of major significance and certain practices may seriously impact on the species.

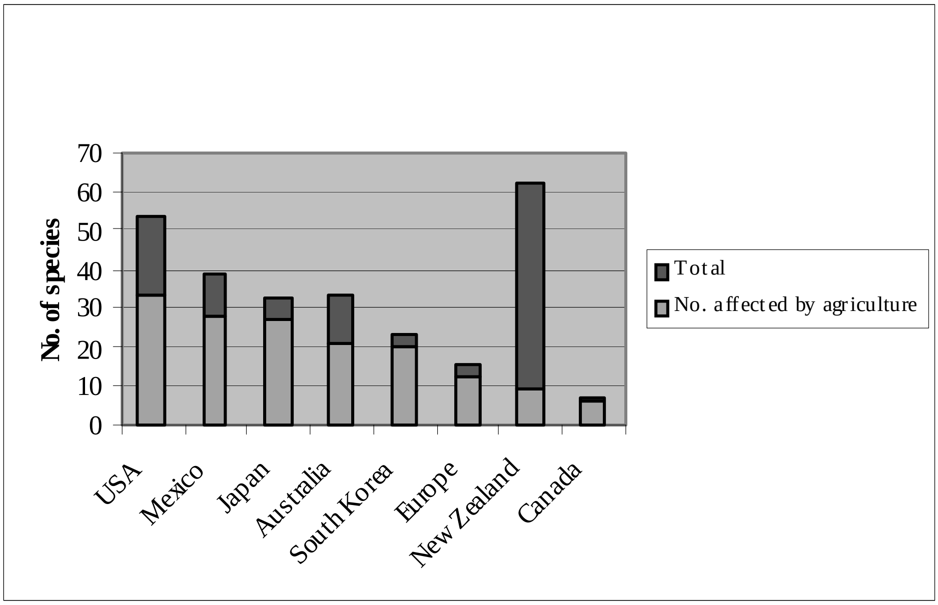
Assessment of the impacts on the 235 globally threatened species in OECD countries shows that agriculture is highly significant. Although there are not large numbers of globally threatened species dependent on agricultural habitats, much higher numbers present in other habitat types are affected by agricultural practices. 116 species (nearly 50% of all) in OECD countries are affected by habitat loss or degradation involving agricultural practices (Figure 8). In all countries apart from New Zealand, more than half of the globally threatened species are affected by agricultural practices. In New Zealand, invasive species constitute a more significant problem to species. The types of habitat loss or degradation are diverse (Figure 9), with loss of habitat to arable farming being the most significant and impacting on nearly 50 species.

Figure 7. **Numbers of globally threatened bird species which use agricultural habitats in OECD countries**



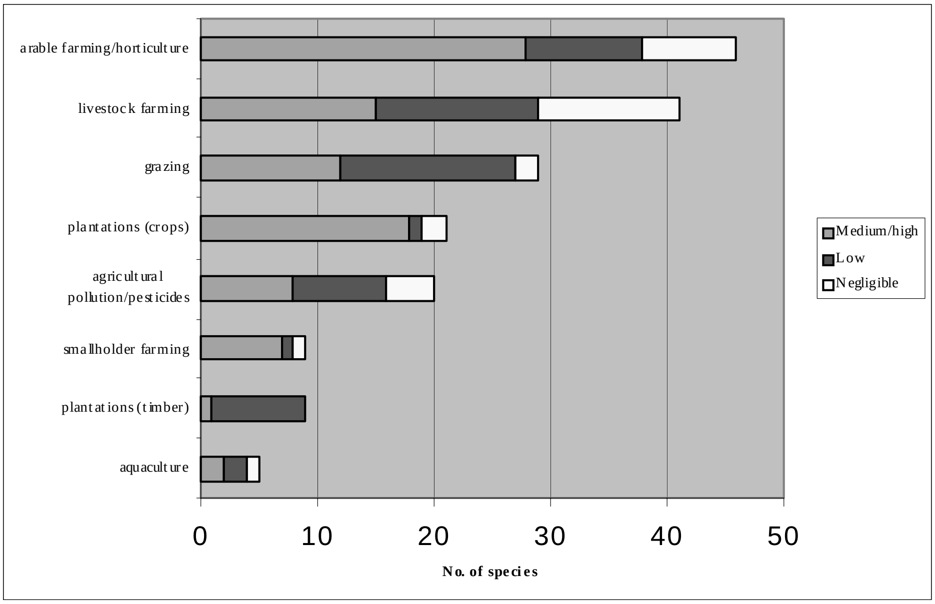
Source: BirdLife International World Bird Database.

Figure 8. **Number of globally threatened bird species affected by agricultural practices by OECD country/region**



Source: BirdLife International World Bird Database.

Figure 9. **Numbers of globally threatened bird species affected by habitat loss or degradation involving agricultural practices in OECD countries**



Source: BirdLife International World Bird Database.

Indicators and globally threatened species

The IUCN Red List is emerging as an important tool for use in long-term monitoring of biodiversity. Undoubtedly monitoring globally threatened species will provide an important indication of the impact of agricultural practices on the most threatened group of birds globally. Complete threat assessments at the global level will be repeated every four years.

IUCN are currently developing a number of indices using Red List data (IUCN in prep.) to characterise globally threatened species. Proposed indices include:

Biodiversity Status Index — A measure of the extent to which biodiversity is threatened with extinction (this could address change in population size or change in threat status).

Biodiversity Knowledge Index — A measure of the extent to which sufficient information is available on species to determine their Red List Category.

Biodiversity Trend Index — A measure of the overall trends among species.

Cause of Threat Index — A measure of the different causal threats that impact on biodiversity.

Conservation Action Index — A measure of the extent to which conservation measures are in place for threatened species.

All these could be linked to species using agricultural habitats and impacted by agricultural practices. For example relevant indicators based on biodiversity status could include:

- The number of globally threatened species affected by agricultural practices in OECD countries.

- The status of globally threatened species affected by agricultural practices in OECD countries.

- The trends in population sizes of globally threatened species affected by agricultural practices in OECD countries.

- The status of globally threatened species which use agricultural habitats in OECD countries.

- The trends in population sizes of globally threatened species which use agricultural habitats in OECD countries.

Extensive consultations are being led by IUCN to agree the means for developing such biodiversity indicators from the IUCN Red List. The first publication of these is planned in 2004. BirdLife plans to test a number of these indices using threat assessments and population data on globally threatened birds from 1988, 1994, and 2000, with a further re-assessment scheduled for 2004.

Indicator development issues

One problem with applying biodiversity indicators is that, although many data are available, there are relatively few complete national, regional or global biodiversity datasets that are available over long time periods. The indicators described in this paper for common and widespread and globally threatened birds, and the sites supporting internationally important numbers of them, are based on large, internationally standardised datasets that will make a significant contribution to measuring the effects of agriculture on biodiversity in OECD countries.

However, many of the indicators presented are largely in the development phase and undoubtedly further discussion is needed on how to take some of these ideas forward.

Areas that require further consideration include:

- Exploration of the value of setting targets for species population levels.

- Reviews of common bird monitoring schemes throughout OECD countries, and the data available from these schemes.

- Development of national monitoring programmes for common species, where none are currently in place.

- Production of guidelines on how to develop a widespread species indicator for OECD countries.

- Review and possible development of more limited monitoring of selected farmland bird species, whilst addressing concerns over pre-selecting species.

- Possibilities for back-calculating indices where historic data are incomplete.

- Putting bird data in the context of other data and indicators held by the OECD.

- Further exploration of the links between agricultural pressures and biodiversity monitoring programmes gathering data on impacts.

- Further autoecological studies examining reasons for changes in species populations.

- The scope for collaboration between different organisations to improve monitoring programmes and indicator development.

- Trialling different approaches to the development of biodiversity indicators.

- Promotion of biodiversity monitoring systems in OECD countries.

Conclusions

- BirdLife strongly supports the development of 'wild species' indicators by the OECD as an essential component of the OECD's set of agri-environment indicators.

- BirdLife believes that trends in wildlife are a good indicator of the effectiveness of agri-environment policy.

- There is no substitute for time series of abundance of selected taxa as a way of detecting biodiversity trends. Measures of species diversity are often inadequate.

- Further research into biodiversity change will help to establish whether birds are always the best group to use as indicators, and the extent to which indicators need to incorporate other taxa. At present, however, the wealth of data available on birds from both governmental and non-governmental organisations throughout OECD countries appear to offer the most promising opportunities for developing wild species indicators in agriculture.

- There are different approaches to describe and assess the state and trends in populations of wild species associated with agriculture. The involvement of NGOs in governmental and institutional initiatives to progress biodiversity monitoring and indicator development is welcomed.

- We propose that it may be useful to divide 'Wild species' indicators into three separate indicator sets, resulting in indices for "wild species" drawn from the monitoring of widespread and common species, site networks for species and globally threatened species.

- Data are presented on the Important Bird Areas programme, a global network of sites of international importance for birds. Indicators that may be drawn from this programme include:

    - Proportion of IBAs in OECD countries with agricultural land-use.

    - Number of IBAs in OECD countries with agricultural land-use.

    - Area of IBAs in OECD countries with agricultural land-use.

    - Trends in wild species populations at IBAs with agricultural land-use.

- Examples of indicators for common wild bird species are presented. The adoption of wild bird indicators in the UK illustrates the potential to use common and widespread birds as indicators of sustainability. This index may also work in other data rich countries with effective national monitoring schemes and it would be beneficial to explore this as a model. Alternative approaches may be to concentrate efforts on monitoring groups of species indicative of certain agricultural practices/habitats.

- A number of indices using Red List data to characterise globally threatened species are under development by IUCN. BirdLife plans to test a number of these indices using threat assessments and population data on globally threatened birds from 1988, 1994, and 2000, with a further re-assessment scheduled for 2004. Relevant indicators based on biodiversity status include:

    - The number of globally threatened species affected by agricultural practices in OECD countries.

    - The status of globally threatened species affected by agricultural practices in OECD countries.

    - The trends in population sizes of globally threatened species affected by agricultural practices in OECD countries.

    - The status of globally threatened species which use agricultural habitats in OECD countries.

    - The trends in population sizes of globally threatened species which use agricultural habitats in OECD countries.

- The indicators described in this paper for widespread and threatened birds, and the sites supporting internationally important numbers of them, are based on large, internationally standardised datasets that, if monitoring continues, will make a significant contribution to measuring the effects of agriculture on biodiversity in OECD countries.

- Producing a set of generic principles and guidelines for member countries to follow in developing and submitting indicators would help to promote the development of a more coherent, consistent and comparable set of wildlife indicators, particularly for widespread species.

- A spectrum of monitoring activities take place across OECD countries. One approach may be to set a minimum level of monitoring required in the short term to measure the impacts of agriculture on biodiversity. From this longer term comprehensive plans should be developed.

- Many of the factors affecting habitat quality (irrigation, chemical use, extent of landscape features etc.) are covered by other OECD agri-environment indicators. This highlights the importance of considering the links between wildlife and habitat indicators and the wider indicator set, rather than considering them in isolation.

Acknowledgements

The authors would like to especially thank Richard Gregory and Alison Stattersfield for very useful discussion and comments which improved the content of the paper. Much information and examples are drawn from the work of Richard Gregory on indicator development of widespread species, Des Callaghan on indicator development for European IBAs and Alison Stattersfield on globally threatened species. In addition, discussion and input from Nigel Collar, Paul Donald, John Fanshawe, Lincoln Fishpool and Colin Bibby were extremely helpful in scoping this work with examples supplied by Knud Flensted, Michael Grell and Urs Weibel.

REFERENCES

Bibby, C. J. (1999), Making the most of birds as environmental indicators. In: Adams, N. J. and Slotow, R. H. eds. Proc. 22nd Int. Ornithol. Congr. Durban. Ostrich 70: 81-88.

BirdLife International (2000), *Threatened birds of the world*. Barcelona and Cambridge, U.K.: Lynx Edicions and BirdLife International.

BirdLife International/EBCC (2001), *European Bird Populations: estimates and trends.* BirdLife and European Bird Census Council. Bird conservation Series No. 10.

BirdLife International (2001), Important Bird Areas and potential Ramsar Sites in Europe. Wageningen, The Netherlands: BirdLife International.

DETR (1999), A Better Quality of Life. A strategy for sustainable development for the United Kingdom. Com 4345. HMSO.

Donald, P. F., Green, R. E. and Heath, M. F. (2001), Agricultural intensification and the collapse of Europe's farmland bird populations. *Proc. R. Soc. Lond. B.* 268: 25-29.

Evans, M. I. (1994), *Important Bird Areas of the Middle East*. Cambridge, U.K.: BirdLife International (Conservation Series 2).

Gregory, R. D., Noble, D. G., Cranswick, P. A., Campbell, L. H., Rehfisch, M. M. and Baillie, S. R. (2001), *The State of the UK's Birds 2000.* RSPB and BTO. Sandy.

Gregory, R. D., Noble, D., Field, R., Marchant, J., Raven, M. and Gibbons, D. W. (submitted), Using Birds as Indicators of Biodiversity. Proceedings of the EBCC Conference, Hungary 2001.

Gregory, R. D., Noble, D. G., Campbell, L. H. and Gibbons, D. W. (2000), *The State of the UK's Birds 1999*. RSPB and BTO, Sandy.

Heath, M F and Evans, M. I. (2000), *Important Bird Areas in Europe: priority sites for conservation*. BirdLife International.

IUCN (draft 2001), *The IUCN Red List of Threatened Species — a tool for monitoring biological diversity- implementation of Article 7 identification and monitoring*. For the sixth meeting of the Subsidiary Body on Scientific, Technical, and Technological Advice (SBSTTA) to the Convention on Biological Diversity (March 2001).

Marchant, J. H., Forrest, C., and Greenwood, J. J. D. (1997), A review of large-scale generic population monitoring schemes in Europe. *Bird Census News* 10, 42-79.

OECD (2001*), Environmental Indicators for Agriculture — Methods and Results*. Volume 3. Paris: OECD.

Pearce, D. (1998), *Measuring Sustainable Development: Implications for Agri-Environment Indicators*. Paper to OECD Workshop on Agri-Environment Indicators, York, September 1998.

SEO/BirdLife (2001), *Tendencias de las poplaciones de aves comunes en Espana* (1996-2000). Programa SACRE. Informe 2000. Madrid: SEO/BirdLife.

Tucker, G. M. and Heath, M. F. (1994), *Birds in Europe: their conservation status*. UK: BirdLife International (Conservation Series 3).

Tucker, G. M. and Evans, M. I. Eds. (1997), *Habitats for birds in Europe: a conservation strategy for the wider environment*. Cambridge, U.K.: BirdLife International (Conservation Series 6).

van Strien, A. J. (1997), Biodiversity declining in the Netherlands: an indicator to describe the changes in the numbers of wild species. Netherlands Official Statistics, Winter 1997, 45-49.

van Strien, A. J. (1999), From monitoring data to policy-relevant summary statistics. Bird Numbers 1998. *Die Vogelwelt* 120.

van Strien, A. J. and Pannekoek, J. (1998), A pilot study on Euromonitoring. Bird Census News 11, 46-49.

van Strien, A. J., Pannekoek, J. and Gibbons, D. W. (in press). Indexing European bird population trends using results of national monitoring schemes: a trial of a new method. *Bird Study*.

Further data and information can be found on www.birdlife.net

OVERVIEW OF BIODIVERSITY INDICATORS RELATED TO AGRICULTURE IN BELGIUM

Visi García Cidad[1], Geert De Blust[2], Jean-François Maljean[1], Alain Peeters[1]

Introduction

There is a strong concern that industrialisation and other changes in agriculture have long term consequences, which may compromise future levels of desired outputs from agricultural and other resources. Remarkable increases in agricultural productivity have occurred in many parts of the world during the last four decades thanks to intensification. Main characteristics of intensive agriculture are: specialisation, concentration, high fertilisation levels, regular biocide application (insecticides, fungicides, herbicides), irrigation/water abstraction, drainage and mechanisation (EEA, 1998). These characteristics however imply the loss or export of certain substances in large amounts (organic matters, nutrients, pesticide residues) and also the deposition in large amounts of other substances (nitrogen, phosphorus), leaving nutrient excess in the environment (García Cidad, 1999). Agricultural practices often affect not only the production areas but also the surrounding habitats, through, for example, water abstraction, and run-off and leaching of excess fertilisers and pesticides. Intensification in agriculture involves the development of capital-intensive and geographically specialised farming, leading to problems for landscape, biodiversity, but also for soil, water and air (ECNC, 1999). A serious decline of many plant and animal species which are traditionally linked to agricultural areas has been demonstrated (Green, 1990; Barr *et al.,* 1993; Fuller *et al.,* 1995; Andreasen *et al.,* 1996; Krebs *et al.*, 1999). Concerns are therefore increasing as to whether productivity gains can be maintained in the long term. As a result of those concerns, the notion of sustainability has arisen. In recent years, criteria have been developed (Van Mansvelt, 1997; Bühler-Natour & Herzog, 1999) and specific measures have been taken to benefit biodiversity and reverse the declines (Ovenden *et al.*, 1998). Society demands on the agricultural landscape have also changed with the increase in urbanisation. People urge a broad spectrum of functions from agricultural landscapes: food production, industrial use, recreation, housing, nature conservation, global environmental control (Vos and Meekes, 1999).

Agricultural management practices and trends have a key impact on biodiversity conservation (ECNC, 2001). Participants of the CBD/COP 5 Conference (CBD, 2000), have recognised that “understanding of the underlying causes of the loss of agricultural biodiversity is limited, as is understanding of the consequences of such loss for the functioning of agricultural ecosystems (Decision V/5)”.

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An approach adopted to better understand those complex relationships is the use of indicators. An indicator can be defined as a representative survey (a qualitative or quantitative variable) of a phenomenon occurring within a complex system (Quintin, 2001). The advantage of using indicators is that they condense information and facilitate the understanding of the complex phenomenon they survey by simplifying it. They help to transmit information to decision-makers and to the general public at the same time that they facilitate monitoring and evaluation of the state of biodiversity.

In general indicators can be classified as *means* and *result* indicators. *Means* biodiversity indicators concern agricultural practices and can be considered as indirect measures of the status of biodiversity. Most of them are included into the different OECD thematic groups (pesticide use, water quality, etc.). It is assumed that the recorded features have an impact (positive or negative) on biodiversity, *i.e.* organic agriculture or pesticide use. R*esult* biodiversity indicators are a direct measurement of biodiversity, *i.e.* species abundance or species richness. *Result* indicators, although more reliable, are usually more expensive to monitor than *means* indicators. Moreover, it is generally difficult to compare *result* indicators between countries or regions, because species and natural habitats concerned are different.

The *means / results* classification is complementary to the OECD methodological frame (Driving Force-State-Response — DSR - model - OECD, 1997), being *result* indicators approximately equivalent to State indicators and *means* indicators to Driving Force indicators. However, as already explained, *means* indicators can also be seen as *indirect* State indicators (*i.e.* length of hedges, surface of extensive grasslands) through a causal relationship. The three sections composing the OECD model take into account agricultural characteristics, its relation with the environment and the role of agriculture in sustainable development. The framework identifies: driving force indicators, focusing on the agricultural elements causing modifications in the environmental conditions, such as changes in farm management practices and the use of farm inputs; state indicators, highlighting the effects of agriculture on the environment, for example, impacts on soil, water, and biodiversity; and response indicators covering the actions taken to respond to the changes in the state of the environment, such as variations in agri-environmental research expenditure (OECD, 2001).

A summary of the state-of-the-art in Belgium (at Federal and Regional levels: Wallonia and Flanders) of the use of indicators to monitor and analyse agricultural impacts on biodiversity, is presented below.

Belgium

Over the past years the Belgian agricultural sector has generated a 1.5% of the Belgian Gross National Product, placing agriculture in eighth position in the rankings of value added generated by the primary and secondary sectors (CLE, 2001). About 2% of the workforce is employed in the agriculture sector. Agriculture is becoming increasingly less important in economic terms, but remains the main activity in the countryside, where more than 45% of land is under cultivation (CLE, 2001). Nowadays, agriculture has become not only a food provider but also a provider of goods and services for tourism, leisure, landscape management, nature conservation, etc. The number of holdings has fallen by 25% in the past decade (CLE, 2001).

Environmental responsibilities in Belgium are shared by the Federal Government and the Regions. Belgium is a Federal State which consists of Communities and Regions. There are three Communities based on language (the Flemish Community, the French Community and the German-speaking Community), and three Regions (the Flemish Region, the Brussels Capital Region and the

Walloon Region). Each Region has been developing its own biological diversity monitoring programme and there is little coordinated information or inventory available at national level (Belgian National focal Point to the Convention on Biological Diversity, 2001). In the case of agriculture, some indicators are compiled at national level by the Federal Ministry of Agriculture and by the National Institute of Statistics (Belgian National focal Point to the Convention on Biological Diversity, 2001).

At Federal level, the report on indicators for Biological Diversity in Belgium has just been produced (Belgian National focal Point to the Convention on Biological Diversity, 2001). The objective was to compile the currently used biodiversity monitoring indicators in Belgium. The report is based on the reference list of biological diversity indicators provided by the CBD Secretariat (CBD, 2001). The report includes the following list of indicators specific to agriculture (indicators marked in bold were added to the original list and are specific to the Belgian context (Table 1).

Flanders

At regional level

Since 1994, the Flemish Environmental Agency produces regular reports on the state of the environment and nature in the Flemish region. After the first two publications of 1994 and 1996 which gave a broad and in-depth insight into the environmental issues in Flanders (Verbruggen, 1994; 1997), the structure of the reporting changed in order to be more useful for policy making and policy evaluation. Indeed, on the one hand, there was the need to have appropriate up-to-date information available for the definition of the yearly environmental action plans, on the other hand, exploring case studies and an extensive evaluation study of past and current policy practice was considered to be of great help to elaborate the five years environmental and nature policy plans. Three different products are published since then:

- The yearly thematic reports (MIRA-T), containing the state of nature and environment in relation to the different environmental themes or disturbance processes (*e.g.* light pollution, fragmentation, eutrofication, acidification, depletion of the ozone layer, etc).

- The five-yearly scenario report (MIRA-S), describing potential developments in the state of environment and nature, given a set of societal, economic, technical hypothesis.

- The five-yearly policy evaluation reports (MIRA-BE) with an in-depth evaluation of environmental policy.

In 1998 and 1999 thematic reports were published (Verbruggen, 1998; Vandeweerd, 1999) and in 2000 the first scenario report was finished (Van Steertegem, 2000).

Except for the first report, the state of nature and environment has been described with the help of indicators, following the OECD approach (pressure, state and response indicators. This has yield an exhaustive list of which some can also be used as agri-biodiversity indicators. Agriculture is recognised to have a huge impact on environment and nature. The extent of this impact is assessed by analysing the use of natural resources and the emissions caused by agriculture. Specific pressure variables are then linked with the relevant environmental themes (see Table 2).

Table 1. **CBD indicators for agricultural biological diversity in Belgium**

	INDICATORS	Federal level	Wallonia	Flanders
ECOSYSTEM	**Land use for agriculture: agricultural area, n°. of farms; average agricultural area per farm**[1]	X	X	x
	Agricultural area per crops (cereal, oil crops, forage, woodlands) [1]	X	X	x
	Agricultural area (intensively farmed, semi-intensively farmed and uncultivated) [2]	X		
	Change in area of agricultural land (conversion to or from agriculture) [3]	X	x	
	Organic farming [4]	X	x	x
	Use of agricultural pesticides[5]	X	x	x
	Use of agricultural fertilizers[5]	X	x	x
	Afforestation of agricultural land (ha); incl. Christmas tree plantations not including hedges[6]	X	x	
SPECIES	Number of species threatened by agriculture by group *e.g.* birds, mammals, vascular plants, vertebrates, invertebrates) [7]		x	x
	Number of vertebrate **or invertebrate** species using habitat on agricultural land by species[7]			x
	Differences in species diversity and abundance of arthropods and earthworms in organically and conventionally cultivated arable land	x		
	Rate of change from dominance of non-domesticated species to domesticated species	Not applicable		
	Species diversity used for food	x		
GENES	Erosion/Loss of genetic diversity patrimony	x		
	Crops/livestock grown as a percentage of number of 30 years before	x		
	Accession of crops and livestock in ex-situ storage (number or percentage)	x		
	Replacement of landraces with few imported ones	x		
	Replacement of indigenous crops	x		
	Accessions of crops generated in the past decade (per cent)	x		
	Coefficient of kinship or parentage of crops	x		
OTHER	Inbreeding/outbreeding rate	x		
	Rate of genetic interchange between populations (measured by rate of dispersal and subsequent reproduction of migrants) [8]			x
	Use of agri-environmental measures (amount of money granted)[9]		x	x

Notes to Table 1:

1. These indicators are compiled annually by the National Institute of Statistics (NIS), both at federal and regional level. See agriculture indicators of the NIS at http://www.statbel.fgov.be/figures/agriculture_fr.htm
2. The NIS provides some data at national level on extensively farmed land: total area of extensive vegetable cultivation and high-stem orchards.
3. The NIS compiles annually the total area of land taken away from agricultural production, both at national and regional level.
4. The NIS also provides data on organic farming, through the number of organic farms and the total area for organic pastures and cultivated land.
5. Data is compiled at federal level by NIS, but additional data is available at regional level. The main indicators used are the product quantity/ha/year (amount of fertilizers used or amount of active matter used for pesticides). Flanders: A monitoring programme specifically evaluates agricultural pressures (MAP — Manure Action Plan). In this regard, the region assesses the pressure from manure spreading on the soil and ground- and surface-water quality (amount of manure produced and spread on fields, in terms of phosphate and nitrogen production).

6. The NIS estimates annually the total area of agricultural land afforested (including the total area of Christmas tree plantations), both at federal and regional level. Wallonia also uses as an indicator the total area concerned by financial support for afforestation (area/tree species planted).
7. Flanders: exhaustive species inventories and red lists have been established for a wide range of habitats, including grasslands. Information is also available for agricultural lands. Species include vascular plants, butterflies, spiders (see indicators 145 and 155-170). Trends analysis has been carried out for some bird species in agricultural areas. Wallonia: data are available for birds in agricultural areas.
8. Flanders: a research project is carried out at regional level on 3 vulnerable vascular plant species (*Primula vulgaris*, *P. veris* en *P. elatior*) typical of agricultural areas.
9. Wallonia, Flanders: the financial assistance (amount of money) given for the implementation of the EU's agri-environmental measures is used as an indicator by both Wallonia and Flanders. These measures include the plantation of hedges, late mowing practices, rare cattle breeds and extensive grazing, establishment of wetlands and ponds, etc.
Source: Belgian National focal Point to the Convention on Biological Diversity (2001). Report on "Indicators for Biological Diversity in Belgium". Royal Belgian Institute of Natural Sciences.

Table 2. **Relations between pressure indicators of agriculture and environmental themes as used in the Flemish 'Reports on the environment and nature'**

Pressure indicator	Theme
Water use	Desiccation
Energy use	Greenhouse effect
Production of animal manure, chemical fertilisers use	Eutrofication, acidification, odour, greenhouse effect, water quality
Pesticide use	Pollution
Emission of NH3	Eutrofication, acidification
Emission of SO2	Acidification
Emission of CH4, N2O, CO2	Greenhouse effect

Source: Helming *et al.*, 2000.

For the different themes the contribution of agriculture to the total pressure is then calculated. However, an unequivocal relation between the pressures exerted by agriculture and effects on nature or biodiversity that result from them, is seldom given; at least for Flanders as a whole. On the local scale however, a lot of case studies are convincing in this respect.

Assessing the impact of agriculture on biodiversity is done the other way around: more general data sets on biodiversity are compiled and analysed in the light of potential agricultural impacts. This state of biodiversity and the associated role of agriculture are well documented in the reports mentioned earlier and especially in the "Nature Report" (Kuijken, 1999). The Nature Report is published bi-annually by the Institute of Nature Conservation. It gives a very detailed description of the state of the different major taxonomic groups, the characteristic communities and the ecosystems of Flanders. In the 2001 edition (Kuijken, in press), an analysis, starting from the relevant disturbance themes, is also included.

Biodiversity and agriculture in Flanders, some figures and trends

From all these reports and from earlier or parallel studies, some general and major trends concerning the impact of agriculture on biodiversity are clear. Some clear examples are given below:

From the 21 bird species typical for agricultural landscape, 15 show a sharp decline and 6 almost got extinct. Habitat area, habitat quality and available non-toxic food seem to be the critical factors. Thus, the presence and abundance of these species reflect land use, landscape structure and scale, agricultural management and crop rotation, presence of semi-natural habitat patches, all aspects that are to a very high degree influenced by the transformations of agriculture. It can be concluded that abundance measurements of the guild of characteristic breeding birds of the agricultural landscape yield a suitable indicator to assess general agricultural impact on biodiversity. As an alternative also the abundance of individual species can be used as an indicator. Once common birds such as the Sky Lark (*Alauda arvensis*), Tree Sparrow (*Passer montanus*), Yellowhammer (*Emberiza citrinella*), have proven to be very suitable in this respect in Flanders. Species that are nowadays very rare in Flanders, such as the Red-backed Shrike (*Lanius collurio*), are only useful in specific regions.

Butterflies are suitable to be used as integrative but also very specific indicators, owing to their (sometimes exclusive) dependence as a caterpillar on a certain host plant and as an adult on nectar plants and biotope structure. Besides that, their often limited dispersion capacity makes them very sensitive to decrease of habitat area and fragmentation (Maes & Van Dyck, 1999). In Flanders, a comparison with data from 1991 showed that rare species are becoming rarer and general species more general (Maes & Van Dyck, 1996). Species of vegetation in early and late succession stages are declining sharply, while species of the intermediate succession stages do not follow this trend. In particular butterflies of dry and wet heath, dry and humid species-rich grasslands, natural forests and marches are threatened. The destruction of the small habitat patches, scattered in the agricultural landscape, the disappearance of host plants through acidification, eutrofication or desiccation, mean the end of the populations.

Finally, vascular plants are widely used as indicators to assess the impact on biodiversity of landscape transformation and changes in environmental qualities. For Flanders it turned out that of the 12 habitat types that have more than 50% of their characteristic plant species in the Red List categories vulnerable, endangered, critically endangered or extinct, 5 biotopes are characteristic for the agricultural land, while 3 are found in what is left of the semi-natural biotopes in that agricultural area (De Blust *et al.*, 1997). It is striking that these plant species all depend on moderately or nutrient poor often calcareous soils.

When analysing the plant species that have recently (after 1972) declined in Flanders (Cosyns *et al.*, 1994) (irrespective their initial abundance), the portion of (potentially) endangered or extinct species is the greatest for the flora that is characteristic for arable land on loamy soils: 80-90 % of those species have declined, the same amount as for the socio-ecological group of the nutrient poor calcareous fens (not an agricultural habitat).

The causes for the current state vary widely. Direct destruction of the habitat is undoubtedly very important. In addition desiccation, acidification and eutrofication of the countryside environment have a very negative impact on the flora as has been shown in very many detailed studies of species and areas. But when ones tries to examine whether clear relations can be established between changes in these specific factors and changes in the total flora of Flanders, results are far less clear. Plant species can be grouped according their ecological amplitude regarding a certain environmental factor. Based on this, species can be assigned indicator values *e.g.* for the humidity and the acidity of the site, the nutrient content relative to the availability of ammonium or nitrate in the topsoil (see *e.g.* Ellenberg *et al.*, 1992). When for the indicator values of different environmental factors, the frequency distribution curves of the sub-sample of the Red List species in Flanders (categories endangered and extinct) and that of the total flora of Flanders are compared and tested for significance, the environmental variables 'nutrient content' and 'light' appeared to be highly significant (De Blust *et al.*, 1997). Thus plant species indicative of open areas and of habitats that are poor in nutrient, appear to be strongly represented among the endangered species. Shading, what means a lack of management, and eutrofication are probably among the most important causes of decline, whatever region or habitat in Flanders.

Deposition rates of N are very high everywhere in Flanders, with an average of 39 kg N/ha and year (Van Gijseghem *et al.*, 2000). When compared with the critical loads for nitrogen deposition for forest ecosystems -the best studied objects in Flanders until now (n = 652)- in more than halve of them, the critical load is exceeded. The critical load for N varies between 7.5 and 13.6 kg N/ha and year. For the other semi-natural ecosystems, most of high importance for nature conservation and hence found in the nature reserves scattered in the countryside, the figures are even more alarming. In a study that compared actual deposition according a deposition model with the critical loads for different types of highly vulnerable mesophilic fen, extensively managed semi-natural grassland and heathland, it was concluded that everywhere in Flanders those critical loads were exceeded.

The problem is that a quick change in this situation may not be expected. A case study revealed that except for the sustainable development scenario, there is little hope that nitrogen deposition will decrease sufficiently to meet the requirements of the vulnerable ecosystems. In 2010 still 38% of the forest ecosystems will suffer from exceeding depositions and hence with the scenario's business as usual (BAU= complete execution of all measures foreseen in current policy) and improved BAU+ (=complete execution of all measures foreseen in current policy + some extra technological measures), the intermediate policy targets will not be reached. The same holds, and even more dramatically, for the most vulnerable ecosystems of interest for nature conservation. Even with BAU+, only for 5% of the area occupied by these ecosystems, the conditions will have improved so far that critical loads are no longer exceeded.

But even when the nitrogen deposition decreases, this amelioration must coincide with an equal improvement of the landscape characteristics and with ecologically sound management. The scale of application will be critical in this respect. For instance, there are chances for birds of agricultural areas to recover in so far that *e.g.* management agreements and restoration of small landscape elements, together with a decrease in the spread of toxic products, are applied on a broad scale. But still, as calculations revealed, even with the BAU scenario for about halve of the species the future will remain uncertain, resulting in unstable populations that may face extinction on the long run (De Bruyn *et al.*, 2000).

Finally, when environmental conditions will improve in the future, there still has to be space for the habitats. That is another bottleneck. Old species-rich semi-natural grassland *e.g.*, the community that is most endangered by agriculture because of it being turned into temporary sown grassland or corn fields over huge areas, only occupies 0.3 to 0.6 % of the total area of Flanders (4 640 – 8 870 ha in total), scattered over hundreds of parcels (Kuijken, 1999). It is unnecessary to underline that the chances to maintain and preserve these ecosystems are becoming very small.

Monitoring land use and biodiversity in agriculture

A comprehensive and integrated monitoring scheme has to be elaborated in order to document regularly the state of a complex landscape and at the same time to shed light on the processes involved in its change. Because of this, variables are selected according their role in the DPSIR-conceptual model (OECD, 1997). Besides the functional interrelations between these variables, the spatially nested surveillance of the variables is another fundamental character of such an integrated monitoring. Variables to be sampled and the calculated indicators must represent the different components of the agroecosystem, the landscape and the associated biodiversity.

A detailed methodology to monitor all these changes has been elaborated in Flanders by Antrop *et al.* (2000). They developed an integrated and nested monitoring scheme that will be executed for the first time in 2002. The selection of variables and indicators was not only based on the DPSIR-conceptual model, but also tried to coincide with the successive sectors of environmental policy and management. Hence, the integrated monitoring programme for landscape and biodiversity of the Flemish countryside will work with a series of linked indicators (Table 3) (De Blust & Van Olmen, in press). The monitoring project developed for Flanders' countryside include 165 objects (the mapping units) with all together 175 attributes and biodiversity measures such as total flora, vegetation descriptions of the major land use types, breeding bird sensus, butterfly inventories and counts of amphibians (Antrop *et al.*, 2000). Monitoring is done within 1 square kilometre plots. 30 sample quadrates distributed in the rural areas of Flanders are proposed. A stratified random sampling was used based upon the division of the traditional landscapes of Flanders.

At Regional level

Since 1993, the Ministry of the Walloon Region (Direction générale des Ressources Naturelles et de l'Environnement) produces regular reports containing the Environmental Status of the Walloon Region (Etat de l'Environnement Wallon). In 1995, the report (Ministère de la Région Wallonne, 1995) was specially dedicated to agriculture, but at that moment no specific mentions to biodiversity was included. The 2000 report (Ministère de la Région Wallonne, 2000) had a chapter dedicated to agriculture and was more focused on indicators but again no specific agrobiodiversity indicators where mentioned.

Wallonia

A study is now being elaborated with the objective of producing a summary of the agri-environmental indicators used in the agricultural sector in the Walloon region (Quintin, 2001). The study adopts the general DSR (Driving Force-State-Response) framework propose by the OECD (OECD, 1997). The objective of this study is the selection of 50 indicators enabling a monitoring of the interrelations between agriculture and environment. In the study, environment is understood as the sum of the different physical environmental compartments (air, water, soil), landscapes and biodiversity parameters (genes, species and habitats). This time agro-biodiversity indicators have been integrated. The ones indicated in the document (Quintin, 2001) are:

- Importance of the ecological network in agricultural land (hectares, km);
- Farmers managing nature reserves (management contracts, hectares);
- Agricultural surface located in an environmentally sensitive area (hectares);
- Afforestation of agricultural land (hectares).

Table 3. **Examples of series of pressure, state and impact indicators as used in the integrated monitoring programme for landscape and biodiversity of the Flemish countryside**

	Pressure indicators to be derived from local data collection	**State indicator**	**Impact indicator**
Desiccation	Area of parcels with subterranean drains Total volume of permitted groundwater extraction	Water level in gauges and ditches Groundwater quality expressed as conductivity and ion ratio	Number of obligate phreatophyte plant species Share of the different moisture plant indicator classes (sensu Ellenberg[1]) in the total flora
Eutrofication	N and P emission from local sources (*e.g.* total number of cattle and pigs)	N deposition (wet and dry) measured in (semi-) natural vegetation to allow comparison with critical loads[2] Soil P saturation in representative parcels	The proportion of clearly dominant plant species in the herb layer Share of plant species characteristic for oligo- to mesotrophic conditions (sensu Ellenberg[1]) in the total flora
Acidification	Potential acidifying emission expressed as total acid equivalents	Real deposition (wet and dry) as total acid equivalents in (semi-) natural vegetation to allow comparison with critical loads[3] pH of phreatic water	Forest vitality, degree of leaf damage Share of the different acidity plant indicator classes (sensu Ellenberg[1]) in the total flora
Fragmentation	Increase/decrease of hard barriers (length/area) Presence of mitigating infrastructure (ecoduct etc.)	Landscape metrics	Difficult to define in general Presence/absence of species functional groups according their dispersion strategies and capacities
Erosion	Total area of land without vegetation cover in winter related to terrain slope Presence of permanent vegetated talus and verges in raised areas	Presence of eroded ground and gullies Length of roads covered with mud Organic matter content of the topsoil of arable land	Area of un-vegetated patches in small landscape elements Number of pioneer plant species in the total flora of small landscape elements

1. Ellenberg *et al.* 1992.
2. Bobbink *et al.* 1998.
3. De Vries, 1988.
Source: Antrop *et al.*, 2000.

Other important indicators for biodiversity have been classified according to Quintin (2001) into Regional agricultural policy:

- Measures for conserving threaten local animal races and vegetal varieties (number of farms, number of animals, Euro).

- Number of farms applying agri-environmental measures; Another study elaborated recently in Belgium (Bogaert *et al.*, 2000) highlights the importance of a very similar indicator (hectares of farmland per region for which a management agreement is signed in the frame of agri-environmental measures) to reflect landscape aspects.

Biodiversity and Agriculture in Wallonia, some figures and trends

The Observatory of Fauna, Flora and Habitat (OFFH, 2001) of Wallonia aims to coordinate the collection and analysis of biological diversity data. Wallonia is one of the Regions in Europe where the biological patrimony is best known. A big number of naturalist have contributed for more than one century to improve the existing knowledge of species distribution and outstanding habitats. The actual situation of biodiversity in Wallonia is rather negative: several of the monitored species have already disappeared (5 to 15%) and several others are declining (30 to 50%), being the main cause the disappearance and fragmentation of habitats (OFFH, 2001).

Four programmes conform the fields of activity of the Observatory of Fauna, Flora and Habitat:

- Inventory and monitoring of biological diversity (ISB) — Monitoring the state of the environment through bio-indicators (SURWAL), to describe and monitor the distribution of species belonging to major biological groups;

- Inventory and monitoring of habitats (ISH), to make a standardised inventory of habitats and to monitor their regional dynamics;

- Inventory of sites of great biological interest (SGIB), to gather information on areas that harbour species and habitats of great biological interest;

- System of information on biological diversity in Wallonia (SIBW), to disseminate information collected within the scope of the first three programmes.

The biological groups being monitored at present in the first programme (Inventory and monitoring of biological diversity — Monitoring the state of the environment through bio-indicators), are (ISB-SURWAL, 2001): birds, reptiles, butterflies, dragonflies, orchids and ladybirds. Although this programme is not specifically focused on agriculture, it is clear that agricultural ecosystems are fundamental for the monitoring of the mentioned biological groups.

Within the thematic group of birds, a monitoring programme was launched in 1990 based on listening points (points d’écoute). The surveys consist of different transects (repeated annually) of 15 listening points all over Wallonia (an average of 2 300 points per year). From a total of 160 observed species, only 77 were analysed (OFFH, 2001). From those 77, the population of 12 was identified as increasing significantly, 27 decreasing and the rest were considered to be stable. The general tendency in Wallonia appears then to be negative.

One of the surveys on butterflies concentrates on 21 species considered prioritaire. All the selected species were surveyed by direct observation or by counting imagos on the ground, either in transects or observation points. Six of the 21 species have sown a significant decline between 1990 and 1999 (*i.e. Eurodryas aurinia*), and other five species presented also a declining trend. Two *species (Coenonympha hero* and *Strymonidia spini*) may have even disappeared in Wallonia between 1990 and 1999. The rest of the species seem to have a stable population. The most threatened species are to be found in semi-natural habitats and therefore always involving a certain degree of human activity, *i.e.* extensive grasslands. The major threats to those species are agricultural, intensification, afforestation of open landscapes and eutrofication. Urbanisation and desiccation of humid areas have also been identified as secondary threats (OFFH, 2001).

At field/farm level

Several studies exist up to date characterising, through the use of indicators, the environmental status or performance of different areas in Wallonia. One of the first studies on biodiversity indicators at farm level started in 1993 in the framework of a European project (Van Bol & Peeters, 1996). The project aimed at the improvement of farm sustainability by developing an ecological network in pilot-farms. Two indicators were finally selected for biodiversity: area of ecological infrastructure (percentage of farm area managed for biodiversity; *e.g.* field margins, hedgerows, extensive grasslands) and the Plant Species Diversity Index (*i.e.* the Shannon Weaver Index calculated on dicot species). Two other indicators, based on birds and butterflies populations, were investigated but finally rejected because both indicators appeared expensive to record at farm level and moreover, both biological groups were not only influenced by farming practices but also by the neighbouring landscapes. During this project, Plant Species Diversity Index and area of ecological infrastructure were thus considered the best indicators of the global state of biodiversity at farm level.

A more recent example is the study about the environmental performance of agriculture inside a Natural Park (Walot *et al.*, 2000), elaborated by the GIREA (Applied ecology interuniversitaire research group). The description of environmental performance of agriculture includes a point dedicated to the impact on biodiversity and ecological network. The indicators selected to characterise this point were:

- Stocking rate (LU/ha).
- Riverside exposed to cultivated fields (m; %).
- Riverside exposed to pastures (m; %).
- Marginal pastures within the farm (%).
- Use of good fertilisation practices (according to the existing legislation in the Walloon region) (ha).
- Average fertilisation applied in grasslands (kg/ha).
- Application of agri-environmental measures (ha; %).
- Average parcel size (ha).

- Hedges density (m/ha).
- Existing natural elements (% surface).
- Threatened livestock breeds and crop varieties.

In order to evaluate environmental performance of agriculture at farm level, there exists in the Walloon region a computer tool under development: PAEXA, Portrait Agri-environmental de l'Exploitation Agricole (Grosjean, 2000). A first version of the prototype was tested in 2000. This programme aims to produce agri-environmental evaluations at farm level through the use of 21 agri-environmental indicators (Cossement, 2000). PAEXA was conceived as a tool for (a) evaluation (in order to identify and estimate the pressures exerted at farm level by different practices); (b) management (fix objectives to achieve in the near future, through the modification of agricultural practices); (c) prediction (modelling, simulating different evolutionary scenarios) and (d) monitoring (evaluation of the achievement of prefixed objectives). PAEXA describes the interrelations between agriculture and the environment at three levels (Josselin, 2001): Agri-environmental indicators (analysed individually); Environmental evaluation (aggregation of indicators), Agri-environmental management plan (interpretation of results and proposals for improvement). Amongst the twenty-one agri-environmental indicators, the following are considered to give information about the state of biodiversity at farm level:

- Stocking rate (LU/ha).
- Use of good fertilisation practices (according to the existing legislation in the Walloon region) (ha).
- Use of alternative techniques to herbicides (ha).
- Area occupied by landscape elements within the farm (% surface).
- Area of extensive practices within the farm (ha; % surface).
- Cutting dates in grasslands for the first cut (date).
- Application of organic nitrogen in grasslands (kg/ha).
- Threatened local breeds and crop varieties.

PAEXA is a programme still under development and some proposals for improvement after the first prototype was tested in 2000, are being considered at present (Walot & Josselin, 2001).

Summary and conclusions

At Federal level, there is little coordinated information or inventory of biodiversity. Each Region has been developing its own biological diversity monitoring system. In the case of agriculture, some indicators are compiled at national level by the Federal Ministry of Agriculture (that has now been regionalised) and by the National Institute of Statistics.

In Flanders, there is big concern of the future trends of biodiversity related to agriculture. Several case studies and scenario analysis have been carried out up-to-date, demonstrating the importance of agriculture. An agrobiodiversity monitoring methodology has been developed and will be tested in 2001. Meanwhile many data are already available about the state of biodiversity in Flanders. The state of biodiversity and the associated role of agriculture are well documented, although not always an unequivocal relation between the pressures exerted by agriculture and effects on nature or biodiversity is provided.

In the Walloon region, the evaluation of agrobiodiversity is mainly based on *means* or Driving Force indicators. This implies that the analysis of agriculture is made with the underlying assumption that certain practices (extensive farming, organic agriculture, techniques that help reducing inputs,…) have positive impacts on biodiversity.

Concerning State indicators in Wallonia, the selected biological groups being monitored at present (birds, reptiles, butterflies, dragonflies, orchids and ladybirds) reveal general changes in the environment. On the other hand many of them can only show the evolution of very particular habitats that have small importance in the total Walloon agricultural sector, like for example: orchids in chalk grasslands; dragonflies in lakes and ponds; reptiles in dry slopes. Nevertheless, using specific species or plant communities as biodiversity indicators in agriculture (*result* or State indicators) must be encouraged. Actually, when such a specific species or habitat is correctly chosen, its monitoring can give precious qualitative information on the interactions between agricultural practices and biodiversity. So, at present, the lack of an indicator based in the evolution of plant communities is certainly a weak point of the programme for "Monitoring the state of the environment through bioindicators" (SURWAL).

In Europe, the advantages of integrated monitoring on a landscape scale are well understood. Consequently a lot of initiatives to implement these schemes on a national or regional scale are developed (Table 4). The challenge is now to co-ordinate these projects on a European level in such a way that they can be used as an umbrella system to analyse the changes taking place in the wide variety of European landscapes. The central and directive role of the European Union and the Council of Europe regarding member states nature, environment and landscape policies, must be the catalyser. Table 4 situates the Belgian projects within the context of other European projects.

