OECD AGRI-BIODIVERSITY INDICATORS: BACKGROUND PAPER

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This paper provides a brief summary, not an exhaustive review, of the key points drawn from papers presented at the OECD Expert Meeting on Agri-biodiversity Indicators and an overview of recent OECD work on agri-biodiversity indicators. The Expert Papers are referenced by first author name, see the list in the bibliography, while selected tables and figures from these papers are attached in the Annex section of this paper. All the papers are available on the OECD website (except the paper by Hietala-Koivu, which is currently unavailable) at www.oecd.org/agr/env/indicators **– see under "What's New".**

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"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from the United States Hewlett Foundation Research Initiative on the Environment, the Economy and Sustainable Welfare, unpublished.

Abstract: This paper provides background to further advancing work on OECD agri-biodiversity indicators by addressing six questions: *1. What is Agri-biodiversity?* (i.e. how can the subject be defined and structured for purposes of developing indicators); *2. What is the Need for Agri-biodiversity Assessment?* (i.e. covering the policy issues and challenges relevant to indicators); *3. How can Agri-biodiversity Indicators Serve as a Tool for Policy Makers?* (i.e. in which can indicators be used as a tool for policy monitoring and evaluation); *4. Which Characteristics are Important for Policy Relevant Agri-Biodiversity Indicators?* (i.e. concerning the criteria to select indicators, the framework to organise the indicators, spatial considerations, and the resources needed to develop indicators); *5. What has OECD Achieved in Developing a Set of Agri-biodiversity Indicators?* (i.e. examining the current set of OECD agri-biodiversity indicators and proposals from experts on how these indicators could be further developed); *6. What are the Future Challenges to Advance Work on Agri-biodiversity Indicators?* (i.e. outlining some of the key challenges to further developing agri-biodiversity indicators).

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;
- 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.

Key points related to defining agri-biodiversity drawn from Expert Papers

1. There is overall agreement as to the essential components of agri-biodiversity, i.e. the genetic, species and ecosystems level, as defined under the CBD. However, Walcott (p.6-7) proposes a classification system to define the scope of agri-biodiversity that can provides a logic for indicator selection (see Annex Table 1), and avoids indicator 'shopping lists' developing with tenuous links to farm

management and policy decision making goals. Wetterich (p.1-2) also proposes to develop a matrix to organise biodiversity indicators (see Annex Table 2).

2. The ecosystem services provided by agriculture are detailed by Simoncini (p.2-3); Smith (p.6).

3. The agricultural driving forces that impact on the state and trends in biodiversity are not the focus here, but are covered through other on-going OECD work on agri-environmental indicators (AEIs), as summarised in Annex Box 1. However, many papers have examined the recent trends of the impact of agricultural activities on biodiversity, see for example: ***Australia***, Walcott (p.2); ***Denmark***, Ejrnaes, (Species paper); ***Italy***, Genghini; ***Japan***, Sprague; ***Korea***, Kim; ***Turkey***, Tan (p.9); ***United States***, Brady (p.9-10), Mac (p.1-2); while across ***Europe:*** Dijk (p.12), Richard (p.2-4). Brink (p.3) also provides a schematic view of biodiversity loss.

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

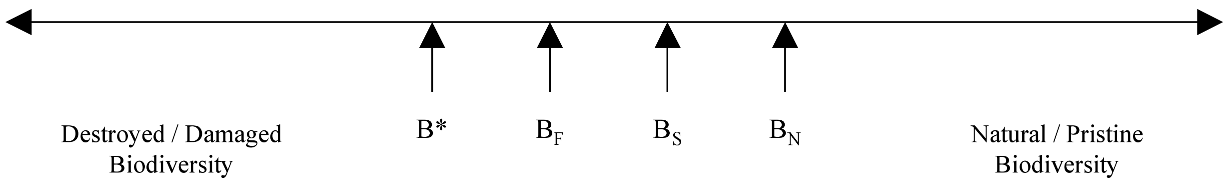
The preservation and enhancement of biodiversity poses a major challenge for agricultural policy decision makers, as world population and demand for food increase. It is estimated that, with current population trends, food production will have to increase over 20% by the year 2020 just to maintain the 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.

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).

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.

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.

Key points related to the policy context of agri-biodiversity drawn from Expert Papers

1. Most papers recognise that biodiversity conservation within agriculture has a high priority in recent policy initiatives and measures, especially associated with implementing national biodiversity action plans as part of the CBD process.

2. Most papers examine the policy context in developing agri-biodiversity indicators, including Heath (p.9-10); and for Australia, Walcott (p.1, 8-9); the EU/Ireland, Feehan (p.2-3); EU/Italy, Geronimo (p.2-3); United States, Brady (p.9-10). Collette also describes the global strategies through FAO for the management and conservation of agricultural genetic resources.

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, 2001b).

