Environmental Indicators for Agriculture

Methods and Results

Volume 3

2001
The attached paper is a chapter in the OECD publication (March 2001) *Environmental Indicators for Agriculture Volume 3: Methods and Results*, Paris, France. The Table of Contents of the Report, including the attached chapter, are as follows:

**EXECUTIVE SUMMARY** *(Separate publication, available as a pdf file see below)*

**Background and Scope of the Report**

**Part I:** *Agriculture in the Broader Economic, Social and Environmental Context*

1. **Contextual Information and Indicators**

   Consideration of the influence on agri-environmental relationships of economic forces, social preferences, environmental processes, and land use changes.

2. **Farm Financial Resources**

   The effects of farm level incomes and public and private agri-environmental expenditures on environmental outcomes.

**Part II:** *Farm Management and the Environment*

1. **Farm Management**

   The relationship between different farming practices and systems and their impact on the environment, covering whole farm management practices, including organic farming, as well as nutrient, pest, soil and irrigation management practices.

**Part III:** *The Use of Farm Inputs and Natural Resources*

   The use of farm inputs and natural resources, covering:

   1. **Nutrient Use** (i.e. use of fertilisers and livestock manure, and nutrient use efficiency)
   2. **Pesticide Use and Risks**
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**Part IV. Environmental Impacts of Agriculture**

The environmental impacts of agriculture on:

1. **Soil Quality**
2. **Water Quality**
3. **Land Conservation**
4. **Greenhouse Gases**
5. **Biodiversity**
6. **Wildlife Habitats**
7. **Landscape**

The *Main Report*, containing over 400 pages with nearly 60 tables and 100 figures (also available in French), is also available in summary form as the *Executive Summary* which can be downloaded free of charge from the OECD agri-environmental indicator website at: [www.oecd.org/agr/env/indicators.htm](http://www.oecd.org/agr/env/indicators.htm) The Main Report can be ordered through this website.

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Context

Agriculture as the human activity occupying the largest share of the total land area for nearly all OECD countries, plays a key role with regard to biodiversity which is highly dependent on land use. The expansion of farm production and intensification of input use are considered a major cause of the loss of biodiversity, while at the same time certain agro-ecosystems can serve to maintain biodiversity. Farming is also dependent on many biological services, such as the provision of genes to develop improved crop varieties and livestock breeds, crop pollination, and soil fertility provided by micro-organisms. In some cases non-native species cause damage to crops from alien pests and competition for livestock forage.

The main focus of policy actions in the area of biodiversity has been to protect and conserve endangered species and habitats, but some countries have also begun to develop more holistic national biodiversity strategy plans. These plans usually incorporate the agricultural sector in biodiversity conservation. At the international level a range of agreements are also important in the context of agriculture and biodiversity, most notably, the International Convention on Biological Diversity.

Indicators and recent trends

A number of biodiversity indicators are being established by OECD within the general framework of genetic, species and ecosystem diversity (the latter is covered under Wildlife Habitat indicators). The indicators provide a coherent, but initial, picture of biodiversity in relation to agriculture.

Concerning genetic diversity, three indicators cover the diversity of crop varieties and livestock breeds used by agriculture. Overall these indicators reveal that diversity has increased for many OECD countries since the mid-1980s, in terms of the share of varieties/breeds in total crop production/livestock numbers. This suggests agriculture has improved its resilience to environmental changes through diversifying the number of varieties/breeds used in production.

A fourth genetic diversity indicator provides information on the extent of genetic erosion and loss of agricultural plants and livestock. While information on genetic erosion or loss is incomplete, evidence for a limited number of countries suggests significant losses and/or the endangerment of loss of genetic resources in agriculture over recent decades. The collections in genebanks, however, in general continue to grow, both public and private collections.

Indicators for species diversity cover trends in population distributions and numbers of: i) wildlife species dependent on or affected by agriculture, and ii) non-native species threatening agricultural production and agro-ecosystems.