Final thoughts

The complete set of indicators selected for monitoring agrobiodiversity must be large enough for giving good information on the different elements of the studied system and at the same time as reduced as possible in order to allow quick an easy survey as well as understanding of the state of the system.

Most of the indicators measured in a system must evolve in a significant manner when a change in a management technique occurs, revealing short-term changes in the system. Other indicators reflecting long term trends, although less sensitive to short term changes and usually more expensive to survey, should also be included in the set as providers of complementary long-term information.

Table 4. **National and regional projects for integrated monitoring on a landscape scale in Europe**

Austria	Der Kulturlandschaftsforschung Österreich	Wrbka, 1998
Denmark	Small Biotope Monitoring System	Agger & Brandt, 1988
Estland	Agricultural Landscape Monitoring	Sepp, 1999
Flanders (B)	Integrated monitoring for the countryside	Antrop *et al.*, 2000
Germany	Ökologische Flächenstichprobe	Dröschmeister, 2001
Great Britain	Countryside Survey	Bunce *et al.*, 1992
	UK Environmental Change Network	Lane, 1997
Hungary	National Biodiversity Monitoring System	Ministry of Environment and Regional Policy, 1998
Sweden	Swedish countryside survey	Ihse *et al.*, 1999
Switzerland	Biodiversity Monitoring	Hintermann *et al.*, 1999
Wallonia (B)	Inventaire général de biodiversité	Defourny *et al.*, 1999

The evolution of indicator's values is informative by itself. But in the context of the implementation of sustainable systems, a norm should be associated to each indicator (Peeters & Van Vol, 2000; AWG, 1998). This norm represents a minimum or maximum value necessary in order to achieve a sustainability target. Norms are to be defined on a scientific basis, although the process may be influenced by economical, social and political considerations. Ideally, the choice of a norm must be the result of a negotiation process between different stakeholders (that will vary according to the monitoring scale): scientist, farmer representatives, farmer advisers, consumers, members of administration and politicians.

Finally it is essential to stress the importance of the monitoring scale. The choice of indicators will certainly vary depending on the monitoring purpose. They will differ at field or farm level from those selected at landscape, regional or country level. The most interesting scale for this OECD exercise is certainly the national (or regional) level. Nevertheless, country indicators are generally derived from values at farm level *(i.e.* aggregation, average, addition,…). However, some state biodiversity indicators are monitored at regional scale (*i.e.* abundance of a bird species in a rural area). Whereas contribution of agriculture is difficult to interpret, those indicators are better adapted to the concept of biodiversity (*i.e.* ecological network) than indicators derived from values at farm level. In Wallonia, for example, indicators such as these proposed by Quintin (2001) are derived from values at farm level, when indicators of the SURWAL program are not. As Wallonia is one of the Regions in Europe where the biological patrimony is best known, it should be rather easy to develop biodiversity indicators in agriculture monitored at regional scale. In addition, the European program NATURA 2000 and more generally, the growing importance given to the concept of ecological network, should also permit to develop such indicators in Europe.

Future developments of agrobiodiversity indicators in Belgium should comply with these general principles.

REFERENCES

Agger, P. & Brandt, J. (1988), Dynamics of small biotopes in Danish agricultural landscapes. Landscape Ecology, 1: 227-240.

Andreasen, C., Stryhn, H. and Streibig, J.C. (1996), Decline of the flora in Danish arable fields. Journal of Applied Ecology 33: 619-626.

Antrop, M., De Blust, G., Van Eetvelde, V. & Van Olmen, M. (2000), Ontwikkeling van een methodologie voor een geïntegreerde en gebiedsgerichte monitoring van de biodiversiteit van de terrestrische natuur in het Vlaamse Gewest. Eindrapport. Universiteit Gent, rapport Instituut voor Natuurbehoud (2000), Brussel, Gent.

AWG, Agriculture Working Group of the European Sustainable Use Specialist Group of IUCN (1998), Biodiversity and Landscape Conservation in Pan-European Agriculture: The IUCN ESUSG/AWG Approach. http://www.iucn-ero.nl/reports_files/reports.htm

Barr, C.J., Bunce, R.G.H., Clarke, R.T., Fuller, R.M., Furse, M.T., Gillespie, M.K., Groom, G.B., Hallam, C.J., Hornung, M., Howard, D.C. and Ness, M. J . (1993), Countryside survey 1990. Main report. HMSO, London, UK.

Belgian National focal Point to the Convention on Biological Diversity (2001), Report on: "Indicators for Biological Diversity in Belgium". Royal Belgian Institute of Natural Sciences.

Bobbink, R., Hornung, M. and Roelofs, J.F.M. (1998), The effects of airborne nitrogen pollutants on species diversity in natural and semi-natural European vegetation. Journal of Ecology. 86: 717-38.

Bogaert, S., Deconinck, M., and Le Roy, D. (2000), 'Ontwikkeling en toepassing van Indicatoren voor een Duurzame Landbouw in België'. Rapport en opdracht van de Diensten voor Wetenschappelijk, Technische en Culturele aangelegenheden (DWTC).

Bühler-Natour C. and Herzog F. (1999), Criteria for sustainability and their application at a regional level : the case of clearing islands in the Dübener Heide nature park (Eastern Germany). Landscape and urban planning 46:51-62.

Bunce, R.G.H., Howard, D.C., Hallam, C.J., Barr, C.J. and Benefield, C.B. (1992), Ecological consequences of land use change. Final report to Department of Environment, Institute of Terrestrial Ecology, Cumbria, UK.

CBD (2000), Decision V/5. Agricultural biological diversity: review of phase I of the programme of work and adoption of a multi-year work programme. Annex III. Decisions adopted by the Conference of Parties to the Convention on Biological Diversity at its fifth meeting. Nairobi, 15-16 May, 2000. http://www.biodiv.org/decisions/default.asp?lg=0&m=cop-05&d=05

CBD (2001), Secretariat of the Convention on Biological Diversity. United Nations Environment Programme. http://www.biodiv.org/doc/notifications/

CLE (2001), Belgian agriculture in a nutshell. Centre for Agricultural Economics. Ministry of Small enterprises, trade and Agriculture. Brussels.

Cossement, N. (2000), Contribution à l'élaboration d'une méthode de diagnostic agri-environmental en Région wallonne sur base d'un logiciel français. Mémoire de fin d'études, Année académique 1999-2000. Faculté Universitaire des Sciences Agronomiques de Gembloux.

Cosyns, E., Leten, M., Hermy, M. & Triest, L. (1994), Een statistiek van de wilde flora van Vlaanderen. Rapport VUB.

De Blust, G. & Van Olmen, M. (in press). Monitoring multifunctional landscapes: an activity relevant to environmental and nature policy.

De Blust, G. (1997), Consequences for nature. In: Verbruggen, A. (ed.) (1997): Report on the environment and nature in Flanders 1996. Learning to change. — Erembodegem: Flemish Environment Agency, p. 449-480.

De Bruyn (2000), Gevolgen voor natuur. In: Van Steertegem,M. (ed.) (2000): MIRA-S 2000, Milieu- en natuurrapport Vlaanderen: scenario's. VMM, Garant, p. 551-574.

De Vries, W. (1988), Critical deposition levels for nitrogen and sulphur on Dutch forest ecosystems. Air & Soil Pollution. 42, 221-39.

Defourny, P., Devillez, F., Giot, P., Bodin, N. and Guissard, V. (1999), Mise au point d'une méthodologie d'inventaire des habitats dans le cadre du suivi de la biodiversité en Région Wallone. UCL — Département des Sciences du Milieu et de l'Aménagement du Territoire.

Dröschmeister, R. (2001), Bundesweites Naturschutzmonitoring in der "Normallandschaft" mit der Ökologischen Flächenstichprobe. Natur und Landschaft, 76: 58-69.

ECNC, European Centre for Nature Conservation (1999), ELISA, Environmental Indicators for Sustainable Agriculture. Proceedings Workshop II. Budapest, May 28-29th, 1999.

ECNC (2001), Agricultural functions and biodiversity — A European stakeholder approach to the CBD agricultural biodiversity work programme. Laura Buguñá Hoffman (ed.), Tilburg: European Centre for Nature Conservation, 2001 (ECNC Technical report series).

EEA, European Environmental Agency (1998), Europe's Environment: the Second Assessment. Copenhagen, Denmark, pp293.

Ellenberg, H., Weber, H., Düll, R., Wirth, V., Werner, W. and Paulissen, D. (1992), Zeigerwerte von Pflanzen in Mitteleuropa. In : Scripta Geobotanica (18), Verlag Erich Goltze KG, Göttingen.

Fuller R.J., Gregory R.D., Gibbons D.W., Marchant J.H., Wilson J.D., Baillie S.R. and Carter N. (1995), Population declines and range contractions among lowland farmland birds in Britain. Conservation Biology 9 : 1425-1441.

García Cidad, V. (1999), Introducing Biodiversity into the agricultural sector. Framework paper on biodiversity and European agriculture. Presented at the 14th Global Biodiversity Forum, Montreal, Canada.

Green, B.H. (1990), Agricultural intensification and the loss of habitat, species and anemity in British grasslands: a review of historical change and assessment of future prospects. Grass Forage Sci. 45 :365-372.

Grosjean, E. (2000), Le Portrait Agri-environnemental de l'Exploitation Agricole. Second rapport au Comité d'accompagnement: 26 pp.

Helming (2000), Landbouw. In: Van Steertegem,M. (ed.) (2000), MIRA-S 2000, Milieu- en natuurrapport Vlaanderen: scenario's. VMM, Garant, p. 169-200.

Hintermann and Weber Ltd. (1999), Biodiversity Monitoring in Switzerland — Report on the status of the project at the end of 1998.

Ihse, M. and Blom, G. (2000), A Swedish countryside survey for monitoring of landscape features, biodiversity and cultural heritage — the LIM-project. In: Mander, U.E. & Jongman, R.H.G. (eds.), Consequences of Land Use Changes. Advances in Ecological Sciences, Southampton, Wessex, Institute of Technology Press, 39-74.

ISB-SURWAL (2001), Système d'Informations sur la Biodiversité en Wallonie. L'Observatoire de la Faune, de la Flore et des Habitats. Programme "Inventaire et Surveillance de la Biodiversité (ISB)- Surveillance de l'Environnement par les bioindicateurs (SURWAL)". http://mrw.wallonie.be/dgrne/sibw/organisations/OFFH/progISB/home.html

Josselin, U. (2001), Protection des eaux de surface: diagnostic à l'échelle du territoire et de l'exploitation agricole. TS Agro-environnement et aménagement rural. Stage Belgique. GIREA, Thierri Wallot, UCL, Unité ECOL, Louvain-la-Neuve, Belgique.

Krebs J.R., Wilson J.D., Bradbury R.B. and Siriwardena G.M. (1999), The second silent spring? Nature 400: 611-612.

Kuijken, E. (ed.) (1999), Natuurrapport 1999. Toestand van de natuur in Vlaanderen: cijfers voor het beleid. Mededelingen van het Instituut voor Natuurbehoud 6, Brussel. 250 p.

Kuijken, E. (ed.) (in press)(2001), Natuurrapport 2001. Toestand van de natuur in Vlaanderen. Mededelingen van het Instituut voor Natuurbehoud, Brussel.

Lane, A.M.J. (1997), The U.K. Environmental Change Network Database: An Integrated Information Resource for Long-term Monitoring and Research. Journal of Environmental Management, 51:87-105.

Maes, D. and Van Dyck, H. (1996), A documented Red List of the butterflies of Flanders (in Dutch with English summary). Communications of the Institute of Nature Conservation, 1996 (1). Brussels. 154 p.

Maes, D. and Van Dyck, H. (1999), Dagvlinders in Vlaanderen. Ecologie, verspreiding en behoud. Antwerpen, Stichting Leefmilieu vzw/KBC, 480 pp.

Ministère de la Région Wallonne (1995), Etat de l'Environnement Wallon 1995. 2. Agriculture. Ministère de la Region Wallonne. Direction générale des Ressources naturelles et de l'Environnement.

Ministère de la Région Wallonne (2000), Etat de l'Environnement Wallon 2000. L'environnement wallon à l'aube du XXI[e] siècle. Approche évolutive. Ministère de la Région Wallonne. Direction générale des Ressources naturelles et de l'Environnement.

Ministry of Environment and Regional policy (1998), National Biodiversity Monitoring System in Hungary.

OECD (1997), Indicateurs environnementaux pour l'agriculture, Publications OECD, Paris.

OECD (2001), Indicateurs environnementaux pour l'agriculture. Volume 3. Méthodes et résultats. Agriculture et alimentation.

OFFH (2001). Système d'Informations sur la Biodiversité en Wallonie. L'Observatoire de la Faune, de la Flore et des Habitats (OFFH). http://mrw.wallonie.be/dgrne/sibw/organisations/OFFH/.

Ovenden G.N., Swash A.R.H. and Smallshire D. (1998), Agri-environmental schemes and their contribution to the conservation of biodiversity in England. Journal of Applied Ecology 35 : 955-960.

Peeters, A. and Van Bol, V. (2000), ECOFARM: a research/development method for the implementation of a sustainable agriculture, in « Methods and tools of extension for mountain farms » PEETERS A. (ed.). FAO, REU technical serie 57: 41-56.

Quintin, L. (2001), Recherche d'indicateurs environnementaux appliqués au secteur agricole en Région wallone. Pour le compte du Ministère de la Région wallonne, DGA. Synthèse de la recherche menée du 1/4/00 au 30/4/01. Centre d'Etudes du Développement Durable (IGEAT).

Sepp, K. (1999), The methodology and applications of agricultural landscape monitoring in Estonia. Tartu University Press, 167 p.

Van Bol, V and Peeters, E. (1996), Advanced Ecological Farming Systems (E.F.S.) based on best practices with Organic Farmers Pilot-Groups. 3rd Consolidated Progress Report + 3rd Individual Progress Report (Mars 1995 – Fév 1996), CCE (DG VI, AIR): 101 p.

Van Gijseghem (2000), Vermesting. In: Van Steertegem,M. (ed.) (2000). MIRA-S 2000, Milieu- en natuurrapport Vlaanderen: scenario's. VMM, Garant, p. 367-382.

Van Mansvelt, J.D. (1997), An interdisciplinary approach to integrate a range of agro-landscape values as proposed by representatives of various disciplines. Agriculture, Ecosystems and Environment 63: 233-250.

Van Steertegem, M. (ed.) (2000), MIRA-S 2000, Milieu- en natuurrapport Vlaanderen: scenario's. 637 p. VMM, Garant.

Vandeweerd, V. (ed.) (1999), MIRA-T 1999, Milieu- en natuurrapport Vlaanderen: thema's. 365 p. VMM, Garant.

Verbruggen, A. (ed.) (1994), Leren om te keren. Milieu- en natuurrapport Vlaanderen. 833 p. VMM, Garant.

Verbruggen, A. (ed.) (1997), Report on the environment and nature in Flanders 1996. Learning to change — Erembodegem: Flemish Environment Agency.

Vos, W. and Meekes, H. (1999), Trends in European cultural landscape development : perspectives for a sustainable future. Landscape and urban planning 46: 3-14.

Walot, Th., Grosjean, E., Ledant, J-P. (2000), Diagnostic environnemental de l'agriculture dans le Parc Naturel de la vallée de l'Attert. Rapport final au CRA Gblx. Août 2000. Groupe interuniversitaire de recherches en écologie appliquée.

Walot, Th. and Josselin, U. (2001), Analyse des indicateurs du PAEXA et propositions d'améliorations. Groupe Interuniversitaire de Recherches en Ecologie Appliquée (GIREA).

Wrbka, T. (1998), Landscape structure as indicators for sustainable land use? — a case study in alpine and lowland landscapes of Austria. In: Dover, J.W. & Bunce, R.G.H. (eds.), Key concepts in landscape ecology. Proc. of the 1998 European Congress of IALE, IALE-UK: pp. 177-180.

ECO-FAUNA-DATABASE: A TOOL FOR BOTH SELECTING INDICATOR SPECIES FOR LAND USE AND ESTIMATING IMPACTS OF LAND USE ON ANIMAL SPECIES

Thomas Walter and Karin Schneider[1]

Introduction

The primary objective behind the development of an Eco-Fauna-Database was to establish a tool that considered the needs of wildlife during the planning stages of projects and management plans. A database was therefore constructed which contains information regarding the habitat requirements, phenology, distribution, mobility, diet, Red List category and systematics for a large number of animal species. The data were added to the database by the experts of the different animal groups using a combination of their own personal knowledge together with information gained from the literature. To date information for nearly 3000 animal species is available within the database. This includes complete information for the following groups of Swiss fauna: Mammalia, Aves, Reptilia, Amphibia, Apoidea, Carabidae, Heteroptera, Mollusca, Odonata, Rhopalocera and Hesperiidae, Saltatoria.

The database is financed by the Swiss Agency for the Environment, Forests and Landscape. The Swiss Federal Research Station for Agroecology and Agriculture (FAL) and the Centre Suisse de Cartographie de la Faune (CSCF) are responsible for both its management and further development.

Structure of the database

The database has been developed in MS Access and is relational in structure. An important aspect of the database is that it differentiates between the development stages of the individual animal species. The following list gives an overview of the most important tables within the database:

- Habitat: This table specifies in which habitats the different development stages of a species may occur.

- Structure: The structure table lists the use of the different habitat structures by each animal species at their various development stages (*e.g.* ground-, moss-, herb-, bush-, tree-layer, death wood, tree holes, etc.).

- Traits: *e.g.* daily activity period, habitat specialisation, favourite range of moisture, temperature.

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1. FAL, Swiss Federal Research Station for Agroecology and Agriculture.

- Mobility: This table details the swim-, flight- and ground locomotion-ability of the animal species at the different development stages.

- Phenology: This table lists the occurrence of each animal species together with their monthly development stage.

- Diet: This table details the diet of each animal species at their different development stages.

- Distribution: This table lists the distribution of each animal species within 11 biogeographical regions of Switzerland and within the altitude gradients — colline, montane, subalpine, alpine.

- Threats: The Red List categories (national and international) of each animal species.

- Climate: The climate-table lists the occurrence of each animal species within a range of average July-temperatures, annual sum of degree days and precipitation per year.

- Systematics: The table lists the scientific, german, french, italian names.

- Record: A record corresponds to one registration of an animal species in the database of the Schweizerische Vogelwarte or the CSCF. It contains the species name, the geographical coordinates of the location, the date of the observation, the name of the observer.

Potential target and indicator species

The database enables the rapid listing of potential target and indicator species for agricultural areas at varying altitudes and within different habitats and biogeographic regions in Switzerland. An example is given here for butterflies (Rhopalocera and Hesperiidae) and grasshoppers (Saltatoria), which occur in grassland habitats (Table 1, see the pdf file of the paper on the OECD website at http://www.oecd.org/agr/env/indicators.htm). Butterflies and grasshoppers are very suitable biodescriptors for grassland as more than 80% of these species inhabit grasslands. Furthermore, they are easy to observe and are also representative of the biodiversity for the grassland-fauna. In the following example the grassland is divided into three main ecological groups:

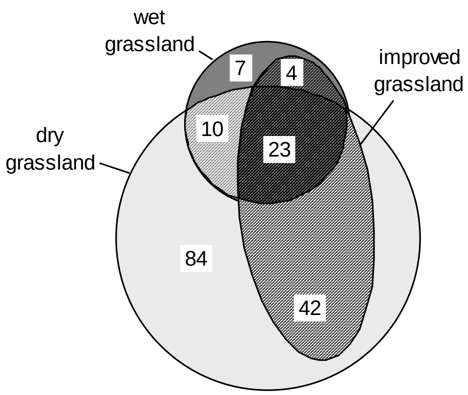
- wet grassland as purple moor-grass meadow, meadowsweet fen meadow, small sedge fen and tall sedge fen;

- dry grassland as semi arid meadow and arid meadow;

- improved grassland as fodder meadow rich and poor in plant species.

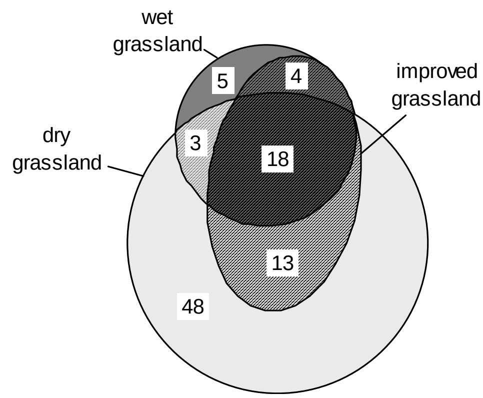
If necessary a more differentiated classification level of the grassland can be chosen. Target species can be selected for the different regions and ecological grassland groups. Species of different Red List categories as well as not threatened species should be chosen. This enables the user to measure the success or the failure of a program at different start — levels of biodiversity. To get the most exclusive describers for the different ecological grassland groups, species which occur only in one or a few grassland-types should be chosen.

Figure 1. **The number of butterfly species in different ecological grassland groups**



170 butterfly species (Rhopalocera and Hesperiidae) inhabit grassland habitats in Switzerland.
The ecological grassland groups are defined in the text.

Figure 2. **The number of grasshopper species in different ecological grassland groups**



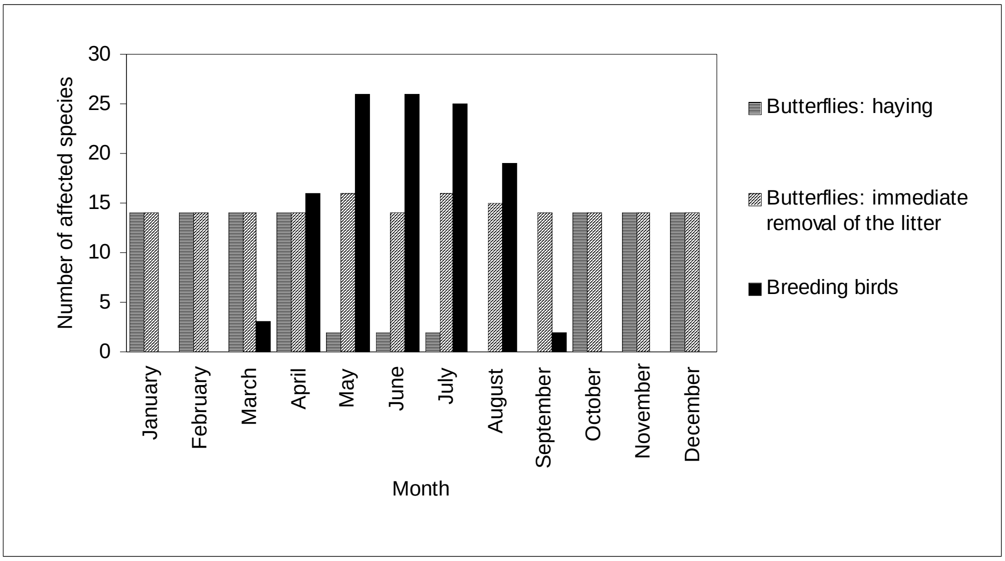
91 grasshopper species (Saltatoria) inhabit grassland habitats in Switzerland.
The ecological grassland groups are defined in the text.

Figure 1 and 2 show the number of species occurring in the three ecological grassland groups mentioned above. Forty per cent (84 species) of the “grassland butterflies” inhabit dry grassland only, whereas 6% (7 species) inhabit only wet grassland. By way of contrast, no species inhabit only improved grassland. The grasshoppers show similar proportions.

The potential impact of cutting a litter meadow (Magnocaricion) at different time periods on butterflies and birds

The database can help to estimate the possible impacts of mowing time and mowing technique on different species. The following example shows the impact of cutting a litter meadow on butterflies and birds at different time intervals. Phenology, habitat and structure information can be used to provide a list of the species which may be affected by the cutting of a litter meadow at different time periods. Furthermore, the database will also detail the development stage that the animal is in at the time of mowing. Information about mobility enables the user to find out, whether a development stage can escape the impact of cutting. It is clear that cutting a meadow will have an impact on the immobile development stages in a herb layer, *e.g.* the eggs and pupae of butterflies and the eggs and nestlings of birds. The mowing technique also decides the death or survival rate of the slowly mobile caterpillar. Some of the caterpillars should survive mowing if the herbs are left to dry as the caterpillars should be able to crawl out of the herb layer. However, if the mowed herb is carried away immediately, the caterpillars will have no possibility to escape. Figure 3 shows the number of threatened species (Duelli, 1994) which are affected by mowing a litter meadow at different time periods. The optimal mowing date varies for different species or animal groups and also depends on the mowing technique. Therefore the management of the meadow has to be adapted to the target species. The database is a helpful tool to optimize this management.

Figure 3. **Threatened butterfly and bird species affected by litter meadow cut in different months**



Notes:
The eggs and nestlings of birds will not survive.
The survival of the butterflies depends on the cutting management: For example, leaving the hay to dry will allow the survival of some of the caterpillars whereas the immediate removal of the litter will kill the caterpillars.

REFERENCES

Duelli, Peter (1994), "Rote Liste der gefährdeten Tierarten in der Schweiz." Swiss Agency for the Environment, Forests and Landscape (BUWAL), Bern.

ESTIMATING WILDLIFE HABITAT TRENDS ON AGRICULTURAL ECOSYSTEMS IN THE UNITED STATES

Stephen J. Brady[1] *and Curtis H. Flather*[2]

Introduction

The kind, amount, and distribution of life supporting elements on the landscape collectively determine the quality of habitat useful to wildlife. Each species has unique requirements with regard to these various elements. Our knowledge of these requirements for most species is very limited while for a few species our understanding of their habitat needs is better. Species response to management of habitats exhibits great variability over scales of both time and space. While our ability to measure ecological pattern continues to improve there is much to be learned about ecological processes and functions. Although scientists continue to make models of ecological systems there remains a substantial amount of unexplained variance in the explanatory power of those models. Habitat management is therefore a combination of both science and art. Aldo Leopold (1966: p. 177-178) provided an interesting description: “There is much confusion between land and country. Land is the place where corn, gullies, and mortgages grow. Country is the personality of the land, the collective harmony of its soil, life, and weather. ….Poor land may be rich country and vice versa. Only economists mistake physical opulence for riches. Country may be rich despite a conspicuous poverty of physical endowment, and its quality may not be obvious at first glance, nor at all times…. It [wildlife] often represents the difference between rich country and mere land.” All land can be considered habitat, but its quality varies from extreme poverty to abundance.

The task at hand is a challenging one, again as per Leopold (1933:p. 124): “When the game manager asks himself whether a give piece of land is suitable for a given species of game, he must realize that he is asking no simple question, but rather he is facing one of the great enigmas of animate nature. An answer good enough for practical purposes is usually easy to get by the simple process of noting whether the species is there and ready, or whether it occurs as ‘similar’ range nearby. But let him not be cocksure about what is ‘similar’, for this involves the deeper questions of why a species occurs in one place and not in another, which is probably the same as why it persists at all. No living man can answer that question fully in even one single instance.”

Land use is the principal factor determining the base level of abundance of indigenous species. In most cases land use has a greater impact on species abundance than does the management of land (*e.g.* application of practices for agricultural production or soil and water conservation).

1. US Department of Agriculture, Natural Resources Conservation Service. Natural Resources Research Center, 2150 Centre Ave., Ft. Collins, Colorado 80526-1891.

2. US Department of Agriculture, Forest Service Natural Resources Research Center, 2150 Centre Ave., Ft. Collins, Colorado 80526-1891.

Agriculture affects habitat directly through converting natural habitats to cultivation, grazing, or other manipulation and the associated repeated disturbances that accompany those conversions. Agriculture indirectly affects wildlife habitat through water management practices for irrigation and drainage, soil erosion and sedimentation, and elevated nutrient and pollutant discharges into the environment. The direct effects of land use conversions on habitat are more easily measured than are the indirect effects. While the use of land is relatively easy to document, assessing its quality (productive, economic, habitat, etc.) is more challenging.

Most indicators of agriculture's affect on habitat reflect habitat patterns across the landscape. Those patterns and the biological diversity associated with them are the cumulative result of many ecological processes operating over time. It is much easier to describe the resulting patterns than it is to quantify the processes. Natural systems are inherently variable, and this variability is expressed both spatially and temporally. Because wildlife populations are the result of many processes operating together, the quantity and quality of habitat are just two of the indicators affecting the distribution and abundance of wildlife. Population density is often an inaccurate estimator of habitat quality (Van Horne, 1983) and some population fluctuations are not related to habitat but may be the result of catastrophic weather conditions, disease, or overexploitation (Schamberger 1988). Habitat indicators may be useful for comparing between alternative agricultural land management scenarios for regional or national program planning and related purposes. However, they must be designed so that they may be tested against empirically derived wildlife population estimates. Ideally they will be designed as falsifiable hypotheses.

Testing of habitat indicators should be done with multiple measures of biological diversity to properly reflect the complexity of natural systems. This is a problem because extant data sources representing many species are usually not available. Where data are available for a class of organisms, such as birds, the measures of diversity within that class should include statistical estimates of species richness as well as equitability or dominance. One should examine population responses by the very abundant species, very rare species, and those in between. Tests of habitat indicators for community diversity should accompany tests of habitat indicators for favored species (*e.g.* ring-necked pheasants, *Phasianus colchicus*, or gray partridge, *Perdix perdix*).

The National Resources Inventory

Much of the data in the succeeding pages is the result of analyses of the 1997 National Resources Inventory (NRI, Natural Resources Conservation Service, 2000). The NRI is an inventory of soil, water, land cover/uses and related resources on the nonfederal lands of the U.S. It is a stratified random sample of over 800,000 points that has been repeated at 5-year intervals since 1982. The purpose is to obtain statistically reliable estimates of the conservation treatment of the nonfederal lands for use by the U.S. Department of Agriculture, Congress, policy makers, and others in evaluating national programs and policies pertaining to agriculture, land use and natural resources occurring on nonfederal lands. In the following pages NRI data are displayed by Farm Resource Regions and by hydrologic units. The Farm Resource Regions are defined primarily for economic analyses by the Economics Research Service, U.S. Department of Agriculture. The hydrologic units represent the boundaries of large watersheds defined by the U.S. Geological Survey. This scale represents the 4-digit hydrologic unit scale although hydrologic units can be aggregated or divided from this scale for other purposes. It should be noted that neither of these categories are "ecological regions" although as progress is made we will move toward ecological regions as an analysis framework.

Land Use

Seventy-nine percent of the land in the United States is in nonfederal ownership. Land in federal ownership consists primarily of forests, rangelands, and parks. Some federally owned rangeland is used by private individuals to graze livestock on an annual fee basis. However most agricultural production occurs on non-federal land. Major land uses in the United States for 1997 (Natural Resources Conservation Service, 2000) are rangeland (20.9%), forest (20.9%), federal (20.7%), cropland (19.4%), pasture (6.2%), urban, built-up and roads (5.0%), Conservation Reserve Program (CRP, 1.7%), and miscellaneous (water bodies, mined land, barren, etc., 5.2%). Rangeland is land used by grazing animals where the management consists of manipulating the vegetation primarily by adjusting grazing extent, or by prescribed fire, and other methods generally without cultivating the soil. Most rangelands would fall under the OECD definition of *semi-natural agricultural habitats*. Pasture is also land used by grazing animals but management consists of planting desired vegetation and applying soil amendments to increase productivity. Pastures with low intensity management would be classed as *semi-natural agricultural habitats* while those under a high level of management would be classed as *intensively farmed agricultural habitats*. The CRP is a cropland diversion program where lands with serious soil erosion or related problems were converted from cropland to permanent vegetative cover under 10-year contracts with the United States Department of Agriculture. Cropland as used here includes land used to produce all agricultural commodities including grains, seeds, hay, fruits, vegetables, and orchards. Cropland would generally fall under the OECD definition of *intensively farmed agricultural habitats*.

The distribution of land uses is primarily determined by landscape characteristics including climate, geology, soil, topographic characteristics, and water. While cropland occurs nearly throughout the United States it is most abundant in the Heartland (29.2%), Prairie Gateway (19.3%), Northern Great Plains (15.6%), and Northern Crescent (10.5%, Table 1, Figure 1). Rangeland occurs primarily in the arid west-central regions of the Prairie Gateway (32.2%), Basin and Range (23.7%), Fruitful Rim (22.1%), and Northern Great Plains (20.5%, Table 1, Figure 1). Cropland, pasture, rangeland and other agricultural fields occur in mosaic patterns with other land uses across the landscape. Their value as habitat, and the value of habitat attributes associated with them, are governed by the particular characteristics of the landscape mosaic in which they occur. Consequently it is difficult to quantify the habitat value of agricultural fields without including an analysis of the larger landscape mosaic in which they occur. The concept of ecological regions will be useful for large-scale analyses. Even at finer scales the value of habitat elements on agricultural fields will be primarily defined by the permanent or residual vegetation (*i.e.* hedgerows, field margins, borders, or buffer strips, riparian features, etc.) remaining on the landscape and the surrounding land uses.

Land use changes occur as economic conditions and farm needs dictate. Cropland, pasture, and rangeland all exhibited net declines during the period 1992-1997 while forest and developed land both increased (Table 1). These net changes are the result of many local changes as land use shifts to and from each land use category. For example, although the net change in cropland was -2 141 100 hectares this was the result of converting 17 180 500 hectares of cropland in 1992 to other land uses in 1997, while converting 15 039 400 hectares of other land uses to cropland in 1997. Hence the effect on wildlife habitat is substantial as 32 219 900 hectares were involved in land use changes centered on cropland. The rate with which land use changes occur may make it difficult for some species to adapt to those changes. Permanent habitat interspersed throughout the landscape mosaic can have an important dampening effect on short-term land use changes. Vegetative composition of natural plant communities, such as forests and rangelands, are complex, diverse assemblages of plant

Table 1. **Extent of important land cover/uses and wetlands in 1997 and net changes during 1992-1997 by Farm Resource Region (hectares X 1000)**

FRR	1997 Cropland	Net Change Cropland	1997 Pasture	Net Change Pasture	1997 Range	Net Change Range	1997 Forest	Net Change Forest	1997 Wetland	Net Change Wetland	1997 Devel-oped	Net Change Devel-oped
H	44 510.2 (251.4)	322.0 (90.4)	7 888.6 (167.7)	-609.9 (90.1)	745.5 (62.9)	-14.2 (8.7)	9,496.5 (164.4)	198.3 (42.7)	2 816.0 (96.6)	-2.1 (4.3)	5 251.7 (104.5)	418.8 (26.5)
NC	16 022.4 (215.4)	-583.9 (74.3)	4 845.3 (132.9)	-527.2 (79.4)	0	0	43 985.1 (348.8)	252.0 (73.4)	13 326.6 (300.8)	-27.1 (6.4)	8 666.9 (125.4)	942.9 (33.7)
NGP	23 744.0 (403.9)	317.1 (107.5)	2 235.8 (173.7)	-31.3 (93.1)	33 659.3 (671.5)	-221.2 (93.0)	1 762.7 (139.4)	4.4 (39.1)	3 132.7 (165.1)	-0.2 (4.0)	1 258.0 (64.0)	53.4 (10.9)
PG	29 371.9 (341.3)	-511.9 (93.7)	6 004.3 (162.2)	79.3 (80.8)	52 667.6 (656.7)	17.2 (97.7)	3 322.6 (271.5)	89.6 (44.9)	893.9 (65.3)	12.1 (3.7)	3 920.3 (113.2)	331.8 (33.6)
EU	4 763.1 (128.7)	-145.3 (61.7)	10 844.6 (177.2)	-542.0 (83.5)	959.2 (73.5)	-10.6 (13.8)	25 733.1 (220.6)	103.3 (67.6)	736.8 (56.6)	1.3 (2.7)	3 869.6 (102.3)	585.8 (29.0)
SS	7 636.9 (154.9)	-528.5 (63.7)	7 227.9 (167.0)	-440.1 (80.4)	568.8 (57.8)	5.2 (14.6)	37 375.8 (251.1)	-12.7 (82.0)	9 639.9 (187.3)	-25.0 (6.9)	6 018.9 (123.2)	908.7 (39.6)
FR	12 078.6 (369.2)	-494.5 (101.5)	4 123.4 (168.1)	-270.2 (93.1)	36 237.4 (815.1)	-222.9 (155.6)	18 696.4 (457.7)	-153.9 (113.0)	6 767.5 (192.0)	-4.7 (21.3)	7 199.4 (214.2)	880.7 (58.9)
BAR	5 990.7 (269.6)	-207.2 (65.6)	2 591.1 (221.2)	45.3 (67.5)	38 880.0 (1 204.6)	-122.9 (153.4)	13 127.8 (543.7)	40.8 (137.7)	2 028.6 (157.2)	-4.7 (6.1)	1 966.5 (100.8)	207.8 (29.7)
MP	8 202.6 (138.8)	-308.7 (46.5)	2 605.1 (94.9)	-55.4 (49.9)	112.2 (17.5)	1.1 (4.7)	10 271.7 (144.1)	132.0 (41.5)	5 599.0 (129.0)	-16.0 (6.7)	1 332.8 (49.6)	161.2 (14.6)
Total	152 320.2 (811.1)	-2 141.1 (242.3)	48 366.1 (497.8)	-2 351.6 (242.3)	163 829.9 (1 735.1)	-568.4 (257.8)	163 771. 7 (937.8)	653.9 (235.4)	44 941.1 (497.7)	-66.4 (26.1)	39 484.1 (357.4)	4 491.2 (100.3)

Notes:
Margins of error are in parenthesis. The 95% confidence interval is defined as the estimate +/- margin of error. Farm Resource Region (FRR) names are: H - Heartland, NC - Northern Crescent, NGP - Northern Great Plains, PG - Prairie Gateway, EU - Eastern Uplands, SS - Southern Seaboard, FR - Fruitful Rim, BAR - Basin and Range, and MP - Mississippi Portal.
Source: Natural Resources Conservation Service, 2000.

species. Their conversion to agriculture or other land uses represents a substantial loss of biologically diverse habitat. This complexity is not replaced merely by planting but rather it develops over long periods of time. The measurement of land use changes between agriculture and other land uses, and changes within different agricultural land uses can only be accomplished accurately by an inventory or census where specific fields or sample points are tracked repeatedly over time. Merely reporting the total area of agricultural lands or specific crop types over time fails to document actual dynamics of land use change.

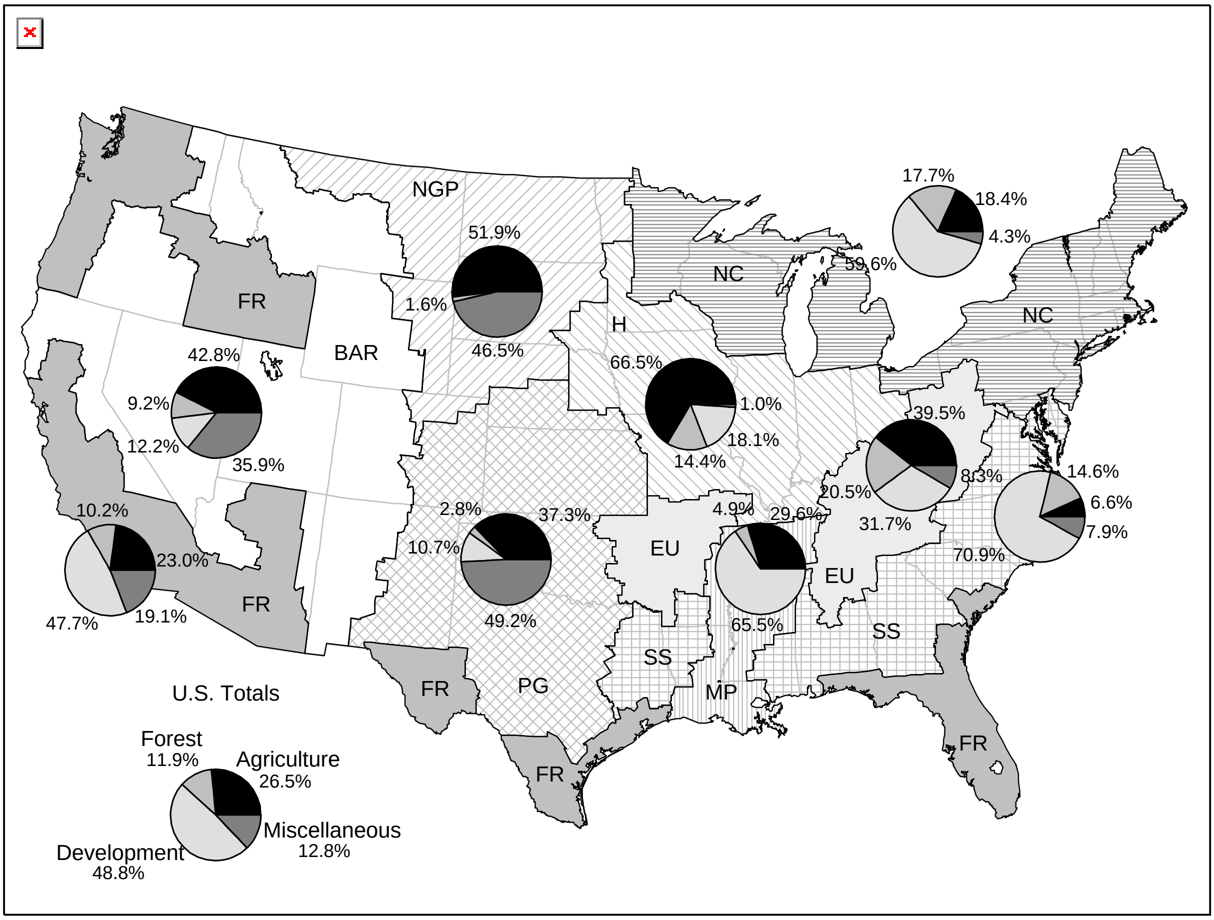
Wetlands represent a valuable ecological resource with very significant habitat values. Their very high biological value results from their occurrence at the land-water interface where both terrestrial and aquatic organisms may interact. Wetlands occur on all land uses (*e.g.* cropland, forestland, etc.). There were almost 45 million hectares of wetlands in the U.S. in 1997 (Table 1). There was a net loss of 66 400 hectares of wetlands during the interval from 1992-1997 (Table 1). This net loss consisted of a gross gain of 138 000 hectares of wetlands and a gross loss of 204 400 hectares. Conversion of wetlands to development accounted for 48.8% of the gross wetland loss while losses due to agriculture accounted for 26.5% and losses on forest land accounted for 11.9% (Figure 1). It is only since the early 1980's that development has exceeded agriculture as the principal reason for wetland loss. Wetland losses due to agriculture are declining in the U.S., as farmers are becoming more conscious of environmental values and as federal wetland conservation incentives have been implemented. Many of the recent wetland gains are also the result of farmers creating or restoring wetlands on land previously used for agriculture, a large portion of which comes under the Wetland Reserve Program of the U.S. Department of Agriculture. As with all natural resources, geographic variation is apparent in wetland abundance, and the reasons for wetland losses. Note from Table 1 that there were "no net wetland changes" in five of the Farm Resource Regions (*i.e.* Heartland, Northern Great Plains, Eastern Uplands, Fruitful Rim, and the Basin and Range). The margins of error in those five regions were larger than the estimates; hence the 95% confidence interval includes both positive and negative numbers.

The rate with which man induced activities can change the landscape or land uses can exceed the rate that ecological communities can adapt to those changes. Consequently we feel that it is imperative to use the land such that human derived services are within the capability of the land to preserve the integrity, stability, and beauty of the biotic community.

Spatial Patterns

Spatial patterns are also important determinants of the ecological value of agricultural habitats. Wildlife are rarely distributed uniformly in space. Species exhibit a spatial structure in their occurrence and abundance that is caused by habitat heterogeneity, natural disturbance patterns, land use, and resource management activities. Questions concerning the likely persistence of populations within a network of habitat patches, or questions about the most appropriate layout and schedule for land management actions are now commonplace (Flather *et al.*, in press). In order to account for this spatial complexity, the 1997 NRI sampled spatial patterns along X-shaped sets of transects centered over each sample point where each of the 4 transects was 152.4 meters long. Nine general cover types were interpreted from aerial photographs of each sample point. From these data several indices of spatial pattern can be developed.

Figure 1. **Important reasons for wetland loss during 1992-1997 by Farm Resource Region**



Notes:
Losses displayed represent gross losses while gross gains and net changes are not displayed in this figure. Farm Resource Region names are: H — Heartland, NC — Northern Crescent, NGP — Northern Great Plains, PG — Prairie Gateway, EU — Eastern Uplands, SS — Southern Seaboard, FR — Fruitful Rim, BAR — Basin and Range, and MP — Mississippi Portal.
Source: Natural Resources Conservation Service, 2000.

The mean length of the first cover type along each of the 4 transects is an indicator of the patch size of the cover type. The size of habitat patches can be of critical importance for some species. As expected the largest cropland patch sizes generally also occur where cropland is most abundant (Figure 2). Smaller cropland patches interspersed among other cover types such as forest or rangeland generally provide greater habitat values for many species, however large cropland fields may attract large flocks of migrating birds for feeding areas during migration. The indicator of rangeland patch size (Figure 3) reveals that rangelands generally occur in larger patches than cropland.

An index of fragmentation was defined as the number of cover type segments per unit of length, or segments per unit. Cropland cover types are much more highly fragmented in the eastern U.S. than elsewhere (Figure 4), corresponding also to the areas where the indicator of cropland patch sizes was smaller. Fragmentation of rangelands was also greatest where rangeland patch size was the smallest (Figure 5).

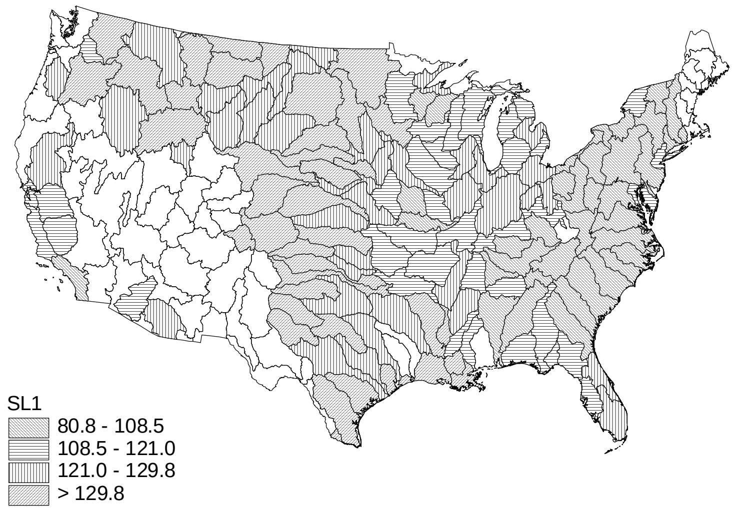
Many wildlife species will utilize multiple habitats within their daily home range or to complete their life cycles. For example waterfowl and shorebirds may utilize perennial herbaceous vegetation (*i.e.* grasses and forbs) as nesting cover, then move to wetlands for brood-rearing purposes. They also may feed on insects in hay meadows or grain from agricultural fields. If any one of these components is missing the habitat may be useless to them. Consequently ecological or landscape context plays an important role in determining the value of habitats associated with agricultural lands. Correct interpretation of theses spatial patterns can only be made via empirical studies correlating measures of biodiversity with these spatial landscape patterns.