- *Agri–environmental related policy studies*, an irregular series of reports which examine different agri-environmental related policy issues, summarised in OECD (2001c). For further information on related agri-environmental studies see the web–site: 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, 2000d) and Slovenia (OECD, 2000e), 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, 1999b).

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

- *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, 2001d; and the OECD sustainable development web-site for further information: http://www.oecd.org/subject/sustdev).

Key points concerning using indicators as a tool for policy makers drawn from Expert Papers

1. A number of papers describe the need for indicators as a tool for policy makers, for example, Feehan (p.3-4).

2. Some authors provide details of their national systems used for monitoring agri-biodiversity, including: Fjellstad (p. 2-3) on Norway's 3Q monitoring programme; Brady concerning the US National Resources Inventory (p.2) and also Mac on habitat/species monitoring; Walcott (p.3-5) for Australia. Garcia-Cidad (p.13) and also Dijk provide reviews of European biodiversity monitoring initiatives.

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.

Key points related to indicator criteria drawn from Expert Papers

1. All experts agree on the need to use a set of criteria in selecting indicators to avoid the ‘shopping list’ approach, see Brink (p.9); Heath, (p3-4); Simoncini (p.4); Smith (p.3). Also Dijk (p.4), notes that the OECD and the CBD criteria for indicator selection are similar.

2. A number of experts point to the need to develop headline indicators, as well as larger sets of more detailed indicators for use in policy analysis; and that while indicators are a useful policy tool they need to be supplemented by other analytical tools and forms of policy assessment.

3. Because for many countries there is currently little baseline data to monitor agri-biodiversity, this provides the opportunity that indicator development can be problem led and not data driven (Feehan, p.12).

4. A number of experts emphasise the importance of developing standardised international biodiversity data sets, and consider that there is potential to make progress on achieving this. 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).

5. Mac (p.2) observes that indicators need to be identified on the basis of what needs to be known rather than indicators that rely only on existing data. Such indicators, even in the absence of data, can provide guidance to policy makers on the data sets that are needed for biodiversity monitoring.

6. Several experts outline criteria specific to the selection of indicators for wild species and ecosystem indicators, these are examined under the respective sections below.

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.

Key points related to the indicator framework drawn from Expert Papers

1. In terms of the framework in which to organise and develop indicators many experts have used the Driving Force-State -Response model.

2. Walcott (p.7-8) outlines an evaluation framework for agri-biodiversity which facilitates the specification of sustainability objectives and can be used at any scale (see Annex Table 3). While the author observes that conservation and biodiversity theory and management still requires more work to devise the best framework for assessing biodiversity, the evaluation system proposed begins the process of setting out biodiversity objectives in a consistent and common framework regardless of the spatial scale of analysis.

3. Garcia Cidad (p.2) classifies indicators into *means* and *result* biodiversity indicators. Means indicators are indirect measures of the status of biodiversity concerning farm management practices, while result indicators provide direct measures of biodiversity, such as species richness. The author (p.8-9) also considers a more comprehensive and integrated framework to link pressure-state-response indicators (see Annex Table 4).

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.

Key points related to spatial coverage of indicators drawn from Expert Papers

1. All experts have emphasised the importance of the need to consider the spatial dimension in developing agri-biodiversity indicators. However, the choice of indicators will depend on the monitoring objective (i.e. to help farm management, local planners, regional authorities and national policy makers), see for example, Dijk (p.2).

2. Examples of agri-biodiversity indicators being developed at regional and national scale are provided by Garcia Cidad (p.3-5; 14) for Belgium (see Annex Table 5); and also by Kuusaari for Finland.

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.

Key points related to the feasibility of completing work on indicators drawn from Expert Papers

1. For many countries extensive species and habitat monitoring is impractical and prohibitively expensive, and will require care in indicator choice and design, see Smith (p.5) for example.

2. The Canadian Habitat Matrix approach (McRae) has been developed, in part, because of the absence and expense of collecting species data. However, in the context of the United States Mac (p.5) suggests that a lack of resources for biodiversity monitoring is a limiting factor to critically assess biodiversity trends.

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).

5.1. Genetic diversity

OECD Indicator Definitions and Methods of Calculation

1. For the main crop/livestock categories (e.g. wheat, rice, cattle, pigs) the total number of crop varieties/livestock breeds that have been registered and certified for marketing.

2. The share of key crop varieties in total marketed production for individual crops (e.g. wheat).

3. The share of the key livestock breeds in respective categories of livestock numbers (e.g. the share of Friesian, Jersey, Charolais, etc., in total cattle numbers).

4. The number of national crop varieties/livestock breeds that are endangered.

The first three indicators track the extent of diversity in the range of crop varieties and livestock breeds used for agricultural production. The fourth indicator, provides information on the extent of genetic erosion and loss of domesticated varieties/breeds from the much wider genetic pool than just those varieties/breeds marketed for production.