While information on the impact of agriculture on wild species is limited for many OECD countries, it appears agricultural land provides an important habitat area for the wildlife that remains following the conversion to agricultural land use, but especially birds, vascular plants and some invertebrates, such as butterflies. Also, the population trends of wildlife species using agricultural land as habitat indicate in most cases a reduction over the past decade. This represents the continuation of a longer-term trend, although the decline has slowed or even reversed over recent years in some countries. Even so considerable numbers of wildlife species using agricultural land as habitat are under threat of being lost.

For non-native species, there is no systematic time series available across OECD countries, although their harmful effects on agricultural production and agro-ecosystems are reported for many countries. There has been a long history of non-native species introductions across countries, with the extent of economic losses to farming and damage to native biodiversity from their introduction varying widely.
1. Background

Policy context

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 by 24 per cent by the year 2020 just to maintain the existing levels of food consumption and without any significant expansion of agricultural area. Policy makers will therefore need to find ways of minimising the conflicts between expanding production and biodiversity conservation, enhancing the many complementarities between agriculture and biodiversity, and finding ways to prevent the loss of biodiversity on agricultural land (Pagiola and Kellenberg, 1997).

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 natural and semi-natural 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 (Smith, 1996).

In practice, implicitly or explicitly, government policy towards biodiversity involves balancing the trade-offs between socio-economic values and biodiversity conservation. Typically policy target options with a low level of ambition (such as target 1 in Figure 1, the threshold level below which species are endangered), can avoid short-term costs but may potentially lead to costs over the long term, such as risks to agricultural production due to genetic erosion. Different policy options and targets with a higher level of ambition toward biodiversity conservation (such as targets 2 and 3 in Figure 1), will require scientific research, including developing biodiversity indicators. Indicators can help support the decision-making process by providing information about the risks and degrees of sustainability associated with these different options.

Figure 1. Policy target options for biodiversity

Source: Adapted from Ed van Klink (National Reference Centre for Agriculture, The Netherlands), presentation to the OECD Workshop on Agri-environmental Indicators, York, United Kingdom, September, 1998.
Environmental Impacts of Agriculture

Up to present the main focus of policy actions in the area of biodiversity has been to protect and conserve endangered species and habitats. Many OECD countries have introduced legislation for the protection of specific endangered species and habitats, and also designated certain areas as biosphere reserves, nature parks, and other protected sites.

In moving toward a more holistic approach, some OECD countries have begun to develop national biodiversity strategy plans, 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.

In most OECD countries a wide spectrum of organisations are also involved in the conservation of plant and animal genetic resources. However, the way these conservation efforts are organised varies across countries, ranging from involvement of governmental and non-governmental organisations, and from amateur collections to commercial companies. Some countries have national genebanks, others have several specialised agricultural research institutes responsible for the maintenance of agricultural genetic resources, while some countries work together in regional genebank networks.

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 (Box 1). 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 (Box 1). 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 (see Box 6), 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 in North America, including the role of agriculture (CEC, 2000).

Environmental context

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 falling 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 interactions between agriculture and biodiversity are complex and diverse. This complexity is, to a major extent, reflected in the large range of services that biodiversity provides to society as, for
example, illustrated in Box 2 for New Zealand. The importance of biodiversity for agriculture involves (OECD, 1996, p. 20):

- facilitating the functioning of ecosystems, 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 definition of biodiversity (Box 1):

- **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 three levels of diversity is dependent on the health of each other, as genetic diversity fosters the survival of species, enabling it to adapt to changing ecosystem conditions (see also Box 1 in the Wildlife Habitats chapter). A loss of species or the introduction of non-native species, can disturb the ecosystem diversity and alter its resilience to further changes (OECD, 1997).

**Genetic diversity**

Genetic diversity provides the means for agriculture to improve crop and livestock yields. Selective plant and animal breeding programmes in all OECD countries, drawing on a variety of genetic material, has helped to increase agricultural production with fewer inputs. In the United States it is estimated that genetic improvement increased crop yields by 29% from 1940 to 1980.
estimated that over the past 60 years, half of agriculture’s productivity increases can be attributed to genetic improvements.