U.S. Department of Agriculture Programs

As noted previously, agricultural land uses are determined to a large extent by attributes of natural features, including the soil, water, climate, and landscape, then to a lesser extent by policy. Economic conditions and analysis of the 1982 NRI data prompted federal agricultural policy makers to evaluate cropland use in relation to soil erosion and land capability factors. Consequently a shift in agricultural policy since 1985 has discouraged producing annually cultivated crops on lands where the risks of increased soil erosion were greater. As a result, soil erosion rates on cropland and CRP land have declined from an average of 6.9 metric tons/hectare in 1982 to 4.3 metric tons/hectare in 1997. In similar fashion, 80.8% of cultivated cropland now has estimated soil erosion rates less than the "tolerable" soil loss level, while in 1982 only 73.4% of cultivated cropland had soil erosion rates that were below the "tolerable" soil loss level. The term tolerable here refers to the rate of soil erosion that does not jeopardize the long-term sustainability of the soil resource and represents a specific value for each soil map unit component. These points illustrate the environmental benefits of those policy shifts — wildlife and aquatic habitats associated with downstream receiving waters and wetlands now receive much less sediment and associated pollutants than they did in 1982. While these changes may not fall neatly within the realm of the proposed OECD habitat indicator criteria, they certainly improve habitat quality. We believe it is important to recognize and receive credit for national policies resulting in these small, but perhaps extensive, improvements to habitat condition. The approach to habitat indicators should incorporate all agricultural land and not just the most valued agro-ecosystems.

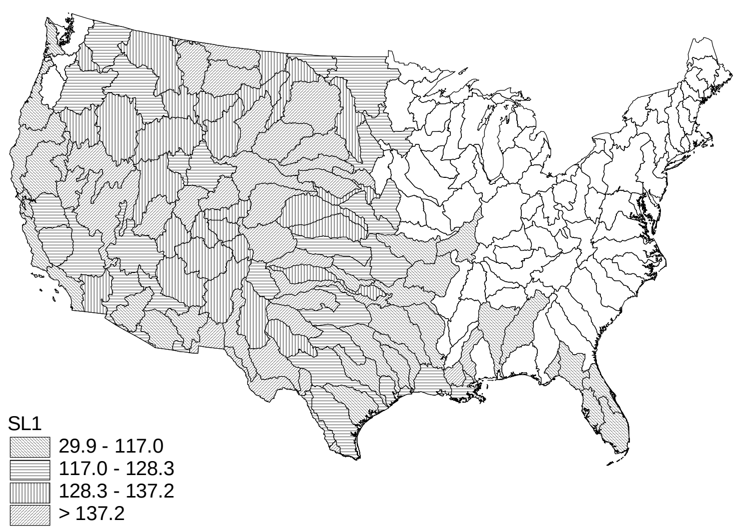
The Conservation Reserve Program has been one of the most beneficial programs for wildlife habitat in the U.S. The CRP was passed into law in response to massive overproduction of agricultural grains accompanied by low prices and excessive soil erosion rates. Erosion reduction from eroding cropland was the primary criteria for participation in the early years of the program. Eligibility criteria were broadened in 1990 to include improving water quality and other environmental goals, while in 1996 establishing wildlife habitat was also added. Overall enrolment peaked at 14.7 million hectares in 1993. Nearly 9.5% of the nation's cropland was enrolled in perennial vegetative cover for 10-year contracts. The combined size of the new wildlife habitats created by the CRP was twice as large as the National Wildlife Refuge System and all state-owned wildlife areas in the contiguous 48 states combined (USDA Farm Service Agency Online). Recruitment of grassland nesting birds, many waterfowl species, and other wildlife have shown improvements, some of which are attributable to the CRP. Wildlife habitat was one of many environmental benefits resulting from the CRP.

Figure 2. **Patch size indicator for non-federal cropland displayed by hydrologic unit**



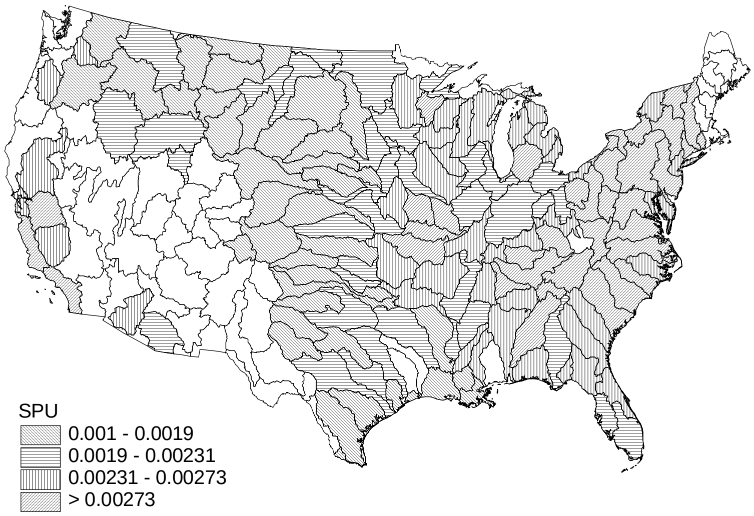
Notes:
The variable SL1 represents the mean radius in meters for cropland sites. Federal land occurs over about 21% of the U.S., predominantly in the west, but is not identified in this map.
Source: Natural Resources Conservation Service, 2000.

Figure 3. **Patch size indicator for non-federal rangeland displayed by hydrologic unit**



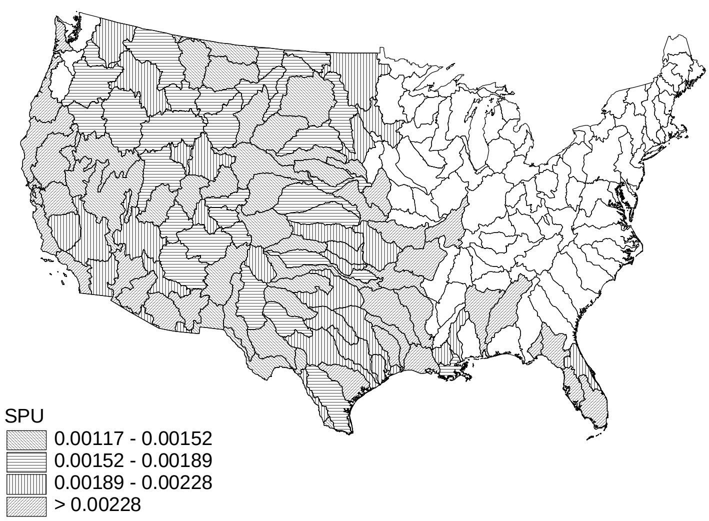
Notes:
The variable SL1 represents the mean radius in meters for rangeland sites. Federal land occurs over about 21% of the U.S., predominantly in the west, but is not identified in this map.
Source: Natural Resources Conservation Service, 2000.

Figure 4. **Indicator of fragmentation for non-federal croplands displayed by hydrologic units**



Notes:
The variable segments per unit (SPU) is an indicator of landscape fragmentation with lower values representing more homogeneous cropland patches. Federal land occurs over about 21% of the U.S., predominantly in the west, but is not identified in this map.
Source: Natural Resources Conservation Service, 2000.

Figure 5. **Indicator of fragmentation for non-federal rangelands displayed by hydrologic units**



Notes:
The variable segments per unit (SPU) is an indicator of landscape fragmentation with lower values representing more homogeneous rangeland. Federal land occurs over about 21% of the U.S., predominantly in the west, but is not identified in this map.
Source: Natural Resources Conservation Service, 2000.

Other provisions of U.S. agricultural legislation since 1985 also directly or indirectly improved habitat in agro-ecosystems. The Wildlife Habitat Incentives Program provides technical and financial assistance to farmers who implement specific habitat management practices on their land. The Wetland Reserve Program provides technical assistance and long-term rental payments to farmers who create or restore wetlands in agricultural landscapes. The Environmental Quality Incentives Program also provides habitat and water quality improvements by applying conservation practices on working lands and reducing soil erosion rates. The impact of these programs on wildlife habitat is described in Heard *et al.*, 2000.

Formal efforts to manage U.S. farmland for wildlife habitat and other natural resource benefits go back to the 1930s when the Soil Conservation Service (name was changed to the Natural Resources Conservation Service in 1994) was established to combat the "Dust Bowl". Technical assistance and guidance were provided to farmers for conservation of all natural resources. Wildlife habitat did not have an economic value that could be easily traded in the market place so it was often a secondary or lower management concern. Nonetheless many individual farmers have implemented wildlife habitat management practices as secondary uses of the land behind agricultural production. Often, practices installed to reduce soil erosion can be applied in such manner as to add habitat elements to agricultural lands (Brady, 1985). More comprehensive habitat management practices can also be installed and integrated into the overall agricultural land management scheme (Warner and Brady, 1994). It is important to note that many of these practices may not be obvious to the casual observer nor would they necessarily be easy to quantify. For example the combination of conservation tillage, grass back-sloped terraces, grass border strips (*i.e.* field margins), and contour strip cropping would improve habitat values on a farm without reducing economic production. Wildlife habitat management at this level is not intensive, but may be extensive. Yet most of these practices would go undetected or at least without receiving credit as part of the OECD habitat indicators proposal.

The beneficial effects of habitat elements occurring on agricultural fields (*e.g.* field margins of beneficial perennial vegetation, hedgerows, etc.) are directly dependent upon the landscape setting, particular ecological region, and intensity of land uses. Studies of bird communities indicate that different measures of bird diversity respond differently to land use and land cover patterns leading us to conclude that multiple measures of wildlife community structure should be examined in assessing impacts from land intensification (Brady and Flather, 1995). Empirical analyses of wildlife abundance with habitat attributes occurring on agricultural fields are confounded by other habitat attributes occurring across the landscape matrix. Consequently it is important to conduct empirical studies using measures of biodiversity with the full suite of landscape attributes. Perhaps from such analyses meaningful indicators of habitat will be identified.

Ecosystem/Habitats Impacted by Agricultural Activities

From the preceding discussion we submit that the approach to habitat indicators should incorporate all agricultural lands rather than the most valued agro-ecosystems. As described above, substantial area of U.S. cropland has been removed from production and is serving as a "conservation reserve" while producing substantial wildlife habitat and other environmental benefits. It is important not to ignore this significant contribution. Relatively high value crops occur in nearly every region because of the diversity of specialty crops. Attributes of the landscape matrix within which agro-ecosystems occur should be evaluated jointly with agricultural fields. Therefore all field margins and not just field margins for arable crops should be included in the analysis. Again suggesting a landscape-level approach to the quantification of habitat indicators. We demonstrated one technique using NRI data for documenting spatial patterns, but other techniques including Geographic Information Systems can be useful. Many of these techniques are either labor, capital, or technologically intensive and may not be available in all countries. However at the very least natural resource and/or land use inventories or censuses should be conducted to monitor changes across the agricultural landscapes. Merely reporting the area in agricultural production yields little information regarding habitat values. Special programs that impact agricultural habitats such as the Conservation Reserve Program, Wetland Reserve Program, as well as subtle habitat management efforts occurring secondarily on working agricultural landscapes are also worthy of reporting.

The concept of habitat matrices is good, but as with other indicators of habitat, they may be poor predictors of species occurrence or biodiversity. Williams *et al.*, (1997) reported that matrices of vegetative cover types were of marginal value in representing patterns of vertebrate biodiversity, and that ecological attributes other than vegetative cover types were more important in recognizing patterns of species occurrence. Their results suggested that the level of detail in a classification of vegetative cover could influence patterns of association exhibited by vertebrate species. Likewise because of the inherent variability of natural systems one must be careful to separate statistical artifact (*i.e.* noise) from true ecological patterns.

Conclusion

Wildlife habitat relationships are very complex and at best we can say that we have developed theoretical frameworks against which we can test hypotheses about how we think these relationships work. Predictive models based upon empirical data about species-habitat relationships have proven useful for land managers. However they are more apt to confirm to us what we know about the area we have studied than to accurately yield a biodiversity profile of similar habitats that as yet have not been inventoried (*i.e.* models tend to lack generality). This is not to say that we should abandon the task before us, but rather the advancement of the state-of-the-art regarding habitat indicators must be undertaken with scientific rigor. As habitat indicators are selected and evaluated they must be tested against empirically derived patterns of biodiversity, including even the basic verification of presence/absence of a species on a landscape. This is an iterative process based upon continually refining the store of our knowledge.

REFERENCES

Brady, S. J (1985), Important soil conservation techniques that benefit wildlife. Pp. 55-62 *in* Technologies to Benefit Agriculture and Wildlife — Workshop Proceedings (Washington, DC: US Congress, Office of Technology Assessment, OTA-BP-F-34, May 1985).

Brady, S. J. and C. H. Flather (1995), Using the National Resources Inventory in wildlife assessment models. Pages 92-101 *in* Lee, L. K. Proceedings of the 1992 National Resources Inventory.

Environmental and Resource² Assessment Symposium. U.S. Department of Agriculture, Natural Resources Conservation Service, Washington, DC.

Flather, C. H., M. Bevers, J. Hof. In Press. Prescribing habitat layouts: analysis of optimal placement for landscape planning. Pp. 000-000 *in* K. J. Gutzwiller, ed. Concepts and applications for landscape ecology in biological conservation. Springer-Verlag, New York, New York.

Heard, L. P., A. W. Allen, L. B. Best, S. J. Brady, W. Burger, A. J. Esser, E. Hackett, D. H. Johnson, R. L. Pederson, R. E. Reynolds, C. Rewa, M. R. Ryan, R. T. Molleur, and P. Buck (2000), A comprehensive review of farm bill contributions to wildlife conservation, 1985-2000. W. L. Hohman and D. J. Halloum, eds., U.S. Department of Agriculture, Natural Resources Conservation Service, Wildlife Habitat Management Institute, Technical Report, USDA/NRCS/WHMI-2000. 208 p.

Leopold, Aldo (1933), Game Management. Charles Scribner's Sons, New York, New York. 481 p.

Leopold, Aldo (1966), A Sand County almanac with essays on conservation from Round River. Oxford University Press, New York, New York. 295 p.

Natural Resources Conservation Service (2000), 1997 National Resources Inventory. U.S. Department of Agriculture, Natural Resources Conservation Service. http://www.nhq.nrcs.usda.gov/NRI.

Schamberger, M. (1988), Monitoring wildlife habitat — a critique of approaches. Statistical Journal of the United Nations ECE 5:303-313.

USDA Farm Service Agency Online. The Conservation Reserve Program. http://www.fsa.usda.gov/dafp.cepd/12crplogo/tableof.htm. 39 p.

Van Horne, B. (1983), Density as a misleading indicator of habitat quality. J. Wildlife Manage. 47(4):893-901.

Warner, R. E. and S. J. Brady (1994), Managing farmlands for wildlife, pp. 648-662 *in* T. A. Bookhout (ed.) Research and Management Techniques for Wildlife and Habitats. The Wildlife Society, Bethesda, Maryland.

Williams, B. K., S. Mahabir, J. Schlagel, and D. E. Capen (1997), Patterns in wildlife-vegetation association matrices. Journal of Environmental Management 51:1-13.

MONITORING HABITAT CHANGE IN JAPANESE AGRICULTURAL SYSTEMS

David S. Sprague[1]

Introduction

Agriculture impacts biodiversity by altering the composition of landscapes where wildlife species find habitats. Measuring the impact of agriculture on habitats is a major concern in conservation biology. While species-by-species ecological assessments form the foundation of conservation biology, both ecologists and policy makers also need wide-scale indicators of biodiversity in agricultural ecosystems to assess the ecological content of nations and regions.

The OECD has proposed biodiversity indicators as part of the framework for agri-environmental indicators. The OECD nations recognize that agriculture occupies a large share of the total land area for nearly all OECD countries, and plays a key role in the conservation of biodiversity. Indicators of wildlife habitats are part of this framework (OECD, 2001).

The proposed wildlife habitat indicators recognize that both agricultural practice and ecology vary among the OECD nations. The indicators are designed to be applicable to many nations and ecosystems. In applying the indicators, however, ecologists must carefully assemble regional data to provide useful ecological information about the nation or region at hand, and yet formulate indicators that remain comparable across nations. This is a formidable task, and requires detailed analyses of the ecological content of the concepts and data on which the indicators are based.

In this paper, I consider two issues that pertain to the application to Japanese agro-ecosystems of the proposed OECD indicators for wildlife habitats (OECD, 2001). First, one characteristic of the proposed OECD indicators is that they seem to be designed to apply primarily to Europe. The key concepts are defined based on landscapes formed by European agricultural practices. In applying the indicators to East Asia, the key concepts must be reexamined to determine how they apply to the landscapes formed by agricultural practices in the nations of that region. How key concepts apply will seriously alter the assessment of the ecological quality of Japanese agricultural environments.

Second, reasonable baselines need to be identified for measuring change in Japanese agro-ecosystems. The proposed indicators (OECD, 2001) do no explicitly take up the issue of the baseline. However, a baseline underlies all indicators of change. Theories for choosing a baseline have been debated in prior OECD discussions as well as in other forums where agro-biodiversity has been discussed, especially the Convention on Biological Diversity (*e.g.* OECD, 1999). A pre-industrial

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baseline could put the baseline back even to the 19th century. A practical alternative is a year when farmers started to apply modern forms of intensive agriculture, and governments started to collect statistics on agricultural environments, such as about the year 1950.

Proposed Habitat Categories and Indicators

The proposed indicators (OECD, 2001) suggest that one way to measure the impact of agriculture on wildlife habitats is to consider agricultural land in terms of three broad categories which have wide applicability across all OECD countries. The three categories are:

- Intensively farmed agricultural habitats;
- Semi-natural agricultural habitats;
- Uncultivated natural habitats.

Five indicators are proposed under the three habitat categories, as follows:

Intensively farmed agricultural habitats

1. The share of each crop in the total agricultural area.
2. The share of organic agriculture in the total agricultural area.

Semi-natural agricultural habitats

1. The share of the agricultural area covered by semi-natural agricultural habitats.

Uncultivated natural habitats

1. Net area of aquatic ecosystems converted to agricultural use.
2. Area of “natural” forest converted to agricultural use.

The distinction between intensive and semi-natural habitat is especially important. These categories account for most of the agricultural environment. The habitat categorization affects which of the proposed indicators apply to a habitat. The valuation of habitat quality differs clearly between them.

How should Japanese agricultural land-uses be categorized into each habitat category? The question arises, first, because the examples of each habitat given in OECD (2001) are poor guides for classifying Japanese land-uses. The examples are European land-uses, such as fallow land, olive groves, or heathland, many of which are rare or do not exist in Japan. The Japanese wildlife habitats need to be categorized into one of the three habitat categories based on landscapes formed by Japanese agricultural practice.

Second, even traditional Japanese agricultural land-use was often extremely intense. The intensity of land-use is an issue because, in Europe, semi-natural habitat is associated with traditional, extensive, often pastoral, land-uses. Semi-natural habitat is especially important since this habitat category is expected to play the largest role in agro-ecosystems in providing wildlife habitat. Since Japan did not experience the same type of extensive agricultural land-uses, the question arises whether traditional Japanese agricultural land-use should be categorized as intensive or semi-natural. In particular, the classification for rice paddy is extremely important. Rice paddy agriculture occupied much of Japan’s alluvial plains. Furthermore, rice paddy occupies a large proportion of cultivated field area in Japan today, about 55% in 2000 (MAFF, 2001).

Rice paddy fields are artificial constructions that replaced wetlands. The rice paddy was subject to farm management practices, such as ploughing, sowing, weeding, and harvesting. Thus, according to the proposed criteria, rice paddy is clearly an intensively farmed agricultural habitat.

Nevertheless, many Japanese ecologists argue that traditional agriculture supported a rich fauna and fauna in Japan as in Europe. By that criterion, the traditional Japanese rice paddy may be classified as semi-natural, despite the intensity of land-use in the OECD definition. This approach leaves open, however, the question of what criteria should be applied, and from which temporal baseline, to measure agricultural intensification in rice paddy. Similar issues occur for rural woodlands and grasslands since they too were under intense utilization under traditional Japanese agriculture, although their roles in Japanese agriculture have diminished today with the increased intensification of agriculture since the 1950’s.

A meaningful classification of agricultural land needs to examine how and why biodiversity is preserved in an agricultural environment. The important question for the agro-ecologist is how agricultural practice creates an ecosystem, and how biota find niches in the agro-ecosystem. When these are known, it should be possible to identify the changes in agricultural practice or land-use that affect the capacity of agricultural land to serve as wildlife habitat.

In the case of Japan, agro-ecologists have been studying the intricate relationship between agricultural practice and the life histories of the rural fauna and flora. The temporal baseline for this research paradigm is the late-nineteenth century, soon after the Meiji Restoration of 1868, when Japan started on the path toward modernization, westernization, and industrialization. Not least of the reasons for choosing this baseline is the availability of land-use maps starting from the 1880's that provide a snap-shot of the configuration of the paddies, fields, grasslands, and woodlands of rural Japan.

Rural Land-Use under Traditional Japanese Agriculture

While differing radically from the natural state, the Japanese agro-ecosystem was a place where humans and biota interacted to produce a unique range of biodiversity. According to agro-ecologists, two aspects of traditional Japanese agricultural land-use played large roles in providing wildlife habitats (Moriyama, 1997*a*,*b*).

First, the expansion of rice paddy agriculture did not mean the obliteration of all wetland biodiversity. The rice paddy system remained an interconnected aquatic network that received water from natural sources or ultimately flowed into rivers. Many aquatic organisms could travel into and through the rice paddy system to find their niche within the paddies, canals, and irrigation ponds (Table 1). When flooded, the rice paddy was a shallow, still water pond. Streams provided niches for species preferring running water. Irrigation ponds provided deeper, still water habitats. The rice paddy

Table 1. **Representative aquatic organisms that utilize habitats in the rice paddy ecosystem**

	Red Data SpeciesEnglish name	Japanese name	List species	
Fishes:	*Misgurnus anguillicaudatus*	loach	dojo	
	Oryzius latipes	killifish	medaka	*
	Carassius langsdorfi	crucian carp	funa	
Frogs:	*Hyla japonica*	tree frog	amagaeru	
	Rana japonica	brown frog	akagaeru	
	Rana porosa	Tokyo pond frog	darumagaeru	*
Snail:	*Cipangopaludina chinensis*	mystery snail	marutanishi	*
Insects:	*Sympetrum frequens*	red dragonfly	akiakane	
	Lethocerus deyrollei	giant water bug	tagame	*
	Ranatra chinensis	water scorpion	mizukamakiri	
Birds:	*Nipponia nippon*	crested ibis	toki	*
	Ciconia boyciana	white stork	konotori	*
	Egretta garzetta	little egret	kosagi	
	Bubulcus ibis	cattle egret	amasagi	
Weeds:	*Marsilia sp.*	water clover	dennjiso	*
	Salvinia natans	floating fern	sanshomo	*

system was also able to support a large range of birds that could feed on rice paddy fishes or invertebrates. When rice paddy systems had been built in wetlands, the paddy and its associated waterways were often wet throughout the year, allowing many aquatic species to over-winter in the agro-ecosystem.

Aquatic organisms are often adapted to a particular disturbance regime of a niche within the flow and flooding of aquatic waterways. Rice agriculture stopped the natural rhythm of the rivers and lakes, but replaced it with the rhythm of the agricultural calendar. The rice paddy followed an annual rhythm as a shallow water pool for at least part of the year, disturbed by plowing and planting in the spring, and harvest in late summer. The waterways were subject to a longer rhythm. Every few years, farmers drained and cleaned the streams or ponds to clear them of mud and grasses. A group of plants that exemplify the tight linkage between agricultural practice and biodiversity are aquatic weeds that survived in the paddy (Itoh, 2000; Table 1). Some of these weeds, are classified as endangered species in Japan. They are adapted to the disturbance regime of the rice paddy, and in some species, evolved to mimic rice in form as well as life cycle.

Second, traditional Japanese agriculture preserved woodlands and created grasslands in the farmer's quest for natural resources. The important point for agro-ecologists was that farm communities did not turn the entire landscape into fields and paddies. Even in the plains, where topography placed fewer restrictions on land-use, farm communities maintained large woodlands and grasslands.

In many parts of Japan, woodlands and grasslands were commanlands guarded by farm villages for their own use (McKean, 1982; Totman, 1989). The commonlands were necessary because traditional Japanese agriculture depended heavily on local sources of organic material, so called "green fertilizer," to fertilize the poor soils. Green fertilizer refers to the leaves and grasses collected from woodlands and grasslands to be plowed into fields to provide organic material to the soils, or mixed with manure to make compost. Farmers needed large amounts of green fertilizer, and field area may have been limited partly by the areas of available woodlands and grasslands (Sprague *et al.*, 2000). The commonlands also provided fodder for farm animals, fuel wood or leaves, and charcoal. Until recently, farmers and foresters recognized large areas of a class of woodland called the "agricultural use woodland" or noyorin (Okutomi, 1998). The woodland flora were often hardy, secondary species that could tolerate poor soils and repeated cutting or firing. Common woodland trees were the red pine (Pinus densiflora) and coppice broad-leaf species (*e.g.* Quercus spp.), as opposed to the natural broad-leaf forest vegetation. The woodland floor was repeatedly cut, which favored the "spring ephemeral" species of grasses and herbs (Yamamoto *et al.*, 2000) that preferred relatively open and sunlit habitats. Other land-uses that provided wooded habitat included hedges and woodlands in the compounds of farm households, shrines and temples. Rural grasslands were maintained by the repeated cutting and firing that kept the vegetation from succeeding to woodland (Tsuchida, 1998). Grass species often consisted of Miscanthus spp. that farmer's collected as fertilizer, fodder, and roofing material for houses.

The heterogeneous, mosaic structure of the traditional rural landscape was another reason suggested to explain why so many species could survive in the agro-ecosystem. Many organisms use different habitats in different parts of their life cycle. Organisms also disperse to new habitats when their immediate environment is disturbed, and new habitat must be available for them to colonize. The ability to disperse was important because the rural environment was in flux. Farmers regularly plowed and planted paddies, cleared the streams and ponds, cut trees, and burned grassland.

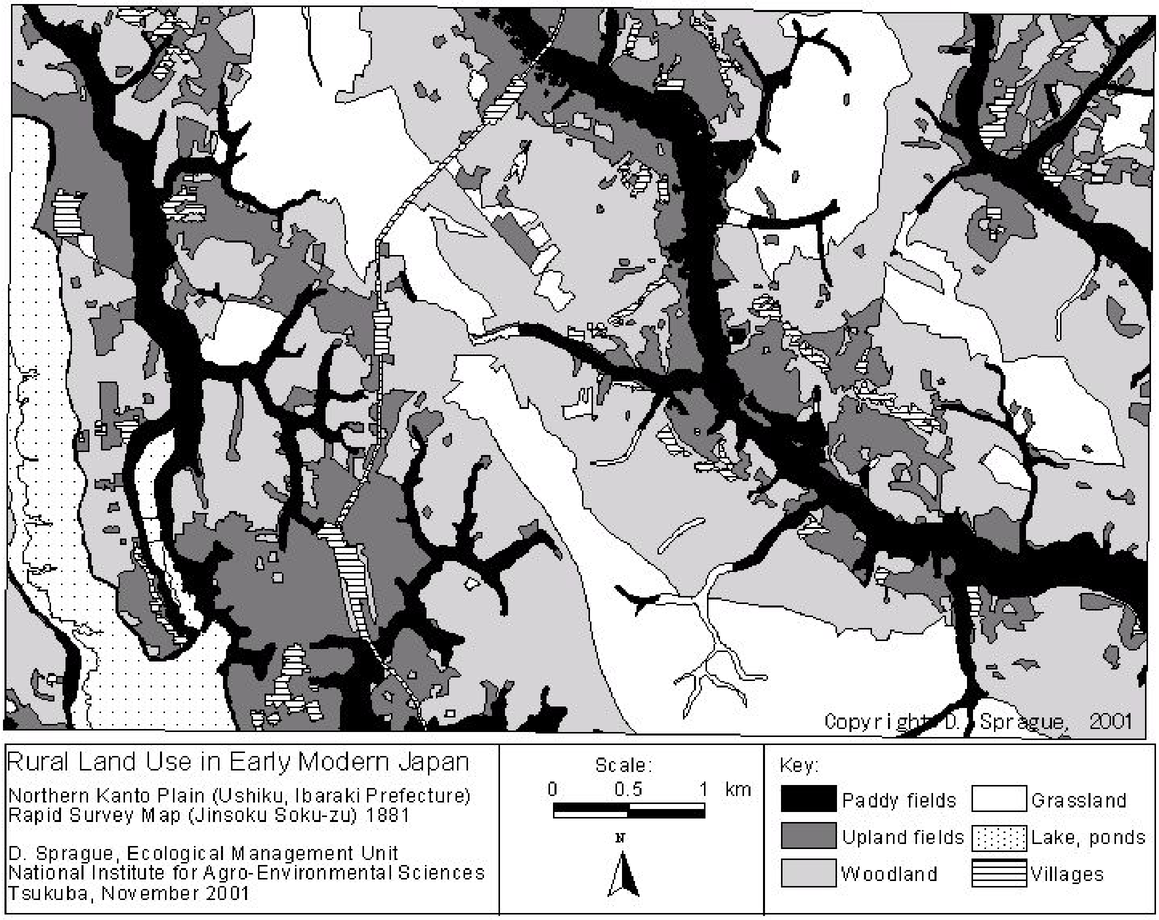
The dragonfly is a good example of an organism requiring many different habitats located within the range of individual dispersal (Moriyama and Sprague, 2000). Dragonflies breed in aquatic habitats, and the dragonfly nymphs can grow in the rice paddy, streams or ponds of the rice agriculture network, depending on the specific adaptations of each species. After emerging from the water, the young adult dragonflies fly to their preferred dry-land habitats in the woodlands or grasslands where they mature until they once again return to aquatic habitats to breed. Japanese rural environments can still allow a large number of dragonfly species to survive.

Spatial Structure of Traditional Japanese Agriculture in the Kanto Plain

To study past agricultural landscapes, agro-ecologists can use historical maps. Figure 1 shows a rural area in 1881 which is now Ushiku City, near Tsukuba Science City, in the northern Kanto Plain (Sprague *et al.*, 2000). The source map is called the Rapid Survey Map, surveyed by the Japanese Army in the early Meiji Period, that depicts details of both topography and land-use for much of the Kanto Plain that surrounds the Tokyo metropolitan region.

The map shows that the traditional rural landscape provided a range of aquatic, wooded and grassland habitats within the distances that many organisms could travel. The Tsukuba region is an upland plain with narrow river valleys. Most of the river valleys had been turned into rice paddy. On the plateau, the grasslands occupied the central axis between the river valleys. Woodlands surrounded the fields and villages distributed along the rivers. In the land area of this map (*i.e.* excluding the lake), 43% was woodland and 15% was grassland. The woodlands and grasslands were located adjacent to water, and the river networks stayed within 1 km of each other through the tips of the river branches (Moriyama and Sprague, 2000).

Figure 1. **Land-use in the Ushiku City area of southern Ibaraki Prefecture, 1881**



Source: Based on the Rapid Survey Map, modified from Sprague *et al.* (2000).

While many landscape features are interconnected, ponds were separated by some distance. Farmers often built irrigation ponds at the tips of the rivers or took advantage of natural ponds. Ponds can become ecologically isolated if they are scattered too far apart. However, in the traditional rural landscape, farmers often maintained ponds near their fields. In the Tsukuba area of the early Meiji Period in 1883, Moriyama (1997*b*) found that many ponds distributed across the farm landscape were located within 1 km of one another.

Based on the knowledge about agricultural practice and the landscape, Moriyama (1997*a*) postulated a model for an agro-environment that could support a rich fauna. Aquatic animals, such as dragonflies and frogs, could disperse between ponds and rice paddy distributed within about 1 km of one another. The high proportion of woodland in the rural landscape provided habitats for birds of the mountainous forests when they flew down to the plains. The periodic cutting and mowing of the underbrush in woodlands created habitats for birds adapted to sparse woodlands and clear understory. One example of a bird species that depended on agricultural practice was the Ural owl (*Strix uralensis*). This predatory bird nested in the large trees near houses, and fed on ground prey. The understory of woodlands needed to be cut and cleared for the owl to be able to feed on its ground-dwelling prey.

Modern Japanese Agricultural Practice

Both land-use and agricultural practice changed drastically in the century following the time when the Army commissioned the Rapid Survey Maps. Ecologists need to identify how subsequent changes in agricultural practices affected the capacity for the agro-environment to provide wildlife habitats. Land-uses are reviewed in order of temporal change. The agro-ecosystem envisioned here is based on the upland Kanto Plain depicted in Figure 1.

Grasslands in the plains of Japan diminished from the late nineteenth century. One main reason for this was the expansion of fields in the grassland commons. In the map area of Figure 1, the grasslands were commons that were distributed to new farmers. The expanding market economy allowed more farmers to purchase fertilizers, and reduced their dependence on self-supplied "green fertilizer" collected from woodlands and grasslands.

Especially from the 1950's, new technology further reduced the need for woodland and grassland usage throughout Japan. Petroleum fuels replaced charcoal, firewood, and dried leaves as the commonly used fuels. Chemical fertilizers have almost completely replaced compost, and the extremely intensive forest and grassland utilization on which compost depended, has all but disappeared. The mechanization of agriculture also reduced the need for fodder to feed the horses and cattle that once drew ploughs. Rural communities are often surrounded by woodland that has been "abandoned," in the parlance of agronomy. Many woodlands are being turned to urban land-uses. The city of Ushiku in Figure 1 is now a bustling city. In the Tsukuba area, adjacent to Figure 1, the proportion of woodland on the landscape had gone down from 31% in 1905, to 26% in 1960, down to 16% in 1988 (Ide, 1992; Figure 2). The remaining woodland habitats are increasingly fragmented and dispersed.

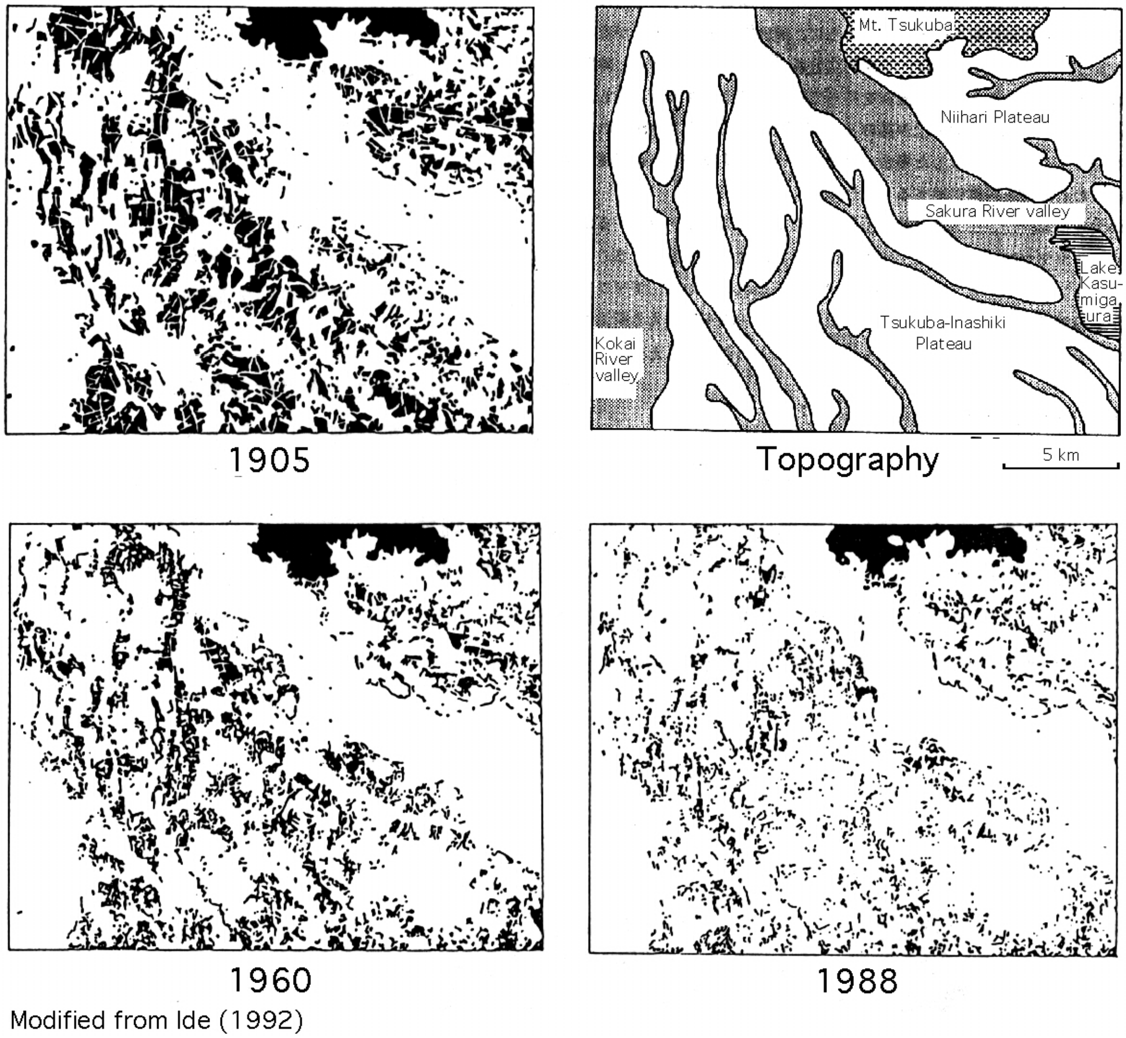
In rice paddy, the strict control of water flow may diminish the capacity to support diverse biota, in addition to the use of pesticides and chemical fertilizers. Aquatic organisms cannot overwinter in rice paddy if the paddies are left dry in the winter. Many waterways and ponds are lined with concrete, and not continuously inter-connected in ways that allow aquatic organisms to move freely through the system. Field studies have found that the new rice paddies and waterways may have fewer numbers and biomasses of frogs, tadpoles, loach and other fish, which in turn may affect the abundance of aquatic birds that feed on them (Lane and Fujioka, 1998).

Identifying Indicators of Japanese Rural Land-uses

Given the recent history of agriculture in Japan, ecologists need to identify convenient and informative indicators of the capacity for the agro-environment to serve as wildlife habitat. The indicators need to provide information on agricultural intensification that has meaning in the Japanese context.

Grassland indicators for Japan today may be similar to those for Europe. Rural grassland has been diminishing in Japan as a whole. The remaining grassland is often planted with improved grass varieties, in contrast to the traditional grasslands of native grasses.

Figure 2. Historical changes in woodland distribution in the Tsukuba area in the northern Kanto Plain



Source: Ide (1992).

Woodland area has been diminishing rapidly in the plains areas of Japan today, primarily due to urbanization. Indicators for remaining woodland need to distinguish between at least two directions that most "abandoned" woodland may take. Woodland may be left to natural succession. In this case the tree species gradually succeed toward whatever flora that can disperse and grow at each locality. In some cases, succession may lead to a mature broad-leaf forest approaching the presumed natural state. Alternatively, woodland can be replanted to become a commercial conifer plantation, primarily of cedar or hinoki. While plantation species are native to Japan, large single-species stands of conifer are relatively unusual in natural vegetation. Some ecologists argue that plantation conifers are not able to support as much biodiversity as either rural woodlands or natural forests. Although "abandoned" woodland may be more "natural," many agro-ecologists argue that rural biodiversity is changing because secondary species common in rural woodlands and grasslands depended on the management of forests.

The capacity for rice paddy to support aquatic biodiversity is affected by how the paddy field is constructed. Since the 1960's, a policy of paddy field reconstruction has rebuilt paddy fields into larger, more regularly shaped plots with strict water control. The rate of field reconstruction can be an indicator, although a variety of new field designs exist, assuming that rebuilt fields in general have reduced capacity to support aquatic biodiversity. For Japan as a whole today, 65% of villages have had over 90% of their paddy fields rebuilt (MAFF, 2001).

A Tentative Application of Indicators

It is beyond this paper's scope to provide an extensive list of possible indicators, or even to suggest that the indicators given here are immediately applicable or that all necessary data are available. The intent is to tentatively apply the indicators to anticipate what the indicators may show, based on the information given above, and suggest further avenues of investigation that will lead to valid indicators for the Japanese agro-environment.

Uncultivated natural habitats

1. Net area of aquatic ecosystems converted to agricultural use.
Many wetlands, even at the baseline, would have been converted to rice paddy. With improved irrigation and engineering technology, more wetland was converted to paddy.

2. Area of "natural" forest converted to agricultural use.
At the baseline, few of the rural woodlands, especially in the plains areas, would have been natural. Ironically, it is possible to argue that natural forest is increasing today because past woodland usage has ceased, and many woodlands are now allowed to regenerate through natural succession.

Semi-natural agricultural habitats

1. The share of the agricultural area covered by semi-natural agricultural habitats.
At the baseline, rice paddy, woodland, and grassland could be considered to be semi-natural agricultural habitats. Only dry fields perhaps should be removed from the semi-natural category even at the baseline.

Remaining woodland today perhaps still can be considered semi-natural as a first estimate. More detailed indicators may recognize the conversion of woodland to relatively natural states or plantation conifer.

Intensively farmed agricultural habitats

1. The share of each crop in the total agricultural area.
At present, the majority of rice paddy may be classified as intensively farmed agricultural habitat based on the criteria of re-built fields, strict water control, and agro-chemical usage that became widespread from the 1950's and 1960's. Most rural grasslands today probably have been converted to fields or improved pasture.

2. The share of organic agriculture in the total agricultural area.
Organic agriculture is growing in importance in Japan as well as in other OECD nations. However, the definition for organic agriculture was recently defined more strictly, and the statistics on organic agriculture in Japan will need to be reassessed.

Discussion

In classifying agricultural habitats, the distinction between intensive and semi-natural habitat must be applied carefully. The proposal broadly defines intensively farmed areas as artificial habitats subject to regular disturbances of the soil and dominated by crop species, with generally low value as wildlife habitat because of the paucity of non-crop vegetation combined with the use of pesticides. Semi-natural agricultural habitat is broadly defined as areas of land subject to "low intensity" farming practices, relatively undisturbed by ploughing, mowing, and weeding, where farm chemical use is absent or applied at considerably lower rates per unit area. The examples of habitats typical of agricultural ecosystems include extensive grassland and pasture, fallow land, and "low intensity" permanent crop areas, such as fruit orchards and olive groves. Semi-natural aquatic habitats include grazing in marshes and water meadows. Semi-natural forest habitats cite agro-forestry and pastoral woodland. In addition, the definition of natural aquatic ecosystems mentions loss of aquatic ecosystems through drainage or reclamation for farming.

The definitions do not seem to apply in a straight-forward way to Japan. Many of the examples of land-uses given in these definitions are relatively rare in Japan. Agricultural practices in Japan may not occur in the same combinations. Agricultural practices in Japan need to be listed and reviewed one by one for each major type of land-use to consider how they fit into the categories of agricultural habitats.

Traditional rice paddy can be classified either as intensively farmed agricultural habitat or semi-natural habitat. The distinction between intensive and semi-natural habitat is important because it defines the baseline state for the rice paddy ecosystem. Researchers and policy makers need to decide whether the indicators of wildife habitats show that rice paddy agriculture started in the intensive state, or show that it started in the semi-natural state and shifted to the intensive state. Rice paddy can be considered intensively farmed agricultural habitat because it is artificially built, subject to farm management, and dominated by a single crop plant. Alternatively, traditional rice paddy can also be considered semi-natural aquatic habitat, if the ability to serve as wildlife habitat is the primary criterion for classifying agricultural land to define habitat indicators. Building rice paddy did not require draining a wetland. Farmers utilized wetland for the purpose of growing a wetland crop. Many of the wetland functions potentially remained in rice paddy, and non-crop fauna and flora may have continued to live there. Pesticide use, of course, did not exist originally.

In both cases, the definition of the modern intensification in rice farming cannot depend on traditional farm management. Measures of modern agricultural intensification must focus on technological innovations that diminished the capacity for rice paddy to support biodiversity in the last few decades. For these indicators, the baseline year would be about 1950. Whether or not farm chemicals are used is one obvious and universally understood measure. Other possible criteria that apply to rice paddy include strict water management and new methods to construct waterways.

Indicators of woodland and grassland may more easily correspond to those of Europe. Japanese rural woodland and grassland can be treated as forms of semi-natural agro-forestry, with or without pastoralism. Rural woodlands probably should not be considered natural, since species composition differed from the natural broad-leaf forest. Most rural grasslands were artificially maintained by repeated cutting and burning that prevented grassland from succeeding to woodland. If the indicators need to recognize the role of grasslands in the plains, then the temporal baseline should be at the end of the 19th century before they were redistributed to new farmers.

Two issues complicate the application of indicators for rural woodland in Japan. First, since over 60% of Japan is classified as mountainous, woodland indicators need to distinguish between those for the plains and the mountainous regions. Woodland indicators for the plains probably would show a consistent decline in woodland area due to urbanization. Woodland indicators for mountainous regions is in effect a proxy for topography. National level indicators would consistently show a large proportion of forest because mountainous terrain is often unsuited for farming. Despite changes in land-use, mountainous regions often remained forested, or abandoned farmland and grassland may revert to forest. In the mountainous regions, a topographic criteria can sharpen the focus of indicators on regions where agriculture is actually practiced. Other nations with large proportions of mountains in national land area may need to distinguish between indicators for flatland and mountainous rural environments. The second complicating issue, as previously described, is the value attached to present-day forests. Ecologists disagree on whether abandoned rural woodland can be reclassified from semi-natural to natural, and whether conifer plantations have habitat value for wildlife. Some agro-ecologists argue that woodland management should be revived to return woodlands back to the semi-natural state to preserve the range of biodiversity under traditional agriculture.

Formulating meaningful indicators requires detailed comparisons of classification criteria and agricultural practice. The indicators need to be ecologically informative. The baseline should be well chosen and explicitly justified. Furthermore, ecologists and policy makers need to agree on the appropriate classification for agricultural habitats of each nation. Agreement is necessary both domestically and internationally. International agreement is especially important if the indicators are to be consistent and authoritative in comparing the quality of agricultural environments across nations.

The history of agriculture in Japan suggests that classification criteria need to be adapted to fit East Asian rural land-uses into the three major habitat categories proposed in OECD (2001). Agreement on the classification for rice paddy fields is critical for formulating indicators applying to East Asia. Rice paddy agriculture is a distinguishing feature of agriculture in Asia, and occupies large proportions of both current cultivated area and potential wetland. This paper attempted to identify criteria to classify rice paddy as intensive or semi-natural agricultural habitat for Japan. The criteria for other Asian nations is likely to differ, and each nation will need to identify a baseline both in terms of land-use and time.

REFERENCES

Ide, M. (1992), Ecological studies on the rural landscape patterns for the conservation of biotopes. *Bulletin of the Laboratory of Landscape Architecture and Science No. 11*, The University of Tokyo. (In Japanese).

Itoh, K. (2000), Bio-diversity in weeds in agro-ecosystem for rice production. *Proceedings of the International Workshop on the Biology and Management of Noxious Weeds for Sustainable and Labor Saving Rice Production*, National Agriculture Research Center, Tsukuba, pp. 223-236.

Lane, S. J., and M. Fujioka (1998), Impact of changes in irrigation practices on the distribution of foraging egrets and herons (Ardeidae) in the rice fields of central Japan. *Biological Conservation* 83: 221-230.