Key points related to agricultural genetic diversity indicators drawn from Expert Papers

General comments

1. All expert papers provide a rich source of material on the status and trends in agricultural genetic resources (AGR) across OECD countries, and the current methods to monitor AGR.

2. AGR indicators need to cover genetic diversity, erosion and vulnerability (Colette, p.5).

3. Wetterich (p.2-3) provides an overview of the OECD set of AGR indicators and proposals for modifying and expanding the set (see Annex Table 6). The data sets for the proposals are considered by the author to be widely available in Europe.

4. Many experts consider it important to consider the issue of AGR in the context of different production and agro-ecosystems, e.g. organic, low input, intensive, etc (Dotlacil, Georgoudis, Tan).

5. A view expressed by many experts, is that indicators of within crop/livestock population variance should be included into the OECD set.

6. Smith (p.3) is considering assessing the access of farmers to new genetic material and whether appropriate breeding and selection programmes are in operation.

7. Accession of crops and livestock in *ex-situ* storage is used in Belgium as an AGR indicator (Garcia-Cidad, p.4).

Crop diversity indicator proposals

1. A number of experts have proposed to include indicators of the number of crop species in commercial use (Wetterich, p.9;) and the share of crops in the total agricultural land area (Dotlacil, p.12; Garcia-Cidad, p.4; Liro, p.4; Wetterich, p.10). The latter indicator is covered under "Intensively farmed agricultural habitats" (see below under *Ecosystem Diversity*, 5.3).

2. Wetterich (p.9-15) proposes a range of crop genetic resource indicators, summarised in Annex Table 6.

3. An indicator of the number of national endangered crop varieties is not yet feasible for some countries (Liro, p.6-7; Wetterich, p.3, 15)

4. The incidence of local cultivars and landraces in cropping systems is proposed by Dotlacil, p.12.

5. An indicator of within population variance should be included, according to Smith, p.4.

6. Replacement of indigenous crops is an indicator proposed by Garcia-Cidad, p.4.

Livestock diversity indicator proposals

1. Wetterich (p.4-8) proposes a range of livestock diversity indicators, summarised in Annex Table 6.

2. Interpreting changes in the indicators of the number of breeds registered for marketing can be difficult (Groeneveld, p. 3-4).

3. An indicator of within population variance should be included, according to Groeneveld, p. 4.

4. A more precise definition of endangered livestock breeds is required (Georgoudis, p.5; Groeneveld, p. 4).

5. An indicator of the location of the herds/flocks and the number of existing types of production systems, e.g. extensive, intensive, etc., is proposed by Georgoudis, p.6-7.

5.2 Wild species diversity

OECD Indicator Definition and Method of Calculation

1. Trends in population distributions and numbers of wild species related to agriculture.

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. To a large extent this reflects differences in policy priorities, availability of data, and varying stages of scientific research on biodiversity issues. These different approaches have varying advantages and disadvantages in terms of accuracy, sensitivity, feasibility and cost.

Key points related to wild species indicators drawn from Expert Papers

General Comments

1. All expert papers provide a rich source of material both on the status and trends in wild species using agricultural land as habitat across OECD countries, and also the current methods to monitor changes in wild species populations and distributions.

2. The criteria to objectively test that a given wild species is an ideal indicator are described by a number of experts, see for example, Brink, p.10 and Annex Table 8; and also Feehan, p.7-8. Garcia-Cidad (p.13) also notes the advantage of using specific species or plant communities as indicators which can provide important information on the interactions between farming practices and biodiversity.

3. Developing indicators of wild species that are of economic importance to agriculture (e.g. pollinators, soil biodiversity) should be considered (Feehan, p.8; Smith, p.6).

4. Ejrnaes (Species paper, p.6-7), suggests that the OECD wild species indicator be modified to "Trends that can be related to agricultural pressures, in population distributions and numbers of wild species". The objective of this change is to make it apparent that changing diversity has many causes, but the policy maker is only concerned with changes caused by human pressure on the environment. A matrix could be developed that reveals the different pressures on varying wild species (see Annex Table 7).

5. The issue of species abundance versus species richness indicators is discussed by a number of experts (Ejrnaes Species paper, p.7; Heath, p.22).

Bird Indicators

1. The basis of Birdlife International's (see Heath, p. 7-9) indicator reporting system for birds consists of three elements:

Important Bird Areas (i.e. core habitats for birds, see Heath, p.10-14);

Widespread and Common Species (i.e. birds with a widespread distribution, see Heath, p.15-18); and,

Rare and Restricted Range Species (i.e. threatened and endangered bird species, see Heath, p.18-22). The extent of this monitoring system across OECD countries is given in Annex Table 9 (from Heath p.8).

2. Other experts are also using bird species as an indicator to assess the effectiveness of agri-environmental schemes (Geronimo, p.4; Garcia-Cidad; Kim).