Traditionally farmers have relied on “landraces”, that is, varieties of crops or livestock breeds developed over many generations to raise yields. As these “landraces” have been adapted for specific environmental conditions and farming systems, the genetic diversity is usually very high. With the advent of modern “hybrid” breeding methods, which selects for specific desirable traits such as pest and disease resistance, maturation and stature, the yields of crops and livestock have been raised substantially. This process is likely to be accelerated with recent developments in biotechnology, such as those involving genetic modification, cloning, and other such technologies. These “new” technologies, however, have also raised concerns about their possible effects on human health, wild species, genetic erosion, the environment and development of genes resistant to pesticides.6

While more recent advances in genetic improvements have helped raise agricultural productivity, the short-term strategy of relying on a “relatively” small number of varieties/breeds has raised concerns about the greater susceptibility to the risks of pests and diseases spreading through a crop variety or livestock breed. Often quoted examples include the 15 per cent reduction in United States maize yields due to the southern maize leaf blight in the early 1970s causing an estimated loss to producers and consumers of more than US$2 billion. Also, the citrus canker led to the loss of 12 million orange and grapefruit trees in Florida, United States, in the mid-1980s.

Breeding commercial species with wild relatives, however, has played a critical role in combating pests and diseases (Perrings, 1998). A Mexican maize variety led to the recovery of the United States maize crop following losses from the maize leaf blight in the early 1970s and a gene from an Ethiopian barley variety has provided protection for the barley crop in Canada and the United States (California). In general, hybrid crop varieties developed for a specific pest or disease resistance trait retain their resistance for an average of 5 to 8 years, while it usually takes 8 to 11 years to develop new varieties.

Farmers usually react quickly to the financial returns on the crops they cultivate and this can result in rapid changes in the areas of different crops and crop varieties under cultivation. Hence, plant and livestock breeders need to continually search for infusions of new genetic material to maintain and improve yields. In this context, national and international efforts to collect, preserve and utilise plant and animal genetic resources from landraces and “wild” relatives are of vital importance.

Species diversity

While estimates of the global total number of species vary greatly, it is clear that the total number is very large.7 In the context of agriculture, biodiversity “richness” can differ according to specific climatic and agro-ecosystem conditions, and the type of farming management practices and systems adopted. Farming systems based on multiple crops and livestock with natural pasture areas are richer in biodiversity than monocultural farms. However, regardless of the type of farming system, agriculture by seeking to maximise the yield of a limited number of plant and animal species, inevitably weakens and reduces competition from other unwanted species (Debailleul, 1997).

Species diversity and its relationship with agriculture is important in a number of different ways, which can be categorised as follows:

- **Species supporting agricultural production systems**, the so called “life-support-system”, that is crypto-biota, including soil micro-organisms, earth 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.

Important amongst the species that support agricultural production systems are soil micro-organisms or soil biodiversity, although soil life covers an extremely wide range of forms from viruses to mammals.8
main functions of soil micro-organisms are in processing part of the nitrogen and carbon cycle, and thereby, safeguarding soil fertility, although research in this area is still at an early stage (see Soil Quality chapter).

For insect pests the presence of predators is important to agriculture, but where pesticide use has been poorly managed, this has led to the reduction of predator populations, leading to more serious pest outbreaks. Pollinators, mainly insects, are also vital to the production of some agricultural crops. The recent outbreak of a parasitic mite, varroa, in bee populations in North America and Europe, for example, has reduced yields for some crops in affected areas. Bee colonies are also adversely affected, not only by parasitic mites or infectious bee diseases, but from the poor management of pesticides.

**Wild species are also affected by agricultural activities**, especially in OECD countries where agriculture usually occupies the major part of the national land surface area and thereby provides a key habitat for wild species. Even where agriculture's share of the total land area is small, agriculture can increase the diversity of habitat types. The degree to which wild species use agricultural land as habitat range from marginal use, for example some migratory birds, to complete dependence on agro-ecosystems, such as certain insects and plants.