MAFF (2001), *Pocket Agriculture, Forestry and Fisheries Statistics*. Tokyo: Agriculture and Forestry Statistics Association, Ministry of Agriculture, Forestry and Fisheries.

McKean, M. (1982), The Japanese experience with scarcity: management of traditional common lands. *Environmental Review* 6: 63-88.

Moriyama, H. (1997*a*), *Taking Advantage of Rural Nature*. Tokyo: Iwanami Shoten. (In Japanese).

Moriyama, H. (1997*b*), *What Does It Mean to Protect Paddy Fields?* Tokyo: Nobunkyo. (In Japanese).

Moriyama, H. and D.S. Sprague (2000), Traditional paddy field landscape acted to preserve Japanese dragonfly fauna. Paper presented at INTECOL International Wetland Symposia, Quebec, Canada, August 6-12.

OECD (1999), *Environmental Indicators for Agriculture: Methods and Results — The Stocktaking Report Greenhouse gases, Biodiversity, Wildlife Habitats*. Paris: OECD.

OECD (2001), *Environmental Indicators for Agriculture — Methods and Results, Volume 3*. Paris: OECD.

Okutomi, K. (1998), Conservation of secondary forests. In M. Numata ed., *Handbook of Nature Conservation*. Tokyo: Asakura Shoten, pp. 392-417. (In Japanese).

Sprague, D.S., T. Goto and H. Moriyama (2000), GIS analysis using the Rapid Survey Map of traditional agricultural land use in the early Meiji Era. *Journal of the Japanese Institute of Landscape Architecture* 63: 771-774. (In Japanese).

Totman, C. (1989), *Green Archipelago: Forestry in Preindustrial Japan*. Berkeley: University of California Press.

Tsuchida, K. (1998), Conservation of semi-natural grassland. In M. Numata ed., *Handbook of Nature Conservation*. Tokyo: Asakura Shoten, pp. 432-476. (In Japanese).

Yamamoto, S., Y. Kato and M. Yokohari (1998), A study on the distribution and structure of forests for the conservation of spring ephemeral species in mountainous area. *Journal of the Japanese Institute of Landscape Architecture* 61: 557-562. (In Japanese).

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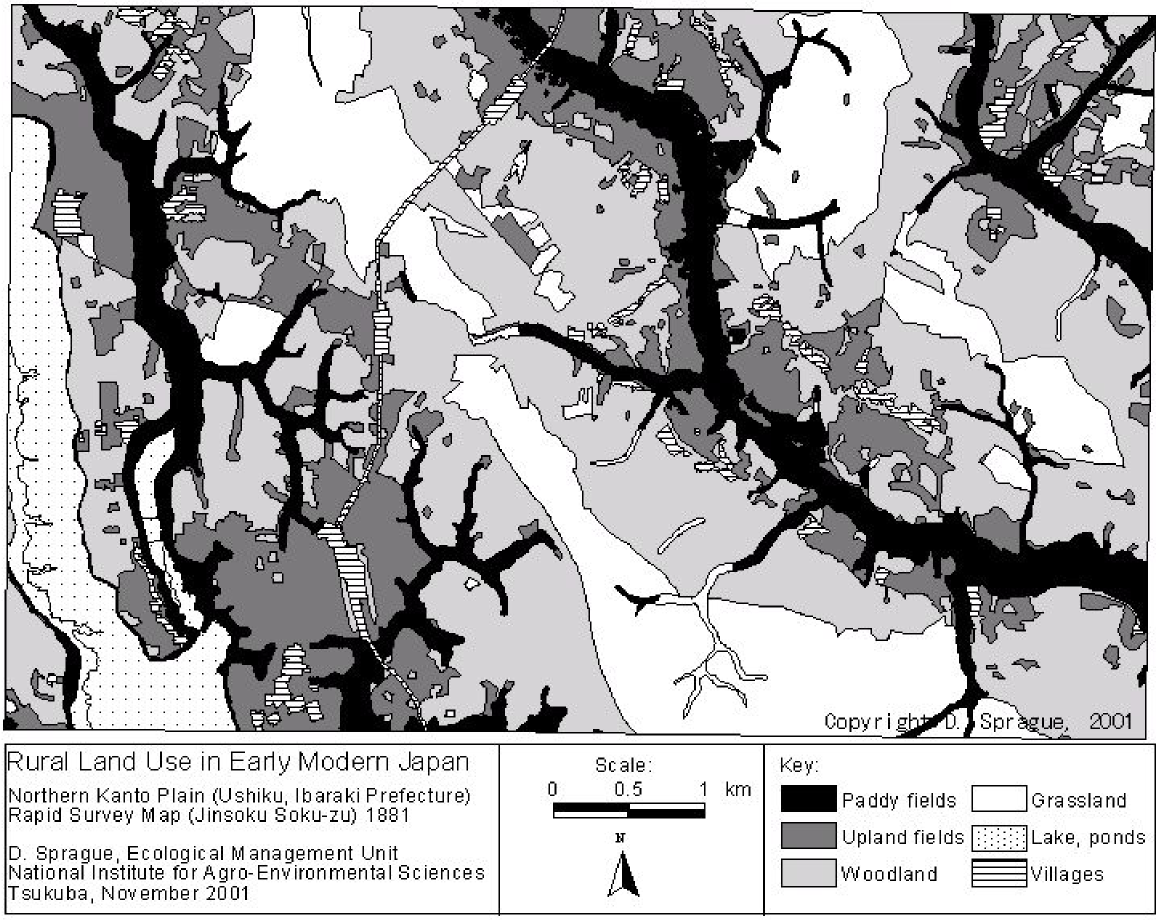

Source: Based on the Rapid Survey Map, modified from Sprague *et al.* (2000).

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NATIONAL AND REGIONAL LEVEL FARMLAND BIODIVERSITY INDICATORS IN FINLAND

Mikko Kuussaari & Janne Heliölä[1]

Introduction

Agriculture in Finland has experienced very large changes during the last 50 years. The last big change happened in the year 1995 when Finland joined the European Union (EU) and adopted the common agricultural policy of EU. Agricultural intensification and loss of open semi-natural farmland habitats has caused large-scale losses of farmland biodiversity in Finland (Pitkänen & Tiainen, 2001) as well as in other parts of Europe (Krebs *et al.*, 1999). Because of the large changes there is a substantial need for useful indicators to measure the extent of change both at the national and landscape level. A preliminary set of indicators for the sustainable use of renewable resources at the national level was approved in Finland in February 1999 (Lahti & Nikkola, 1999). At a smaller spatial scale indicators are particularly needed in the monitoring and further development of the effects of the Finnish agri-environmental support scheme, which is half-funded by EU.

The aim of this paper is to summarize some recent developments and on-going work on farmland biodiversity indicators in Finland both at the national and at the landscape level. We start by showing recent results of four useful measures of the state of farmland biodiversity in Finland. After that we focus on the landscape level indicators and describe an on-going research project, which was started in the year 2000 in order to evaluate and further develop the effectiveness of the current Finnish agri-environmental support scheme to maintain farmland biodiversity. Another object of this project is to identify a set of the most useful indicators of Finnish farmland biodiversity. Finally, we compare the different needs that there are for useful farmland biodiversity indicators at the national and landscape levels.

National level indicators

In this section we give a short overview of the recent trends and current state of farmland biodiversity in Finland by using four selected national level indicators: the trend in the amount of seminatural grasslands and the number of threatened species, threatened species in various farmland habitats and population trends in farmland butterflies.

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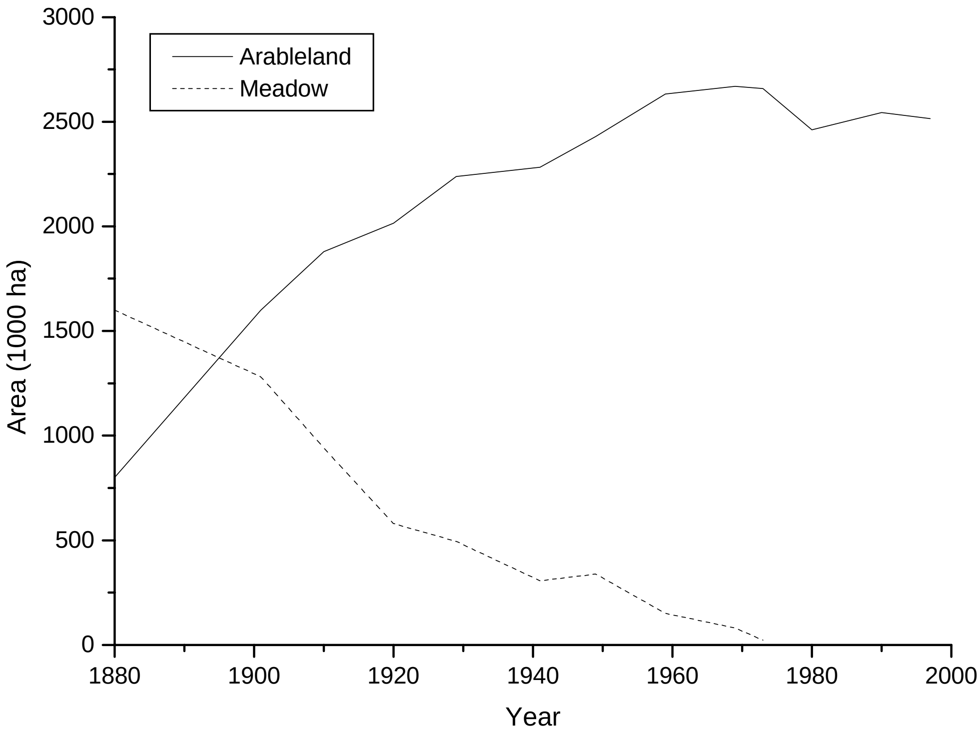
1. Trend in the amount of seminatural grasslands

During the last 100 years Finnish agriculture has gone through a change from small-scale traditional agriculture to much more efficient modern agriculture with increasing farm size and increasing specialization. Traditional Finnish agriculture involved animal husbandry for which it was typical to use extensive areas of semi-natural grasslands and forests for cattle-grazing. This type of agriculture was beneficial for a large amount of grassland-specialized species, especially for many plants and insects (Pykälä, 2001). Presently, the large amount of different kinds of extensively used meadowland, which existed in Finland in the beginning of 20th century, has been mostly lost and converted to intensively used cultivated fields (Figure 1).

Figure 1. **Decline of the area of semi-natural grasslands in Finland 1880-1997**



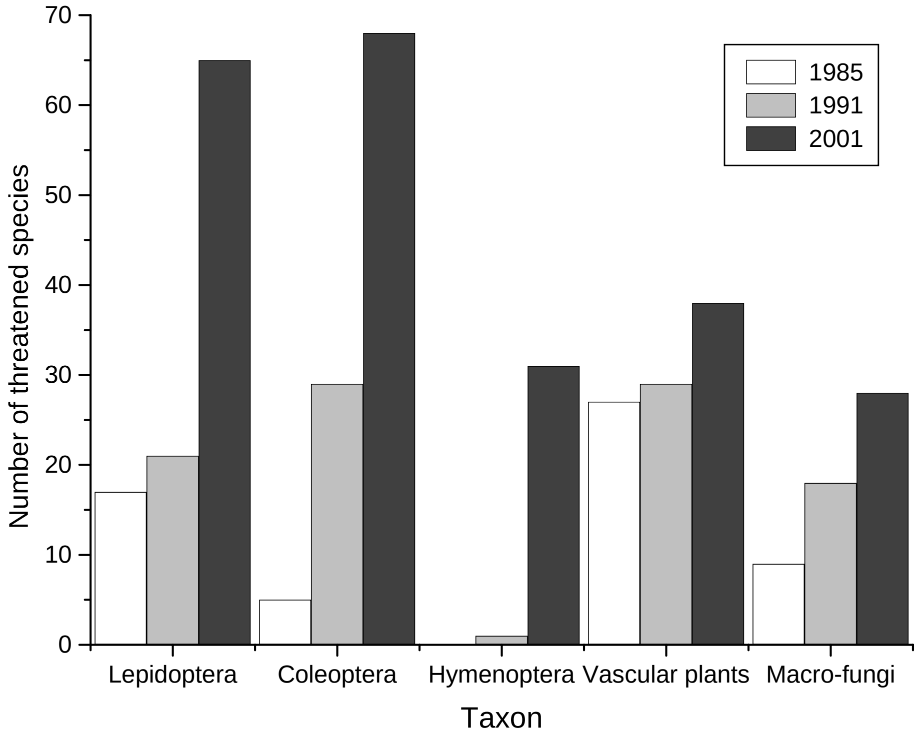
Source: Soininen 1974, Finnish agricultural statistics.

During the last 100 years the amount of medowland has decreased to less than 1% of what it used to be. Such a severe decline of suitable habitat is expected to cause a decline and regional extinctions of many meadow-associated species (Andrén, 1997; Hanski, 1999).

2. Trend in the number of threatened species

A comprehensive evaluation of threatened species in Finland has been made for three times, in 1985, 1990 and 2000 (Rassi *et al.*, 2001). Based on the existing three evaluations, it is possible to analyse trends in the amount of threatened species within different habitat types. Figure 2 summarizes the trends for species which mainly occur in farmland habitats.

Figure 2. **Increase of the number of threatened species in the Finnish agricultural landscapes**



Source: Rassi *et al.*, 2001.

In each of the five groups of organisms in Figure 2 there is an increasing trend. This trend is logically consistent with the observed long-term declining trend of suitable open seminatural habitats (Figure 1). However, a substantial amount of the increase in the numbers of threatened species is due to the increased knowledge of previously too poorly known groups of species. For example in Lepidoptera a substantial proportion of the currently threatened species belong to Microlepidoptera, which could not be thoroughly classified in the previous evaluations because of insufficient knowledge. Nevertheless, the increase of the amount of threatened species in the latest Finnish evaluation was higher in the species of farmland habitats than in any other habitat type (Rassi *et al.*, 2001).

3. Threatened species in different farmland habitats

There is much variation in the numbers of threatened species among various kinds of farmland habitats. In Finland, almost half of the threatened farmland species are primarily species of dry meadows (Table 1). This is not surprising, because the area of dry meadows has decreased more than the area of any other grassland habitat type in Finnish agricultural landscapes (Heritage landscapes working group 2000). The amount of threatened farmland species is particularly high in butterflies and moths (Lepidoptera) as well as in beetles (Coleoptera; Table 1).

Table 1. **Threatened species in different farmland habitats in Finland**

Habitat type	*Lepidoptera*	*Coleoptera*	*Hymenoptera*	*Vascular plants*	*Macro-fungi*	***Total***
Dry meadows	57	43	26	23	13	**162**
Fresh meadows	7	9	-	13	-	**29**
Margin habitats	58	25	11	1	-	**95**
Wooded pastures	7	16	8	10	17	**58**
Shores, river banks	11	19	1	14	2	**47**
Total	**140**	**112**	**46**	**61**	**32**	**391**

Source: Rassi *et al*., 2001.

4. Population trends in farmland butterflies

For the ecologically well-known groups of organisms it is possible to determine which species are primarily inhabitants of agricultural landscapes. In Finland this was recently done for butterflies. According to Pitkänen, Kuussaari & Pöyry (2001) 74 of the ca 100 permanent butterfly species live in agricultural environments. These species were further classified into three categories according to their primary habitat type: species of 1. Field margins and farmyards, 2. meadows (or seminatural grassland) and 3. forest verges and clearings (Table 2). By combining information on observed population trends of each species and the habitat classification Pitkänen *et a*l,. (2001) found that the trends are distinctly different among the species of the three habitat types. While 71% of the meadow species had declined, the corresponding figure for the species of forest verges and clearings was only 25%, and none of the species of fields and farmyards had declined (Table 2).

Table 2. **Population trends in Finnish farmland butterflies**
(Number and % of species)

Habitat type	*Decreased*		*No change*		*Increased*		*Threatened* [1]	
Field margins, farmyards	0	0 %	7	88 %	1	12 %	1	12 %
Meadows	24	71 %	8	24 %	2	6 %	14	41 %
Forest verges and clearings	8	25 %	19	59 %	5	16 %	4	13 %
Total	**32**	**43 %**	**34**	**46 %**	**8**	**11 %**	**19**	**26 %**

1. IUCN classification.
Source: Pitkänen, Kuussaari & Pöyry, 2001.

The trend in the national level farmland biodiversity indicators

All the above mentioned national level indicators of the state of farmland biodiversity indicate that Finnish farmland biodiversity has been declining. Eventhough the general trend has been a decline there are also exceptions, as shown for butterflies in Table 2. The situation is similar in Finnish farmland birds in which the population trends are known in detail (Tiainen and Pakkala, 2001). While many farmland bird species have been severely declining, there are some others, which have become more common and increased in abundance (Tiainen and Pakkala, 2001).

Landscape-level indicators

Agri-environmental support schemes aim at stopping and reversing the trend of environmental deterioration by providing economic support to farmers for applying environmentally friendly farming practices. One of the aims of such schemes is maintaining and improving farmland biodiversity. Because an effective agri-environmental support scheme is a substantial economic investment from the society, there should also be effective means to measure the environmental benefits of such a scheme.

Measurement of changes in biodiversity may be complicated by several issues. For instance, the biodiversity impacts of changing farming practices may be weak and thereby difficult to detect. In addition, populations of many species react to environmental change with a time delay. Therefore, it may take some years before the positive impacts of beneficial changes in farming practices can be seen as increasing biodiversity.

National level biodiversity indicators may be too crude measures for detecting changes in biodiversity at smaller spatial scale. For example the number of threatened species may be a very useful indicator at the national level but almost useless at the level of an ordinary farmland landscape of 10-100 km^2. The occurrence of nationally threatened species at such a small spatial scale may be a too rare event in order to have practical applicability.

In Finland insufficient knowledge on farmland biodiversity has hindered the development of the Agri-environmental support scheme towards better taking into account farmland biodiversity. Quantitative information has been lacking on the existing variation of farmland biodiversity and the primary factors affecting it in ordinary Finnish farmland. To improve the level of knowledge and in order to monitor the biodiversity impacts of the current agri-environmental scheme an extensive biodiversity survey was organized in randomly selected Finnish agricultural landscapes.

Finnish farmland biodiversity survey

A pilot survey on Finnish farmland biodiversity was conducted in 15 farmland landscapes in summer 2000. In summer 2001 the same methodology was applied to 58 randomly selected agricultural landscapes in southern Finland. The aim of the survey was to obtain quantitative information on 1. the amount of variation in plant, insect and bird biodiversity in ordinary Finnish farmland, 2. the key factors affecting species diversity at different spatial scales and 3. the relationship between landscape structure and biodiversity.

Vascular plants, butterflies, bumblebees and birds were quantitatively surveyed in a total of 58 one square kilometer study areas. In each 1 km^2 study area birds were counted from the whole farmland area, while the occurrence of plants and insects were sampled in 20 discrete 50 m long transects (altogether 1 160 discrete transects), which were located in all kinds of open and semi-open uncultivated farmland habitats available within each study square. Some 30 environmental variables (*e.g.* habitat type and location, vegetation height, amount of nectar flowers, habitat management) were recorded from each study transect to measure local habitat quality. Additional data on the details of farming practices in the study areas will be obtained from the farmland database of the Information Centre of the Ministry of Agriculture and Forestry and by interviewing the local farmers. Measures of landscape structure and the intensity of farming will be obtained using detailed habitat maps based on low-altitude aerial photographs and GIS methods.

Multiple regression methods will be used to identify key factors affecting the diversity of various groups of organisms at different spatial scales. Additional interest is in examining the congruence of the variation of diversity among the four taxonomic groups. The results will be used in the evaluation and further development of the Finnish agro-environmental support scheme as well as in the identification of the most useful landscape level indicators of Finnish farmland biodiversity.

Results on butterflies

Results of the large biodiversity survey conducted in summer 2001 are not yet available, but some results from the pilot study on butterflies (Kuussaari *et al.*, 2001) and other pollinator insects conducted in summer 2000 can be shown. Table 3 summarizes the data on the occurrence of various insect groups which was gathered from the 1 km^2 squares. These data can be analysed either at the level of the 1 km^2 square or at the level of the 50 m long sample transects.

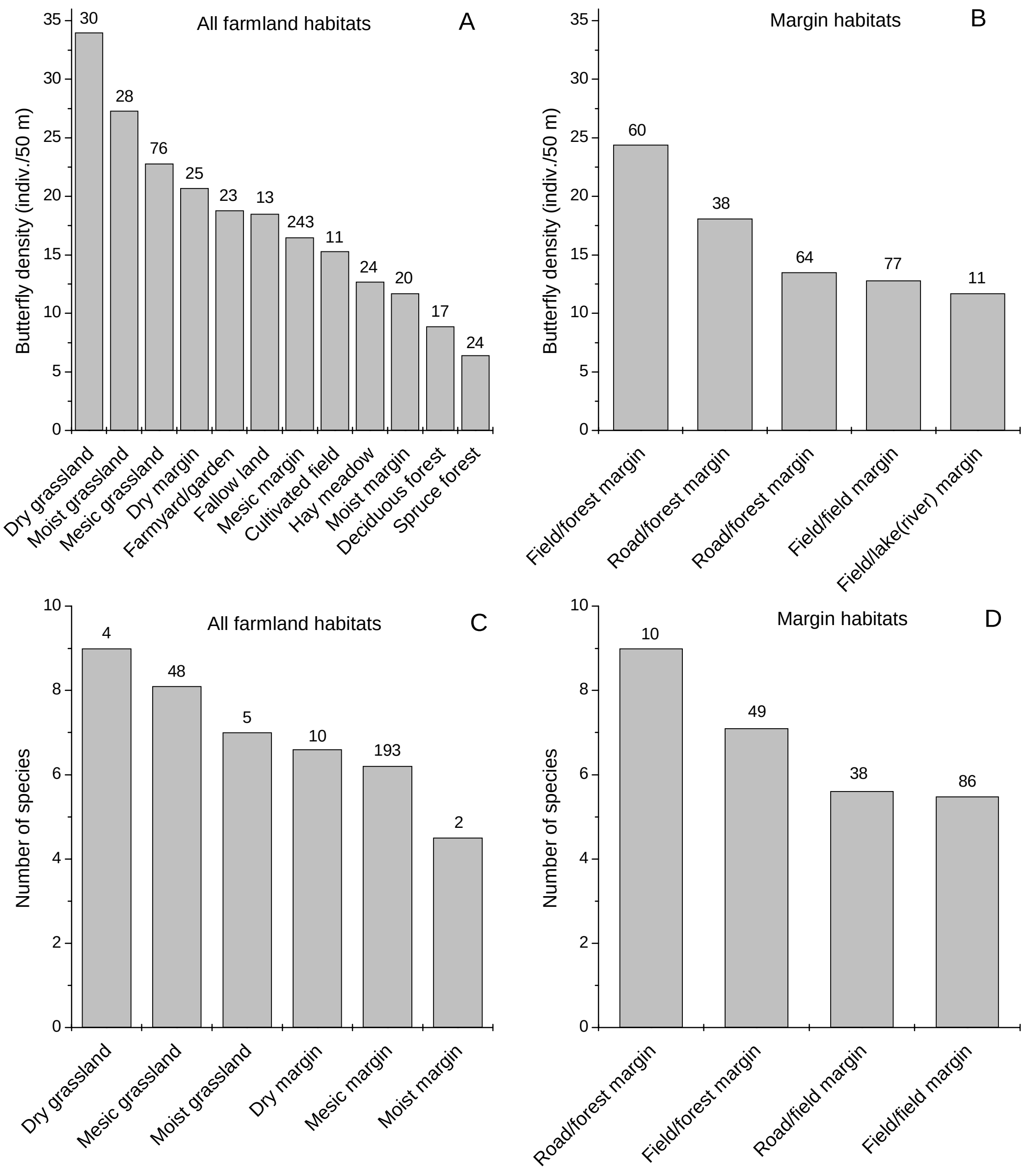
Table 3. **Summary of recorded insects in fifteen 1 km^2 study areas**

Insect group	*All study areas*		*Number of species per study area*			
	Individuals	*Species*	*Mean*	*Sd*	*Min*	*Max*
Line transects						
Butterflies	4 776	51	30.5	3.2	24	35
Other day-active Macrolepidoptera	2 814	69	23.7	3.2	18	30
Yellow-traps						
Bumblebees	3 956	20	12.6	2.8	6	17
Other bees	332	42	6.2	3.5	2	14
Hoverflies (Syrphidae)	11 441	64	16.4	5.5	6	25

Figure 3 summarizes transect level data on the occurrence of butterflies in different seminatural habitats. Three noteworthy results emerge from the figure. First, the highest numbers of butterfly species and individuals are observed in dry meadows. Second, butterfly density and species diversity are higher in meadows than in linear field margin habitats. Third, among the different kind of linear habitats, butterfly density and species diversity are higher in the open margins between field and forest than in the margins located between cultivated fields.

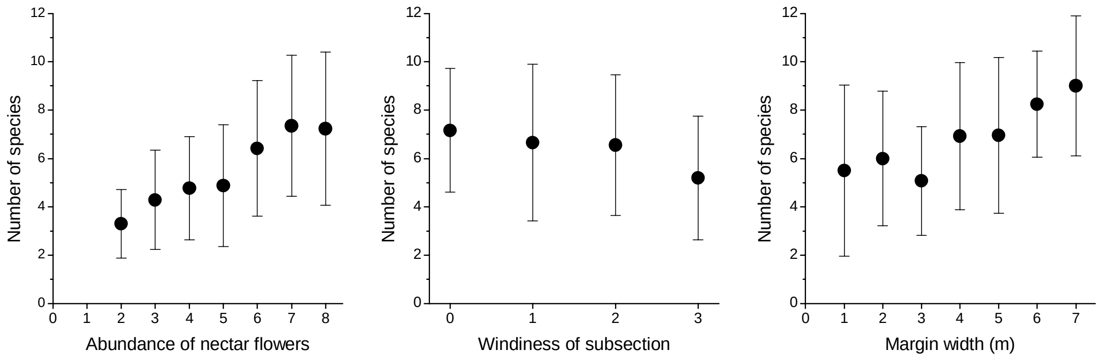
An analysis on the environmental factors affecting butterfly species richness in the linear margin habitats revealed that the most important three factors were nectar flower abundance, windiness of the site and the width of the margin. Increasing abundance of flowers and the width of the margin increased the number of butterfly species, whereas increasing windiness of the site decreased butterfly species richness (Figure 4).

Figure 3. **Average butterfly densities (ind./50 m; A and B) and number of species (in 50 m transect subsections; C and D) in different agricultural habitats**



Notes: Numbers above the bars indicate the number of subsections on which the mean value is based.
Source: Kuussaari *et al.*, 2001.

Figure 4. **Factors affecting butterfly species richness in linear habitat elements (field and road margins)**



Notes: Means and sd bars are shown.
Source: Kuussaari *et al.*, 2001.

The first results of the Finnish biodiversity survey are encouraging, because they show that at least in the case of butterflies, local species richness can be explained to a substantial extent by a few easily measurable local environmental factors. However, the analysis of the extensive farmland biodiversity survey conducted in summer 2001 is just at its beginning. It will take some time before the most interesting analyses, which take into account both the local and regional environmental quality as well as the numbers of species in the different groups of study species, can be made. For example, in the forthcoming analyses an important question will be, to what extent biodiversity at the level of 0.5-1 km^2 can be explained only by measures of landscape structure (*e.g.* habitat diversity or the area of seminatural grassland)?

Conclusions

In this paper we have discussed the need for both national and landscape level (referring here to an area of the size of 0.5-1 000 km^2) indicators of farmland biodiversity. We conclude that both kind of indicators are needed, but that the same indicators are not always useful at both spatial scales. National level indicators are needed for comparisons among countries, while in many countries there is an additional need to have landscape level indicators for example for monitoring the effectiveness of agri-environmental programs. Information on more specific landscape level indicators may help to explain and interprete observed patterns in more crude measures of national level farmland biodiversity indicators.

REFERENCES

Andrén, H. (1997), "Habitat fragmentation and changes in biodiversity." *Ecological Bulletins* 46: 171-181.

Hanski, I. (1999), *Metapopulation ecology*. London: Oxford University Press.

Heritage Landscapes Working Group (2000), "The management of agricultural heritage habitats in Finland. Report by the Heritage Landscapes Working Group." *Suomen ympäristö* 443: 1-162. (In Finnish with English summary).

Krebs, J. R., Wilson, J. D., Bradbury, R. B. & Siriwardena, G. M. (1999), "The second silent spring?" *Nature* 400: 611-612.

Kuussaari, M., Heliölä, J., Salminen, J. & Niininen, I. (2001), "Results of the butterfly monitoring scheme in Finnish agricultural landscapes for the year 2000." *Baptria* 26: 69-80. (In Finnish with English summary).

Lahti, J. & Nikkola, E. (eds., 1999), "The use of renewable resources in Finland." Helsinki: Ministry of Agriculture and Forestry.

Pitkänen, M., Kuussaari, M. & Pöyry, J. (2001), "Butterflies." In *Biodiversity of Agricultural Landscapes in Finland*. BirdLife Finland Conservation Series (No. 3) (Pitkänen, M. & Tiainen, J., eds.): 51-68. Helsinki: Yliopistopaino.

Pitkänen, M. & Tiainen, J. (eds., 2001), "*Biodiversity of Agricultural Landscapes in Finland*." BirdLife Finland Conservation Series (No. 3). Helsinki: Yliopistopaino.

Pykälä, J. (2001), "Maintaining biodiversity through traditional animal husbandry." — *Suomen ympäristö*, in press. (In Finnish with English summary).

Rassi, P., Alanen, A., Kanerva, T. & Mannerkoski, I. (eds., 2001). "*The 2000 Red List of Finnish species*." Helsinki: The Ministry of the Environment and Finnish Environment Institute. (In Finnish with English summary).

Soininen, A. M. (1974), "Old traditional agriculture in Finland in the 18th and 19th centuries." *J. Scient. Agric. Soc. Finland* 46 (Suppl.): 1-459. (In Finnish with English summary).

Tiainen, J. & Pakkala, T. (2001), "Birds." In *Biodiversity of Agricultural Landscapes in Finland*. BirdLife Finland Conservation Series (No. 3.) (Pitkänen, M. & Tiainen, J., eds.): 33-50. Helsinki: Yliopistopaino.

DEVELOPING HABITAT ACCOUNTS: AN APPLICATION OF THE UNITED KINGDOM COUNTRYSIDE SURVEYS

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Policy context

A prerequisite for sustainable development is sound information on the status and trends in environmental, social and economic capital (DETR, 1999). Such information can be used as a basis for setting objectives, measuring progress and shaping appropriate policy responses. Assessing land as an environmental resource poses particular problems. Most countries are faced with finite and fixed land resources. These land resources serve multiple functions. Traditionally viewed as a source of primary production, land has become valued in many different ways, for its aesthetics, its opportunities for leisure and recreation and as a habitat for wildlife. Land varies in quality in respect to all these functions but the monetary value of land is determined primarily by the opportunities it offers for agriculture or development. The market price does not normally measure the important non-market benefits of land (Bartelmus, 1998). As an alternative, we can look at the services that the land provides and measure these services in terms of biophysical parameters rather than monetary units.

In the UK as elsewhere, wildlife habitats form a major focus of nature conservation policies. Such policies take three broad approaches: i) the identification and protection of special habitats in designated sites; ii) the preparation and implementation of action plans for a select list of priority habitats within the UK Biodiversity Action Plan; and, iii) incentives and advice on management of habitats and controls on development in the wider countryside. The amount of different types of habitats, the condition of these habitats, and the losses and gains of habitats form key objectives for biodiversity policy (DETR, 2000; UKBG, 2001. Thus for example, for protected sites there is a target to achieve favourable condition on 95% of Sites of Special Scientific Interest in England by 2010 and for lowland chalk grassland there is a target to restore 1000 ha in the UK by 2010. The amount, condition and trends in habitats are one way of valuing land. Assessment of habitats is essential for appraisal of nature conservation policy. In the UK over 70% land, including many semi natural habitats, is in agricultural use. So any assessment of habitats must also, in large part, be an assessment of agricultural land.

The national indicators of sustainable development and sustainable agriculture include a number of indicators of the extent and condition of habitats (see Table 1). However, these indicators are necessarily selective in terms of the habitats and species considered and can only be regarded as a partial assessment of biodiversity. They also integrate a large number of driving forces and pressures that may be causing change. Thus, it is not straightforward to isolate the key underlying causes and

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thus determine the most appropriate policy response. Many of the UK national indicators can be compared directly with the OECD habitat indicators and others relate to the same issues of concern.

Table 1. **Summary of habitat indicators used in national indicator sets in the UK and comparison with OECD Environmental Indicators for Agriculture**

UK indicator description	Reference [1,2]	OECD comparison [3]
Populations of wild birds/farmland birds	QOLC H13, TSA 35	Intensively farmed Species diversity
Trends in plant diversity	QOLC S3, TSA 34	Intensively farmed Species diversity
Delivery of UK Biodiversity Action Plan targets	QOLC S4	
Characteristic features of farmland (hedges)	QOLC S5, TSA 32	Landscape structure
Area of cereal field margins under environmental management	TSA 33	Intensively farmed
Area of semi-natural grasslands	TSA 34	Semi-natural
Area of woodland	QOLC S10	Uncultivated
Area of ancient semi-natural woodland	QOLC S11	Uncultivated
Biodiversity in coastal/marine areas	QOLC R3	
Extent and condition of Sites of Special Scientific Interest	QOLC S6	Semi-natural
Area of agricultural land in conservation schemes	QOLC D13, TSA 31	Landscape management
Area converted to organic production	QOLC D14	Intensively farmed
Area of agricultural land	TSA 28	Semi-natural
Net loss of soils to development	QOLC S1, TSA 29	Uncultivated
New homes built on previously developed land	QOLC H14	Uncultivated

Sources:
QOLC Quality of Life Counts, DETR, 1999.
TSA Towards Sustainable Agriculture, MAFF,2000.
OECD, 2001.

Accounting framework

A principal criterion of sustainable development is that economic growth should avoid compromising the stock of environmental or social capital. The conventional way of assessing a country's wealth is through monetary accounts providing a calculation of Gross Domestic Product (GDP). Environmental accounts attempt to provide a similar balance sheet of environmental assets, showing the stocks and flows over the accounting period. The accounts provide a means of assessing whether environmental capital has gone up or down. Land use and land cover accounts have been proposed as supplementary to national environmental accounts where the units of accounting are hectares of land. In the framework developed by the UNECE Task Force, economic activity, land use, land cover and measures of habitat condition are inter-related via a series of transition matrices

(Radermacher, 1998). Thus, in principle, the framework provides a system for linking economic drivers to impacts on biodiversity. However, in practice there are few examples of sufficiently integrated data collection to enable the construction of such accounts, especially at a national level. Case studies illustrating parts of this accounting framework have been produced by the UK, Germany and France (Conference of European Statisticians, 1995).

In the UK, pilot land cover or habitat accounts have been produced using the results of the national Countryside Survey (Stott and Haines-Young, 1998; Haines-Young *et al.*, 2000). These accounts take the form of a simple balance sheet presenting the opening stock of habitats, the major transfers of land between habitats, the closing stock and net change. Supplementary accounts provide information on the changing quality or condition of habitats as well as changes in area.

Habitats and land cover types

Classifications of wildlife habitats and land cover are closely related. Land cover is a physical observation of the surface of the ground relating to soils, rock, water bodies, vegetation and various forms of human development. These same features form the basis for the description of wildlife habitats, though often habitats have more specific definitions relating to key biological functions or species. Typically land cover classifications are devised for rapid assessment of large areas using remote sensing techniques whereas habitat classifications rely on more detailed field observations and tend to have a more restricted geographical scope. Numerous systems of land cover and habitat classifications have been devised for different purposes at national and international scales. In the UK, a classification of 'broad' habitats has been developed in an attempt to build a bridge between the two approaches (Jackson, 2000).

Within the UK Biodiversity Action Plan (UK Biodiversity Steering Group, 1995; UKBG, 2001; www.ukbap.org.uk). Biological targets have been agreed for 41 selected 'priority' habitats covering a range of terrestrial, freshwater, coastal and marine habitats. The priority habitats are tightly defined in relation to their conservation status and have limited geographical extents. The UK BAP also has objectives relating to biodiversity in the wider countryside and maintaining the characteristics of local areas. The system of overarching 'broad' habitats was devised as a means of ensuring that all ecosystems present in the UK are included within the scope and objectives of the Biodiversity Action Plan. Given the intention that these broad habitats should be all inclusive and quantifiable it was necessary to develop definitions capable of rapid assessment using existing survey protocols as far as possible. For the terrestrial habitats this has provided an opportunity for convergence between land cover and habitat definitions.

Habitats may further be characterised by their constituent physical and biological components. For terrestrial habitats, vegetation types are crucial. In the UK, two main systems are currently in use: the National Vegetation Classification (NVC) (Rodwell, 1992) and the Countryside Vegetation Systems (CVS) (Bunce *et al.*, 1999*a*). The NVC is a phyto-sociological classification especially focused on vegetation communities of restricted distribution and of conservation interest. The CVS is a statistical classification of randomly sampled vegetation plots into 100 widely occurring classes. The CVS classes can be characterised by the major ecological gradients of fertility, shade and moisture.

Data collection and analysis

Countryside Surveys have been undertaken in Great Britain in 1978, 1984, 1990 and 1998 and in Northern Ireland in 1986-1992 and 1998 (Haines-Young *et al.*, 2000; www.cs2000.org.uk). The surveys involve a randomised sample of land cover, habitats and vegetation from a number of grid squares repeated in each survey year (see Table 2). The sample in Great Britain is stratified by 40 environmental land classes determined by a multi-variate statistical analysis using available mapped attributes such as topography and climate (Bunce *et al.*, 1996). The 40 land classes are aggregated into six major 'environmental zones' for the purpose of summarising sub-national trends (Figure 1). In each sample square details of land cover and linear features are mapped for all land parcels and the botanical composition of around 50 vegetation plots is recorded. Soils, freshwater and bird populations have also been surveyed. The field recording codes can be used to allocate parcels to different classifications of land cover, land use or habitats. In the latest survey, parcels were allocated to the broad habitats as defined in the UK BAP. The sample-based field survey has been co-ordinated and inter-calibrated with synoptic mapping of land cover across the whole country in 1990 and 1998 using satellite imagery.

Table 2. **Number of sample squares surveyed in the Countryside Surveys of Great Britain and Northern Ireland[1]**

	1978	**1984**	**1990[2]**	**1998**
Great Britain	256	384	508 (381)	569 (501)
Northern Ireland	-	-	628	628 (628)

Notes:
Figures in brackets refer to the number of sample squares repeated from the previous survey.
1. In Great Britain the sample squares had dimensions of 1 x 1 km (*i.e.* 100 ha); in Northern Ireland, 0.5 x 0.5 km (*i.e.* 25 ha).
2. The first NI Countryside Survey was undertaken as a rolling survey from 1986 to 1991.

The sample survey enables the calculation of national and regional estimates of the stock or extent of broad habitats (Table 3). The estimates of stock have associated sampling errors related to the size of the sample and the extent and geographical variability of the feature. The environmental stratification reduces the variability within the sampling strata increasing the efficiency of the survey. Accuracy has been improved by progressively increasing the sample size from 276 in 1976 to 569 in 1998, in Great Britain. The condition of habitats can be described by reference to the component vegetation types and botanical composition of the vegetation plots (Bunce *et al.*, 1999*b*).

Changes in stock and condition of habitats are recorded between one survey and the next. Estimated changes in national stock are calculated from the mean changes observed in each land class. The statistical significance and confidence intervals for the change estimates are determined using a boot strapping procedure (Efron and Tibishrani, 1993). Changes in stock include both estimates of net change in the area of habitats and the conversion of one habitat type to another. The results for changes in intensive agriculture habitats 1990 to 1998 are illustrated in Figure 2. In Great Britain, more semi-natural grassland was converted to intensive agriculture than was restored but creation or reversion of woodland and fen, marsh, swamp and bog exceeded intensification. Where habitat types have not changed between surveys, more subtle changes in condition can be assessed with reference to the changing botanical composition of the vegetation plots.

Figure 1. **Distribution of Environmental Zones in (a) England and Wales (EZ1 Westerly Lowlands; EZ2 Easterly Lowlands; EZ3 Uplands) and (b) Scotland (EZ4 Lowlands; EZ5 Marginal uplands and islands; EZ6 Uplands)**

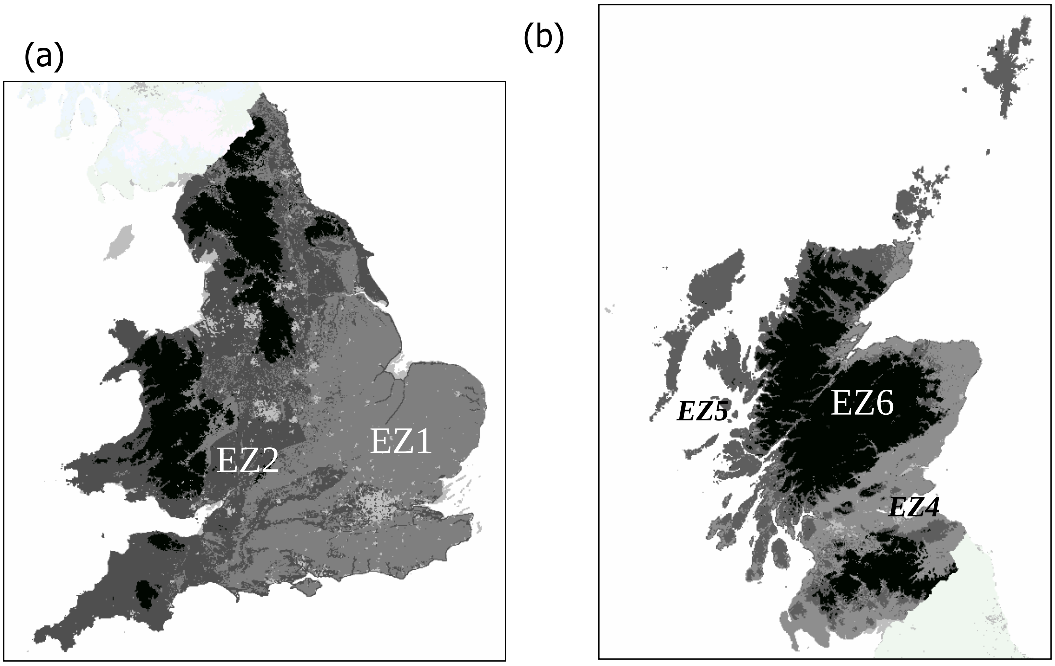
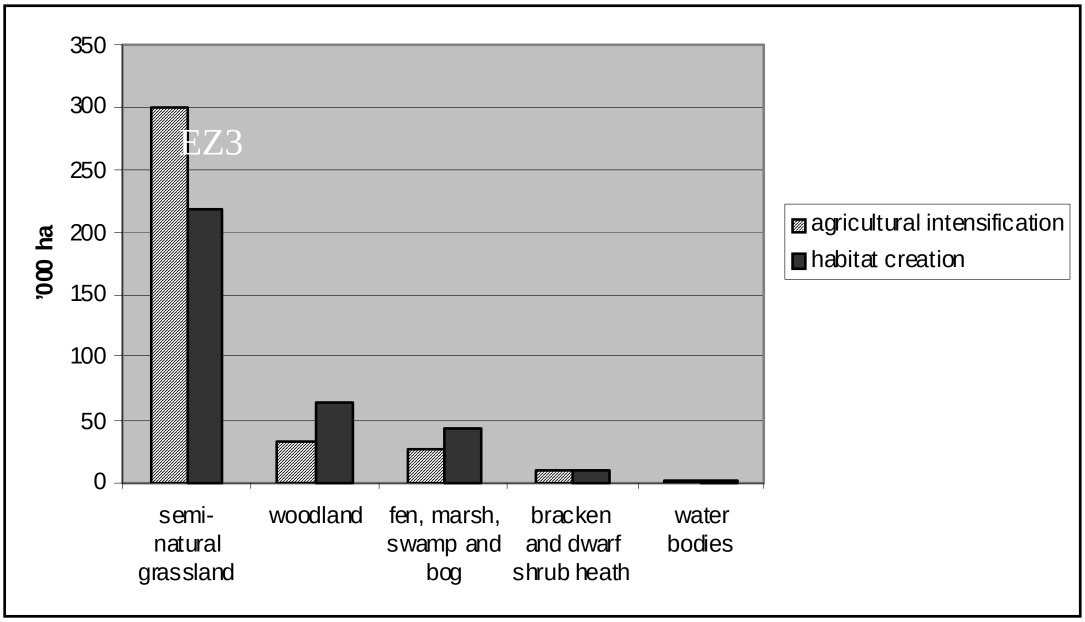


Figure 2. **Gains and losses of intensive agricultural habitats (arable and horticultural and improved grasslands from and to other habitat types in Great Britain, 1990-1998)**



Source: Countryside Survey 2000.

Table 3. **Estimated stock ('000 ha) of broad habitat types in England and Wales, Scotland, Northern Ireland and United Kingdom, 1998**

Broad Habitat Type	*England and Wales*		*Scotland*		Northern Ireland[1]	*UK[1]*
	Stock ('000 ha)	*Standard Error ('000 ha)*	Stock ('000 ha)	*Standard Error ('000 ha)*	Stock ('000 ha)	Stock ('000 ha)
Broadleaved woodland	1 177	*84*	300	*51*	51	1 522
Coniferous woodland	380	*72*	993	*135*	61	1 435
Arable and horticultural	4 609	*205*	639	*98*	59	5 307
Improved grassland	4 431	*187*	1 051	*104*	568	6 050
Neutral grassland	444	*48*	168	*25*	254	867
Calcareous grassland	38	*17*	27	*23*	1	66
Acid grassland	547	*67*	748	*97*	28	1 324
Bracken	273	*49*	166	*28*	4	443
Dwarf shrub heath	485	*78*	1 002	*111*	13	1 500
Fen, marsh and swamp	210	*37*	337	*55*	53	600
Bog	180	*45*	2 038	*168*	148	2 367
Montane	1	*1*	48	*31*	n/a	N/a
Coastal habitats	186	*n/a*	82	*n/a*	3	271
Standing open water	106	*46*	85	*32*	n/a	N/a
Rivers and streams	43	*6*	21	*4*	n/a	64
Inland rock	17	*4*	38	*11*	6	61
Built up areas/gardens	1 180	*111*	151	*28*	n/a	N/a
Linear features	404	*20*	87	*7*	n/a	N/a
Unsurveyed urban land[2]	426	*n/a*	37	*n/a*	n/a	N/a
Unclassified	93	*37*	2	*1*	143	238

1. Separate data are not available (n/a) for some habitat types in Northern Ireland and UK. These are included under 'unclassified'. Standard error estimates are not available for Northern Ireland and UK totals.
2. The Countryside Survey excluded 1 km grid squares with over 75% developed land. This area is included in the table as 'unsurveyed urban land'.
Source: Countryside Survey 2000; Northern Ireland Countryside Survey 2000; see Haines-Young *et al.*, 2000.

Habitat accounts

The pilot habitat account for 1990-98 is constructed from the matrix of change of broad habitats based only on the sample squares surveyed in both 1990 and 1998 in Great Britain. Similar accounts are not yet available for Northern Ireland. The flows between habitat types are summarised into ten main types of change (Table 4). Allocation to the flow categories is determined on the basis of the recorded change in habitats. The processes that are driving the change are inferred and not directly observed. The account includes the opening and closing stock of each habitat over the accounting period, the net change in stock, the amount of the opening stock carried over, the amount of the opening stock lost and the amount of new stock gained (Table 5).