Other Species

1. Other species indicators are being used by some experts to monitor the impact of agri-environmental schemes on wildlife, including plants (Geronimo, p.4, Feehan, p9-11; Garcia-Cidad; Kuussaari; Smith, p.4-6); insects (Feehan, 9-11; Garcia-Cidad, p.4; Kuussaari; Smith, p.4-6), including butterflies (Kuussaari, p.6-8; and Walter); and mammals (Garcia-Cidad; Kim, p.4; Kuussaari; Smith, p.4-6).

5.3. Ecosystem diversity

Ecosystem diversity indicators represent the ‘quantity’ aspect of biodiversity shown at the base of the rectangle in Figure 2. There are three categories draw on the classification of agricultural land into intensively farmed, semi-natural, and uncultivated natural habitats.

1. Intensively farmed agricultural habitats

OECD Indicator Definitions and Method of Calculation

1. The share of each crop in the total agricultural area.

2. The share of organic agriculture in the total agricultural area.

Intensively farmed areas are artificial habitats subject to regular disturbance of the soil and dominated by annual/perennial crop species. The value of these areas as habitat is generally low, because of the paucity of non-crop vegetation combined with the use of pesticides, but they do provide habitat for some vascular plants, invertebrates, small mammals and birds. Often they are temporarily valuable habitats for migratory birds. The richness and abundance of wildlife on intensively farmed land will vary according to the:

- *Type of crops cultivated:* cereals, oilcrops, improved grassland, etc.

- *Methods of production:* farm management practices covering nutrients, soil, water, etc., and the farming system, such as ‘conventional’, ‘integrated’, ‘organic’, etc.

- *Spatial composition of the cultivated areas*: field size, cropping patterns, etc.

- *Proximity to other categories of habitats*: semi-natural and uncultivated natural habitats.

2. Semi-natural agricultural habitats

OECD Indicator Definition and Method of Calculation

1. The share of the agricultural area covered by semi-natural agricultural habitats.

Semi-natural agricultural habitats can be characterised in terms of areas of farmland where the use of farm chemicals is either totally absent or they are applied at considerably lower rates per unit area than in more intensively cultivated areas. Also these habitats are relatively undisturbed by farming practices, such as from ploughing, mowing, and weeding. Typically, semi-natural habitats arise through interaction with other ecosystems, and can be broadly classified as follows:

- *Semi-natural habitats typical of agricultural ecosystems,* such as extensive grassland and pasture; fallow land; extensive margins in cropped land; and 'low intensity' permanent crop areas, including certain fruit orchards and olive groves.

- *Semi-natural habitats arising from the interaction between agricultural and aquatic ecosystems,* including some types of wetlands exploited for agricultural use, such as grazing in marshes and water meadows.

- *Semi-natural habitats arising from the interaction between agricultural and forest ecosystems,* including agro-forestry and pastoral woodland.

- *Semi-natural habitats arising from the interaction between agricultural and mountain ecosystems,* including alpine pastures and grass patches.

- *Semi-natural habitats arising from the interaction between agricultural and steppe ecosystems,* ranging from semi-arid to desert steppe, including dry meadows and pastureland.

3. Uncultivated natural habitats

OECD Indicator Definitions and Method of Calculation

1. The net area of aquatic ecosystems converted to agricultural use.

2. Area of "natural" forest converted to agricultural use.

No commonly accepted definition of 'uncultivated natural habitats' exists, but it is generally considered to include those habitats that are on, crossing, or bordering agricultural areas. The main examples include: small ponds, lakes and rivers, unexploited wetlands, bogs and other aquatic habitats; natural woodlands and forests; and rocky outcrops. The indicators developed here focus on two of these habitat: aquatic ecosystems, in particular, wetlands; and 'natural' forests, by tracking changes in the net area of these habitats converted to agricultural use.

The net area of ***aquatic ecosystems****,* such as unexploited wetlands, bogs, small ponds, lakes, and diverted rivers, converted to agricultural use gives an estimate of the loss of aquatic ecosystems through drainage or reclamation for farming offset by the restoration or reversion of these ecosystems from agricultural use. The conversion of agricultural land back into an aquatic ecosystem, may in some cases be part of efforts to help reduce flooding by the reclamation of farm land in order to increase the free flow of dammed rivers. In other instances this restoration has the objective of restoring the ecosystem as a valued aquatic environment.

The area of ***natural forest*** converted to agricultural use, encompasses both natural "primary" forest, such as areas of tropical rainforest, and also "secondary" forests. Secondary forests are those forests which are, or have been commercially exploited, and in which the physical conditions and diversity closely resemble the natural state, having developed over a long time period. There is generally a contact zone with agriculture, where forests have been cleared for farming through cutting and burning. Farm land is also restored back to use as woodland or forest, and a "net change" approach might be appropriate in these cases. However, the main concern here is the destruction of 'natural' forest which even if restored could take hundreds of years, if not more, to return to its 'original' state.