Agriculture may also affect wild species that use other habitats that are in close proximity to farming areas, such as adjacent forest and coastal areas. In addition, there are wild species that have the possibility to provide potential benefits for agriculture in the future, either to be harvested or serve as inputs in improving the breeding stock, as previously described.

The relationship between agriculture and non-native species concerns their impact on agricultural production and indigenous ecosystems. Non-native species cover alien, exotic or non-endemic species, including plants, vertebrates, invertebrates and pathogens, and can be divided into three categories: intentional introductions, intentional introductions with subsequent escape, and unintentional introductions (Mac et al., 1998, p. 118). Intentional introductions can have positive benefits to agriculture, such as introductions of alien varieties and breeds to increase food production or for biological control purposes. The introduction of non-native species, either escaped species from intentional introductions and/or unintentional introductions, can result in biodiversity destruction by predation, habitat alteration and the out-competing of native species. This can also lead to economic costs to farmers through damage to crops from alien pests and weeds and competition for livestock forage, such as rabbits in Australia.

**Ecosystem diversity**

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.

In some cases agricultural land use patterns and practices support the conservation and sustainable use of biodiversity, while in others they cause serious threats. In this context, agriculture generates both benefits and pressures on biodiversity, which vary across different regions and countries depending on local farming practices, biogeography, grazing periods, climate and other factors. Farming communities have an intrinsic interest in ensuring that land use practices are sustainable and contribute to the conservation and sustainable use of biodiversity. Some semi-natural agricultural habitats can be preserved only if appropriate farming activities are continued. In many situations where agriculture production is a key element to sustain certain ecosystems, the change in land use from agriculture to other uses can lead to the degradation of some ecosystems.

It is evident that both within and across different OECD countries there is considerable ecosystem diversity in agriculture, and that in some cases certain types of biodiversity in semi-natural habitats are dependent on specific farming practices (e.g. low inputs, transhumance) and systems (e.g. alpine pasture, agro-forestry). In Scandinavia, for example, “traditionally” managed hay meadows are one of the most species-rich habitat types to be found in the region, with estimates of 50-60 plant species per square metre not uncommon (Norderhaug, 1987). Also in Britain, 40 species of butterfly (over 70 per cent...
of the butterfly fauna) breed entirely or mainly in agricultural ecosystems of open grassland and hedgerows (Thomas, 1984). Similarly, in a sub-alpine region of Central Switzerland, Erhardt (1985) recorded over 30 butterfly species in unfertilised mown meadows, compared with only five species in heavily fertilised mown meadows.

While agriculture can have a positive impact on biodiversity the displacement of mixed farming, agro-forestry and intercropping by monocultural systems, and the conversion of natural habitats to agricultural land can result in the loss and destruction of biodiversity. For example, the Clouded Yellow (Colias croceus) is the only butterfly in the United Kingdom which is capable of breeding on improved pasture (it uses clover as its food plant), compared with 28 species which breed on the more diverse unimproved pasture which has declined in area (Dennis, 1992).

The inappropriate use of pesticides, for example, can also have a negative effect on the conservation of biodiversity not only in the place where they are applied but also in other ecosystems (i.e. by pesticide run-off, see the Pesticide Use and Risks chapter). Moreover, the expansion of agricultural land can also lead to fragmentation of “natural” ecosystems and, where agricultural land is adjacent to other ecosystems, this can adversely affect diversity through the escape of farmed plants and animals.