Table 4. **Definition of types of change categories used in the habitat account**

Type of Change	Description of flows from 1990 to 1998
Woodland creation	Change from any non-woodland habitat to either broadleaved or coniferous woodland.
Woodland rotation	Change between broadleaved and coniferous woodland.
Agricultural intensification	Change from any other habitat type to either arable and horticultural or improved grassland habitats.
Agricultural rotation	Change between arable and horticultural and improved grassland habitats.
Habitat creation	Change from any other habitat type any of the semi-natural habitat types (neutral grassland, calcareous grassland, acid grassland, bracken, dwarf shrub heath, fen marsh swamp, bog, montane, coastal).
Habitat rotation	Change between any semi-natural habitat types.
Water body creation	Change from any other habitat type to standing open water.
Development	Change from any other habitat type to either inland rock (includes mineral workings), built up areas and gardens or linear features (includes roads and road verges).
Developed land recycling	Change between inland rock, built up and gardens and linear features
Loss to unknown	Change to an unknown habitat type (usually as a result of access denied to surveyors).

There was relatively little net change in the stock of the intensive agriculture habitats in Great Britain as a whole, with a small shift in balance between improved grasslands and arable and horticultural habitats. However, there were high rates of exchange in both directions between these intensive agriculture habitats and semi-natural habitats, leading to a net loss of around 60 000 ha of semi-natural habitats, apparently due to agricultural intensification. But these gains in intensive agriculture were offset elsewhere by losses from agriculture to woodland and developed land habitats. The flows into and out of intensive agriculture are broken down by the six Environmental Zones in Table 6. This regional analysis shows that there were net gains in intensive agriculture habitats, mostly improved grassland, in the three marginal and upland Zones (EZ3, EZ5 and EZ6). Conversely there were net losses in the two lowland Zones in England and Wales (EZ1 and EZ2) as a result of woodland planting and development. There was little net change in intensive agriculture habitats in the lowlands of Scotland (EZ4). Thus a general patterns emerges for the period 1990-1998 in which the national ‘capital’ of intensive agriculture habitats was maintained by ‘acquisition’ of semi-natural habitats in the marginal uplands and ‘disposal’ to woodland and developed land in the lowlands. Such trading is not apparent from simple national estimates of net change.

Some of the semi-natural habitats experienced proportionately large changes in stock at the national level, with net losses of semi-natural grasslands and net gains in fen, marsh and swamp habitats. The reasons for these changes require further investigation but may include changes in land management and grazing regimes.

Table 5. **Pilot habitat account for Great Britain, 1990-1998**

Broad Habitat Type '000s ha	**1990 Stock**	CHANGES IN STOCK 1990-1998										**1998 Stock**	Reductions	Additions	**Net Change**	Net Change (% of 1990 stock)	Stock carried over (% 1998 stock)
		Woodland creation	Woodland rotation	Agricultural intensification	Agricultural rotation	Semi-natural creation	Semi-natural rotation	Water body creation	Development	Developed land recycling	Loss to unknown						
Broadleaved and mixed woodland	**1371**	132	14	-22		-42		-1	-13		-0	**1439**	78	146	**68**	4.9	90
Coniferous woodland	**1369**	67	-14	-9		-48		-1	-5		0	**1360**	76	67	**-9**	-0.7	95
Woodland sub-total	***2741***	***212***	***0***	***-31***		***-90***		***-1***	***-18***		***-0***	***2799***	***141***	***212***	***70***	***2.1***	***93***
Arable and horticultural	**5246**	-29		59	118	-41		-1	-19		-0	**5333**	91	178	**87**	1.7	98
Improved grassland	**5539**	-34		341	-118	-232		-1	-54		-5	**5436**	444	341	**-103**	-1.9	94
Intensive agriculture sub-total	***10785***	***-63***		***400***	***0***	***-273***		***-2***	***-73***		***-6***	***10768***	***416***	***400***	***-16***	***-0.2***	***96***
Neutral grassland	**570**	-24		-154		239	-18	-1	-33		-0	**578**	230	239	**9**	1.5	59
Calcareous grassland	**81**	-1		-13		4	-4	0	-0		0	**67**	18	4	**-15**	-18.0	95
Acid grassland	**1471**	-24		-134		43	-35	0	-5		-1	**1317**	198	43	**-154**	-10.5	97
Bracken	**457**	-22		-9		20	39	0	-1		0	**485**	31	59	**28**	6.1	88
Dwarf shrub heath and montane	**1539**	-25		-1		13	-41	0	-3		0	**1480**	70	13	**-57**	-3.7	99
Fen, marsh, and swamp	**456**	-6		-25		61	71	-1	-1		-1	**555**	34	132	**99**	21.8	76

Table 5 (continued). **Pilot habitat account for Great Britain, 1990-1998**

Broad Habitat Type	**1990 Stock**	**CHANGES IN STOCK 1990-1998**										**1998 Stock**	Reductions	Additions	**Net Change**	Net Change (% of 1990 stock)	Stock carried over (% 1998 stock)
Bog	**2297**	-18		-1		11	-10	-0	-0		-0	**2279**	29	11	**-19**	-0.9	100
Coastal habitats	**274**	-0		-1		3	-2	-0	0		0	**273**	3	3	**-1**	-0.3	98
Semi-natural sub-total	*7143*	***-120***		*-337*		*394*	***0***	*-2*	*-43*		*-2*	*7033*	*504*	*393*	*-110*	*-1.5*	*94*
Standing open water and canals	**208**	-0		-1		-1		5	-1		0	**210**	3	5	**2**	0.9	98
Rivers and streams	**67**	-0		-0		-1		0	-0		0	**65**	2	0	**-2**	-2.3	100
Water bodies sub-total	*275*	*-0*		*-1*		*-2*		*6*	*-1*		*-0*	*276*	*5*	*6*	***0.***	*0.1*	*98*
Inland rock	**54**	-1		-2		-8		0	13	4	0	**60**	10	17	**7**	12.3	72
Built up areas and gardens	**1231**	-14		-12		-9		-1	100	-2	-1	**1291**	40	100	**61**	4.9	92
Boundary and linear features	**495**	-1		-15		-8		-0	22	-2	-0	**492**	25	22	**-3**	-0.7	96
Developed sub-total	*1779*	***-16***		*-29*		*-25*		*-1*	*136*	***0***	*-1*	*1843*	*72*	*136*	*64*	*3.6*	*93*
Sea	**299**	0		0		-1		0	0		0	**298**	1	0	**-1**	-0.2	100
Unknown	**74**	-0		-2		-2		0	0		9	**79**	4	9	**5**	6.3	89
Unsurveyed urban land	**463**											**463**	0	0	**0**	0.0	100
Total	*23558*	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	*23558*	***0***	***0***	***0***	***0.0***	***100***

Notes: The stock estimates for 1998 in Table 5 differ slightly from those presented in Table 3 because the stock estimates are derived from just the 501 squares surveyed in both 1990 and 1998. '-0' indicates a loss between –0.5 and –0.1.
Source: Countryside Survey 2000.

Table 6. **Breakdown of changes in stock 1990-1998 by Environmental Zone for the intensive agriculture habitat types (arable and horticultural and improved grassland)**

'000 ha	Agricultural Intensification	Woodland Creation	Habitat Creation	Development	*Net Change*
EZ1	69	-27	-73	-29	*-60*
EZ2	132	-20	-105	-36	*-34*
EZ3	87	-6	-36	-4	*41*
EZ4	43	-9	-35	-4	*-5*
EZ5	46	-1	-20	0	*24*
EZ6	0	22	-4	0	*17*
GB Total	***400***	***-63***	***-273***	***-73***	***-16***

Note: See Figure 1 for map of Environmental Zones.

Changes in habitat condition

Habitat accounts, presenting stocks and flows, provide a greatly simplified view of the gradual changes in habitats occurring in Britain. The broad habitat classes, by definition include a wide range of habitat types and conditions within each class. For example, the neutral grassland broad habitat includes both unimproved and semi-improved hay meadows and grazing pastures and unmanaged tall grassland herb vegetation. The flow accounts can only show major changes between habitat classes (those generally associated with changes in land use but also including the cumulative affects of more progressive changes, such as the natural regeneration of woodland). Information on habitat condition is needed to assess the more subtle changes taking place within broad habitat classes and to assess the degree to which gains in habitat in one place can compensate for losses elsewhere. It is likely that newly created parcels of semi-natural habitat will, at least initially, lack the full complement of biodiversity associated with long established parcels. Thus even though the extent of some semi-natural habitats may have been maintained or increased, the condition may have fallen as the newly created habitats fail to match the condition of the habitats lost.

To assist the interpretation of changes in habitat condition the Countryside Survey vegetation plots have been classified using the Countryside Vegetation System. This allocates each plot to one of 100 vegetation classes based solely on their floristic composition. These classes are aggregated into eight major vegetation types for the purpose of reporting (Bunce *et al.*, 1999*a* & 1999*b*).

A number of habitat condition measures have been developed based on the plants observed in vegetation plots. The condition measures include both direct measures of biodiversity, such as mean species richness, and measures of ecological status, such as nutrient levels or acidity (Bunce *et al.*, 1999*b*, Haines-Young *et al.*, 2000). Species richness is a simple indicator of conservation significance, especially useful in intensive agricultural habitats and semi-natural grasslands. However its interpretation is not straightforward because not all species may be regarded as equivalent in terms of value for conservation. The other measures of ecological status help to assess changes in habitat condition and identify the processes of change. Thus, increases in nutrient status, for example, are an indication of eutrophication, probably as a result of increased levels of nutrient inputs in agricultural habitats leading to losses of plants restricted to low nutrient situations and increases in more widespread plants associated with artificially raised nutrient levels.

The changes in habitat condition measures over the period 1990-98 can be summarised for the eight major vegetation types. The condition measure of botanical species richness is included as one the Government's Quality of Life Counts indicators. The results show significant losses in species richness in grassland vegetation types over the period 1990-98 (Figure 3A). Increased diversity in crops and weeds vegetation is observed especially in field boundaries. The condition measure for fertility (Figure 3B) shows significant increases in fertility in semi-natural grassland, moorland and bog vegetation. Increased fertility is an indication of artificial nutrient inputs either as a result of intensive agriculture or atmospheric pollution, or both. Fertility decreased in crops and weed vegetation.

The condition measures can also be broken down by broad habitats and environmental zones. Figure 4A provides an update to the sustainable agriculture indicator (MAFF, 2000) for extent of semi-natural grassland in England and Wales. The indicator shows no significant change in stock of neutral grassland but statistically significant losses of calcareous and acid grassland broad habitats. Figure 3B presents information on changes in condition measures for less intensively managed agricultural grasslands. The condition measures show losses in species richness in semi-improved and neutral grasslands and no change in diversity in acid grasslands. Fertility increased in all three grassland types. Thus, in general terms, whilst the extent of neutral grassland was maintained it became less diverse and more eutrophic, and as acid grassland declined in extent it also became more eutrophic. The results show that it is important to avoid a high level aggregation into a single semi-natural grassland category.

An overall assessment of broad habitats can then be made by considering changes in both stock and condition of the broad habitat. These results are illustrated in Figure 5.

Discussion and conclusions

The accounting framework can offer a useful device for analysing and presenting the complex changes in farmland habitats. The pilot accounts produced in the UK:

- include intensively farmed, semi-natural and uncultivated habitats and the flows between them and to other 'off-farm' habitats;

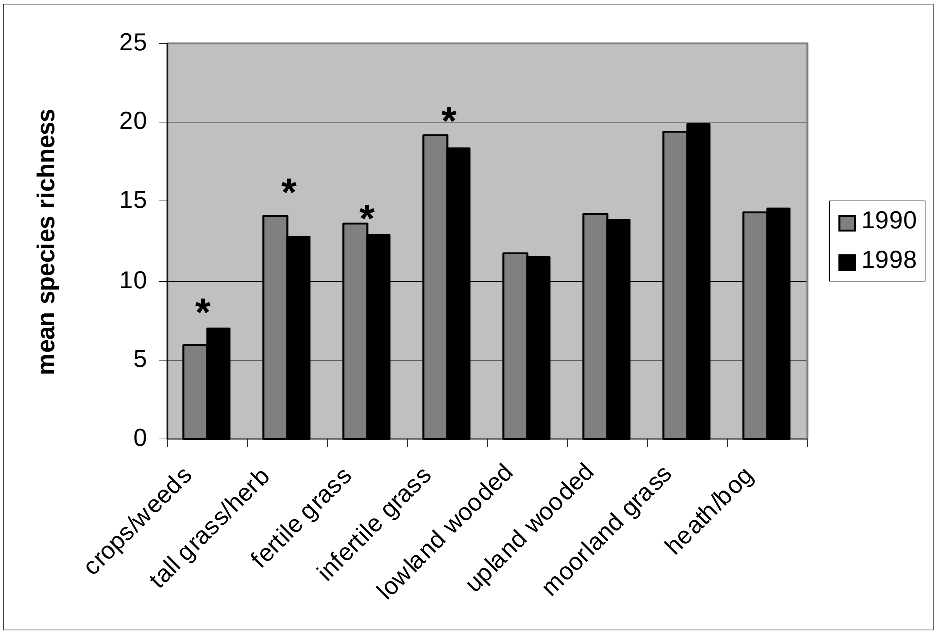
- suggest the underlying driving forces of change and their relative balance in maintaining environmental capital;

- provide an initial view of the turnover of habitats and the extent of compensation or substitution taking place;

- offer an integrated view across major land use sectors of agriculture, forestry and development and a framework for analysing interactions between competing land use objectives; and,

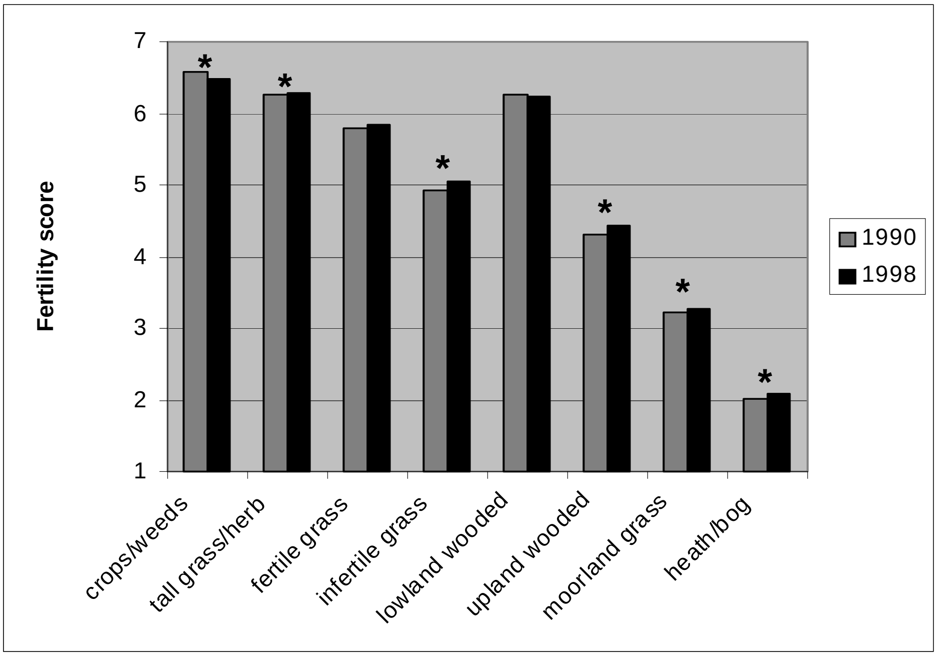
- inform the choice of biodiversity indicators and show they relate to one another.

Figure 3A. **Plant diversity in major vegetation types**



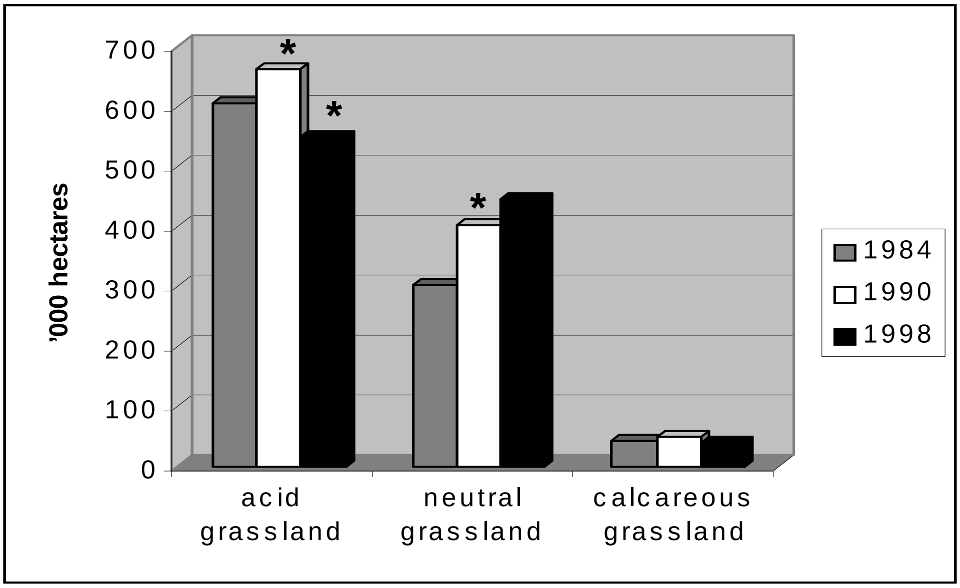
The figure shows mean species richness for eight vegetation types in Great Britain in 1990 and 1998. Significant changes are marked '*'. All vegetation plots sampled in both1990 and 1998 are included in the analysis and they are allocated according to the vegetation type present in 1990.
Source: Countryside Survey 2000.

Figure 3B. **Fertility in major vegetation types**



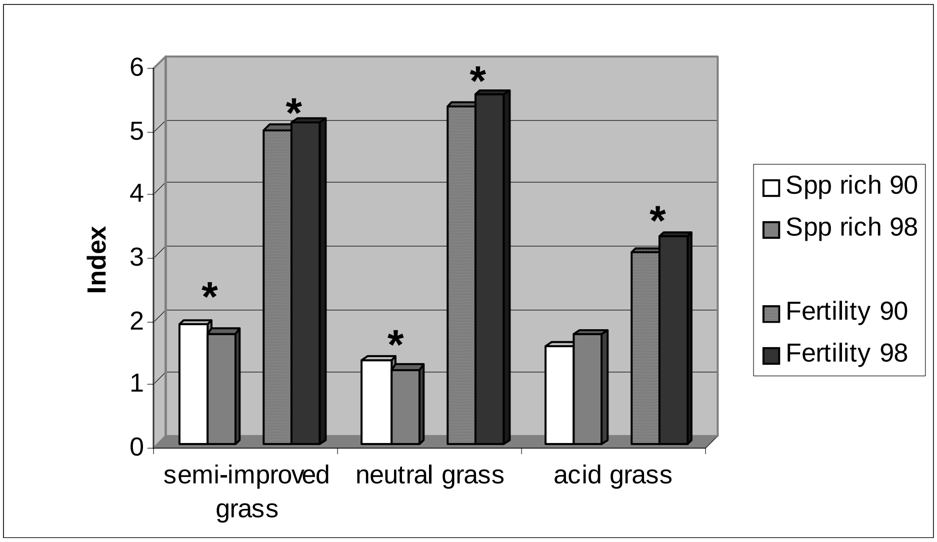
The figure shows mean Ellenberg fertility score for eight vegetation types in Great Britain, 1990-1998. Significant changes are marked '*'. All vegetation plots sampled in both1990 and 1998 are included in the analysis and they are allocated according to the vegetation type present in 1990.
Source: Countryside Survey 2000.

Figure 4A. **Update to sustainable agriculture indicator (34) showing changes in estimated stock of semi-natural grassland in England and Wales in 1984, 1990 and 1998**



Statistically significant changes are marked '*'.
Source: Countryside Survey 2000.

Figure 4B. **Changes in condition measures for three agricultural grassland habitats in England and Wales, 1990-1998**



The index of species richness (Spp rich) is mean species number per plot (divided by 10 for scaling purposes). The index of fertility is the mean Ellenberg Fertility Score. Data are presented for CVS 'infertile grassland' X plots in improved grassland, all Y plots in neutral grassland, and 'moorland grass mosaic' X plots in the acid grassland broad habitat. Analysis included only plots in the same broad habitat type in 1990 and 1998. Statistically significant changes marked '*'.
Source: Countryside Survey 2000.

Figure 5. **Summary of changes in stock and condition of broad habitats as reported in the recent Countryside Surveys of Great Britain and Northern Ireland**

BROAD HABITAT	**STOCK**	**CONDITION**
Broadleaved, mixed and yew woodland	☺	☹
CONIFEROUS WOODLAND	😐	😐
ARABLE AND HORTICULTURAL	😐	☺
Improved grassland	😐	☹
Neutral grassland	☹	☹
Calcareous grassland	☹	**?**
Acid grassland	☹	☹
BRACKEN	😐	**?**
Dwarf shrub heath	😐	☹
Fen marsh swamp	☺	😐
Bog	😐	☹
Montane	😐	**?**
Standing water and canals	☺	**?**
Rivers and streams	😐	☺
Boundary and linear features	☺	☹

Notes:
Assessment of stock refers to net changes in the extent of habitats in the UK, 1990-98. Assessment of condition refers to changes in vegetation composition and biological quality of rivers and streams, in GB, 1990-98. Assessment is made against general UK BAP objectives. (☺ = some favourable trends; 😐 = no significant or consistent change; ☹ = unfavourable trends; **?** = insufficient data).

The results also demonstrate the importance of disaggregation in both ecological and geographical dimensions. There is a clear dilemma between the detailed disaggregation necessary for interpretation and policy development, the production of summary indicators for national and international reporting and the costs of acquiring suitable data. Geographical disaggregation needs to take account of both administrative requirements and underlying environmental variability. The approach adopted in Countryside Survey 2000 to disaggregate between two administrative units, England & Wales and Scotland, and six Environmental Zones was a pragmatic compromise in this instance. Ecological discrimination of habitat types is also necessary to take account of nature conservation objectives and land management options but without becoming over-complicated or too data demanding. Again the broad habitats used in the Countryside Survey were intended to provide this compromise.

However, the accounts which present stocks and flows in terms of area, need to be supplemented by additional information on changes in habitat condition. In the results from Countryside Survey 2000 reported above, condition assessment was based on changes in botanical composition. The space available in this paper only permits presentation of two condition measures — species richness and fertility — but several others relating to plant strategies and benefits for other organisms are available (Haines-Young *et al.*, 2000). The results show that although the stock of habitats may be maintained the condition may deteriorate (or improve) either because of effects of habitat turnover or of more subtle and gradual effects such as land management or climate change. Assessment of habitat condition inevitably links to other biodiversity indicators.

The sampling approach adopted in Countryside Survey is not without its shortcomings and limitations. Whilst its strength lies in the ability to collect data for a national overview of the typical countryside, the downside includes:

- less robust analyses at sub-national resolution;
- national assessment of significance may not reflect local importance — habitat values vary with place;
- limited coverage of rare or localised habitats which make a disproportionate contribution to biodiversity in terms of both biology and human value systems;
- infrequent sampling intervals of 6-8 years;
- complex statistical analyses;
- processes and drivers of change inferred from biological outcomes; and
- inadequate understanding of the ecological processes occurring and the complex interaction of factors causing change.

Further work is required to extend and develop the pilot accounts derived from Countryside Survey 2000. Work in progress and planned includes:

- investigation of the processes of change in the soil-vegetation system and the significance of botanical changes for other elements of biodiversity and biodiversity indicators;
- survey of land managers and advisers to better understand the drivers, individual motivations and policy impacts;

- developing the linkages between national datasets on countryside change and creating an integrated indicator of countryside quality which takes into account local character and priorities; and,

- using the habitat accounts to inform a review of the pilot set of sustainable agriculture indicators.

The above discussion has considered some of the methodological implications of the pilot habitat accounts. From a broader, policy perspective the accounting framework starts to provide an insight into what we actually mean by the environmental dimension of sustainable development or sustainable agriculture. We can ask ourselves what type of changes in the account would be regarded as sustainable and then how those types of change might be achieved. Unlike individual indicators, the accounts can offer a more integrated, cross-sectoral and transparent view of environmental capital.

REFERENCES

Bartelmus, Peter (1998), "The value of nature: valuation and evaluation in environmental accounting." In *Environmental Accounting in Theory and Practice*, K. Uno and P. Bartelmus (eds.), 263-307, Kluwer Academic Publishers, GB.

Bunce, R.G.H., Barr, C.J., Clarke, R.T., Howard, D.C. and Lane, A.M. (1996), *The ITE Land Classification of Great Britain.* Journal of Biogeography 23, 625-634.

Bunce, R.G.H. et el (1999*a*), *Vegetation of the British Countryside — the Countryside Vegetation System*, DETR, London.

Bunce, R.G.H., Smart, S.M., van de Poll, H.M., Watkins, J.W. and Scott, W.A. (1999*b*), *Measuring Change in British Vegetation*, Centre for Ecology and Hydrology, Merlewood, Grange-over-Sands.

Conference of European Statisticians (1995*), Report of UN Commission for Europe Task Force on Land Use Accounting*, UNECE, Geneva.

DETR (Department of Environment Transport and the Regions) (1999), *Quality of Life Counts: indicators for a strategy for sustainable development in the UK — a baseline assessment*, DETR, London.

DETR (Department of Environment Transport and the Regions) (2000), *Our Countryside — The Future: A fair deal for rural England,* DETR, London.

Efron, B. and Tibishrani, R. (1993)*, An Introduction to the Bootstrap,* Chapman and Hall, London.

Haines-Young, Roy *et al.*, (2000), *Accounting for Nature: assessing habitats in the UK countryside,* DETR, London.

Jackson, Deborah (2000), *Guidance on the interpretation of the Biodiversity Broad Habitat Classification (terrestrial and freshwater types),* Joint Nature Conservation Committee Report n0 307, JNCC, Peterborough.

MAFF (Ministry of Agriculture Fisheries and Food) (2000), *Towards Sustainable Agriculture: a pilot set of indicators*, MAFF, London.

OECD (2001). *Environmental Indicators for Agriculture — Volume 3: Methods and Results.* Paris: OECD Publications.

Radermacher, Walter (1998). “Land use accounting — pressure indicators for economic activities”. In *Environmental Accounting in Theory and Practice*, K. Uno and P. Bartelmus (eds.), 229-243, Kluwer Academic Publishers, GB.

Rodwell, John, Ed. (1992), *British plant communities, Vol. 3: grassland and montane vegetation.* CUP, Cambridge.

Stott, Andrew and Haines-Young, Roy (1998), “Linking land cover, intensity of use and botanical diversity in an accounting framework in the UK. In *Environmental Accounting in Theory and Practice,* K. Uno and P. Bartelmus (eds.), 245-260, Kluwer Academic Publishers, GB.

UK Biodiversity Group (UKBG) (2001), *Sustaining the variety of life: 5 years of the UK Biodiversity Action Plan*, DETR, London.

UK Biodiversity Steering Group (1995), *Biodiversity: The UK Steering Group Report. Volumes 1 & 2,* London, HMSO.

AGRI-BIODIVERSITY INDICATORS: THE VIEW FROM UNILEVER SUSTAINABLE AGRICULTURE INITIATIVE

Gail Smith[1], Jamie McMasters[2] and David Pendlington[2]

Introduction

Unilever is one of the largest consumer goods businesses in the world. Our food and home and personal care brands are on sale in over 150 countries, and include Flora/Becel spread, Dove soap, Knorr, Lipton, Magnum, Lux, Omo and Cif.

Agriculture provides more than three-quarters of the raw materials for Unilever's branded products. Our supply chains are therefore challenged by the environmental, social and economic constraints on agriculture, and our markets are continually changing in response to growing consumer concerns about food safety and the environment.

We have therefore undertaken a major project 'the Sustainable Agriculture Initiative' to develop guidelines for sustainable farming practices that will ensure continued access to our key raw materials.

> Message from the chairmen:
>
> One of the challenges in our strategy to build a robust business in the 21st century — called Path to Growth — is to ensure that our actions are compatible with sustainable development.
>
> Finding ways to balance economic, environmental and social challenges is absolutely necessary if we are to follow a sustainable path. If we get this wrong, we will increasingly find ourselves in an unsustainable relationship with society.
>
> **Antony Burgmans and Niall FitzGerald, Chairmen of Unilever.**

As well as guidelines, we are developing a range of indicators to use to monitor progress in our own pilot projects across a range of crops. Some of these indicators are applicable across many crops , but others are inevitably be crop- or region- specific. All our chosen indicators are intended to support at least one of our 'Sustainability Principles'.

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Unilever believes that sustainable agriculture should support the following principles:

- It should produce crops with high yield and nutritional quality to meet existing and future needs, while keeping resource input as low as possible.

- It must ensure that any adverse effects on soil fertility, water and air quality and biodiversity from agricultural activities are minimised and positive contributions are made where possible.

- It should optimise the use of renewable resources while minimising the use of non-renewable resources.

- Sustainable agriculture should enable local communities to protect and enhance their well-being and environments.

In 1998, Unilever established sustainable agriculture pilot projects for five crops that are particularly important to our foods businesses; oil palm, tomatoes, peas, spinach and tea. More pilot projects on these and other crops and farming systems followed later. The indicators we have developed differ significantly from those appropriate to an OECD programme in several important ways;

- The indicators are crop- or farm- based. OECD indicators relate more easily to geographical regions or political units.

- Some of our crops are grown in none-OECD countries (oil palm, tea).

- In some countries, and for some crops, the sophistication and availability of background information from which to develop indicators may be limited (*e.g.* local Biodiversity Action Plans or soil maps may not exist — or the crop may be considered sufficiently 'minor' by National Research Institutes that few data are available on critical pests or diseases).

- Our indicators relate to things **farmers** can actually do (*i.e.* management) rather than the larger-scale consequences of action or inaction.

- In general, we have tried to develop indicators that will respond to management changes in a relatively short time-frame (although we have not always succeeded *e.g.* in areas related to soil composition and functionality).

- The assessment of frog abnormalities is an example of a short term indicator, and

- The assessments of vegetation (native) size, shape and floristic composition are examples of indicators influenced over the longer term.

- Our indicators tend to **avoid** issues related to subsidies (either crop, social- or environmentally- based) and support for farming systems.

Nowhere has the diversity of opinions on the implications of 'sustainability' been as great among pilot project members, partners and other stakeholders as in the area of biodiversity and its relationship with crop production! We agree that biodiversity is important for its intrinsic value, because it is a vital part of the natural capital resource we aim to preserve for future generations and that biodiversity provides important ‘ecosystem services’ — but we are less sure how to ‘value’ biodiversity in terms of indicators. The various pilot projects have developed a wide range of potential indicators at the crop, field or farm scale, and we are still trying to learn from the different approaches that have been used. This paper will attempt to relate the findings from several projects to OECD indicator proposals.

Most of the indicators discussed below appear in our ‘biodiversity’ indicator cluster but others (*e.g.* those related to pesticide use and choice, or pollution or ecosystem services) appear elsewhere, related to soil fertility, soil loss, nutrient management, pest management, water, product value, social and human capital or local economy clusters.

Indicator development

The Australian **tomato** pilot designed a useful process for selection of biodiversity indicators that involved;

- Detailing a exhaustive range of possible fauna and flora indicators
- Evaluating each indicator based on five primary criteria;
    1. Measurable.
    2. Interpretable against a threshold value.
    3. Representative of high quality biodiversity.
    4. Sensitive to environmental change.
    5. Cost effective.
- Developing a revised list of indicators for on farm assessment.

Given the wide array of possible indicators, this approach to indicator selection and review provided an objective process for indicator selection and adoption.

The **oil palm and tea** projects used a rather different approach, perhaps more suitable for crops grown in several countries, in some of which the background information on agro-biodiversity might be limited.

- Identifying the critical biodiversity 'issues' that the indicators should relate to
- Identifying potential indicators to use in relation to each issue
- Gathering data together to
    1. see how the available data related to the proposed indicators across several sites in different parts of the world (*i.e.* was the indicator transferable?)
    2. evaluate the available data against the proposed indicator to determine whether the result was a

– quantitative or semi-quantitative output;

– sensitive to change in management;

– could be used to compare operations and management practices; and was

– not oversensitive to short-term changes (*e.g.* bird migration dates).

1. Genetic diversity

1.1. Genetic diversity - in crop of interest

Oil palm and **tea** pilot projects have developed an indicator for this parameter based on the results of a questionnaire. The long term sustainability of production of these crops was felt to be strongly dependent on the maintenance of a wide genetic base (‘genebanks’) from which future progenies, varieties or clones could be developed. We agreed that larger plantation companies and growers have a responsibility for the maintenance of this resource — either directly or by support of local, national or international research collections. The questionnaire is designed to assess

- whether there are appropriate breeding and selection programmes in place; and
- whether growers have access to the ‘new’ material produced by the breeding programmes.

Although some of our own pilot project companies do have their own genebanks and breeding programmes we clearly do not see this as being mandatory for all growers. What is more important is that the farm should show **support** for germplasm collections (or at least lobby for their establishment if they do not exist). Small-scale growers of perennial crops should reduce their vulnerability by planting more than one — preferably unrelated — clone (or variety) of a tree crop such as tea and should have access to new varieties as they are developed.

By contrast, conservation of genetic resources is considered to be a commercial (plant breeding companies), state or international issue by most farmers and for **most crops**. None of the annual-crop projects has felt the need to develop indicators for this parameter.

For many crops the ownership of genetic resources and germplasm collections is a highly competitive business. Breeding companies often have exclusive collections and do not share these. State and internationally-funded organisations do nevertheless have some germplasm collections — for instance there is a tomato germplasm bank at the University of California at Davis, funded by the University of California. Local tomato growing operations contribute to the maintenance of this resource as part of a relationship in which information and advice are offered in return.

Genetic diversity is therefore clearly an important political issue and one that should be addressed by OECD indicator systems. But we argue that the number of varieties registered or certified for marketing, either in total, divided by area or by crop production may not relate well to the reduced risk (now or in the long-term) that genetic diversity brings. The number of varieties on the market is a reflection of the successes of breeding companies, and not necessarily of the maintenance of a wide genetic base — after all a plant breeder can create thousands of potential new varieties in an afternoon for some crops.

As extreme examples, two varieties of one crop may differ in their genetic base by only a few genes (for instance a change in flower colour); conversely, a polyploid species may have an extremely wide genetic background within a single variety. If a variety has a narrow genetic base (also available in gene banks), and has no obvious merit (profit, quality, taste, disease resistance, ease of growing, etc.), does it matter if it disappears? We therefore believe that indicators related to variety mix should relate to the **genetic diversity of the varieties**.

Public/private conservation of genetic diversity will vary for different crops, but it may be sufficient to view the sum total for another indicator related to the **safeguarding of genetic diversity**.

1.2. Genetic diversity — related to impact of farming on native ecosystems

This is an important issue, *e.g.* in Australia, where the diversity of seed stocks of native species is declining. However, addressing the issue directly is beyond the scope and budget of all our pilot projects.

2. Species diversity

2.1. Species diversity - Plants and animals using the crop or farm as habitat

At least three of our projects, the **peas** project begun in 1998 and a more recent projects looking at **tomatoes** in Australia and **whole-farm and rotational crop systems** (based in the UK) are basing their work on

- detailed census systems (animals, birds, insects etc.);
- habitat assessments; and
- relating crop and farm features to seasonal and locational differences in wildlife that uses the crop or farm as habitat.

This work has been superbly supported by a wide range of volunteer and commercial partners with biodiversity census expertise — the British Trust for Ornithology, the Wildlife Trusts, Centre for Ecology and Hydrology , Farming and Wildlife Advisory Group and University of Essex (micro biological diversity) in the UK and via. ‘Outsourced Environmental’ in Australia.

Baseline biodiversity assessments are an excellent starting point for the ‘journey’ towards farm management plans incorporating environmental enhancements. Such biodiversity assessment systems will also satisfy the requirements of a wide range of stakeholders and researchers who wish to understand the relationships between species and their habitat requirements.

Interestingly, neither of the UK-based projects has felt the need to incorporate the priorities defined by UK local government ‘Biodiversity Action Plans’ (BAP) into their own action plans. (Around 160 Local Government Action Plans are in preparation or being implemented across Great Britain. Each Action Plan works on the basis of partnership to identify local priorities and to determine the contribution they can make to the delivery of the national Species and Habitat Action Plan targets. The Bedfordshire and Luton area (within which the Colworth Farm project lies) has just published a BAP for “Arable and horticulture ecosystems”). Part of the reason for this is that the on-site assessments and management plans for the Pilot Projects go way beyond those envisaged in a BAP, and a BAP may lack practical guidelines that enable farmers to develop suitable management plans. However, in the UK projects, many of the same stakeholders, partners and specialists are the same as those consulted by the local authority in developing the BAP and it seems likely that similar management priorities will emerge. For instance, some of the biodiversity baseline assessments in the UK have been directly related to farmland species *e.g.* skylarks *(Alauda arvensis)*, yellowhammers *(Emberiza citrinella)* arable weeds or butterflies that are in decline, a decline thought to be directly related to modern conventional farming practices; in Australia, the pilot project is working with local authorities (Government Agencies, Catchment Management Groups etc.) to identify vulnerable and endangered species on a local and regional scale and where possible linking these into on farm biodiversity management plans.

The local government/catchment management goal of 'no net loss' of biodiversity has proved to be an important conceptual framework from which to develop indicators for the Australian **tomato** project.

Indicators

Once census data has been collected for our pilot projects, indicators will be developed based on changes in species, numbers or habitats present. It will obviously be impractical and prohibitively expensive to perform detailed surveys similar to our pilot project baseline surveys in every year and on every site. We will be talking to partners and stakeholders to help identify the 'key' species or habitats that need to be monitored over the years to develop appropriate indicators. The peas project is evaluating the numbers of plant, butterfly and bird species/ha as useful indicators, as well as 7 'key' bird species. The UK-based projects see certain bird species as potentially-useful indicators — also identified by the BTO (British Trust for Ornithology), RSPB (Royal Society for the Protection of Birds) and UK Government as indicators of 'quality of life'. However, thinking in the Australian project is that fauna indicators will be over-affected by factors such as migration, climatic issues and connectivity within the whole region — over which the farmer or local land holder has little control — and that such indicators are therefore unlikely to be useful.

We are in agreement that our indicators should be related as closely as possible to practical measures that farmers can take. Farmers clearly have more control over habitat than over the presence or absence of particular species. There is a general feeling within the pilot projects that habitat-based indicators are going to be much more useful for our purposes than species-based indicators.

2.2. Species diversity — Enhancing the farm environment for biodiversity

Where existing knowledge or research can make the link between individual species and their habitat requirements, indicators can be developed based on enhancing the farm environment for that species. The **peas** pilot project, for example, has been able to link pea management systems to skylark breeding and foraging requirements, and has developed an indicator based on 'skylark selection value'.

The **farm** project has really brought home to us the low biodiversity value of conventional short-term set-aside in the UK. Enhancement of field margins, either specifically for game birds (Game Conservancy Trust, UK) or as wild flower meadows with high value for butterflies and bees (300 %+ increases *The Manor Farm Project —Farmed Environment Company*, Yorks, UK) as well as being aesthetically pleasing (Figure 1) — can result in significant improvements in the biodiversity value of farmland. Many of declining farmland species within the EU were historically associated with low-intensity grazing meadows and haymaking practices, and 'wild flower' field margin mimics many of the characteristics of grassland managed in these 'traditional' ways. Current CAP set-aside systems do nothing to encourage the development of this type of margin enhancement on set-aside.

Our **tea** pilot project sites in both Kenya and S. India have also committed themselves to large programmes designed to enhance the biodiversity of the farm environment by planting native tree species, mainly in field margins or along riparian strips or in specific 'arboreta'. Native tree planting programmes are also important considerations for developing 'Biodiversity Enhancement Plans' for **tomato**-growing farms in Australia.

In our farm project in the UK, we are measuring the agro-ecological benefit of flower margins and beneficial insect attractants (Semio-chemicals) placed within field margins (3D Farming DEFRA LINK project) for renewable crop protection systems or IPM. We are also attempting to green to the 'middle of the field'. In our UK farm project we already have one years data on the impact of non-use of pesticides and its effect on flora/birds and crop yield and quality (Wildlife Trusts, BTO Colworth project work 2001, unpublished). The initial impressions are encouraging *i.e.* less inputs results in more diversity.

Indicators for environmental enhancement that we do develop are likely to be in two main areas:

- related to enhancements made for individual endangered, threatened or vulnerable species where these have been identified, and the link has been made between the species and critical aspects of habitat (*e.g.* nesting sites, foraging sites) or timing of farm operations, and

- more general enhancements to encourage a wider diversity of wildlife (*e.g.* nesting or roosting sites, wildflower areas or native tree planting schemes).

2.3. Species diversity Ecosystem services provided by biodiversity

The ecosystem services we feel to be most relevant to our projects are

- soil fertility maintenance and enhancement by micro-organisms and micro-fauna;

- soil and water micro-organisms that detoxify waste, pollution and runoff;

- soil micro-organisms and plants affecting nutrient supply and availability — nitrification, denitrification, phosphate availability (mycorrhyzae and acidic root exhudates);

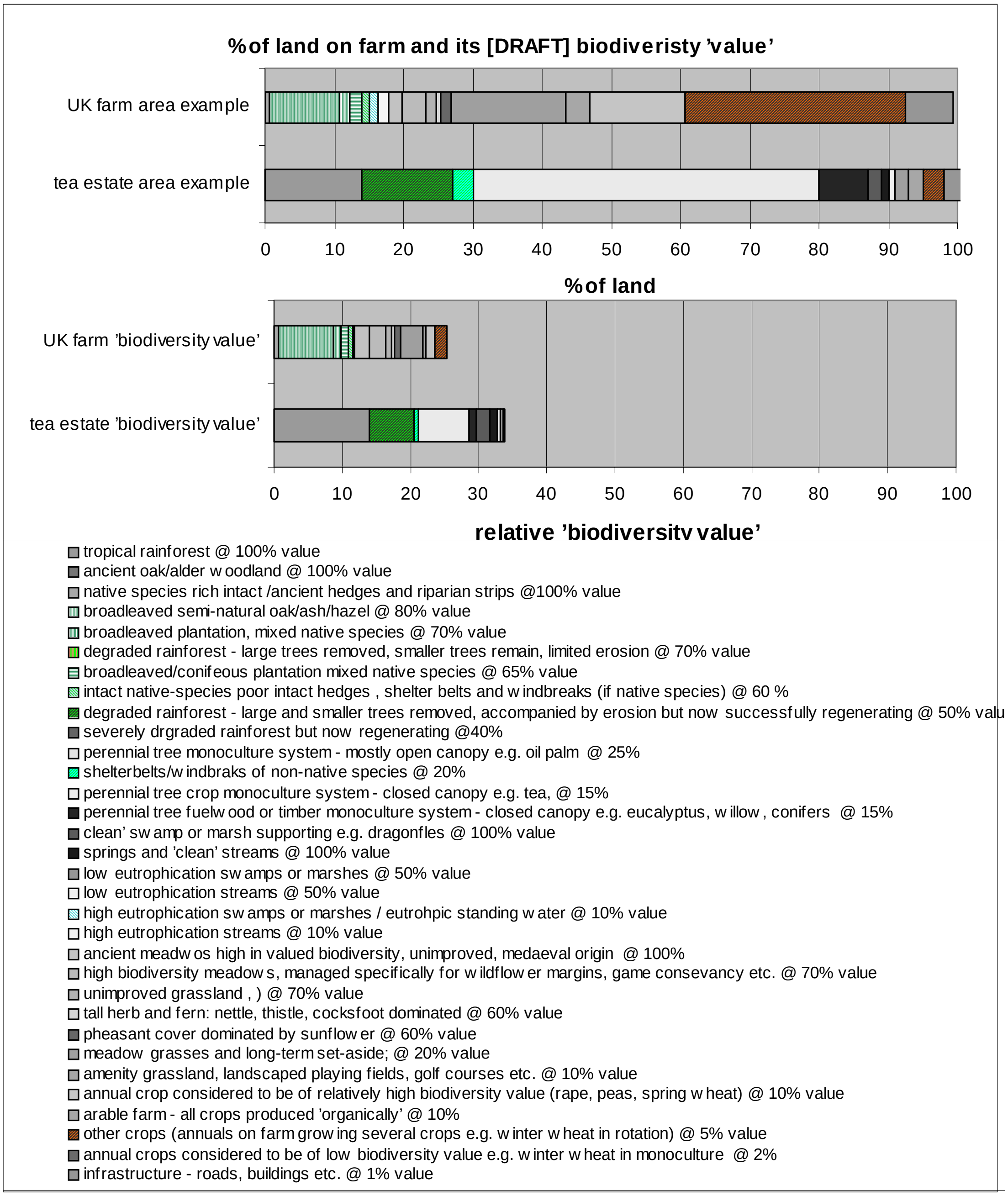
- soil saprophytic micro-organisms reducing the pathogenic potential of any soil pathogens present;

- predatory mites, insects etc. that reduce pest and disease organism numbers;

- insectivorous birds and mammals that feed on pests;

- seed-eating birds and mammals that eat weed seed (and may also damage crop);

Figure 1. **Example of a potential 'biodiversity value' indicator**



- trees as pumps for water to help lower water tables (important for **tomato**-growing in Australia and possibly in **tea**-growing in Assam — although tea is itself a tee, tea rooting systems do not survive well in water that is waterlogged);

- Riparian strips of mixed vegetation, including tree species, that protect watercourses from agricultural runoff;

- Trees as windbreaks, shelter or shade for workers (**tea** in India) or farm stock;

- Nitrogen fixation by shade trees (**tea** in Assam);
- Carbon fixation and storage.

Indicators — some projects have proposed or developed indicators for one or more of these 'ecosystem services', where there is the scientific knowledge available to relate the biodiversity to the benefit. Other projects have preferred to deal with these issues indirectly, such as by developing a 'questionnaire approach' to the implementation of Integrated Pest Management principles (including an understanding of the role of predator species in pest population management).

Unilever is also working with partners to work towards an **economic evaluation of biodiversity** that could be used as part of Life-Cycle Analysis or as Sustainable Agriculture indicators. A good example of this type of indicator would be 'clean-up costs' for water contaminated with pesticides before it can be used for drinking. This approach is not enthusiastically endorsed by all pilot project members, who point out difficulties in assigning a 'value' to conserving genetic material or the relative benefits of Nitrogen fixation vs. eco-tourism.

2.4. Species diversity- none-native species threatening agro-production or agro-ecosystems

None of our pilot projects have felt the need to develop indicators in this area. However, by carrying out baseline biodiversity surveys, we understand the importance of these non-indigenous species *e.g.* Muntjak deer in the UK — which prevent coppicing and devour bluebells (*Hyacinthoides non-scripta*). Introduced species are clearly an enormous problem in Australia.

3. Ecosystem diversity

Land stewardship issues and habitat have been high on our agenda in many discussions, in particular:

- in terms of landscape mosaics within the farm, habitat diversity and links (riparian strips and wildlife corridors) between habitats; and
- in terms of appropriate use of land;
- in terms of 'functional diversity' of species present or habitats present.