Key points related to ecosystem indicators drawn from Expert Papers

General Comments

1. Many expert papers provide a rich source of material on the status and trends in agricultural ecosystems across OECD countries, especially concerning semi-natural agricultural ecosystems.

2. The criteria to objectively test the variability of habitat indicators is described by a number of experts, see for example, Aubrecht, p.5 and Annex Table 10. A key criterion for many experts is that indicators of agricultural ecosystems should include all agricultural land and not just the most valued habitats (see for example, Brady, p.9).

3. There is need to improve international definitions, classification systems and standards for land use and land cover types (Fjellstad, p.11). In the paper on automated habitat classification by Ejrnaes, he suggests a possible way to improve habitat classification, particularly related to semi-natural agricultural habitats (p.5).

4. Rather than develop indicators for different types of agricultural habitats, the United Kingdom is developing habitat accounts which provide a framework to analyse and present complex changes across all types of agricultural habitats (Stott, see also Annex Table 11). Such an accounting framework can provide insights into what is meant by sustainable agriculture, and can offer an integrated, cross-sectoral and transparent view of environmental capital.

5. Aubrecht (p.12-13) proposes a set of indicators that help identify the protection status and trends of agricultiral land (i.e. land with a high status implies biodiversity on that area should at a minimum remain on the endangered status). The indicators also reveal the extent of agricultural land currently under nature protection schemes, and the conversion of agricultural land to other uses. Smith (p.8) also proposes the identification of agricultural areas of high biodiversity value.

6. Many countries are developing indicators to track land use changes both between different agricultural uses (e.g. pasture to wheat) and across different sectors (e.g. land conversion from agricultural to use for forestry). The UK habitat account (Stott) is based on this approach, but see also Aubrecht (p.15); Brady (p.3-5); Garcia-Cidad (p.4); and Richard (p.6).

7. The importance of the spatial aspects of agricultural habitat change are highlighted in many papers. A number of papers examine indicators that express spatial variation in habitats, including habitat patch size and fragmentation indices, see Brady (p.5-9); Fjellstad (p.7-10); Genghini (p.7); Hietala (p.4); and Walcott.

8. Smith (p.12) has found in her research that habitat based indicators are more useful that species based indicators, because habitats are a more stable part of the ecosystem and are the components over which farmers have most control.

Intensively Farmed Habitats

1. In distinguishing between intensive and semi-natural habitat, care is required when applied across different farming systems (see Genghini, p.7, and Sprague).

2. Under the discussion of genetic diversity indicators, a number of experts have proposed to include indicators of the number of crop species in commercial use (Wetterich, p.9;) and the share of crops in the total agricultural land area (Dotlacil, p.12; Garcia-Cidad, p.4; Genghini, p.8-9; Liro, p.4; Smith, p.8; Walcott, p.3, 12; Wetterich, p.10).

Semi-Natural Habitats

1. A number of experts consider that developing indicators of grassland (rangeland) health is a key aspect of monitoring the status and trends of semi-natural habitats in agriculture (see Dijk, p.11-12; Mac, p3-4; Richards, p.6; and Walcott, p.4, 13-14).

2. Linking semi-natural agricultural types in a matrix to different farm management practices is an approach being developed by a number of experts, both to help better define semi-natural habitats and also focus on the key driving forces impacting on these habitats (see Annex Table 12 drawn from Genghini, p.9-11; and Fjellstad, p.3). The issue of linking the status and trends in habitat condition to farm management practices is further discussed under the final section of this paper concerning future challenges.

Uncultivated Habitats

1. For some experts there are difficulties with interpreting the meaning of a change in the indicators related to the net changes in areas of aquatic ecosystems and natural forests (see Fjellstad, p. 4-5, 10; Sprague).

5.4 Linking Wild Species and Ecosystems

OECD Indicator Definition and Method of Calculation

1. A habitat matrix identifies and relates the ways in which wild species use different agricultural habitat types.

The habitat matrix identifies the ways in which various wild species use agricultural habitat types, ranging from cropped land to uncultivated habitat on agricultural land, and then relates this use to changes in the areas of these habitats. The indicator is then used to identify which habitat types on agricultural land support the most wildlife use and whether these habitat types are increasing, decreasing or remaining constant over time (this approach draws on Neave, *et al* 2000; and Neave and Neave, 1998). The methodology recognises that all farm land has some value as habitat. The matrix explicitly incorporates information on how various species use farmland to meet their habitat needs. It is also restricted to habitat change occurring within the agricultural land base only and not that due to other land uses. The agricultural land base is defined to include areas of uncultivated natural habitat (e.g. marshes) and man-made features on agricultural land (e.g. farm buildings).