3.1. Ecosystem diversity — landscape structure

We are investigating methodologies to evaluate farm landscape structure in terms of habitat area, isolation and connectivity in several of the pilot projects. Most pilot projects have collected data on land use on the farm, and we now hope to collect data on the nature of connections within the landscape to determine whether this approach (*e.g.* Swetnam, R.D. (1999) yields useful indicators. The nature of the connections will vary with project — they will be hedgerows and stream margins for the UK **farm** project, windbreaks, drainage ditches, roadsides and riparian reserves for **tea** projects.

Indicators are currently related to the proportion of available land used for different purposes (*e.g.* % of natural forest on Australian **tomato** farms, % of land in forest reserves on **tea** estates). Indicator Performance Thresholds may then be related to catchment management or state level targets where these are available.

Such indicators are relevant to the OECD 'Wildlife habitats' indicators 'changes in area of semi-natural habitats on agricultural land'.

An understanding of the implications of such targets for local farmers, such as is developing within our pilot projects (for instance, developing agronomic 'best practices'), may also be useful to the local government in developing and refining targets.

Where such targets do not exist — or maybe even when they do exist, to provide a common baseline for comparisons — a baseline may be set in terms of biodiversity 'value', where '100%' represents natural vegetation and unpolluted watercourses and habitats that have priority in local, national or international conservation plans (such as extensive grazing land or habitats necessary for the survival of endangered species) (see Figure 2). Alternatively, the 'V' index methodology developed by ICRAF as part of the 'Alternatives to Slash and Burn' programme may be particularly useful for tropical crops. The 'V' index can be used at any scale and may therefore be particularly useful for assessing the same crop grown in large plantations, small farms or agroforestry.

In future, some projects may also develop indicators based on landscape interconnectivity (wildlife corridors, links between important habitats etc.) or the size/shape of landscape features related to edge-effects. However, there is also a feeling that 'connectivity' and 'habitat features' are too difficult to work with because of difficulties in determining threshold values for them and their lack of sensitivity to farm management practices. For these reasons they were eliminated from the tomato project assessment process.

3.2. Ecosystem diversity — appropriate use of land

For all farming systems it is important that crops are planted on appropriate soils and slopes and in a suitable climatic area. This basic tenet is profoundly disturbed when subsidy systems (mainly in OECD countries), traditional farming systems developed in times of lower population density or different climatic conditions, or increasing wealth or poverty of populations intervene. Conventional [traditional] farming methods may then be used inappropriately on land outside 'sustainable' growing zones, or intensification may burden the agri-ecosystem beyond its intrinsic ability to self-renew. Good examples of this are found throughout the world where livestock overstocking has resulted in serious land degradation.

The first fundamental requirement for assessing appropriate use of land for our projects is to try to determine the parts of the farm where growth of the crop of interest is uneconomic, and to use the land in these areas for other purposes. The reasons for the failure of any field or part of a field to provide an economic return are varied — drainage, accessibility difficulties, expensive location to irrigate, shading, pest problems, continued vandalism etc. In some cases (*e.g.* **farm** project) this will be done using GPS monitoring systems on harvesting machinery. In other cases, other harvesting records or visual clues may be used.

We argue that just taking land out of production of one crop should be beneficial to biodiversity because the land will then be available to plant with something else (increasing functional diversity) or left as set-aside or other semi-natural habitat (that will have the *potential* for biodiversity-related enhancements, see above).

Ideally, of course, such land should not have been planted to the crop in the first place. Programmes such as in the **palm oil** pilot, where rainforest has never been removed in areas identified as of high biodiversity value or low economic return (*e.g.* riparian reserves, habitats for particular species or slopes > 20^{o}) have remained unplanted since the plantation was first developed.

Indicators for these issues will therefore be related (most probably using a 'questionnaire approach' to scoring) to:

- impact assessments performed in relation to land conversion to agricultural purposes;

- identification of areas of low economic return or particularly high biodiversity value — and not planting crop inappropriately in such areas;

- appropriate planting of our crops of interest in relation to the whole farm portfolio (crop rotation systems, location, soils, woodland or tree crops on most vulnerable soils and watersheds, agroforestry where appropriate etc.);

- no inappropriate planting of the crops of interest *e.g.* rocky outcrops, fragile soils, frost pockets, thin soils, unimproved hut sites for **tea** in Africa,, areas that are regularly swamped for **peas** in the UK.

These ideas are most closely related to OECD indicator proposals on 'changes in semi-natural habitats on agricultural land' although they obviously relate to land use on a larger scale.

3.3. Ecosystem diversity — functional diversity

Rather than developing species-based inventory approaches to assess diversity, the projects based in tropical areas (where species classification is more complex, expensive and regional are unlikely to be already available) will probably be evaluating biodiversity within habitats on the farm in terms of 'functional diversity' or 'plant functional attributes'. This is a procedure that derives plant functional types from functional attributes. This approach has worked well for ICRAF in assessing agroforestry systems in Indonesia and W.Africa.

The ***indicator*** we develop for this parameter, 'Functional Diversity Index' will probably use local rainforest (if available) diversity as a baseline. For larger farms, the index should be calculable from the % of land used for each crop or other purpose (see 3.1.), once these land types have been calibrated, although different types of sampling will be appropriate for smallholder and agroforestry growing systems. If this indicator works well, and farmers efforts to conserve and enhance biodiversity can be quantified using this method, it will avoid the never-ending debates on the 'value' assigned to particular land uses as shown in Figure 1. Discussions with stakeholders will be critical to agree 'values' to use for various habitats if this is to become a useful indicator.

4. Other issues and potential indicators

4.1. Externalities of farm activities. Farm activities that affect off-farm biodiversity

Many of the indicators we have developed for clusters other than 'biodiversity' will impact on off-farm biodiversity. We have identified examples of the main indicators from our draft listings as in Table 1.

Table 1. **Impacts of farm-based activities on on-farm and off-farm biodiversity**

Cluster	*Parameter*	*Impacts on biodiversity*			
		On-farm	*Local*	*National*	*World*
Soil loss	Soil loss /ha	***	**		
Nutrients	N loss to water	**	**	*	
	P loss to water	**	**	*	
Pest management	Pesticide losses to water	**	**	*	
Energy	Total energy use/ha or tonne of product			***	**
	Polluting emissions, Nox, Sox, ozone depleters	*	***	**	*
	Greenhouse gases & carbon credits			*	****
Water	Consequences of extraction and drainage for downstream users	*	***	*	
	BOD/COD in effluent	*	***	*	

We are in the early stages of developing a methodology for combining the data we have on the diversity of land use areas on the farm (see Section 3.1. above) with the above indicators to develop a 'Biodiversity footprint' indicator. One option for this is to use an 'auditable questionnaire' (Table 2) and another to develop a more quantitative approach (Figure 2).

4.2. Land conversion issues

Our remit is to address the issue of 'sustainability' in current crop growing areas.

Our sustainable agriculture projects are **not** designed to evaluate the implications of land conversion from forest, grasslands or wetlands to farmland — the issue addressed in the OECD indicator 'uncultivated natural habitats'. However, Unilever does have views in this area, particularly in relation to rainforest destruction and forest conversion. As a major palm oil buyer, we feel that an industry-led Code of Practice needs to be introduced in the palm oil industry. This should address the issue of rain forest conservation for plantation establishment as well as all other aspects of sustainable plantation management. In order for a Code of Practice to be credible, it is vital that it is supported by the whole palm oil community. We believe that regulations and enforcement, and stricter requirements both from financiers and governments are also essential in helping to curb unwanted rain forest destruction.

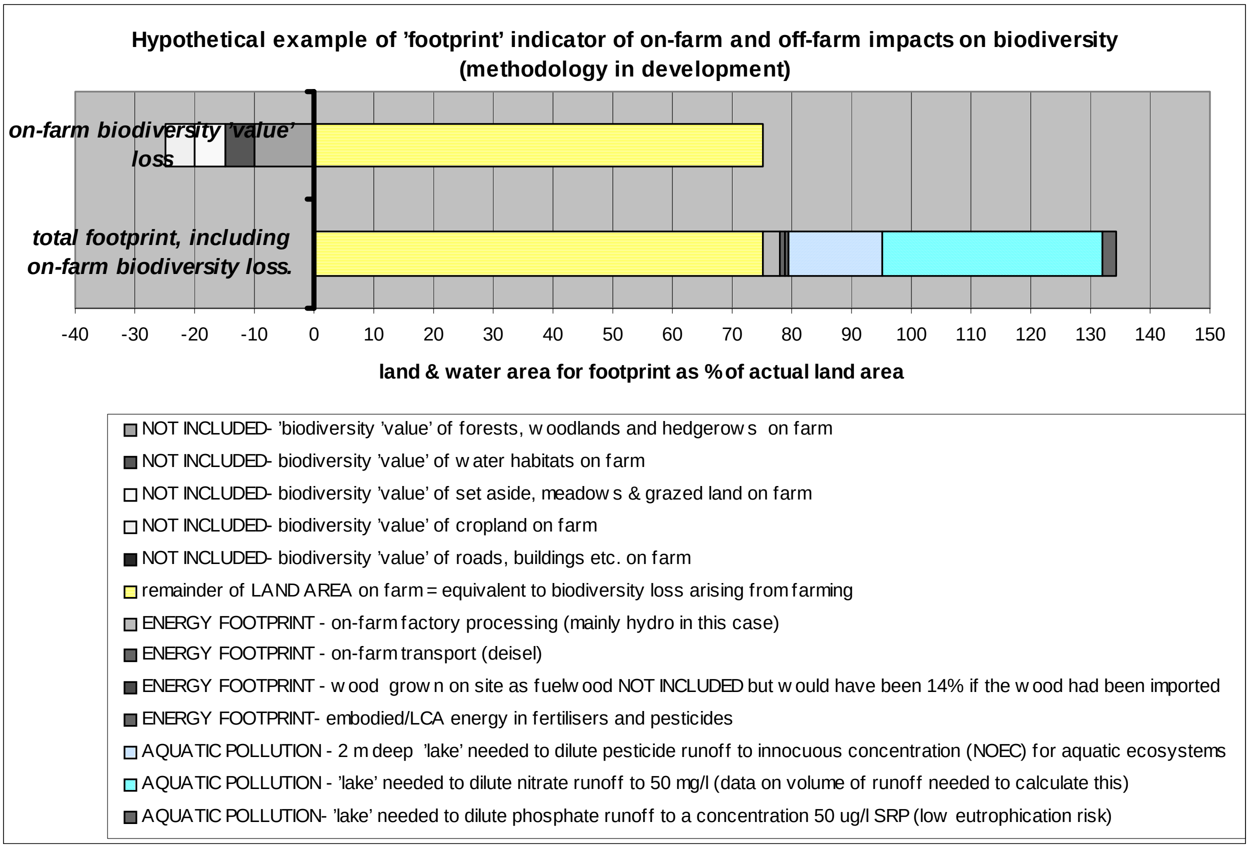
In future, we hope to evaluate the use of our indicators to determine whether they provide useful insights into land conversion from one crop to another (*e.g.* rubber to oil palm), or of varying crop rotations (*e.g.* including peas or oilseed rape in rotations) or of different production systems.

Table 2. **Proposal for 'Biodiversity footprint' indicator based on responses to a questionnaire**

	Question	*Answer*	
1	Has there been a site survey to determine if rare or endangered species (of local, national or international importance) or ecosystems are present on site?	Yes	Score 10. Go to 2.
		Partial	Score 9. Go to 2.
		No	Score 8. Go to 2.
2	Are there action plans being taken to help conserve such species or ecosystems identified (whether or not as a result of a full survey)?	Yes- for all species identified (or no specific species identified)	Keep score. Go to 3.
		Partial	-1. Go to 3
		No	-2. Go to 3
3	Are riparian reserves maintained along major watercourses?	Yes	Go to 4.
		No	-5. Go to 6.
4	Are these wide and deep enough to cover areas vulnerable to floods, to "catch" a high proportion of runoff and so prevent the ingress of soil, silt and pesticides into waterways?	Yes	Go to 5.
		No	-1. Go to 5.
5	Are riparian strips (and wildlife corridors, if present) planted with native species?	Yes- and selection criteria include value for wildlife	+1. Go to 6.
		Yes	Go to 6.
		No	-1
6	Do planting plans and land management plans take into account wildlife protection such as maintaining wildlife corridors, keeping strips of native trees to link riparian strips to pockets of forest, locating villages away from the forest edge (less temptation to use forest for firewood)?	All of these	Go to 7
		Some of these	-1 go to 7
		No	-2 go to 7
7	If BOD/COD is present in effluent (parameter 6.5.[1]), is this discharged into a small or sensitive aquatic life (*e.g.* fish, dragonfly larvae)?	No BOD/COD	Go to 8
		Low BOD/COD discharging into large river.	-1 Go to 8
		High BOD/COD OR discharge into sensitive waterway	-2 Go to 8
		High BOD/COD AND discharge into sensitive waterway.	-2 Go to 8
8	If runoff of P (parameter 3.4. [1]) into streams is ever significant, does the watercourse eventually enter a P-sensitive (eutrophication-sensitive) water body such as a large lake?	No sig. P runoff	Go to 9
		No sensitive water body.	Go to 9
		Sig. Losses into sensitive water body.	-2 Go to 9
9	If runoff of N (parameter 3.3. [1]) into streams is ever significant, does the watercourse enter an N-sensitive (eutrophication-sensitive) water body such as an estuary? Or an N-sensitive (naturally poor in nutrients) ecosystem?	No sig. N runoff	END- record score
		No sensitive water body or ecosystem	END- record score
		Sig. Losses into sensitive area.	-2 END- record

1. Parameter references are to indicators developed in 'clusters' other than 'biodiversity'.

Figure 2. **Example of a potential ‘biodiversity footprint’ indicator, related to externalities of on-farm activities**



Notes:
Discussions with stakeholders will be critical to agree values to use for parameters. In the example below, the ‘biodiversity footprint’ would be around 1.3 times the farm area. The methodology (still in development) relies heavily on WWF/UNEP/Centre for Sustainability Studies methodology (see, for example, Chambers *et al.*, 2000) and the concept of ‘Critical Dilution Volume’ (European Commission, 1995).

4.3. Wildlife as indicators

Biodiversity surveys and evaluations can be used as ‘bio-indicators’ for a number of issues related to agricultural sustainability. The Australian **tomato** project is using developmental abnormalities in local frog populations as an indicator of the externalities of farm management practices. Algal blooms in farm ponds and watercourses are an obvious indicator of inappropriate nutrient or soil management.

Conclusions

Unilever is engaging with a range of internal and external stakeholders to develop indicators that link into the sustainable production of our major raw materials. We have found it particularly difficult to develop indicators for biodiversity and wildlife habitat-related issues, but we feel that we are making significant progress with help from our current partners and in discussions with a range of people and organisations.

Many local and international voluntary governmental and non-governmental organisations (NGOs) have an interest in farming systems and crops from an environmental and social perspective especially regarding habitat and biodiversity impacts. We hope some of these organisations will be willing to engage with us in the various sustainable agriculture projects: their critique and their support are essential to help deliver the changes necessary.

In summary, we are engaging in a great deal of data gathering for some of our pilot projects and are in the process of developing indicators based on these data.

Workers on several pilot projects have concluded that they find habitat-based indicators more useful than species based indicators because habitats are the more stable part of the ecosystem and are the components over which farmers have most control.

In cases where assessments of fauna (especially birds) are likely to become important indicators, there is a real need for a much better understanding of the habitat- and other requirements of the particular indicator species.

The next steps include:

- Further rationalisation of indicators.
- Data collection and evaluation for indicators.
- Development of on farm biodiversity management plans and integration of biodiversity assessment and management strategies into on-farm EMS systems (for crops where Unilever buys direct from growers).
- Incorporation of biodiversity issues into Birds Eye Walls ‘Fieldsmans Handbook’ and agreements with farmers on biodiversity management in relation to the **pea** crop.
- Publishing ‘Good practice guides’ for oil palm and tea that include guidance on management for maintaining and enhancing on-farm biodiversity.

Acknowledgements

Most of the biodiversity baseline survey and evaluation work described superficially in this paper was performed by NGOs or academic partners. Much of this work is still at an early stage or contained within Unilever reports. We apologise of we have misrepresented these findings through misunderstanding and hope that more detailed information will be published in due course by the researchers themselves. Thanks are also due to members of Unilever Sustainable Agriculture pilot projects and consultative groups for comments and data, including Vengeta Rao, Sikke Meerman, Hereward Corley and Jos van Oostrum.

REFERENCES

Chambers, N. and Lewis, K (2001), Ecological Footprint Analysis: Towards a Sustainability Indicator for Business. ACCA Research Report No 65. *Pub*. Certified Accountants Educational Trust, London, UK. 73 pp. <http://www.accaglobal.com/research/summaries/23915>

Chambers, N., Simmons, C. and Wackernagel (2000), *in* Sharing Natures Interest: Ecological Footprints as an Indicator of Sustainability. *Pub* Earthscan Publications Ltd. 185 pp.

European Commission, (1995), Commission decision of 25th July 1995 establishing the ecological criteria for the award of the Community eco-label to laundry detergents (95/365/EC) Official Journal of the European Communities No L 217/14.

Swetnam, R.D. (1999), Integrating extensive and intensive data on relationships between game anagement, landscape structure and biodiversity. Chapter 6, p. 117-147. *In* Firbank, L.G. (ed.) Dowland Game Shooting Study, Centre for Ecology and Hydrology, U.K. Report.

INDICATORS OF AGRI-BIODIVERSITY — AUSTRALIA'S EXPERIENCE

James Walcott, Jean Chesson, and Peter O'Brien[1]

Introduction

Biodiversity is an important issue in Australia. Our National Strategy for Ecologically Sustainable Development (Council of Australian Governments, 1992) lists the protection of biological diversity and the maintenance of essential ecological processes and life-support systems as one of its three overarching objectives. In 1996 this objective was elaborated in the National Strategy for the Conservation of Australia's Biological Diversity (Commonwealth of Australia, 1996). More recently Commonwealth (federal) environmental legislation has been consolidated in the *Environmental Protection and Biodiversity Conservation Act (1999)*. Associated with this emphasis on biodiversity, considerable amount of effort has been devoted to the development of indicators of biodiversity.

We have previously presented to an OECD forum on agriculture/environment indicators details of Australia's efforts to measure progress towards sustainable development using indicators (Delegation of Australia, 1999).

This paper provides an overview of Australia's experience to date with indicators of biodiversity, emphasising those relevant to agricultural systems. It also discusses future directions and their implications for reporting on biodiversity at a national level.

Biological and institutional background

The biota of the Australian continent evolved in isolation from that of the other continents over the last 50 m years. The first significant incursion of exotic species was about 50 000 years ago when humans and the dingo (a wild dog) first came to the continent, but few other species came with them. At this time there was a drying of the climate and an almost total loss of the megafauna from the continent only kangaroos and emus remained. Land use practices of these first humans altered the pattern and distribution of biodiversity over much of the continent over thousands of years.

At the end of the 18th century, a new incursion of humans from Europe began a train of exotic species introductions that continues to this day. Spreading over the continent with sheep and cattle, they indirectly effected considerable change to the biodiversity of the continent. Many endemic mammal and bird species became extinct as a result of habitat loss, competition and predation (State of the Environment Advisory Council, 1996). Some introduced species became feral — pests and weeds — to both agricultural and native systems.

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1. Bureau of Rural Sciences, Agriculture, Fisheries and Forestry – Australia.

Australia is an ancient continent, and its fragile soils have been extensively eroded over time so that much of what remains has low structural stability, fertility and organic matter. Much of the continent is semi-arid, with highly variable rainfall both between and within years, which exaggerates the risks to production and environmental services (State of the Environment Advisory Council, 1996). However, the wide range of climate in Australia, with latitudes ranging from 10 to 43 ^{o}S, permits considerable diversity of agricultural production on Australia's 120 000 farms, which occupy about 60% of the land area.

Most of this agricultural land is used for grazing and pastoralism with sheep and cattle. Only about 6% of the total area of Australia is cropped, and less than 3% in any year. Only 2.1 m ha are irrigated to some extent, about half of which is pastures, and represents less than 0.5% of total agricultural land. Most of the horticultural produce is consumed domestically by Australia's 19 million citizens, but most (60-80%) of the products from broadacre agriculture (grains, meat, wool, sugar, cotton) are exported and now earn Australia about USD 15 billion each year (see www.nlwra.gov.au/atlas).

However, the actions undertaken in agriculture often have impacts on the condition of land, vegetation and water resources. For instance, within the last 200 years, nearly 90% of temperate woodlands and mallee have been cleared, and more than 99% of temperate lowland grasslands in south-eastern Australia have been greatly modified.

Overarching issues between federal and State levels of government are coordinated through high level councils, supported by public service committees. The councils of most interest to this forum (Agriculture and Resource Management Council of Australia and New Zealand — ARMCANZ — and the Australian and New Zealand Environment and Conservation Council — ANZECC) strongly contributed to the National Strategy Ecologically Sustainable Development (ESD) and the National Strategy for the Conservation of Australia's Biodiversity. Later, their standing committees coordinated the development of indicators for sustainable agriculture and for the State of Environment reporting.

Biodiversity Indicators Used in Australia

We describe several recent exercises at a national scale that include development of indicators of biodiversity. We have selected those indicators, relevant to agriculture, that are used for measures of the impact or condition of biodiversity likely to be of most interest to this audience. They include both endemic and exotic organisms at the three levels of gene, species and ecosystem. Further details of the exercises are given in the Appendix.

Indicators of sustainable agriculture (SCARM 1998)

The Standing Committee on Agriculture and Resource Management (SCARM) instigated the development of indicators of sustainable agriculture as a direct result of the 1992 National Strategy for Ecologically Sustainable Development. The first results were presented in SCARM (1998). The indicators, which are part of a larger group, that are particularly relevant to biodiversity are:

Natural resource condition indicator included these attributes or measures;

- Rangeland condition and trend — representing the ability of the landscape (used here as a scale between habitat and catchment) to respond to rainfall, a surrogate for landscape functioning. Below average response is often associated with erosion or weedy shrub development while above average response indicates a productive, resilient landscape that recovers well from grazing.

- Agricultural plant species diversity — provides some estimate of biological resilience for a region over time, by maximising ability to withstand adverse climate and minimise build-up of diseases, weeds and pests. It is less useful to compare between regions. There was no evidence of a decline in this index.

Off-site environmental impacts indicator included these attributes or measures of the impact of agriculture on native vegetation (representing the whole ecosystem);

- Impact of agriculture on native vegetation in conservation reserves. The results ranged from a very low estimated impact in the arid regions to a potentially high impact in the semi-arid tropical and subtropical regions.

- Impact of agriculture on biodiversity of native vegetation. The need for conservation of biodiversity off-reserve appears to be highest in the cropping zone, and the semi-arid tropical/subtropical slopes and plains.

State of Environment reporting

The National Strategy for Ecologically Sustainable called for regular state of the environment (SoE) reporting. Most of the major government jurisdictions, State and Commonwealth, undertake reports on the state of their environment every two to five years. They commonly include biodiversity as a major component with emphasis upon native biodiversity (Saunders *et al.*, 1998), but the development of suitable indicators is a continuing project (ANZECC, 2000).

The 1996 national State of the Environment report (Commonwealth of Australia, 1996) reported on the basis of biogeographical units and included the following aspects of biodiversity:

Gene

- Cryptic species.

- Exotic genes.

- Changes in gene flow vectors.

- Habitat loss.

- Habitat fragmentation.

Species

- Species richness.
- Percentage described.
- Conservation status of species.

Ecosystem

- Representation in protected areas.
- Area of vegetation cleared.
- Percentage of area in intensive production.
- Livestock densities on pastoral land.

The next Commonwealth State of the Environment report, to be released in early 2002, will use a revised set of biogeographical units and a set of indicators that will be continued in subsequent reports. The indicators relevant to measuring changes in biodiversity (but mostly off-farm) are:

- Native vegetation clearing — decreases the total area of habitat available to species.
- Introduced species — contribution to species loss by predation and economic loss to agriculture.
- Species outbreaks — can be a threat to other native species and commercially valuable resources.
- Extinct, endangered and vulnerable species and ecological communities — the best available surrogate for loss of species or a loss of diversity.
- Extent and condition of native vegetation — a surrogate for terrestrial ecosystem diversity.
- Populations of selected species — a surrogate for identifying trends in genetic diversity.

Australia's National Land and Water Resources Audit

The National Land and Water Resources Audit (http://www.nlwra.gov.au) is a four year program to improve decision making on land and water resource management by providing (*inter alia*):

- a clear understanding of the status of, and changes in, the nation's land (including vegetation) and water resources and implications for their sustainable use; and
- a framework for monitoring Australia's land and water resources in an ongoing and structured way.

It has seven themes one of which, Ecosystem Health, includes the project Landscape Health that deals with biodiversity at a systems level. The reporting framework is based on the State of Environment national indicator system with condition and trend attributes. This project reports on condition indicators (described in the Appendix) at Interim Biogeographical Regionalisation of Australia (IBRA 5) subregions (354 in total) that are distinctive landscapes with characteristic patterns of landforms, soils and vegetation.

This project synthesised the indicators into a Landscape stress rating (that accommodates the primary determinants of the remaining native biodiversity in a region). The map for this synthesised Continental landscape stress (Figure 84 in Morgan 2001) and other maps from the Audit will be available at www.nlwra.gov.au/atlas . This study showed the geographic distribution of biodiversity status across the continent, and the scale of the challenges to landscape health. At present, there are severe limitations in terms of the quality of the data. In the absence of appropriate data, surrogates have been used that are not underpinned by a body of clear and irrefutable scientific literature.

A partnership of a dozen agencies will form the Australian Collaborative Rangeland Information System to coordinate rangeland information from a wide range of sources. In particular, as a result of the Audit's work, they are developing a framework for monitoring biodiversity within the rangelands. It will be an operational system using remote sensing and approaches rangelands management from a perspective of how landscapes function, rather than how they are used. Key attributes for monitoring changes in biodiversity include:

- change in composition of perennial plant species and abundance of specified invasive, fire sensitive, threatened and grazing-sensitive species;

- change in the composition of ant communities; and

- change in distribution and abundance of threatened vertebrates (mammals and birds) from repeat surveys of wildlife.

Other themes of the 'Audit', such as Agricultural Productivity and Sustainability and Catchment Condition, contain indicators of relevance (see Appendix).

Montreal process of indicators for forests

Australia, as a member of the Montreal Process, has been developing criteria and indicators to assess sustainable forest management at national and regional levels. We include it here because of potential synergies — and possibilities of harmonisation of indicator systems — particularly concerning remnant vegetation in rural areas.

This sub-national framework takes a pragmatic, phased approach to implementation (MIG Secretariat, 1998). The indicators that are largely implementable now, rather than in the next 5 years, are the only ones that have been seriously addressed so far. They include:

- Extent of area by forest type and tenure.

- Area of forest type by growth stage distribution by tenure.

- List of forest-dwelling species.

- The status (rare threatened vulnerable endangered or extinct) of forest-dwelling species at risk of not maintaining viable breeding populations as determined by legislation or scientific assessment.

As with the other exercises, there are major issues relating to consistency of data, its availability and timely analysis. There are some confidentiality concerns regarding data from private land owners.

Discussion

The indicators described above address a variety of issues, such as on-site and off-site changes to cultivated, feral and native components of biodiversity, with an emphasis on wild biodiversity. The SCARM indicators for sustainable agriculture form the only set that explicitly addresses biological resources needed for agricultural production, although some products of the National Land and Water Resources Audit do address diversity on farms and in cropping systems. The State of the Environment and landscape health indicators in the 'Audit' are quite explicitly concerned about the 'natural' state and do not consider productive condition. The SCARM indicator set is also the only one that explicitly considers the impact of agriculture on biodiversity although some of the general indicators such as native vegetation clearing could be regarded as impacts of agriculture in at least some regions.

Saunders *et al*., (1998) concluded from a review of biodiversity indicators that there is a distinct bias towards species level indicators and a focus on nature conservation. This focus is at the expense of ecosystem processes noted as a major reason for conservation of biodiversity (along with ethical, aesthetic, cultural and economic reasons). A scan through recent issues of the *Australian LANDCARE* magazine, which is supported by the National Heritage Trust partly to distribute information about community Landcare activities, shows that articles about biodiversity conservation on farm are mostly concerned with trees and native pastures.

There is a tendency to regard biodiversity as something that is inherently desirable without describing what is meant by 'biodiversity' in a particular context, the values associated with that aspect of biodiversity and the objective we wish to pursue. We believe that this situation needs to change before biodiversity indicators can play an effective role in the management of agricultural systems and the development of agricultural policy. We discuss this more fully in the next section and provide some suggestions for the way forward.

Future Directions

Definition of biodiversity and agri-biodiversity

Strictly, biodiversity (literally the "variety of all life forms") is a particular property of a collection of biological entities distinct from other properties such as abundance or distribution. From an evolutionary perspective, biodiversity provides the raw material on which a range of pressures act to select the best adaptations to current environments and niches. In agricultural systems, cultivation selects those species and varieties that provide goods and services of importance to human society. These goods and services include nutritious food such as meats, milk, eggs, grains, vegetables and fruit; fibres for clothing and furnishings; and industrial products like oils, leather, starches and building materials. However, there is an emerging recognition that the breeding of these productive species may need to also consider their contribution to ecosystem functions (Williams, 2000). The prevalence of weeds and pests could be a symptom that ecological niches are not being effectively filled by cultivated species and systems.

It is not uncommon for the term 'biodiversity' to be used more broadly to the point where it becomes almost synonymous with 'biological resources' and encompasses issues such as quantity and productivity in addition to the more precise ecological notion of diversity or variety.

Because 'biodiversity' can encompass a variety of issues involving different values and objectives depending on the context, we propose a simple two-way classification in order to define the scope of agri-biodiversity indicators (Table 1). The classification is based on two simple dimensions: the extent to which particular biological resources are needed for agricultural production; and the extent to which agriculture has management capability or responsibility.

Consistent with this workshop's objective of tracking the state and trends in agriculture's impact on biodiversity, we define the scope of agri-biodiversity as biodiversity issues for which agriculture has management capability or responsibility (categories 1 and 2 in Table 1). These categories encompass biodiversity issues on which agriculture has an impact and therefore has the potential to modify the biodiversity outcome. Agri-biodiversity indicators are quantities used to measure that impact and inform subsequent management decisions. Ideally, of course, jurisdictions would specify **objectives** in relation to biodiversity and use indicators as simple measures of **performance**.

Table 1. **A classification system for specifying the scope of agri-biodiversity indicators**

	Biological resources that directly influence agriculture	Biological resources that do not directly influence agriculture
Situations for which agriculture has management capability/responsibility	**1** Livestock, crops, pastures, soil biota On-farm pollinators, biological control agents, pests, diseases, weeds, etc.	**2** Remnants of native biodiversity, endangered species, wildlife corridors, etc.
Situations for which agriculture has no or limited management capability/responsibility	**3** Off-farm pollinators, biological control agents, pests, diseases, weeds, etc	**4** Reserves, national parks, etc.

1, 2	Issues for which indicators of the impact of agriculture are appropriate
3	Issues that affect the ability of agriculture to perform
4	Issues that are not relevant to the topic of agri-biodiversity

Category 1 covers biological resources on which agriculture depends and influences directly through its actions. Agriculture seeks to manipulate these resources to obtain the best outcome. This requires the reduction of some aspects of biodiversity (*e.g.* genetic diversity within a crop or livestock to provide uniform products, elimination of pests and diseases), modification of other aspects (*e.g.* soil biota conducive to legume growth) and enhancement of yet others (*e.g.* insect predators, pollinators). Some of these modifications that are designed to increase production and profits may also increase risks of system failure. Examples include increased susceptibility to pandemics of diseases like the southern leaf blight of corn and stem rust in wheat, and wider impacts such as dryland salinity. On the other hand, increased diversity of biological resources can sometimes provide resilience to agricultural systems in the face of uncertainties and stresses such as those imposed by the weather (SCARM 1993), and 'biological ploughing' with well chosen crop rotations.

Category 2 covers biological resources that are not required by agriculture but are valued by the community at large for a variety of reasons. They include nature conservation which can be expressed in terms of reserve systems, wildlife corridors, habitat for endangered species etc; ecosystem functions for purposes such as water catchment, salinity management etc.; and many other objectives.

The separation of agri-biodiversity issues into these two categories allows the explicit identification of corresponding objectives and the opportunity to explore the impact of various policy instruments. In particular, it facilitates the identification of policies that do not distort production or trade, but focus specifically on biodiversity indicators.

A framework for developing operational objectives

The specification of objectives is a precursor of indicator development. This is particularly true with biodiversity, because the word is used by different people to mean different things and without a clear statement of an objective in each case, the relevance and interpretation of any indicator will be ambiguous.

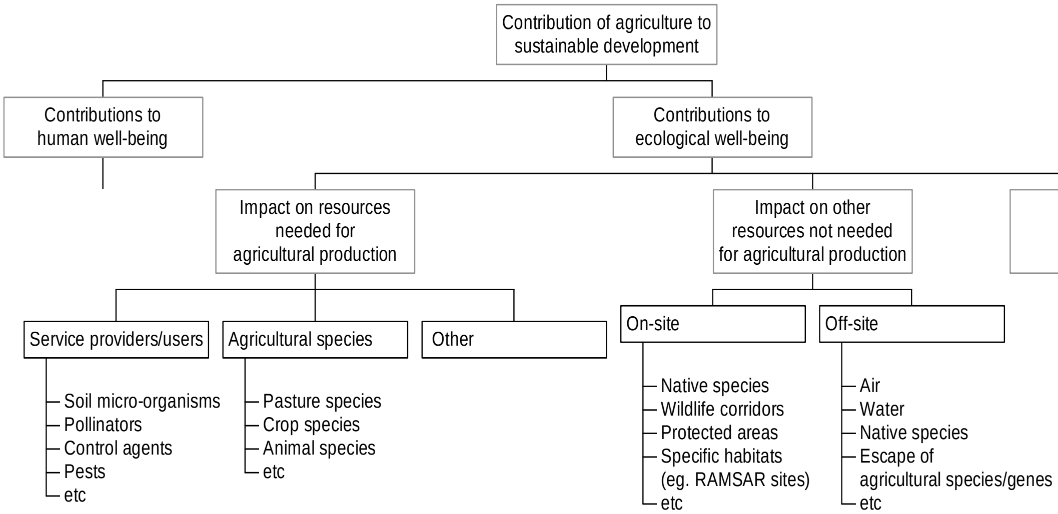
The Bureau of Rural Sciences (BRS) has developed an evaluation framework which facilitates the specification of sustainability objectives and can be applied at any scale (Delegation of Australia, 1999; Chesson and Smith, 2001). The framework is designed to address the question 'How does this entity contribute to sustainable development?' where the entity can be, for example, an individual agricultural enterprise, a catchment, a region or a state.

Contributions to sustainable development are first subdivided into two components: the direct contributions (both positive and negative, short and long term) to human well-being and to ecological well-being (which indirectly affects human well-being). These components are further subdivided in a hierarchical fashion until all relevant issues have been included and a level of specificity has been reached where it is feasible to specify objectives against which performance can be measured. We call these measurable objectives 'operational objectives'.

Ideally, the identification of relevant components and specification of operational objectives is carried out in an open, consultative manner involving all stakeholders. We have found the visual impact of the hierarchical structure extremely useful in encouraging and structuring stakeholder participation in a series of case studies applied to Australian fisheries. Using computer projection equipment, components can be added, deleted, moved and modified on the spot in response to stakeholder input. Component identification is carried out first. Operational objectives, the most controversial part of the process, are tackled only after components have been agreed. Once an operational objective has been specified, the development of an indicator to measure performance is relatively straight forward.

Figure 1 illustrates a hypothetical result of applying the BRS framework to an individual farm. Only those parts of the structure containing components relating to agri-biodiversity are expanded. Following the classification scheme in Table 1, the structure makes a distinction between the impacts of the farm on biological resources needed for agricultural production and the impacts of the farm on biological resources valued for other reasons. Objectives for resources needed for agricultural production should be consistent with obtaining good performance over the long-term. These objectives will not necessarily correspond to maximising biodiversity or mimicking a natural system. Objectives for resources that are not needed for agricultural production are likely to be motivated by objectives set a larger spatial scale by, for example, a catchment management group or a national conservation plan. The BRS framework is equally applicable for specifying objectives at any of these scales. Clearly, objectives at each scale need to be consistent and using a common approach at each scale encourages consistency.

Figure 1. **A hypothetical example of an ESD framework applied to agriculture with components relevant to agri-biodiversity shown in expanded form**



Drivers of the need for agri-biodiversity indicators

Several recent policy developments in Australia are driving the need to specify objectives that only make sense above a certain spatial scale (*e.g.* bioregion, catchment) but require action at a smaller scale (*e.g.* farm) for their implementation. They include:

- The setting of national objectives and targets for biodiversity conservation for 2001-2005 as part of the National Strategy for Biodiversity Conservation. It includes targets for representative samples of each bioregion to be protected in part on private land and levels of grazing pressure by livestock within threatened native grasslands.

- A National Action Plan for Salinity and Water Quality that was endorsed by the Council of Australian Governments in November 2000 (www.affa.gov.au/actionsalinityandwater) to support regional action by communities to control salinity and improve water quality. As part of this plan, and recognising the influence of biodiversity in salinity and water quality and to further implement ESD, national outcomes and targets will be developed for biodiversity conservation by December 2002.

- The Murray-Darling Basin Commission, a consortium of 6 governments to oversee activities that concern cross-border issues in Australia's largest drainage basin, is investigating the setting of targets for biodiversity management within its jurisdiction.

- Work on developing market-based incentives to manage biodiversity, including the use of Environmental Management Systems (EMS) for gaining market acceptance, is in train in several arenas.

Most of these initiatives recognise the central role of local communities within catchments in managing and conserving biodiversity. In some places this is likely to have significant implications for agricultural land use. These initiatives will obviously require the setting of clear objectives with measurable targets, the development of indicators to measure progress, their monitoring and interpretation.

Implications for reporting at a continental level

Dealing with an issue not specifically assigned to Commonwealth responsibility covering a large land area, but with only a medium size economy, means that there are limited resources given to indicators of agri-biodiversity at a continental and national scale. Therefore, to be useful for policy purposes and for decision-making the indicators have to capture the essence of the local variability, but provide a broader summary. In other words the indicators attempt to capture the variety of biota at several scales — of organisation, time and space. In particular, the setting of desirable standards requires greater understanding of the system *i.e.* agriculture's biodiversity needs differ from those of, say, nature conservation.

Biodiversity indicators such as the number of threatened species or the area of natural vegetation will not be sufficient to deal with the very specific management issues that these initiatives are attempting to address. Thus, while these types of indicators will undoubtedly continue to have a role in places such as state of environment reporting, the focus in Australia is likely to be directed more and more towards indicators with direct management implications. We expect to see more indicators expressed in terms of the proportion of catchments meeting their individual biodiversity targets.

There is intuitive appeal in the ecosystem approach of the FAO Committee for Genetic Resources for Food and Agriculture (CGRFA) that recognises the utility of a framework based on appropriate scientific methodologies and focused on biological organization as well as on human interactions. However, implementing this for agri-biodiversity is difficult: much of the changes to the ecology in Australia remain unknown; understanding of the broad-scale processes is at best rudimentary (Morgan, 2001); and there is still much work to be done in constructing models of the roles and functions of biodiversity in agriculture.

The quality of data has a large bearing on the usefulness and credibility of indicators. Promotion of agri-biodiversity as an issue in policy arenas is also dependent upon good data that can be used to demonstrate the costs and benefits of biodiversity to agriculture. There are a range of data sources commonly used in Australia for compiling indicators including: expert opinion and ground-based judgements; small surveys are commonly conducted for unique purposes; large regular surveys conducted usually of farmers; quantitative ground-based monitoring of sentinel sites; and remotely sensed information, commonly the Normalised Difference Vegetation Index (NDVI). Developments in technology may allow fine scale Thematic Mapper (TM) images to differentiate grass from trees to link them to calibrated models to estimate growth and biomass in the field (Hume *et al.*, 2000) and examine impacts of drought and grazing management (McKeon *et al.*, 2000).

Conclusions

Conservation of biodiversity has a high priority in new policy and legislative initiatives in Australia. Understanding the implications of agricultural ecosystems for biodiversity is a significant national activity and there is strong interest in its role in the conservation of representative species and ecosystems outside reserves. Targets for biodiversity are also beginning to be included in contributions to the management of other environmental issues such as salinity. Several trends may thus be converging on the need for indicators of this issue.

Our strongest lesson from using indicators is to set clear objectives first. Once clear objectives have been set, the choice and use of indicators follow logically. In their absence, indicator 'shopping-lists' develop with tenuous relationship to management or decision making. Our sense is that conservation and biodiversity theory and management still have some way to go to be able to devise the best framework for assessing biodiversity, setting objectives and guiding agri-biodiversity indicators. This appears particularly the case for the contribution of biodiversity to delivery of ecosystem services.

There is increasing awareness that the standards of biodiversity for optimum and minimum levels for resilience should be set at local (*e.g.* catchment) spheres of influence. If agri-biodiversity encompasses those biodiversity issues for which agriculture has management capability or responsibility, then agri-biodiversity indicators are quantities used to measure that impact and inform subsequent management decisions. We then expect to see more indicators expressed in terms of the proportion of catchments meeting their individual biodiversity targets.

A recurrent comment from the different developers of indicators is the availability, consistency, currency and quality of data to put into the indicators. Increasingly, remote sensing is being used for monitoring vegetation cover and is developing towards monitoring vegetation classes and even species.

APPENDIX

We describe several recent exercises to develop indicators at a national scale that include biodiversity. Here we note that Australia has 245 major catchments, 10 major climatic regions, 11 major agro-ecological regions, 85 bioregions and 34 landcover types all of which have claims as a reporting unit for some purpose (Hamblin, 1998).

Indicators of sustainable agriculture (SCARM 1998)

1) Rangeland condition and trend

Three methods were employed to assess this attribute: remotely sensed Normalised Difference Vegetation Index (NDVI) data; survey and ground-based judgements; and quantitative ground-based and remotely-sensed monitoring. This indicator is the ability of the landscape (where landscape is a scale larger than habitat but smaller than catchment) to respond to rainfall, where vegetation response is a surrogate for landscape functioning.

2) *Agricultural Plant Species Diversity*

This information is derived from the annual Agricultural Census or Survey, a self-reporting mechanism by agricultural land owners. The attribute is the diversity of plant species used for agricultural production in a region expressed as an index (a modified Two-Way Shannon Index of Diversity) based on the number of species grown, the area of each species, and number of farms growing each species. Provided the set of questions in the Survey remains constant then the index does provide some estimate of biological resilience for a region over time. It is less useful to compare between regions, and because of data limitations is not suitable for sub-regions (confidentiality) nor for rangelands (does not include the constituents of pasture).

3) *Impact of native vegetation in conservation reserves*

Composed of 3 attributes:

- Total length of the boundary between conservation and agricultural areas (km)/total area of conservation reserves (ha). Interpretation poses a problem if some small areas of conservation are added the ratio may increase instead of desired decrease.

- Total area of agricultural land (ha)/total area of conservation reserves (ha) would help overcome the above difficulty.

- Intensity of agricultural production — sown pasture and crops/total agricultural area (%).

4) *Impact on biodiversity of native vegetation*

Composed of 3 attributes:

- Conservation — percentage of original area of each vegetation type now in conservation reserves.

- Disturbance — percentage of original area of each vegetation type occurring on agricultural land that has been disturbed by clearing or grazing.

- Remnant area on agricultural land — percentage of total undisturbed area of each vegetation type that occurs on agricultural land.

This system uses coarse vegetation classification, which may conceal or under-represent some biota; it will not be very responsive to change of policies. Other measures contemplated include land clearing rates and fragmentation of remnant vegetation. These categories have changed from their original proposal, as they were measured and implemented. For instance, indicator (2) was initially proposed as a measure of 'biological resilience', but other measures have since been added such as 'enterprise diversity' and 'rangeland condition'.

State of Environment reporting

Commonwealth SoE 1996

The indicators for condition used in 1996 State of the Environment report (Commonwealth of Australia, 1996) were presented at three levels. At the ecosystem level it was acknowledged that there is no agreed classification system for ecosystems in Australia — Interim Biogeographical Regionalisation for Australia (IBRA 4) of 80 biogeographic regions (Thackway and Cresswell 1995) were used for this report. The report used the representation in protected areas (% area) and threatening processes such as area of vegetation cleared (% area), intensive production (% area), livestock densities on pastoral land (number/ha) as surrogates to report at the ecosystem level. At the species level relevant indicators included estimates of species richness (number/ha), percentage described, and conservation status of species. Gene level indicators included cryptic species, exotic genes and changes in gene flow vectors as well as the threatening process of habitat loss and habitat fragmentation.

Commonwealth SoE 2001

The State of the Environment report for 2001 will report at biogeographical scales of IBRA 5 of about 354 subregions in the 85 bioregions across the continent (Environment Australia 2000). Core indicators, to be used for later reports, for biodiversity (ANZECC 2000) that are relevant to this forum include:

- BD1. Native vegetation clearing. The rate of clearing, in hectares per annum, of terrestrial native vegetation types, by clearing activity. A direct measure of a threatening process. Preliminary assessments note that remote sensing does not yet pick up sparse woodlands and grasslands. The National Vegetation Information System under development may contribute to this.

- BD4. Introduced species. The distribution and abundance of non-indigenous species (plants, vertebrates, invertebrates, and pathogens) identified as pests. The indicator also includes displaced/translocated native species. This is a direct measure of a threatening process. The weeds of national significance is a first start, but some regions are not easy to assess.

- BD5. Species outbreaks. The number and identity of native species outbreaks and the location and area affected. A direct measure. Usually a localised occurrence, and may be combined with BD4.

- BD6. Extinct, endangered and vulnerable species and ecological communities. Number of species and ecological communities presumed extinct, endangered or vulnerable, reported by major group together with the estimated number of endemic species per major group. A surrogate for loss of species.

- BD7. Extent and condition of native vegetation. The vegetation assemblages, by type, to be used as surrogates for ecological communities and ecosystem diversity.

- BD9. Populations of selected species. Estimated populations of selected species, are an important measure for assessing the conservation status of species and surrogates for changes in genetic diversity. Selection of target species a challenge — bird abundance relatively easy, fungi could be useful.

- National Land and Water Resources Audit.

- Landscape health.

- Condition attributes (Morgan, 2001) of interest to this group includes:

- Current extent of native vegetation — a surrogate for ecological disruption.

- Degree of connectivity in native vegetation — where decreasing connectivity (increasing fragmentation) is considered to lead to a general decline in biodiversity, particularly of the less mobile vertebrates with more complex habitat or large home area requirements.

- Protection of native vegetation.

- Conservation reserves — protection and conservation of representative areas of the natural environment is seen as a fundamental part of sustainable land use. Uses the percentage of subregion with protected areas as a surrogate for comprehensive, adequate and representative reserves from the 1999 Collaborative Australian and Protected Area Database. Many of the sub-regions, 173 or 49%, have less than 2% of their area protected and 20% have no protected area.

- Native vegetation outside conservation reserves — an indication of opportunities to increase representation of poorly protected subregions. There are options for significant conservation as 158 of the subregions have more than 70% of remaining vegetation outside conservation reserves.

- Condition of native vegetation — limited data available, so surrogates such as likely intensity of past and present land uses.

    - Impact from total grazing pressures — an indication of 'biophysical naturalness' which also incorporates tenure, rangeland type, and distance to permanent water.

    - Native vegetation in land tenures associated with less intensive land use practices — tenures such as conservation reserves, vacant crown lands, crown reserves, aboriginal reserves, or armed forces reserves.

- Feral plants and animals

    - Distribution and density of non-indigenous plant species (weeds) of national importance.

    - Distribution and density of non-indigenous vertebrate species (feral animals) of national importance.

- At-risk ecological communities and threatened species (those with greater than 70% of original ecosystem cleared and with an original area of less than 10 000 ha).

    – Ecosystems at risk.

    – Threatened species.

Trend attributes were also presented including current rates of clearing of native vegetation (*e.g.* the area of woody native vegetation cleared each year between 1990 and 1995 and change in annual rate of clearing). This report then attempted a synthesis by calculating a Landscape stress rating (remaining biodiversity) using attributes in a hierarchy of priorities going down from (in the case of the more intensive zones):

– current extent of native vegetation;

– connectivity of native vegetation (fragmentation);

– percentage of native vegetation in land tenures associated with conservative land use practices;

– percentage of subregional ecosystems threatened.

Some subsequent modification of the index (up or down) was allowed using the following attributes by:

– percent of native vegetation with high dryland salinity;

– density of weeds;

– density of feral animals;

– number of threatened species.

The map for this synthesised Continental landscape stress (Figure 84 in Morgan, 2001) and other maps from the Audit will be available at http://audit.ea.gov.au/ANRA/atlas_home.html .

Agricultural Productivity and Sustainability

Other indicators from other NLWRA projects of relevance include:

- agricultural plant species index (the same method as used for the SCARM indicators) available at Local Government level, data from Australian Bureau of Statistics (ABS);

- diversity on broadacre farms using financial and production data based on enterprises was interpolated from survey data for the continent;

- diversity in broadacre crops using the proportion of total crop area represented by a particular group, such as pulses, oilseeds, cereals. This was calculated at Local Government level from ABS data.

Catchment condition

The project on developing estimates of Catchment Condition is taking an approach of the user being able to define combinations of attributes, including a layer for biota condition. A working demonstration of the method is given at the website http://www.brs.gov.au/mapserv/catchment/catchment_map.html . Although these attributes are represented at catchment scale and thus represent both agricultural and non-agricultural land, they may help to provide an overview of some aspects of agri-biodiversity. All the attributes are normalised to a 5 point scale ranging from better to worse. Some relevant attributes include:

- % area of catchment cleared of trees (surrogate for habitat quantity and distribution).

- % area of protected lands (surrogate for habitat protection).

- Remnant tree cover occurring in stands of >50 ha as % of catchment area (surrogate for habitat fragmentation).

- Number of feral animals per unit area (decline of native biodiversity).

- Number of weed species or number of weed species-density combination (decline of native biodiversity).

Montreal process of indicators for forests

This sub-national framework (www.affa.gov.au/docs/forestry/sustainability) recognises that it is not possible, practical or cost-effective to fully implement and monitor all identified indicators at this time and provides a phased approach to implementation (MIG Secretariat, 1998). The indicators have been placed into three broad categories following an initial evaluation of Australia's capacity to report on indicators. These are:

- Category A — indicators which are largely implementable now;

- Category B — indicators for which new data needs to be collected or some development work done (3-5 years); and

- Category C — indicators that require longer-term research and development before they can be applied extensively (> 5 years).

The first criterion in the set of indicators is for **Criterion 1: Conservation of biological diversity.** This is considered at 3 levels 1.1 ecosystem diversity; 1.2 species diversity; and 1.3 genetic diversity. The category A indicators are:

- Indicator 1.1a — Extent of area by forest type and tenure. Refinement of protocols for assigning areas to fit IUCN protected area categories and differences between States in tenure arrangements.

- Indicator 1.1b — Area of forest type by growth stage distribution by tenure. Definition of growth stages may need some refinement.

- Indicator 1.2a — A list of forest-dwelling species. Scientific names, taxonomy and standards of description needs some harmonisation

- Indicator 1.2b — The status (rare threatened vulnerable endangered or extinct) of forest-dwelling species at risk of not maintaining viable breeding populations as determined by legislation or scientific assessment. This indicator is slow to react and needs routine updating of species and categories.

The category B indicators are:

- Indicator 1.1e — fragmentation of forest types

The category C indicators are:

- Indicator 1.2c — Population levels of representative species from diverse habitats monitored across their range.

- Indicator 1.3a — Amount of genetic variation within and between populations of representative forest dwelling species.

REFERENCES

ANZECC (Australian and New Zealand Environment and Conservation Council), State of the Environment Reporting Task Force (2000), *Core environmental indicators for reporting on the state of the environment*; Environment Australia; Canberra.

Chesson, J.; and Smith, T. (2001), *Australia — national reporting framework for fisheries — contributing to the study on economic and social sustainability indicators for fisheries*. In A. Cox(coordinator) 88th Session of the Committee for Fisheries: OECD, Directorate for Food, Agriculture and Fisheries, Fisheries Committee.

Commonwealth of Australia (1996), *The National Strategy for the Conservation of Australia's Biological Diversity*, Commonwealth Department of the Environment, Sport and Territories, Canberra: 54 pp. www.erin.gov.au/portfolio/esd/strategy/contents.html.

Council of Australian Governments (1992), *National Strategy for Ecologically Sustainable Development*, Australian Government Publishing Service, Canberra: 128 pp.

Delegation of Australia (1999), *Scope, scale and sector: the Australian experience with indicators of sustainable development*. Towards Sustainable Development: indicators to measure progress. OECD Conference hosted by the Italian Authorities. Session II.E. Agriculture/environment indicators Rome, OECD.

Environment Australia (2000), *Revision of the interim biogeographic regionalisations of Australia (IBRA) and development of Version 5, Summary Report*, Environment Australia, Canberra.

Gunderson, L.H. (2000), Ecological resilience — in theory and application. *Annual Review of Ecology and Systematics* 31; 425-39.

Hamblin, A. (1998), *Environmental indicators for national state of the environment reporting — The Land*, Department of the Environment and Heritage, Canberra. 126 pp.

Hume, I.H.; McVicar, T.R.; and Roderick, M.L. (2000), *Estimating overstory and understory biomass in woodlands*. In McVicar, T. R.(ed.) Proceedings of the Landsat EnvSat workshop: 10th Australasian Remote Sensing Photogrammetry Conference Adelaide, CSIRO Land and Water; pp. 15-27.

Lambeck, R.J. (1999), *Landscape planning for biodiversity conservation in agricultural regions: a case study from the wheatbelt of Western Australia*, Department of Environment and Heritage, Canberra: 96 pp.

McKeon, G.M.; Hall, W.B.; Carter, J.O.; Day, K.A.; Johnston, P.W.; Paull, C.J.; Stone, G.S.; Crimp, S.J.; Peacock, A.; and Brook, K.D. (2000), *The use of climate-based technologies in the sheep and beef cattle industries of Queensland*. In White, D. H. and Walcott, J. J.(Eds) Emerging technologies in Agriculture: from ideas to adoption. Bureau of Rural Sciences, Canberra: 73-85.

MIG Secretariat (1998), *A framework of regional (sub-national) level criteria and indicators fo sustainable forest management in Australia*, Montreal Implementation Group, Ministerial Council on Forestry, Fisheries and Aquaculture and Australian and New Zealand Environment and Conservation Council, Canberra.

Morgan, G. (2001), *Landscape health in Australia. A rapid assessment of the relative condition of Australia's bioregions and subregions*, Environment Australia and National Land and Water Resources Audit, Canberra: 109 pp.

Norton, T.; Nix, H.; and Williams, J. (1996), *Risk, uncertainty and cumulative environmental change*. In Norton, T. W., Beer, T., and Dovers, S. R.(Eds.) Risk and Uncertainty in Environmental Management.1995 Australian Academy of Science Fenner Conference on the Environment Australian Academy of Science Fenner Conference on the Environment, Centre for Resource and Environmental Studies, the Australian National University: 33-43.

Saunders, D.; Margules, C.; and Hill, B. (1998), *Environmental indicators for national state of the environment reporting — Biodiversity*, Department of the Environment, Canberra.

SCARM (Standing Committee on Agriculture and Resource Management) (1998), *Sustainable Agriculture: Assessing Australia's recent performance*. A report to SCARM of the National Collaborative Project on Indicators for Sustainable Agriculture, CSIRO Publishing, Collingwood.

Smyth, A.J.; Dumanski, J. (1993), *FESLM: an international framework for evaluating sustainable land management*, Land and Water Development Division, Food and Agriculture Organization of the United Nations, Rome.

State of the Environment Advisory Council (1996), *Australia: State of the Environment 1996*, CSIRO Publishing, Collingwood, Victoria. (http://www.erin.gov.au/soe/soe96/index.html)

Thackway, R.; Cresswell, I.D. (1995), *Interim biogeographical regionalisation for Australia: a framework for establishing the national system of reserves, Version 4.0*, Australian Nature Conservation Agency, Canberra.

Williams, J. (2000), *Potential uses and implications of gene technology for the environment*. In D.H. White and J.J. Walcott (eds). Emerging technologies in Agriculture: from ideas to adoption. Bureau of Rural Sciences, Canberra: p 57.

USING BIOLOGICAL AND LAND USE INFORMATION TO DEVELOP INDICATORS OF HABITAT AVAILABILITY ON FARMLAND

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Introduction

Under the auspices of the OECD Joint Working Party on Agriculture and Environment (JWP), the OECD Secretariat and many Member countries are developing environmental indicators for agriculture (AEIs) to both inform and support the agri-environmental policy process. At a workshop held in September 1998 in York (UK), OECD countries discussed how certain AEIs might be defined and measured (OECD, 1999). Work continues through the JWP to advance the development of AEIs.

One issue for which indicators are required is agriculture's impact on wildlife habitat. This paper describes the approach used by Agriculture and Agri-Food Canada to develop an indicator of ***wildlife habitat on farmland***, as a contribution to the OECD Expert Meeting on Agro-Biodiversity Indicators (Zurich, 5-8 November 2001). The paper draws on the work of Neave Resource Management (1998*a*, 1998*b*, 1998*c*) supported by Agriculture and Agri-Food Canada.

1.0 Agriculture and Agri-Food Canada's Agri-Environmental Indicator Project

Agriculture and Agri-Food Canada initiated work to develop AEIs in 1993. Through a process of scientific and public consultation (see McRae and Lombardi, 1994; McRae, 1995; and Environmental Indicator Working Group, 1994), six clusters of AEIs were identified and have since been developed, as follows:

- Farm management of land, nutrients (fertilizers, manure) and pests.
- Risk of water contamination from nutrients (nitrogen and phosphorous).
- Net emissions of agricultural greenhouse gases.
- Availability of wildlife habitat on farmland.
- Risk of soil degradation from erosion, salinization, compaction and loss of soil carbon.
- Production efficiency (for nitrogen and energy).

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These indicators and their sub-components share a number of features but also differ in several respects.

- They are concerned with environmental conditions and risks ***within*** the Canadian agricultural land base, and not (at this stage) with how agricultural conditions interact with non-agricultural conditions.

- For most, 1981 was chosen as the base year from which change is measured at five-year intervals: 1986, 1991 and 1996 (the most recent year for which national data are available).

- They are spatially disaggregated, from the national level to ecozones, ecoregions, ecodistricts and, at the most detailed level, soil landscape polygons. Spatial disaggregation increases the regional sensitivity of the indicators and allows areas at risk to be identified and mapped. However, some indicators are only available at the national and provincial levels of spatial detail.

- They are sensitive to farm management practices. Many were developed using regionally validated models which use data on management practices and other relevant variables (*e.g.* soil type, weather) as inputs.

- They are expressed in physical units appropriate to the processes of interest (*e.g.* tonnes of greenhouse gas equivalents emitted). No attempt has been made to aggregate the indicators into an index or to express them in equivalent units (such as monetary units).

A report on the findings and results of the Canadian work: *Environmental Sustainability of Canadian Agriculture: Report of the Agri-Environmental Indicator Project* was released in March, 2000 (McRae *et al.*, 2000).

2.0 Indicators of Habitat Availability Result of the York Workshop

Building on a paper prepared by Switzerland, participants at the 1998 York workshop identified three indicators related to wildlife habitat:

a) Intensively farmed agricultural habitats, defined as the share of each crop in the agricultural area;

b) Semi-natural agricultural habitats, broadly defined as farmland areas not subject to intensive farming methods;

c) Uncultivated natural habitats, defined as habitat areas (wetlands, aquatic ecosystems and natural forests) converted (lost) to agriculture.

The habitat matrix, defined as a tool to identify and relate the way in which wild species use different agricultural habitat types was later added to this list, and is now included in the OECD set of wildlife habitat indicators.

Several areas requiring further work to operationalize these indicators were identified:

> "A key prerequisite before measuring these indicators may be the establishment across OECD countries of common definitions of the major habitat types defined here [...] In some cases wildlife habitat indicators overlap and/or could draw on the agricultural land cover and land use indicators [...]" (OECD, 1999).

3.0 Indicators of Habitat Availability: Agriculture and Agri-Food Canada's Approach

The Indicator of Wildlife Habitat on Farmland builds on the York workshop approach by:

a) incorporating the concept of land use or cover as habitat; and

b) recognizing that all farm land has some value as wildlife habitat.

The AAFC approach differs from the York approach in that:

a) it explicitly incorporates information on how various vertebrate species use farmland to meet their habitat needs;

b) the indicator is expressed as the proportion (percentage) of habitat uses supported by an increasing, constant or decreasing land base (and not as areal change in agricultural land use);

c) the analysis is restricted to habitat change occurring within the agricultural land base only (and not with changes between agriculture and other land uses).

The concepts and methods used to develop this indicator are explained in detail in Neave Resource Management (1998*a*; 1998*b*; 1998*c*). What follows is a brief summary.

3.1. Linking agricultural habitat to species uses of habitats

To construct the indicator, it was necessary to identify how different species use various agricultural habitats. To accomplish this, *habitat suitability matrices* were developed individually for the seven main Ecozones in which agriculture is practised in Canada. These matrices identify wildlife species (birds, mammals, amphibians, and reptiles, with invertebrates excluded at this stage) and the specific uses each makes of agricultural land and adjacent habitats. Each "habitat use" was ranked according to how dependent a species is on a certain habitat for this use. *Primary* use means that a species is dependent on, or strongly prefers, a certain type of habitat (equivalent to the concept of *critical habitat*). *Secondary* use means that a species uses a habitat type (*e.g.* to obtain food) but is not totally dependent on that type. Matrices for the seven Ecozones were constructed using information from written sources and from wildlife and agricultural experts. An example matrix is included in Annex 1 for Canada's Prairie Ecozone.

3.2. Calculating the Habitat Availability on Farmland Indicator

Once the matrices were completed, primary and secondary habitat-use entries were separately summed for five main use categories:

- breeding, nesting, and reproduction;
- feeding and foraging;
- cover, resting, roosting, basking, and loafing;
- wintering;
- staging (for birds only).

Each separate use of a habitat type by a species was recorded as one *habitat-use unit* (*i.e.* not the number of species using a habitat type, but the number of individual ways in which a habitat is used, for example, Mallard feeding, Mallard nesting, and Mallard loafing equals three habitat use units).

Habitat-use units were then summed by habitat type for each ecozone. The habitat types correspond to the five main land-use categories defined in the 1996 *Census of Agriculture*, which are:

- **Cropland** (land on which field crops are grown (*e.g.* grains, oilseeds, fruits, nuts, vegetables, tame hay.
- **Summerfallow** (cultivated land not cropped for one growing season but part of the crop rotation)
- **Tame or Seeded Pasture** (land that has been cultivated and seeded, usually to introduced forage species / may be fertilized, irrigated, drained.
- **Natural Land for Pasture** (native pasture land, native hay, grazeable bush)
- **All Other Land** (land under farm buildings, greenhouses, windbreaks, wetlands, woodlots, and idle land).

As an example, Table 1 below provides a summary of combined primary and secondary habitat use of agricultural habitat types by wildlife species in the Prairie Ecozone, and changes in the area of each habitat type between 1981 and 1996.

The habitat use unit data in Table 1 are derived from the habitat suitability matrix developed for the Prairie ecozone and land use data obtained from the Census of Agriculture. The Table clearly shows that the "All Other Agricultural Land" and "Natural Land for Pasture" habitat types support the greatest number of habitat uses and are the most valuable forms of agricultural habitat in this ecozone (which is also the case in other ecozones).

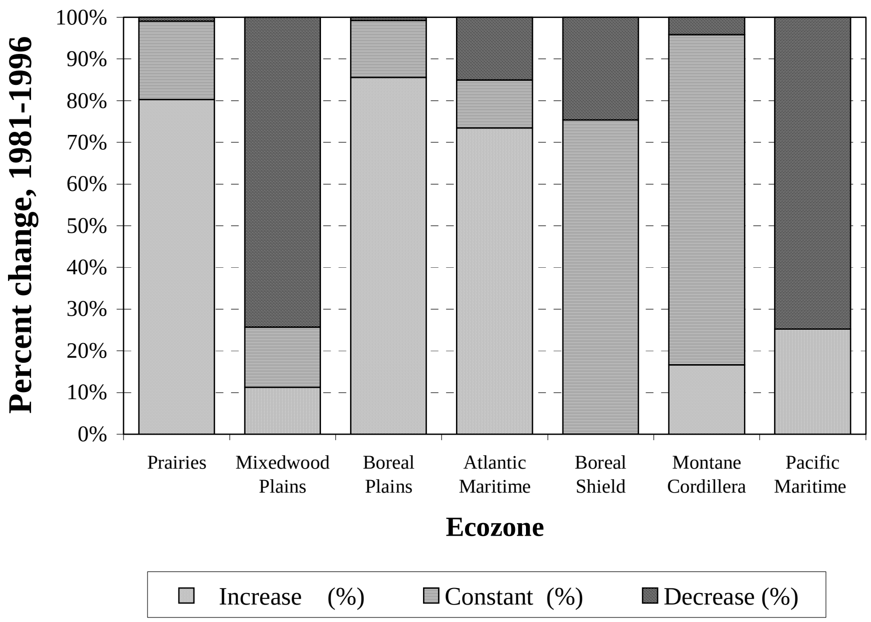
From Table 1, the Availability of Wildlife Habitat on Farmland Indicator can easily be calculated for the Prairie ecozone showing that, between 1981 and 1996, 80% of the habitat uses were supported by an increasing agricultural land base whereas the land base declined or remained constant for 20% of the habitat uses. Overall, the data are interpreted as a positive trend for wildlife habitat in this Ecozone.

Matrices and tables were constructed for each of seven ecozones in which agriculture is practised. The results of the indicator are displayed nationally in Figure 1, which shows trends in the indicator between 1981 and 1996 land use conditions.

Table 1. **Summary of combined primary and secondary use of agricultural habitat types in the Prairie ecozone, and change in area of habitat type, 1981-1996**

Habitat type	*Total habitat use units*	*Habitat type area (million ha)*			*% change from 1981*	*Trend*
		1981	*1991*	*1996*		
Cropland	664	18.76	20.86	21.95	16.9	Increase
Summerfallow	34	8.22	6.99	5.51	- 33.0	Decrease
Tame or seeded pasture	161	1.99	1.98	2.25	13.2	Increase
Natural land for pasture	727	10.79	10.57	10.16	- 3.9	Constant
All other agricultural land	2279	0.81	1.71	1.99	16.1	Increase

Figure 1. **Share of habitat use units for which habitat area increased, decreased, or remained constant between 1981 and 1996**



4.0 Analysis of the Habitat Availability on Farmland Indicator

4.1. Relationship to OECD criteria

The OECD has suggested that to be useful, indicators must be policy relevant, analytically sound, and measurable (OECD, 1997). This section of the paper reviews the AAFC habitat indicator against these criteria.

Policy Relevance

To be relevant to policy, a habitat indicator should (among other things) be able to identify trends in whether habitat is increasing or decreasing over time, identify areas where critical habitats are threatened, and provide a link to the species making use of agricultural habitats. We believe the proposed indicator meets these criteria.

As demonstrated in Figure 1, trends over time are readily calculated using land-use change data. Areas of different habitat types, and changes in those areas, can be mapped thereby allowing policy efforts to target both valuable and/or vulnerable areas. Policy relevance is further enhanced because, through the habitat-species matrices, changes in habitat over time can be directly linked to the species making use of these habitats. In this way, species that may be affected by changes in land use and habitat can be identified, including species at risk.

Analytical Soundness

The robustness of the indicator is a function of the accuracy of the agricultural land use data used in its calculation, and an understanding of how species use agricultural land. The land use data are obtained through Statistics Canada's national Census of Agriculture. This census covers all farms every five years, is spatially detailed, undergoes extensive testing with respondents prior to its distribution to farmers, and is validated prior to publication. The matrices are based on the biological and ecological literature and on interviews and consultations with field biologists and agrologists across Canada.

Because of the link to land use, the indicator can readily be linked to models which forecast agricultural land use trends. Economic valuation of habitat is also possible, at least for those species and habitat types around which economic activity is organized (such as hunting, birdwatching, wildlife viewing etc).

Measurability

The indicator is readily measurable in countries which collect agricultural land use data and for which information exists on how various species use agricultural land to meet their habitat requirements. The habitat-ecozone matrices represented the bulk of the work required to develop this indicator. No new field research was carried out but a considerable effort to obtain and collate this information was required. However, this largely represents a one-time effort (with potential for fine-tuning by experts over time). Mechanisms to collect national agricultural land use statistics every five years are already in place.

4.2. Limitations

Notwithstanding the above points, there are several key limitations to this approach:

a) Because the indicator records only information about the absence or presence of certain habitat uses, it does not reveal much about habitat quality. An effort was made to factor in habitat quality by dividing habitat types (*e.g.* Cropland, Natural Land for Pasture, and All Other Land) into finer categories that may have different value for different species. However, the great variation in quality across the five main habitat types shows the difficulty in using census data for habitat studies. In particular, accuracy and quality would improve if a way of disaggregating the "All Other Land" category, which is very coarse, can be found. For *e.g.* the present analysis may overestimate the value of the All Other Land type because of the inclusion of wetlands and woodlands whereas actual areal extent of wetlands and woodlands cannot presently be obtained from the Census of Agriculture data.

b) Related to this, the indicator does not consider how successful a habitat use is. Success of use is sometimes reflected in the ranking system (*e.g.* for mallard nesting, a primary ranking was used for habitats where nesting success is considered higher and a secondary ranking for habitats with lower nesting success). This information was often available for waterfowl, but rarely for other species. Thus, even if the area of a certain type of wildlife habitat in agricultural settings grows, that habitat may not be of sufficient quality to support wildlife populations that can replace themselves by successful reproduction. In addition the present analysis is constrained because it gives equal weight to a Primary habitat use unit and a Secondary habitat use unit.

c) The indicator does not examine the effects of various agricultural land-management practices. The effects on habitat use of practices such as tillage and weed-control have, however, been studied. Using the broad land-use categories also does not account for biological factors that may limit a species' use of a particular habitat type. For example, a species may not be able to use a habitat type where one need may be met (*e.g.* food) while other needs are not (*e.g.* water, cover); also the habitat may be too fragmented, there may be behavioural barriers to use, or the species may be too widely dispersed.

d) The habitat-species matrices would be enhanced with inclusion of Invertebrate, fish and endemic plant species.

Conclusions

Agricultural policy issues and questions surrounding genetic, species and ecosystem biodiversity have risen in importance in OECD Member countries, many of which have now signed the United Nations Convention on Biological Diversity. The scientific community is being challenged to develop environmental indicators to inform and support the agricultural policy discourse concerned with biodiversity conservation issues.

The development of biodiversity indicators for agriculture poses a particular challenge. Unlike other resource issues for which considerable research has been conducted (such as soil and water quality), the development of biodiversity indicators is hampered by several factors, including the lack of rigorous analytical frameworks and models, incomplete understanding of biological processes in agroecosystems and often sparse biological inventory data. Habitat is one aspect of biodiversity being considered by the JWP, and conceptual work undertaken to date has identified changes in agricultural land use as a proxy indicator of habitat change. However, this approach is limited in that there is no specific linkage made to how various species use agricultural lands to meet their habitat needs.

Recent work in AAFC in concert with Canadian biologists has lead to the construction of an agricultural indicator of habitat, the ***Availability of Wildlife Habitat on Farmland*** indicator. This approach builds on the JWP proposal but includes a new tool — the habitat-species matrix — which allows agricultural land use data to be interpreted more directly from a natural biodiversity perspective.

The approach used for this indicator may be of interest to other OECD countries. It allows changes in area of habitat to be identified and mapped, and identifies wildlife species most likely to benefit from or be adversely affected by the changes observed. The proposed indicator is readily developed from standard agricultural land use data likely available in most Member countries. It is expected that the development of habitat-species matrices will represent the bulk of additional work required to operationalize this indicator elsewhere. There are, however, important limitations to the indicator, some of which can be overcome through further biological inventory work and refined spatial analysis of land cover changes.

ANNEX 1.
AGRICULTURAL HABITAT-SPECIES MATRIX FOR THE PRAIRIE ECOZONE

Matrix Development

Habitat types:

The Census of Agriculture database from Statistics Canada is the key national source of information for documenting areas of different land cover. Habitat types have been assembled around this database. The Census provides information for 5 main land cover types:

a) Cropland: subdivided into crop types.

b) Summerfallow.

c) Tame or Seeded Pasture.

d) Natural Land for Pasture.

e) All other land.

These 5 main types are too general for the needs of this project, so we have subdivided some categories into habitat types, distinguished both by species on the ground and by wildlife managers in the field as follows:

1. Cropland

- any crop whose area is greater than 1% of total farm area for the ecozone will be considered as a separate habitat type
- crops that are less than 1% of total farm area will be grouped into other categories such as:

  – other grains;
  – other oilseeds;
  – other crops;
  – fruits and vegetables.

2. Summerfallow:

3. Tame or Seeded Pasture:

4. Natural Land for Pasture:

- natural land for pasture will be broken into 2 categories:

  A. Natural grassland.
  B. Pasture with shrubs/ woodland. In the Prairie and the Montane Cordillera Ecozones, this category will be sagebrush/ shrubs.

5. All other Land: All other land is defined as a variety of potential habitat types including farm buildings, barnyards, lands, gardens, greenhouses, mushroom houses, idle land, woodlots, sugar bushes, tree windbreaks, bogs, marshes, sloughs, etc. This category will be broken into a number of habitat types in the matrix:

A. Farm houses and outbuildings: this category represents on average 2% of total farmland (farm buildings, barnyards, lanes, gardens, greenhouses, mushroom houses, feedlots).

B. Shelterbelts/ fencerows/ ditches: with distinction between shelterbelts/fencerows/ ditches with and without trees.

C. Wetlands: with distinction between:

   a) riparian areas;
   b) shallow seasonal ponds with extensive margins;
   c) shallow seasonal ponds without extensive margins;
   d) deep permanent ponds with extensive margins;
   e) deep permanent ponds without extensive margins.

D. Woodland: with distinction between:

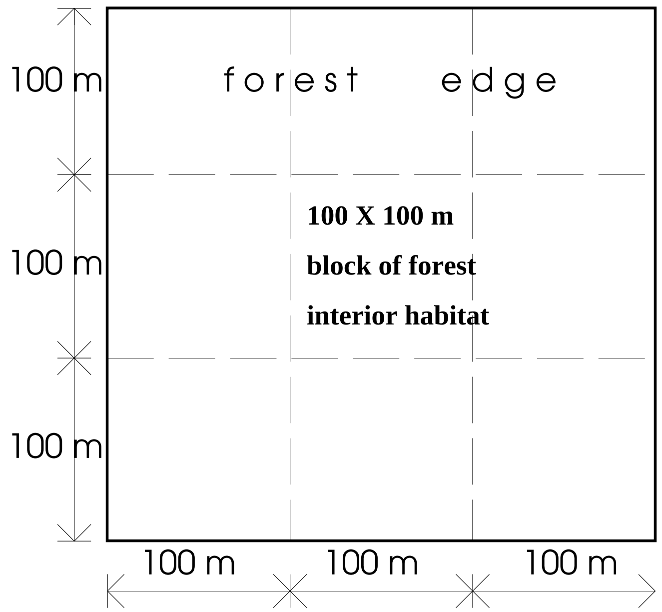
   a) plantations;
   b) woodlot with interior habitat;
   c) woodlot without interior habitat.

Woodland interior habitat is that habitat which falls at least 100 m from the edge of a woodlot. This definition was frequently used by the Ontario Ministry of Natural Resources when discussing forest fragmentation and planning reform. For a forest to have interior habitat, it must be a minimum size (see Figure A1). Based on the 100 m edge definition this translates to approximately 300 m X 300 m (9 ha or 22 acres).

Species

When developing species lists for the matrices for each of the 7 ecozones, the focus was on species that used agricultural land and adjacent habitats to meet one or more specific habitat requirement. For example, the Common Loon was not included in any species list although it is found in every ecozone (except the southern prairies) as its habitat needs did not overlap with the agricultural land base. Similarly the American Pika was not included in the Montane Cordillera Ecozone, as it is only associated with talus slopes and rock debris, not with agricultural land.

Figure A1. **Diagram of interior habitat with a 100 m edge**



Birds: Preliminary species lists were developed for each ecozone using AThe Birds of Canada@ (Godfrey 1966) range maps. These lists were updated with more current reference material such as the Birds of North America journal series and expert opinion.

Mammals: Preliminary species lists were developed from the National Audubon Society=s Field Guide to North American Mammals (Whitaker, 1996) and updated with additional reference material such as the American Society of Mammologist=s Mammalian Species series.

Amphibians and Reptiles: Preliminary species lists were developed from the National Audubon Society=s Field Guide to North American Reptiles and Amphibians (Behler and King, 1996) and updated with additional reference material.

Defining Habitat Uses

Habitat types are used by species for a variety of purposes. The following habitat uses were distinguished for each habitat type (Table A.1):

For birds:	R= use of habitat for breeding/ nesting/ reproduction
	F= use of habitat for feeding/ foraging
	L= use of habitat for roosting/ loafing/ resting
	C= use of habitat for escape/ cover
	W= winter use of habitat
	S= use of habitat for staging
For mammals:	R= reproductive needs
	F=use of habitat for feeding/ foraging
	C= use of habitat escape/ cover
	W= winter use of habitat
For amphibians:	R= reproductive needs
	F= use of habitat for feeding/ foraging
	C= use of habitat for escape/ cover
	W= winter use of habitat
For reptiles:	R= reproductive needs
	F= use of habitat for feeding/ foraging
	L= basking/loafing
	C= use of habitat for escape/ cover
	W= winter use of habitat

Ranking of Habitat Use

In addition to identifying habitat types and uses, it is also important to distinguish the level of use of a habitat by individual species. We used a 5 level ranking system in the matrices defined as follows:

Primary (1): Equivalent to critical habitat, without this habitat the species cannot use the area. Examples of this level of habitat use by species includes: nesting habitat (heron rookeries), deer yards for overwintering and staging areas. Strongly preferred habitats are also identified by this category.

Secondary (2): Often species can use several habitat types for the same purpose. For example, deer can feed in alfalfa, corn, soybeans and pasture and are frequently observed in these habitat types. Deer require some feeding habitat, but not all of these types, the individual type is not critical. Heavily favoured habitat types will still retain the primary rating.

Tertiary (3): This is a level of habitat use where the habitat type is not needed by the species, but it is occasionally observed in the habitat. That is, the habitat type might still be used, but its presence/ absence has no influence on the species being present in an area. For example, the grasshopper sparrow and bobolink occasionally use shelterbelts for nesting. Grasshopper sparrows usually nest in native grassland or pasture, and the presence of shelterbelts in an area has little/ no impact on their populations.

Table A1. **Summary of Primary Use of selected agricultural habitat types by species for the Prairie Ecozone**

Habitat type	Number of habitat use units per habitat type B	F	L	W	S	Total	Area in habitat type 1981	1991	1996	% change Increase* From 1981	Decrease Constant
							Millions of ha				
Cropland											
General Use	3	23	10	7	2	45	**18.8**	**20.9**	**21.9**	**+16.9%**	**Increase**
Spring Wheat	3	13	3	2	5	26					
Durum Wheat	2	14	3	2	5	26					
Oats	2	11	3	2	7	25					
Barley	2	12	3	2	5	24					
Winter Clover / Corn	4	14	4	2	8	32					
Canola	0	3	0	0	0	3					
Other Oilseeds	0	10	1	1	2	14					
Alfalfa	7	20	13	1	2	43					
Tame Hay	10	24	18	2	2	56					
Other Crops	0	4	0	0	0	4					
Fruits and Vegetables	9	12	6	1	0	28					
						(326)					
Summerfallow	0	4	1	1	0	6	**8.22**	**6.99**	**5.51**	**-33%**	**Decrease**
Tame or Seeded Pasture	21	38	26	12	3	100	**1.99**	**1.98**	**2.25**	**+13.2%**	**Increase**
Natural Land for Pasture							**10.79**	**10.57**	**10.16**	**-3.9%****	**Constant**
Natural Grassland	65	86	69	38	3	261					
Shrubs / woodland	71	90	78	39	3	281					
						(542)					
All other land							**.81**	**1.71**	**1.99**	**+16.1%****	**Increase**
Houses / Outbuildings	10	13	12	9	0	44					
Woodland											
Plantation	9	8	8	4	0	29					
Woodlot with interior	98	97	103	46	1	345					
Woodlot without interior	100	101	104	47	1	353					
Shelterberts/Fencerpws											
Treed	45	51	48	12	1	157					
Grass	12	24	22	9	0	67					
Wetlands											
Riparian	75	98	87	33	0	293					
Shallow with margins	61	80	59	16	4	220					
Shallow without margins	15	43	27	4	2	91					
Deep with margins	41	64	46	9	6	156					
Deep without margins	6	28	19	1	5	59					
						(1 814)					
Total						**(2 788)**	**40.57**	**42.11**	**41.86**		

Notes:
Blank: species is typically not found in this habitat.
X: the species actively avoids this habitat.
* Greater than +5% change constitutes an increase, and less than –5% a decrease; from –5 to 5% is defined as constant.
** Percent change is based on 1991 for *Natural Land for Pasture* and *All Other Land* due to the change. in Census definitions associated with these land cover types from 1986-1991.

Table A1 (continued). **Summary of Primary Use of selected agricultural habitat types by species for the Prairie Ecozone**

Habitat type	Arctic Shrew				Masked Shrew				Pygmy Shrew				Northern Shorttailed Shrew				<…>
	r	f	c	w	r	f	c	w	r	f	c	w	r	f	c	w	
Cropland																	Only a small sample is presented here. The same type of information was generated for the whole matrix, which contains all mammals (53sp), birds (189sp) and reptilians (25sp) that are present in the Ecozone.
General Use																	
Spring Wheat																	
Durum Wheat																	
Oats																	
Barley																	
Winter Clover / Corn																	
Canola																	
Other Oilseeds																	
Alfalfa																	
Tame Hay	1	1	1	1	1	2	2						2	2	2		
Other Crops																	<…>
Fruits and Vegetables																	
Summerfallow																	
Tame or Seeded Pasture	*1*	*1*	*1*	*1*	*1*	*2*	*2*						*2*	*2*	*2*	*2*	
Natural Land for Pasture																	
Natural Grassland	1	1	1	1	1	1	1	2	1	1	1	1	2	2	2	2	
Shrubs / woodland					1	1	1	2	1	1	1	1	2	2	2	2	
All other land																	
Houses / Outbuildings																	
Woodland																	
Plantation																	
Woodlot with interior					1	1	1	1	1	1	1	1	1	1	1	1	
Woodlot without interior					1	1	1	1	1	1	1	1	1	1	1	1	
Shelterberts/Fencerpws																	
Treed					1	1	1	1									
Grass					1	1	1	1	1	1	1						

Table A1 (continued). **Summary of Primary Use of selected agricultural habitat types by species for the Prairie Ecozone**

Wetlands																	
Riparian					1	1	1	1	1	1	1	1	1	1	1	1	
Shallow with margins	1	1	1	1	1	1	1		1	1	1	1					
Shallow without margins																	
Deep with margins	1	1	1	1	1	1	1		1	1	1	1					
Deep without margins																	
NOTES	Christian *et al.*, 1997 Whitaker, 1996 VanZyll and DeJong, 1983 Banfield 1974				Kirkland, 1997 Peterson, 1991 Christian *et al.*, 1997 Whitaker, 1996 Yahner 1983 VanZyll and DeJong, 1983 Banfield, 1974				Churchfield, 1997 Whitaker, 1996 Long, 1974 –bog margins and uplands –habitat varies seasonally				Christian *et al*., 1997 Kaufman *et al*., 1990 Yahner, 1983 George and Choate, 1986				

REFERENCES

Environmental Indicator Working Group (1994), “Developing Agri-Environmental Indicators for Canada: General Proposal”. Environment Bureau, Policy Branch, Agriculture and Agri-Food Canada, Ottawa.

McRae, T. and N. Lombardi (1994), “Consultation Workshop on Environmental Indicators for Canadian Agriculture: Final Report.” Environment Bureau, Policy Branch, Agriculture and Agri-Food Canada, Ottawa.

McRae, T. (1995), “Report of the Second National Consultation Workshop on Environmental Indicators for Canadian Agriculture”. Environment Bureau, Policy Branch, Agriculture and Agri-Food Canada, Ottawa.

McRae. T., C. Smith and L. J. Gregorich (eds) (2000), “Environmental Sustainability of Canadian Agriculture — Report of the Agri-Environmental Indicator Project”. Agriculture and Agri-Food Canada. <www.agr.ca/policy/environment>

Neave Resource Management. (1998*a*.), “Agroecosystem Biodiversity Indicator — Habitat Component: Review and Assessment of Concepts and Indicators of Wildlife and Habitat Availability in the Agricultural Landscape — Concept Paper”. Report No. 26, Agri-Environmental Indicator Project, Agriculture and Agri-Food Canada, Regina.

Neave Resource Management (1998*b*), “Habitat and Habitat Availability Indicator: Final Report”. Agriculture and Agri-Food Canada Agri-environmental Indicator Project, Ottawa.

Neave Resource Management (1998*c*), “Habitat Suitability Matrices”. Agriculture and Agri-Food Canada Agri-Environmental Indicator Project, Ottawa.

OECD (1997), *Environmental Indicators for Agriculture*. Paris.

OECD (1999), *Measuring the Environmental Impacts of Agriculture: The York Workshop*. Paris.

ASSESSING BIODIVERSITY IN AGRICULTURAL ECOSYSTEMS

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Introduction

Agricultural lands in the United States are critical for maintaining the biodiversity of native flora and fauna. If one considers all types of agricultural lands, cropland and grazing land, approximately 55% of the contiguous lower 48 states is devoted to agriculture. The impacts that this has on wildlife habitat in the U.S. is exacerbated by the fact that these agriculture lands are the most productive and have the greatest potential for sustaining diverse wild populations. By contrast, only about 5% of the conterminous land area, or about 400,000 km^2 is held in some type of conservation reserve (Scott *et al.*, 2001) and these conservation areas make up only 1% of the most productive soils, and much of the conserved lands are at higher elevations – 45% of conservation land is above 3 075 m (Scott *et al.*, 2001). The consequence of this is that the greatest number of species that are federally listed as endangered in the US, occur on privately held lands (Groves *et al.*, 2000), a significant proportion of which are agricultural.

It is also essential that in viewing the land base dedicated to agriculture that one considers the distribution of these lands across the landscape and within each ecoregion. Because of the extensive land base in the U.S., and the variety of ecoregions that exist in this land base, how the land is converted to agriculture within an ecoregion is important. If an extremely high percentage of a single ecoregion has been converted to agriculture, conserved lands in other regions will do nothing to protect species endemic to those converted areas. One example of this can be seen in western California where much of the coastal grassland habitat (>95%) has been lost to agriculture and urbanization (Veirs and Opler, 1998). Because of the high endemism in this area, this loss of habitat has resulted in over 150 imperiled species, mainly rare plants (Chaplin *et al.*, 2000).

It is safe to assume that agricultural lands are important to sustaining biodiversity, and will become more important as habitat loss continues. Has agriculture already had an effect on biodiversity in the U.S.? Wilcove *et al.* (2000) ascertained that for 1880 endangered or imperiled species for which data could be found, habitat destruction was the leading cause of endangerment in 85% of the cases. The leading type of habitat destruction was agriculture development (38% of species), and the fifth most frequent type of destruction was livestock grazing (22% of species). Combining these two agricultural practices results in a significant amount of the habitat loss affecting biodiversity in the U.S. Improved understanding of what organisms use agricultural lands, and how agricultural practices can change to benefit the native flora and fauna are integral to the conservation of biodiversity.

1. U.S. Geological Survey 12201 Sunrise Valley Dr Reston, VA 20192.

Efforts in the US

In 1996, the Clinton Administration, working through the Office of Science and Technology Policy, requested the development of an environmental report card. This report card would identify a set of scientifically credible indicators to characterize the state of the Nation’s ecosystems. The task was led by the H. John Heinz III Center for Science, Economics and the Environment, a non-profit institution dedicated to improving the scientific and economic foundation for environmental policy. The Heinz Center has engaged the expertise and experience of the U.S. environmental monitoring programs and professionals, from across all sectors of government and industry to develop a suite of indicators that would be nonbiased, and scientifically sound. This State of the Nation’s Ecosystems Report (Heinz, 2001) is still in draft form but provides information useful to the purposes of this conference.

Indicators were selected in ten categories for the Nation as a whole, and for six specific types of systems (Table 1). The draft indicators selected when taken together, are intended to provide a reading of the state of the U.S. environment as a whole, and thus are not just focused on biodiversity. In addition, in selecting indicators, experts were not limited to areas where they knew information existed. Instead, the intent of the report is to identify indicators based on what needs to be known rather than being limited to indicators that rely on existing data only. Therefore, for some indicators that may be included in the final product, insufficient data, or possibly no data will be available to describe the indicator. However, these indicators will provide guidance to policy makers and inform the public on monitoring or measurements that are needed to complete the State of the Nations Ecosystems.

Table 1. **Types of systems addressed and categories of indicators**

System	*Indicator Categories*
Coastal Waters	Extent
Farmlands	Fragmentation and Ecosystem Patterns
Forests	Plant Nutrients
Freshwater	Chemical Contaminants
Grasslands/Shrublands	Physical Conditions
Urban/Suburban	Plants and Animals
Nation	Biological Communities
	Plant Growth
	Food, Fiber, and Water
	Other Services, including Recreation

Source: State of the Nations Ecosystems Report. Heinz, 2001.

Of the six ecosystem types that are being addressed in the State of the Nation’s Ecosystems, two incorporate agricultural systems — Farmlands, and Grasslands/Shrublands. This discussion will focus on the indicators developed for those systems.

The Farmland system includes areas used for agricultural production such as croplands, as well as areas associated with field edges, windbreaks, and nearby woodlots. Pasture is also included in this system so overlap with the grasslands systems is expected. Draft indicators for the categories associated with biodiversity in farmland areas are described in Table 2, in addition to a preliminary assessment as to whether data are available to quantify the indicator.

Table 2. **Biodiversity indicators for farmland ecosystems**

Indicator Categories	*Indicators*	*Data*
Plants and Animals	What % of species found in regions with large amounts of farmland are increasing, decreasing, or stable? Of rare or declining species in this area, what % is increasing, decreasing, or stable?	No
Plants and Animals	In areas with large amounts of farmland, is most of the remaining vegetation native or non-native?	No
Biological Communities	What is the quality of the habitat in streams in farmland regions?	Some

Source: State of the Nations Ecosystems Report. Heinz, 2001.

Examination of those indicators related to biodiversity — plants and animals, and biological communities, show that data are not available for adequately assessing this set of indicators. For the indicator on trends of species, the experts working on this Report recognize that most wildlife associated with farmlands are species that would have been found in the native habitat of the area before the land was converted to agriculture. This makes it impossible to report on the status of "farmland" species when it is indeed a mix of forest, shrubland and grassland species, which may be opportunistically using farmland. It is also impossible to adequately assess the status of native plant and animal populations on farmland because data are available for only a few species. Where data are available, for example for birds, declines in grassland groups have been documented. However, these data are developed on too large of scale to adequately determine the specific role of farmland relative to the other habitats mixed in with farmland.

The Grasslands/Shrublands system is defined as lands dominated by grasses, and would include, but not be limited to, rangelands and pastures. Thus considerable overlap with the Farmlands system occurs. Grasslands/shrublands make up the largest land cover type in the United States, and significant areas have been converted to agriculture. Grasslands indicators are similar to those for Farmlands and are identified in Table 3.

Table 3. **Biodiversity indicators for Grasslands/shrublands**

Indicator Categories	*Indicators*	*Data*
Plants and Animals	What fraction of grassland species is at risk? What fraction is presumed secure?	Yes
Plants and Animals	What percent of grassland and shrubland plant cover is not native to the region?	No
Biological Communities	What is the ratio on non-native species to native species?	No
Plants and Animals	Are non-native bird populations increasing more than native populations?	Yes

Source: State of the Nations Ecosystems Report. Heinz, 2001.

Because the Grasslands/shrublands is more inclusive of the habitat types found in the area than the farmland ecosystem, broad scale information can be applied to two of the suggested indicators. For example, for the first indicator in Table 3, the Report points out that one fifth of the 1900 species that depend on grassland habitats are at risk of extinction either because of their inherent rarity or because their populations have been greatly reduced (Association for Biodiversity Information, 2001). Grasshoppers and amphibians have been identified as having the greatest number of species in this category. For the fourth indicator, the Report states that between 1996 and 2000 significantly more invasive species populations increased than did native species. (Sauer *et al.*, 2001). Data gaps prevented assessment of the other indicators.

Regionalization

As was briefly mentioned in the introduction, land use or conservation must be viewed within its ecoregion. If the native grassland habitat of an ecoregion is all converted to cropland, biodiversity will be lost and conservation efforts in other regions can do little to protect those species relying on that habitat. In the State of the Nation's Ecosystems, some effort is made to regionalize indicator data, however it seems insufficient to adequately address this concern. For farmlands, the extent indicator would be reported for 10 separate geographic regions. Although this division will help identify ecosystem types that may be at more risk than others, the geographic boundaries are more political (drawn on state lines) rather than ecological. Also, there is no plan currently to assess the biodiversity indicators (plants and animals, biological communities) on any regional or ecoregional basis.

For the grassland/shrubland system, regional assessment of information for the biodiversity indicators is planned, and the grassland habitat within the U.S. has been subdivided into three ecoregions (Figure 1). This division enables differentiation among grassland/steppe areas, desert/shrub, and California and coastal grass, shrub and chaparral. Partitioning data by these three ecoregions will provide a more detailed assessment than a national indicator would, however these areas are still very large, and combine a number of unique ecosystems. For example the Palouse Prairie grasslands (Smith and Collopy, 1998), and the Mojavean vegetation zone (Brussard *et al.*, 1998) are in the same zone, yet are quite different ecologically.

Figure 1. **Grassland/Shrubland Regions in the U.S.**

Source: State of the Nations Ecosystems Report. Heinz, 2001.