To construct the matrix it is necessary to identify how different species use various agricultural habitats. To accomplish this, *habitat suitability matrices* are developed individually for the main agricultural ecozones across a country (or bio-regions). These matrices incorporate information on all flora and fauna, or more partial information where detail for all taxonomic groups does not exist. The particular use each species makes of agricultural land habitats in each ecozone (see below) is then identified. Each "habitat use" is ranked according to how dependent a species is on a certain habitat for this use, including:

- *Primary use,* meaning that a species is dependent on, or strongly prefers, a certain type of habitat (also called *critical habitat*).

- *Secondary use,* meaning that a species uses a certain habitat (e.g. to obtain food in the case of fauna) but is not dependent on it.

Matrices for each specified ecozone are then collected. This information might be assembled from a range of sources, depending on the quality and quantity of data available in any given country, including written sources, expert judgements by wildlife and agricultural specialists and, ideally, actual field survey data of wildlife species. Once the matrices are completed, primary and secondary habitat use entries are summed separately into five main categories (this applies to fauna only), including first, breeding, nesting, and reproduction; second, feeding and foraging; third, cover, resting, roosting, basking, and loafing; fourth, wintering; and fifth, staging (for birds only).

Each separate use of a habitat type by a species is recorded as a *habitat use unit*, that is not the number of species using the habitat, but the number of individual ways in which the habitat is used, such as, for feeding and nesting, these habitat use units are then summed by habitat type for each ecozone. The habitat types can correspond to any classification system for which data is available, but for many countries, at present, this will generally correspond to the main land use categories defined in the annual Census of Agriculture. In general, the habitat matrix can provide an alternative or surrogate for the wild species diversity indicator. Where species population data is not available the matrix approach can provide an indirect measure for species diversity.

Key points related to indicators linking wild species and ecosystems drawn from Expert Papers

1. Identifying ways in which various wild species use agricultural habitat types is considered in a number of expert papers, which can be categorised into three approaches:

Habitat Matrix: McRae, has developed a habitat matrix, drawing on data in Canada, which is the basis of the OECD indicator described above.

Landscape Approach: Kuussaari, provides an approach that identifies in Finland numbers of threatened species (flora and fauna) according to different agricultural landscapes (habitat types), with further detail provided for butterflies.

Natural Capital Index: Brink, has developed the Natural Capital Index (NCI) which combines into a single index attributes of habitat quantity and quality, drawing on data from the Netherlands.

2. Commenting on the ***Habitat Matrix*** various experts have raised the following points:

-- A strength of this approach is that is covers all agricultural land (Dijk, p.7), and can be calculated on the basis of currently existing data which can be improved as more and better quality data become available (Fjellstad, p.6; Genghini, p.15). The matrix can also highlight areas of inadequate knowledge (Fjellstad, p.6; Genghini, p.15).

-- Weaknesses of the approach include: 1) that the species (habitat quality) are not directly monitored (Dijk,p7) (but this could be included where data is available); 2) the matrix does not take into account different farming practices and systems (Fjellstad, p.6) (again this could be improved where data is available, such as areas of organic agriculture, but Fjellstad, p6-7, observes there are also limitations in the extent to which different farming systems can be defined in terms of their varying biodiversity impacts); 3) there are limitations with this approach in that vegetative cover types can be poor in representing patterns of vertebrate biodiversity (Brady, p.11); and, 4) there may be important differences in biodiversity within habitats (ecozones in the Canadian example) relative to the differences between ecozones (Dijk,p.7).

3. Commenting on the ***Natural Capital Index*** (NCI) various experts have raised the following points:

-- The NCI has the strengthen of a balanced approach of combining information on habitat quantity and quality (species) (Dijk, p.9), and draws on actual species data (Fjellstad, p.6). The approach could be improved by including the main types of farmland, instead of all agricultural land (Dijk, p.9).

-- A particular problem for the NCI is determining a suitable baseline from which changes are monitored (Dijk, p.9). In the paper by Dijk (p.13) he proposes how the NCI could be improved.

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, 1999d). 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 TABLES, FIGURES AND BOXES

The Annex Tables and Figures provided here are drawn from Expert Papers, except Annex Box 1 which provides the complete list of the current set of OECD Agri-environmental Indicators.

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 research
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 methods – 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 emissions*
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.