Improving our knowledge Base

The U.S. State of the Nation's Ecosystems Draft Report, and the Organisation for Economic Cooperation and Development Indicators Report express the need for more and improved information to adequately address the recommended indicators. The lack of status and trend information on habitats and even to a greater degree on populations of native, and non-native flora and fauna greatly reduce our ability to conduct these environmental assessments.

Biological monitoring information is critically needed and monitoring efforts need to be increased. Although the U.S. spends over USD 600 million on environmental monitoring, population monitoring is limited and taxonomic coverage is not good. Cost is partly prohibitive for some species such as wide ranging marine species (*e.g.* whales, sea turtles), and the greatest investment of funds in marine environments is devoted to exploited populations of marine fish and shelllfish. Funding is not always a limitation as some monitoring programs have generated critical status and trends information at a very reasonable cost, such as the U. S. Breeding Bird Survey, where volunteers provide much of the needed manpower.

In many cases, the limiting factor to expanding monitoring is the availability of standardized and scientifically valid protocols. Over the last few years there has been expansion of monitoring efforts with other species that over time will begin to provide the long-term trend information needed to critically assess populations. Some of these newer efforts include:

Amphibians: The concern over worldwide amphibian decline in the last 5-10 years has prompted an increase in U.S. investment into amphibian research and monitoring and the initiation of amphibian monitoring efforts. Several new programs have been initiated in recent years including the North American Amphibian Monitoring Program. This program is structured like the Breeding Bird Survey and monitors calling amphibians in the Eastern U.S. and Canada.

The Amphibian Research and Monitoring Initiative, which is coordinated by the U.S. Geological Survey (USGS), will establish a network designed to monitor the status and changes in the distributions and abundance of amphibian species and communities in the United States, and not rely just on surveys of calling amphibians. A general national approach will use presence/absence of species at a collection of sites to estimate a population level parameter — proportion of area occupied by each species and a community level parameter — species richness. This program will also incorporate high intensity, selected field sites to determine demographic and life history characteristics of key species, study cause-effect relationships, and evaluate new techniques and protocols

Current research has also begun to demonstrate the value of agricultural lands to amphibian habitat. Constructed farm ponds have been found to provide significant breeding, rearing, and overwintering habitat for amphibians in the upper Midwestern U.S. Studies will examine amphibian individual, population and community health associated with land uses surrounding farm ponds, such as row crops, grassland, and grazed grassland, and what design features associated with a pond (size, depth, vegetation) will maximize amphibian benefits (Knutson, 2001).

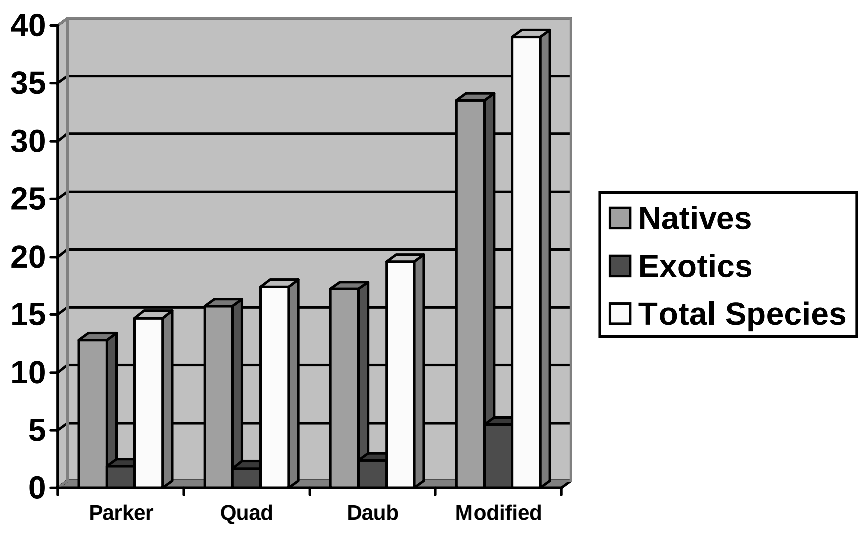
Bats: In addition to their value in natural habitats, bats provide significant benefits to agriculture as pollinators and as insectivores that can help in controlling some agricultural pests. A large number of bat taxa (26) have been identified as potentially at risk by the U.S. Fish and Wildlife Service, indicating the need for increased information on distribution, population status and trends, and life history requirements. Recent efforts are underway to further the science of bat monitoring. The "Workshop on Monitoring Trends in U.S. Bat Populations: Problems and Prospects" held in 1999, provided a forum for reviewing bat status and trends, identifying current methods and challenges involved in estimating bat populations, and recommending future monitoring efforts (O'Shea and Bogan, 2000).

The USGS has developed a Bat Population Database that is serving to synthesize existing information from published literature and state agency databases. The database will serve as a basis for hypothesis testing and statistical analysis and for designing long-term monitoring efforts (O'Shea, 2001). The efforts of this workshop and the development of the database will begin to provide scientifically credible data on bat status and trends and serve as a focal point for bat conservation information.

Invasive plants: Invasive species pose one of the singular most dangerous threats to maintaining biodiversity across the US. Destruction of fisheries, significant alteration of habitats, increased risk of fire, competition with native species, and devastating diseases are some of the impacts invasive species have caused. Invasive plants are closely linked to agriculture, particularly in rangelands. Noxious weeds have invaded over 17 million acres of public rangelands in the western US, driving out native species, and reducing the value of these lands for grazing (Westbrooks, 1998).

New methods for inventorying plants have recently been developed that are far more effective at characterizing both native and non-native vegetation (Figure 2). This is especially important for early detection of an invasive plant species (Stohlgren *et al.*, 1998). Improvements are also being made in resolution of vegetation measurements. Techniques that incorporate satellite imagery, high resolution aerial photography, and multi-scale field sampling can now create predictive, GIS-based models that can discriminate much finer detail and distinguish between small but unique habitats (Stohlgren *et al.*, 1997). This feature can be valuable when assessing the small habitats associated with intensive agriculture.

Figure 2. **Comparison of methods for plant sampling**



Source: Stohlgren *et al.*, 1998.

Grizzly Bears: Although monitoring information on large mammals, especially those that are hunted for sport, has usually been available due to efforts of game managers, new techniques have been developed that can provide managers with improved information. Recent advances in genetic technology allow for identification of species, sex, and individuals from DNA extracted from bear hair and scats without handling bears (Kendall, 2001). DNA is analyzed from bear sign collected along survey routes and from a grid of systematically positioned hair traps. The number of individuals and species identified from survey routes yields minimum counts and a baseline index of population size. This is used to design a non-intrusive population trend monitoring scheme. Bears identified from hair trap collections will be used in a mark-recapture model to estimate the population density and will provide an independent calibration of the population index developed from survey routes. DNA profiles with information on the degree of genetic variation, relatedness of individuals, and sex can then be used to address bear conservation issues. These techniques could be applied to other species and generate individual and population level information on wildlife use of specific habitats, such as farmland. With the type of data on individuals generated by genetic techniques, the productivity of the habitat can be assessed with a much greater degree of confidence than with previous methods.

These are but a few examples of improved monitoring methods and increased effort for different taxonomic groups that in the long term will produce the kinds of status and trends information needed to adequately assess agricultural systems. Increased efforts in other areas are also progressing that are not described in this paper, for example, butterflies, bees, and other pollinators, and freshwater mussels. Despite the increase in our capabilities to monitor new species through improved protocols, or enhanced monitoring activity, we will never be able to provide enough information on status and trends of populations to assure that biodiversity is being sustained. This is especially true for selected habitats, such as farmland, where issues of scale, as well as the mixture of habitat types complicate assessment efforts. Other approaches may be needed to provide regulators and managers with information that will help take the greatest advantage of agricultural ecosystems.

Adaptive management

One approach that may be used on the agriculture landscape would employ adaptive management strategies. This approach enables recognition of the uncertainty inherent in resource management and could provide a framework through which agricultural lands could best contribute to sustaining biodiversity. Adaptive management merely provides a structure for feedback between the management strategy and the assessment of progress toward a specified goal (Williams and Johnson, 1995). Adaptive management requires 1) focused management objectives, 2) monitoring of the resource and, 3) a process by which management decisions can be assessed.

Use of adaptive management requires that specific biodiversity objectives need to be established for the matrix of habitats that are incorporated into agricultural systems. Because agriculture lands are often already compromised in terms of their habitat value, it may not be feasible to expect them to maintain diverse biological communities — especially in row cropland. Instead, some attainable conservation objectives should be set for agriculture lands, and these could no doubt vary among crop types, and most likely among ecoregions. For example, along the west coast flyway in the U.S., habitat for migratory waterfowl has been greatly reduced by conversion to agriculture. Changes in agricultural practices in rice fields were tested that involved winter flooding of fields. These practices were evaluated and found to result in increased habitat for invertebrates that serve as a valuable food source to overwintering waterfowl (Hill, 1999), helping to bolster populations. This example demonstrates that by setting specific objectives that can be achieved on agricultural lands, and then monitoring for achievement of those objectives, changes in agricultural practices can be adopted that maximize the value of agricultural lands to sustaining biodiversity.

Conclusions:

1. Efforts in the U.S. at assessing the state of the Nation's ecosystems, and the efforts of the OECD to develop agri-biodiversity indicators show some remarkable similarities. Similarities can be found in the proposed U.S. indicators for measuring extent of croplands and grasslands, and the OECD wildlife habitats indicators. Also, the measures for assessing species and biological communities in the U.S. compare favorably to the OECD biodiversity indicators. The OECD has placed a greater emphasis on genetic diversity than the U.S., however, which seems to be a valuable inclusion.

2. One of the key similarities that both efforts describe is the shortage of information to adequately use the indicators to assess agricultural systems. This lack of information points to the need for more status and trend information on wildlife trends, improved techniques for collecting this information, and more effective tools for estimating population sizes and changes. It is critical to emphasize the need for the U.S. and OECD countries to enhance monitoring activities and increase the supporting science.

3. As was mentioned in the Introduction, the U.S. has converted extremely high amounts (+99%) of some systems with significant implications for the endemic species in these areas. Assessing agricultural systems on a more ecoregional scale would be an important feature to enhance the U.S. and the OECD efforts in agricultural biodiversity. Not only should farmland extent be considered ecoregionally, but specific regional indicators may be useful as well.

4. Employing adaptive management to agriculture lands could provide a usable framework for maximizing their benefits to biodiversity. With agricultural lands already being compromised in terms of their habitat value to broadly diverse biological communities, specific management objects could provide a much more realistic endpoint. This approach still requires monitoring to assess whether the agricultural practices are achieving stated goals, and the management feedback to make needed changes in those practices if achievement is not reached. One of the most attractive aspects of using adaptive management would be an indicator that could measure the percentage the agricultural lands that are using those agricultural practices that have been determined to meet intended management goals.

REFERENCES

Association for Biodiversity Information (2001), Natureserve. http://www.natureserve.org

Chaplin S.J., R.A. Gerrard, H.M. Watson, L.L. Master, S.R. Flack (2000)? The geography of Imperilment: Targeting Conservation toward critical biodiversity areas. In Precious Heritage, B.A. Stein, L.S. Kutner, and J.S. Adams, eds., Oxford Press, New York, 399 p.

Groves, C.R. L. S. Kutner, D.M. Stoms, M.P. Murray, J.M. Scott, M. Schafale, A.S. Weakley, R.L. Pressey (2000)? Owning up to our responsibilities: Who owns lands important to biodiversity. In Precious Heritage, B.A. Stein, L.S. Kutner, and J.S. Adams, eds., Oxford Press, New York, 399 p.

Heinz, H.J. III Center for Science, Economics, and the Environment (2001), The State of the Nation's Ecosystems. Aug. 15 Draft. http://www.heinzctr.org/DRAFTREVIEW/index.htm

Hill, J. (1999), Integrating rice cultural practices and waterfowl habitat. http://agronomy.ucdavis.edu/uccerice/DUCKS/waterfwl.htm

Kendall, K. (2001), Monitoring grizzly bear populations using DNA http://nrmsc.usgs.gov/research/beardna.htm

Knutson, M. (2001), Farm ponds as critical habitats for native amphibians. www.umesc.usgs.gov/terrestrial/amphibians/mknutson_5003869.html

O'Shea, T. J. and M. A. Bogan (editors) (2000), Interim Report of the Workshop on Monitoring Trends in U.S. Bat Populations: Problems and Prospects. [On-line Interim Report]. U.S. Geological Survey, Midcontinent Ecological Science Center, Fort Collins, Colorado, 124 pp. Available: http://www.mesc.usgs.gov/BPD/ireport.htm

O'Shea, T.J., (2001), Bat Population Status in the United States and Territories. www.mesc.usgs.gov/research/5001595.shtml

Sauer, J. R., J. E. Hines, and J. Fallon. (2001), The North American Breeding Bird Survey, Results and Analysis 1966-2000. Version 2001.2, USGS Patuxent Wildlife Research Center, Laurel, MD. http://www.mbr-pwrc.usgs.gov/bbs/bbs.html

Scott, J.M., R.J.F. Abbitt, and C.R. Groves (2001), What are we protecting? Conservation Biology in Practice. Vol. 2 no. 1, p. 18-19.

Stohlgren, T. J., K. A. Bull, Y. Otsuki. (1998), Comparison of rangeland sampling techniques in the Central Grasslands. Journal of Range Management 51:164-172.

Stohlgren, T. J., G. W. Chong, M. A. Kalkhan, and L. D. Schell (1997), Multi-scale sampling of Plant Diversity: Effects of the minimum mapping unit. Ecological Applications 7:1064-1074.

Veirs, S.D. JR, and P.A Opler (1998), California, 593-644. In Mac, M.J., P.A. Opler, C.E. Puckett Haecker, and P.D. Doran. Status and Trends of the Nation's Biological Resources. Vol. 2, U.S. Department of the Interior, U.S. Geological Survey, Reston, VA 437-964.

Westbrooks, R. (1998), Invasive plants, changing the landscape of America:Fact Book. Federal Interagency Committee for the Management of Noxious and Exotic Weeds, Washington D.C. 109 p.

Wilcove, D.S., D. Rothstein, J. Dubow, A. Phillips, and E. Losos (2000), Leading threats to Biodiversity: Whats imperiling U.S. species. In Precious Heritage, B.A. Stein, L.S. Kutner, and J.S. Adams, eds., Oxford Press, New York, 399 p.

Williams, B.K. and F.A. Johnson (1995), Adaptive management and the regulation of waterfowl harvests. Wildl. Soc. Bull. 23(3):430-436.

THE STATE OF AGRO-BIODIVERSITY IN THE NETHERLANDS INTEGRATING HABITAT AND SPECIES INDICATORS

Ben ten Brink[1]

1. Introduction

This assessment deals with **wild-living species in agricultural ecosystems** at the national level. It focuses on the loss of biodiversity since 1950 when most modern intensive agricultural management practices were introduced. It builds further on species and habitat indicators discussed in the CBD (1997) and OECD (2001).

This paper has been produced by the RIVM and is based on information of i) the Central Statistical Office (CBS) and Alterra; ii) various organisations monitoring plant, reptile, bird, mammal, fish, butterfly and aquatic macro fauna species; iii) research institutes and universities which carried out research on baseline values (Floron, 1997; Ravon, 1999; Kleunen, 2001; Kleunen en Sierdsema, 2001; IWACO, 2001; Vlinderstichting, 1999; Hollander, 2000).

The assessment has been made to support national policy making in The Netherlands. The set of requirements on biodiversity indicators for this purpose is presented in Appendix 1. The results will be extensively reported in the Dutch Nature Outlook (RIVM, in press); the method in the report Technical design of the Natural Capital Index (Ten Brink *et al.*, in press).

2. Biodiversity loss defined

For the purpose of this assessment agro-biodiversity has been tangibly defined as:

the complete set of agro-dependent wild-living species
with their corresponding abundance and distribution.

The aim of the assessment is to measure the clear decrease in the abundance of many species and increase of a few other species in agro-ecosystems since the introduction of intensive management practices. As a result, the various agricultural ecosystems are getting more and more uniform. Common species are becoming more common, rare species more rare (Figures 1 and 2).

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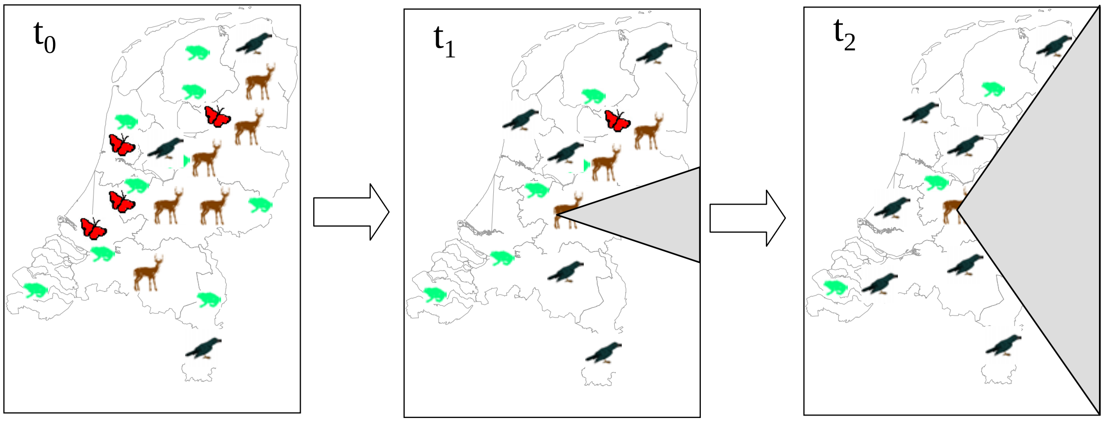
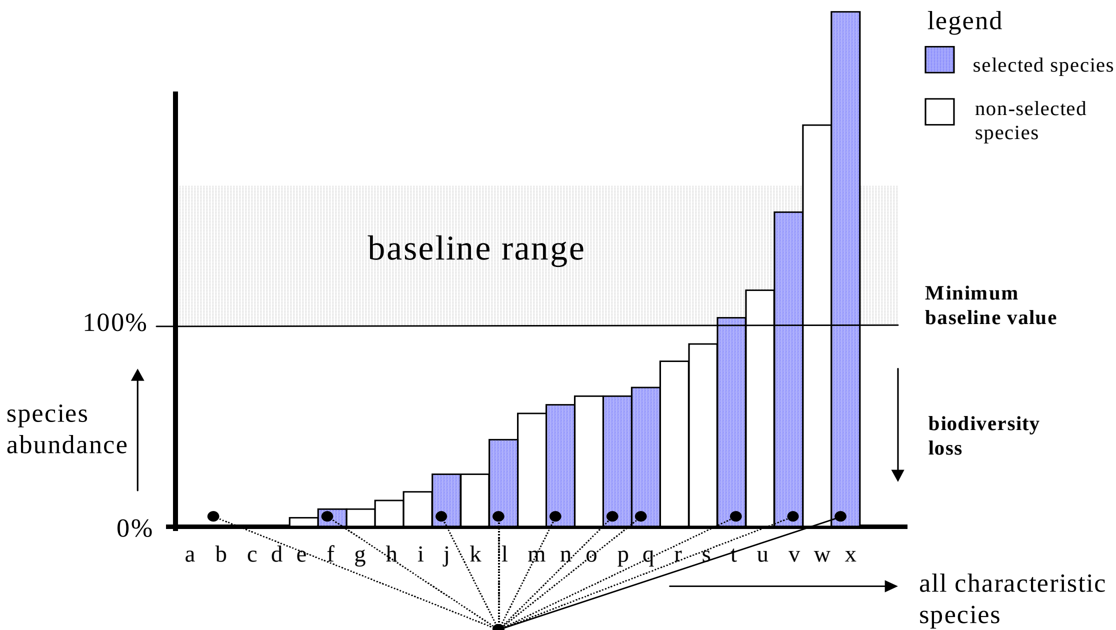
1. RIVM, The Netherlands.

Figure 1. **Schematic picture of the process of biodiversity loss of wild species, as a result of habitat loss (grey cut out) and ecosystem quality in the remaining habitat**



As a result, the abundance of many species decline, while the abundance of some -mostly common species- increase. This process applies for natural as well as for agricultural ecosystems.
Note: the decrease of species abundance is a far more sensitive indicator than "species-richness".

Figure 2. **Ecosystem quality can be calculated with a selection of species of the agro-ecosystem (grey bars)**[1]



Note: 1. For each species quality is calculated as the ratio between the current state and (minimum) baseline state (% of the baseline). The ecosystem quality is the average quality of the selected set of species. This approach is very similar to that of economic indicators. To determine the Price Index or inflation of a country it is not the prices of millions of products that are monitored in all shops. Instead, a so-called theoretical "shopping bag" is filled with a representative core set of products and subsequently monitored in a subset of shops. The changes in prices are averaged with different weightings because the price increase of bread cannot simply be averaged with the price increase for a car.

Species extinction or extirpation is only the last step in a long process of ecosystem degradation (UNEP, 1997). This process is caused by two factors:

i) the loss of agricultural area on the one hand;

ii) the decrease in ecosystem quality within agricultural area on the other hand, due to the use of fertiliser, pesticides, lowering groundwater tables, clearance of (semi)-natural habitats such as hedge rows, extensive used pasture, etc.

3. Method

In order to measure the change in biodiversity, both factors, the loss (gains) of agricultural area and the loss of ecosystem quality have been determined since about 1950. The agricultural area (ecosystem quantity) has been defined as % of the total country. The national area includes the entire terrestrial area, freshwater systems and marine watersystems within the 12 miles zone of the North Sea. This area is set at 100% in Figures 3, 4 and 5. Ecosystem quality has been calculated by the change in abundance of various species. It was not necessary or possible to measure all wild-living species dependent on agro-ecosystems. A core set of characteristic species has been selected from the different agro-regions and their main land-use types, including their (semi-) natural habitats (Figure 2 and Box 1).

The species were selected with the help of 10 considerations (Appendix 2). The calculation procedure for ecosystem quality has been elaborated in Appendix 3.

Box 1. **Selected species for agricultural regions and land-use types**

<table>
<tr><td colspan="2">Selected Species from six species groups:

1) higher plants (number of species 228)
2) butterflies (number of species 27)
3) reptiles (number of species 1)
4) birds (number of species 31)
5) mammals (number of species 1)
6) aquatic macro fauna (number of species 42)</td></tr>
<tr><td>Species selected for 5 agricultural regions:

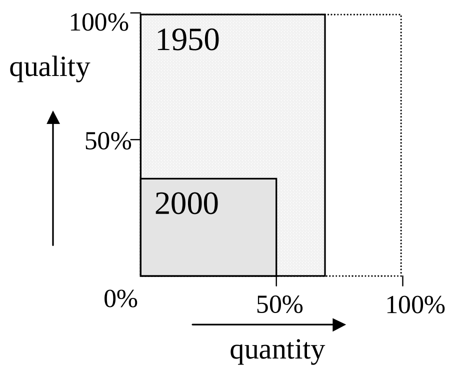
1. marine clay area
2. higher sandy soil area
3. peat area
4. riverine area
5. hilly area</td><td>Species selected for various land-use types:

1. arable land
2. permanent pasture
3. natural and semi-natural habitats within arable land and permanent pasture: ditches, forest patches (< 6,25 ha), hedges, etc.</td></tr>
</table>

The reference year 1950 as a baseline has been chosen on an arbitrary but practical point in time. On the one hand, biodiversity was still high and biodiversity loss was about to accelerate rapidly due to intensification, while on the other hand sufficient data was available to reconstruct the abundance of a core set of species. Current and baseline data were produced by various universities, institutes and volunteer groups organisations, commissioned and co-ordinated by RIVM. Appendix 4 elaborates on the functions of baselines.

Both agricultural area (habitat) and its quality can be expressed in one single figure (Figure 3). The lower the quantity and quality, the lower the remaining natural capital. In this fictitious figure agro-biodiversity has been decreased a factor 4 due to loss of habitat and quality. In simple terms this means that todate, the abundance of characteristic agro-dependent species is on average 25% of their abundance around 1950.

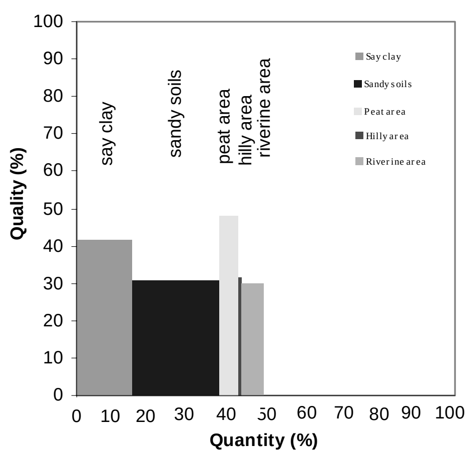
Figure 3. **The state of agro-biodiversity in 1950 and 2000 in terms of habitat (quantity) and its quality (fictitious). Quantity is expressed as % of the national area**



4. Results

Figure 4 shows the state of the regional agro-biodiversity in terms of the remaining habitat and quality in the Netherlands around 1995.

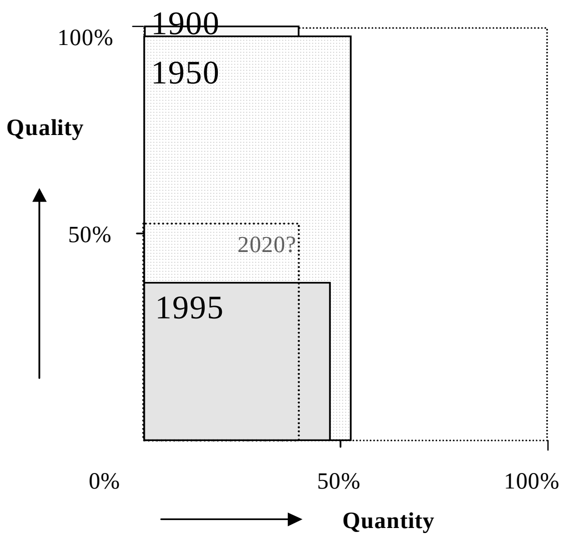
Figure 4. **The state of agro-biodiversity in the 5 Dutch regions in terms of the remaining habitat and quality around 1995**



Source: RIVM, Ten Brink *et al.* (in press).

Figure 5 shows the change in national agro-biodiversity in terms of habitat and quality of the Netherlands from 1900 to 1950 and 1995.

Figure 5. **The national agro-biodiversity in terms of habitat[1] and quality of the Netherlands in 1900, 1950 and 1995**



1. Due to loss of habitat and quality agro-biodiversity has been decreased a factor 2,9 in the last 45 years.
Source: RIVM, Ten Brink *et al.*, in press.

The agricultural area expanded until 1950 by large-scale conversion of natural areas. Then its quality declined significantly, due to broad scale introduction of intensive agricultural practices. Moreover, the area declined because of conversion into build up area and reconversion into nature. Combining habitat and quality, 66% of the agro-biodiversity was lost in the last 45 years. *This means that the abundance of characteristic agro-dependent species is on average 34% of their abundance around 1950.* Studies on various policy scenarios are running todate, amongst which agriculture practices on a smaller area with higher and lower ecosystem quality and agricultural productivity (Figure 5).

5. Discussion

1. The ecosystem quantity (habitat) and quality indicators match with the set of requirements on biodiversity indicators as listed in Appendix 1. They provide quantitative information on the past, current and future state of agro-ecosystems at the regional and national scale, on species and ecosystems. Further they are feasible and easy to communicate to policymakers and the public, are linkable with socio-economic scenarios to assess policy options and sensitive to track changes over time.

2. A dramatic loss of agro-biodiversity has taken place since 1950. This corresponds with the loss of important species-rich semi-natural elements and intensification of agricultural practices. Losses which have taken place before 1950, such as the loss of significant part of the poor extensively used grasslands, are not taken into account.

3. Although the average abundance of species is 34% of 1950, several species have a far lower abundance due to specific loss of suitable habitat.

4. According to OECD (2001) wildlife species diversity related to agriculture could be expressed with species and habitat indicators:

   A. the quantity of the agricultural area

      – the extent and changes in agricultural area, land use and land type;
      – proportion of semi-natural and uncultivated natural habitats on agricultural land.

   B. the quality of the agricultural area

      – *trends in population distributions and numbers of wild species related to agriculture;*
      – *trends in population distributions and numbers of key "non-native" species threatening agriculture.*

In this implementation the extent and changes in agricultural area and trends in abundance of species have been used.

5. Changes in agricultural land uses, and proportion of semi-natural and uncultivated natural habitats have not been applied here as indicators. By selecting species dependent on various land uses and (semi-) natural habitats, the effects of changes in their extent are included in the ecosystem quality indicator.

6. Actually, land uses and proportion of (semi-) natural habitats are alternative indicators for the ecosystem quality indicator. They do provide similar information. The formers are favourable in case data on species are lacking.

7. If the various land use types and (semi-) natural habitats are assessed on their biodiversity they can be expressed in terms of ecosystem quality. This opens up perspectives to a common approach for OECD-countries to assess their own specific agro-biodiversity in their own way, but resulting in similar terms of ecosystem quantity and quality.

8. In all cases, baselines are necessary in order to track, value and aggregate changes over time. In order to find a common denominator, as discussion on baselines is desirable.

9. It is of great importance the OECD framework on agro-biodiversity indicators fits well with the framework developed and discussed under the Convention on Biological Diversity (UNEP, 1997). The ecosystem quantity and quality approach is promising in this respect.

APPENDIX 1.
REQUIREMENTS ON BIODIVERSITY INDICATORS FOR THE NATIONAL NATURE OUTLOOK

To fit into the National Nature Outlook biodiversity indicators should:

- provide information on the state of nature:
  - at the regional and national scale;
  - at species and ecosystem level;
  - on their naturalness for self-regenerating ecosystems and species-richness for made-made ecosystems.
- be quantitative, feasible and affordable;
- be easy to understand and policy significant;
- be sensitive and able to show trends;
- be interlinkable with socio-economic scenarios for future projections;
- allow aggregation at regional and national levels;
- take into account regional-specific biodiversity;
- be scientifically sound.

APPENDIX 2.
10 CONSIDERATIONS FOR CHOOSING SPECIES (QUALITY VARIABLES)

Each species should:

1. **have available quantitative data**
   - is *quantitative data about abundance, distribution and use for the past and present available or reconstructible? Is there data for pressure-effect relations?*

2. **be policy and ecosystem relevant**
   - *e.g. ecosystems/species of high economic, cultural or ecological interest (key species, see annex 1 UN-convention on biological diversity), red list species, extinct or threatened (endemic) species;*

3. **be susceptible to human influence**
   - *steerable and predictable, is linkage possible to the outputs of socio-economic and environmental models?;*

4. **be accessible to accurate and affordable measurement**
   - does a monitoring programme exist? Is it financially feasible?

5. **have indicative value**
   - does the *species provide more information about biological diversity than only its own value?*

6. **be stable**
   - can anthropogenically-caused fluctuations be reasonably distinguished from natural fluctuations?

7. **be useful for at least a 20-30 year period.**
   - does the species indicate a problem that will not definitely be solved within a few years (in that case it would *lose political significance)?*

The set of species should:

8. **provide a representative picture of the changes of biological diversity at the regional and global level;**
   - *the species must be a cross-section of the entire ecosystem to provide a representative picture relating to:*
     - *different sub-systems;*
     - *different taxonomic classes;*
     - *high and low parts of the food web;*
     - *terrestrial and aquatic ecosystems;*
     - *present day and former biological diversity;*
     - *sessile, migratory and non-migratory species;*
     - *key species, threatened species, endemic species, species of socio-economic importance;*

9. **reflect the effects of the main anthropogenic pressures and nature conservation programmes affecting biological diversity:**
   - the species must be a cross-section of main pressures in considered area such as: exploitation, pollution, fragmentation, habitat destruction, disturbance, exotic species, climate change;

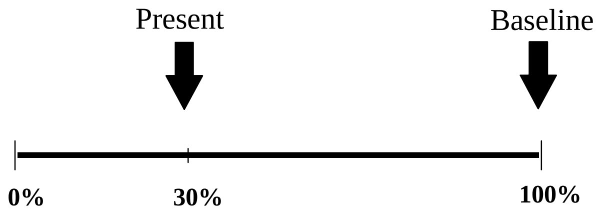
10. **be as few in number as possible;**
    - *the less species the more communicable to policy makers and the public; therefore aggregation to only a few, preferably one, quality indicator must be possible.*

Note:
In this case, mainly species have been choosen as quality variables to assess ecosystem quality. It is also possible to choose structure variables at the ecosystem level (*i.e.* ratio of dead and living wood) or ecosystem processes.

APPENDIX 3.
THE CALCULATION PROCEDURE OF AGRO-ECOSYSTEM QUALITY

1. Quality per species:

For each species the abundance in the baseline state and current state has been estimated. The current quality of each species is determined as the percentage of the baseline state.



2. Quality per species group

the average quality of plants, vertebrates and evertebrates is determined as the average of the species within that group.

3. Quality per agro-region

the quality of the agro-ecosystem per region is determined by averaging the quality of the three species groups.

4. Quantity per agro-region

The agro-ecosystem area is calculated for each region in 1950 and 1990 as percentage of the countries total area.

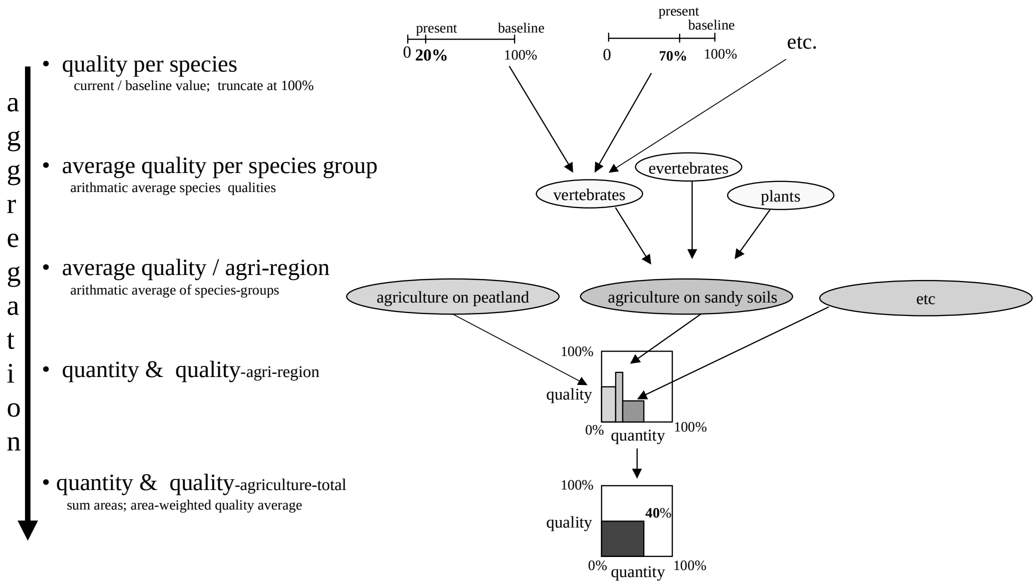
5. Quality national agro-ecosystem

The national agro-ecosystem quality is the area-weighted average of the regions-quality.

6. Natural Capital Index

If politically desired, a natural capital index might be calculated for each region by the product of agro-ecosystem quantity and quality. If these regional natural capital indices are added a natural capital index is achieved at the national level, as shown in the Figure below.

Calculation procedure on agro-ecosystem quality and area



APPENDIX 4.
BASELINES AND THEIR ROLE IN POLICY MAKING

Baselines have various functions:

1. baselines transform data into policy significant information;

2. baselines provide a common denominator to assess ecosystems (parts) in a consistent and comparable way;

3. baselines enable aggregation of many variables to a few or one single indicator.

Baselines are common and indispensable instruments in many fields, such as medical surgery (blood pressure, O_2 concentration, pulse etc.), climate change (pre-industrial CO2 concentration), water and soil quality (natural background values of nutrients and heavy metals), economy (price index with its shopping basket and consumption frequency), education (exams).

It has to be stressed that baselines serve in this assessment as a calibration point or benchmark to quantify the extent of change due to human activities in modern times. The baseline is *not* necessarily the targeted state. Policy makers choose their targets on ecosystem quantity and ecosystem quality somewhere on the axis between 0 and 100% (see Appendix 3) depending on their balance of social, economic and ecological interests.

Below in Box 2 is an example of the function of a baseline in nature conservation.

Box 2. **Baselines in conservation policy**

Example: "**currently are 1 000 dolphins** in the Sea". This data has no significance as such, it only have significance in relation to baseline values. Baselines make such statistics meaningful indicators. The type of baseline determines the policy message. Some examples:

Baseline type	*Baseline value*[1]	*Meaning of current value Vis a vis baseline*	*Policy signal*
1. Natural state	> 10 000	Currently 10% of original population is left. 90% was destroyed by anthropogenic factors, such as pollution, depletion of major fish stocks and drowning in fish nets.	The population is still heavily deteriorated. Let's work out further measures for decision making.
2. Specific year 1993: CBD was ratified	500	The current population has been doubled	Policy makers did a very good job. Fishermen speak about a plague. They propose to limit the population to 500. Limitation measures?
3. Genetically Min. pop. size	250	The current population is 4 times above the critical level	No need to worry about dolphins
4. Red list	750	The current population is 33% above red list criterion	Great job done in last years. Dolphins can be removed from the red list. "Let's go back to business"
5.Species richness	200 species	Much of the population can still be lost without losing a species. Even if extirpated it would not affect the species-richness. An alien seal species compensates the loss.	1 000 dolphins is fine but not interesting. The species richness is only affected when the population is zero. No measures are needed, even if the dolphins were to disappear.
6. None	---	1 000 dolphins seems a lot, and the population appears to be growing.	Fishermen say dolphins are becoming a plague and must be limited. Conservationists state that 1 000 is not much at all. To restore a healthy marine ecosystem it should increase to several 1 000s. A political discussion is unavoidable

Note:
1. In numbers of dolphins.

REFERENCES

Brink, B. ten, A. Hinsberg, M. de Heer, B. de Knegt, O. Knol, W. Ligtvoet, R. Rosenboom, R. Reijnen (2002 in press), *Technical design of the Natural Capital Index*. RIVM, Bilthoven.

FLORON (1997), *Een Ecologische Kapitaal Index voor de Flora, aanzet tot kwantificering van de floristische kwaliteit*. Landelijk Bureau FLORON, Leiden.

Hollander, H. (2000), *Ecologisch Kapitaal Index Zoogdieren; referentiewaarden voor de periode rond 1950.* Mededeling 48, Vereniging voor Zoogdierkunde en Zoogdierbescherming, Arnhem.

IWACO (2001), *Referentiewaarden voor macro-faunasoorten in laagveensloten*. IWACO.

Kleunen, A., H. Sierdsema (2000), *Natuurlijke referentiewaarden van enkele zeer zeldzame of in Nederland uitgestorven broedvogelsoorten.* SOVON-ondrzoeksrapport 2001/05.SOVON Vogelonderzoek Nederland, Beek-Ubbergen

OECD (1998*a*), Agriculture and Biodiversity, OECD workshop on agri-environmental indicators, Paris.

OECD (1998*b*), *Report on the OECD workshop on agri-environmental indicators*. York, September 1998, Paris.

OECD (2001), *Environmental Indicators for Agriculture, volume 3, methods and results*. Paris: OECD publications.

RAVON (1999), *EKI-Reptielenindexen op basis van het referentiejaar 1950.* Aut: A. Zuiderwijk, A Groenveld, G. Smit, RAVON Werkgroep Monitoring, Amsterdam.

RIVM (2002, in press), *National Natural Outlook 2*, RIVM/Alterra, Bilthoven.

SOVON (1997), *Ecologische Kapitaal Index voor Vogels*. Aut.: Hagemeijer, W., H. Sierdsema, SOVON, Beek-Ubbergen.

Kleunen A. (2001), *Reconstructie van broedvogelpopulaties van zeldzame broedvogels en kolonievogels in 1950 en 1998 ten behoeve van de Ecologische Kapitaal Index.* SOVON-onderzoeksrapport 2001/03. SOVON Vogelonderzoek Nederland, Beek-Ubbergen.

UNEP (1997*a*), *Recommendations for a core set of indicators of biological diversity*. CBD secretariat, Montreal (nr: UNEP/CBD/SBSTTA/3/9).

UNEP (1997*b*), *Recommendations for a core set of indicators of biological diversity*. CBD secretariat, Montreal (nr: UNEP/CBD/SBSTTA/3/13 inf.).

Vlinderstichting (1999), *Ecologisch Kapitaal Index — Dagvlinderindexen op basis van referentiejaar 1950.* Aut.: Swaay, C.A.M. van. De Vlinderstichting, Wageningen, rapportnr. VS 99.12.

ANNEX.
COMPLETE LIST OF DOCUMENTS[1] PRESENTED BY EXPERTS AT THE MEETING

- *OECD Agri-biodiversity indicators: Background paper — Kevin Parris, OECD.

Plant and Animal Genetic Resources for Food and Agriculture

- Indicators of Agricultural Genetic Resources: FAO's Contribution to Monitoring Agricultural Biodiversity — Linda Collette, FAO, Italy.

- *Biological Diversity of Livestock and Crops: Useful Classification and Appropriate Agri-environmental Indicators — Frank Wetterich, Institute for Organic Agriculture, Germany.

- Agri-biodiversity Indicators used in Poland — Anna Liro (Ministry of Agriculture), Elzbieta Martyniuk (National Animal Breeding Centre), Tadeusz Oleksiak and Wieslaw Podyma (Plant Breeding and Acclimatization Institute), Poland.

- Animal Genetic Resources Indicators in Germany — Eildert Groeneveld (Institute for Animal Science) and Jörg Bremond (Information Centre for Genetic Resources), Germany.

- *Developing Biodiversity Indicators for Livestock in Greece — A. Georgoudis (University of Thessaloniki), A. Baltas (Ministry of Agriculture), Ch. Tsafaras (Ministry of Agriculture), Ch. Ligda (National Agricultural Research Foundation), E. Danou (Ministry of Agriculture), and K. Fragos (Ministry of Agriculture), Greece.

- *Plant Genetic Resources and Agri-biodiversity in the Czech Republic — Ladislav Dotlacil, Zdenek Stehno, Anna Michalova and Iva Faberova, Research Institute of Crop Production, Czech Republic.

- Assessment of Crop Diversity in Hungary: Possible Indicators for Genetic Variation — Laszlo Holly and Bertalan Szekely, Ministry of Agriculture, Hungary.

- Agricultural Plant Diversity in Turkey — Ayfer Tan, Aegean Agricultural Research Institute, Turkey.

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1. Documents are available on the OECD website at: http://www.oecd.org/agr/env/indicators.htm, and papers marked by an asterisk are those included in this publication.

Wild Species Dependent or Impacted by Agricultural Activities

- A Perspective on Indicators for Species Diversity in Denmark — Rasmus Ejrnæs, National Environmental Research Institute, Denmark.

- *Wild Flora and Fauna in Irish Agro-ecosystems: A Practical Perspective on Indicator Selection — Jane Feehan, Trinity College and TEAGASC, Ireland.

- Agro-biodiversity Indicators for Policy Evaluation: The Experience of Emilia Romagna — Gianfranco De Geronimo, Franco Marchesi and Roberto Tinarelli, Emilia Romagna Administrative Region, Italy.

- *An Agricultural Habitat Indicator for Wildlife in Korea — Jin-Han Kim, Byung-Ho Yoo, Changman Won, Jin-Young Park and Jeong-Yeon Yi, National Institute of Environmental Research, Korea.

- *Using Bird Data to Develop Biodiversity Indicators for Agriculture — Melanie Heath and Matthew Rayment, Birdlife International, United Kingdom.

Analytical Tools for Measuring Trends in Biodiversity

- *Overview of Biodiversity Indicators Related to Agriculture in Belgium — Visi Garcia Cidad (Catholic University of Louvain), Jean-François Maljean and Alan Peeters (Institute of Nature Conservation), Geert De Blust (Institute of Nature Conservation), Belgium.

- Automated Classification of Habitats — Rasmus Ejrnæs, National Environmental Research Institute, Denmark.

- *Eco-Fauna Database: A Tool for Both Selecting Indicator Species for Land Use and Estimating Impacts of Land Use on Animal Species — Thomas Walter and Karin Schneider, Swiss Federal Research Station for Agroecology and Agriculture, FAL, Switzerland.

- New Opportunities for Habitat Monitoring: Linking Plant Species and Remote Sensing Techniques — Andreas Grünig and Erich Szerencsits, Swiss Federal Research Station for Agro-ecology and Agriculture, FAL, Switzerland.

- From Scientific Analysis to Agri-environmental Measures — Riccardo Simoncini, University of Florence, Italy, representing IUCN.

Ecosystem/Habitats Impacted by Agricultural Activities

- *Estimating Wildlife Habitat Trends on Agricultural Ecosystems in the United States — Stephen J. Brady and Curtis H. Flather, US Department of Agriculture, United States.

- *Monitoring Habitat Change in Japanese Agricultural Systems — David Sprague, National Institute for Agro-Environmental Sciences, Japan.

- Agriculture and Biodiversity: Reporting on Trends at European Level — Dominique Richard, European Topic Centre on Nature Protection and Biodiversity (EEA), France.

- Constraints in Land Use by Agriculture, Nature Protection Issues, Rural Development and Biodiversity in Various Regions of Austria — An Analytical Approach Based on Spatial Information Techniques — Peter Aubrecht, Bettina Götz and Gerhard Zethner, Federal Environmental Agency, Austria.

- How to Measure the Ecological Value of Conventional Agricultural Landscape? — Reija Hietala-Koivu (MTT Agrifood Research), Tiia Jokinen (Helsinki University of Technology) and Juha Helenius (University of Helsinki), Finland.

- *National and Regional Level Farmland Biodiversity Indicators in Finland — Mikko Kuussaari and Janne Heliölä, Finish Environment Institute, Finland.

- Environmental Indicators for Farmland Habitats: The Situation in Italy — Marco Genghini, National Institute of Wild Fauna, Italy.

- Measuring the Impact of Norwegian Agriculture on Habitats — Wendy Fjellstad, Institute of Land Inventory, Norway.

- *Developing Habitat Accounts: An Application of the United Kingdom Countryside Surveys — Andrew Stott, Department for Environment, Food and Rural Affairs, United Kingdom.

- Agri-biodiversity Indicators: A View from Unilever Sustainable Agriculture Initiative — Gail Smith (Unilever, UK), Jamie McMasters (Outsourced Environment, Australia), and David Pendlington (Unilever, United Kingdom), representing BIAC.

Linking Wild Species with their Use of Different Agricultural Habitats

- *Indicators of Agri-biodiversity: Australia's Experience — James Walcott, Jean Chesson and Peter O'Brien, Bureau of Rural Sciences, Australia.

- *Using Biological and Land Use Information to Develop Indicators of Habitat Availability on Farmland — Terence McRae and Ted Weins, Agriculture and Agri-Food Canada.

- *Assessing Biodiversity in the United States Agricultural Ecosystems — Michael J. Mac, US Geological Survey, United States.

- *The State of Agro-biodiversity in The Netherlands: Integrating Habitat and Species Indicators — Ben ten Brink, RIVM (National Institute of Public Health and the Environment), The Netherlands.

- Biodiversity Indicators in Agriculture: A Combination of Species and Habitat Approaches — Gerard van Dijk, UNEP — Regional Office for Europe, Switzerland.