Annex Table 1 – Walcott, p. 6

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

Annex Table 2 – Wetterich, p. 2

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:

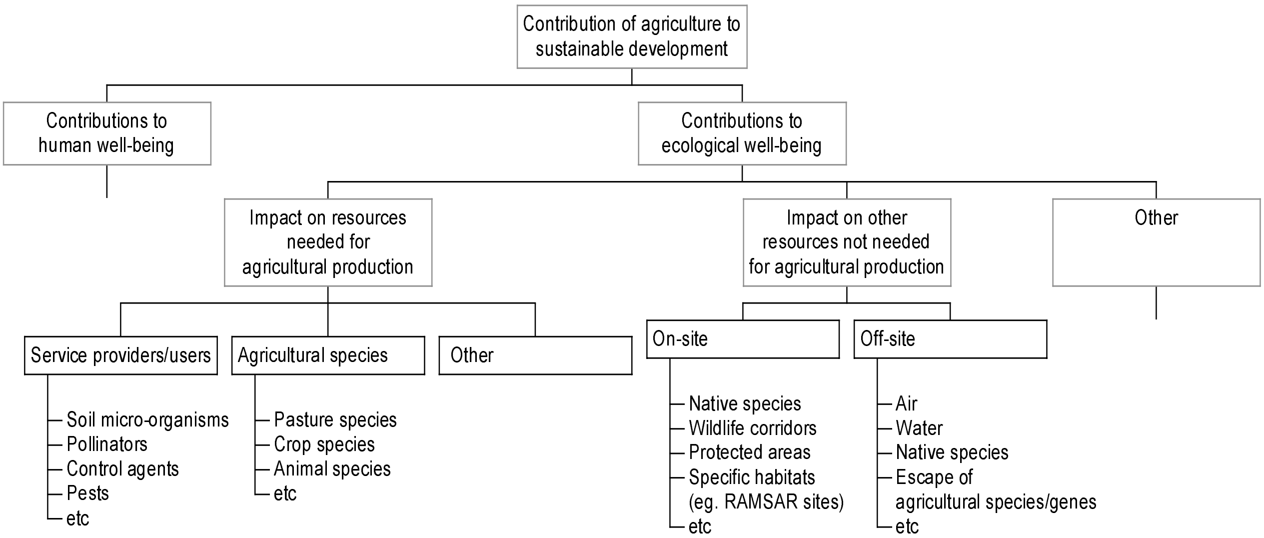
Biodiversity			**Wildlife Habitats**
Non-native Species	Genetic Diversity (→ livestock, crops)	Species Diversity (→ wildlife species)	(→ wildlife species)

Classification of agri-environmental indicators suggested in this work:

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

Source: CBD, 1992; OECD, 2001; own

Figure 1. A hypothetical example of an ESD framework applied to agriculture with components relevant to agri-biodiversity shown in expanded form.



Annex Table 4 – García Cidad, p.9

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

Annex Table 5 – García Cidad, pp. 4-5

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

[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.

Annex Table 6 – Wetterich, p. 3

Table 2: 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 breed's 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 heterogenous and homogenous 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; own

Annex Table 7 – Ejrnaes, Species paper, p. 7

Table 2. Sensitivity of different species groups to recognised agricultural pressures in semi-natural meadows and grasslands.

Pressures	Vascular plants[1]	Bryophytes[2]	Birds[1]	Butterflies[2]
Fertiliser application	+++	+++		+++
Dereliction	+	+++	+	++
Drainage	+++	+++	+++	+++
Fragmentation (e.g. past habitat destruction)	+		+	+++

1. Easy to identify and count.
2. Complications regarding sampling or species identification.

Annex Table 8 – Brink, p.10

Appendix 2: 10 considerations for choosing species (quality variables[2])

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.*

[2] In this case, mainly species have been choosen as quality variables to assess ecosystem quality. It is also possible to chose structure variables at the ecosystem level (i.e. ratio of dead and living wood) or ecosystem processes.

Annex Table 9 – Heath, p. 9

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)

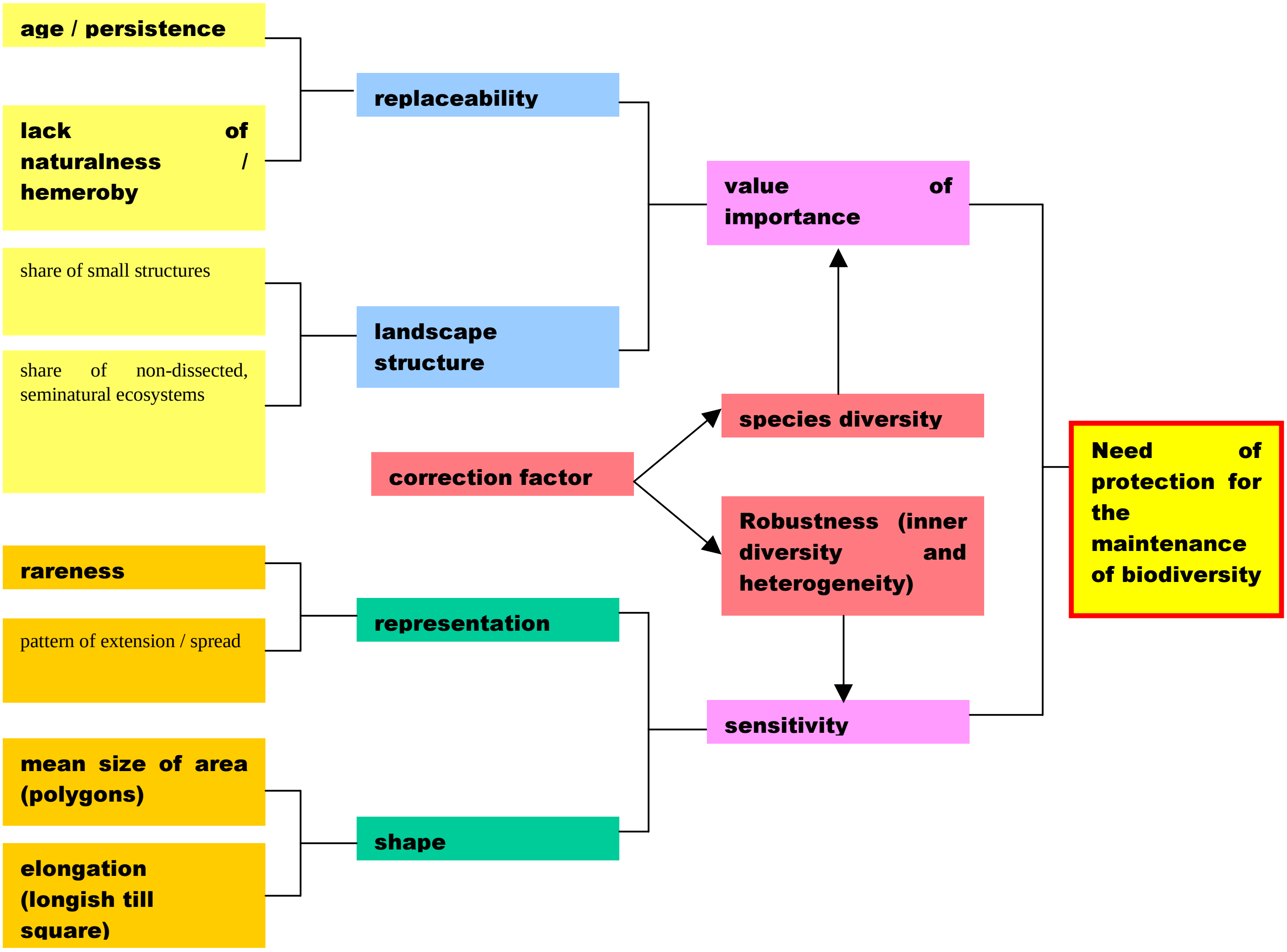


Fig. 2: Decision tree for ecological evaluation of Austrian cultural landscapes (WRBKA et al., 2001, modified)

The “replaceability” of landscapes results from the combination of the criteria “age” or “persistence” and “lack of naturalness” or “hemeroby”. Old, seminatural ecosystems are not replaceable because they are beyond man’s time and planning horizon and cannot be restored within short periods of time. The replaceability of very young ecosystems lacking naturalness, among them industrial and settlement areas, ruderal sites and fallow land, is very high due to their dynamic development.
WRBKA *et al.* (2001) lately aggregated the criteria “replaceability” and “existence/richness of seminatural ecosystems” to one value which is meant to describe the importance of Austria’s cultivated and natural landscapes to the maintenance of biodiversity.
Consequently, the need to protect landscapes results from the “importance of biodiversity maintenance” and the “sensitivity” of the respective areas. It is highest in areas of rare, small-structured landscapes or in landscapes important to the maintenance of biodiversity.

Annex Table 11 – Stott, p. 6

Table 5. Pilot habitat account for Great Britain, 1990-1998. *Source: Countryside Survey 2000.*

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
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.

Annex Table12 – Genghini, p. 10

Table 4 – Extensive or low intensive agricultural cultivations*

HABITATS	MANAGEMENT	PRODUCTION PRACTICES
Extensive permanent grassland	**No fertilisers treatments (mineral or manure) and no pesticides treatments**	Fodder production (maximum two cuts per year) and limited grazing. Grazing limited to short periodes (1-2 weeks), maximum twice a year.
Low intensity permanent grassland	Low fertilisers use (only manure) and no pesticides treatments	Fodder production (maximum two cuts per year) and limited grazing. Grazing limited to short periodes (1-2 weeks), maximum twice a year.
Meadows used for litter	No fertilisers and no pesticides	Primarily cut for litter, hence not used for fodder. Meadows maybe on marsh land.
Extensive pastureland	**No fertilisers treatments (apart from manure from livestock grazing) and no pesticides treatments**	Grazing with low animal density or limited to short periods.
Wooded pastureland	**No fertilisers treatments (apart from manure from livestock grazing) and no pesticides treatments**	Wood cover on 5-50 % of pasture area.
Extensive cultivation of winter cereals	**Low fertilisers use (only manure), no pesticides treatments and no irrigation**	Stubbles mantained for long period.

*(OECD, 1998 mod.; Genghini and Busatta, 2001)

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