The negative impacts of agriculture on biodiversity must also be considered in terms of the benefits agriculture brings to society through providing food and fibre, employment and incomes. A better understanding of the processes and trade-offs involved between agricultural production, biodiversity loss and agriculture’s role in some situations to maintain biodiversity are, nevertheless, critical to improving land use decision making.\(^\text{10}\)

The difficulty for scientists at present, is to quantify the critical thresholds of biodiversity resilience to stress, and identify the measures and likely costs of restoring biodiversity stability. Equally the different forms in which agriculture impacts on biodiversity, while widely recognised, vary in their intensity and effects across countries. There are also other influences on biodiversity besides agricultural activity, such as from natural processes, for example, fires; non-indigenous species; other economic activities, for example, forestry and industry; and global climate change (European Commission, 1998; Mac \textit{et al.}, 1998).\(^\text{11}\) For policy makers to improve their responses in reducing biodiversity loss associated with agriculture, this will require a better understanding and measurement of the driving forces and state of biodiversity in agriculture.

2. 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, described in Figure 2. Together the indicators establish the initial steps in providing a coherent picture of biodiversity in relation to agriculture.\(^\text{12}\)

It is the impact of agriculture on biodiversity which is the emphasis in this chapter, and not the effects on agriculture of biodiversity and related ecosystem services. An exception is the indicator concerning the impacts of non-native species on agriculture and agro-ecosystems. In examining the relationship between agriculture and biodiversity, the discussion here is also limited to biodiversity that is either dependent on agricultural activities and/or affected by it. The range of agriculture’s impact on biodiversity mainly concerns the area of ecosystems that are in the immediate vicinity and bordering on agricultural land. However, this is not to exclude the possibility that agriculture’s impact on other ecosystems may extend further than the area adjacent to agricultural land, although this issue is not covered in the chapter.

For genetic diversity three indicators are reviewed in this chapter that monitor the diversity of crop varieties/livestock used in agricultural production. These indicators help to reveal the resilience of agricultural production to environmental changes and risks which occur through diversifying the number of varieties/breeds in production. A fourth genetic diversity indicator provides information on the extent of genetic erosion and the loss of domesticated agricultural plant varieties and livestock breeds.
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 and agro-ecosystems. Ecosystem diversity is covered in the Wildlife Habitat chapter.

**Genetic diversity**

**Definitions**

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, rice, rapeseed, etc.).
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.

**Method of calculation**

The first three indicators track the extent of diversity in the range of crop varieties and livestock breeds used for agricultural production. These indicators require data covering the total registered or marketed number of crop varieties/livestock breeds, and total crop production/livestock numbers for the main categories of crops (e.g. wheat, rice, etc) and livestock (e.g. cattle, sheep, etc).

The fourth indicator, on endangered crop varieties/livestock breeds, 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. Sources for species data include national genebanks and breeding organisations, although the FAO has begun to develop internationally co-ordinated databases for genetic resources in agriculture.

**Recent trends**

**General**

There seems broad consensus that global losses of genetic resources for food and agriculture have been substantial over the past 100 years. Even so, trends in the populations and numbers of “wild” relatives of domesticated agricultural plants and livestock are poorly documented.
To a larger extent national definitions, systems of classification and monitoring of the state and trends of genetic diversity in agriculture, are based on the approaches being developed through the Convention on Biological Diversity (CBD), and the related work of the FAO inter-governmental Commission on Genetic Resources for Food and Agriculture (see endnote 1 and the example of Greece in Box 3). In addition, many OECD countries have major genebanks of crop and livestock genetic material (see section on Crop Genebanks below; and FAO, 1996 and 1998).

**Box 3. National System for the Protection and Utilisation of Genetic Resources for Agriculture: Greece**

The Greek National System for Protection and Utilisation of Plant Genetic Resources, established in 1990 by Presidential Decree 80/1990, provides for ecosystem surveying to monitor the distribution of domesticated crops and wild relatives, assessment of the degree of genetic erosion, and collection of the threatened germplasm. It also provides for implementing schemes for on-farm and in-situ protection. Data on ecosystem distribution are maintained at the Greek Gene Bank's Database, but they actually reflect these degree each region of the country has been surveyed and the distribution of the target species in these surveys.

These surveys are near complete for certain staple crops and their relatives (e.g. cereals, grapes, forage) and very weak for other crops, particularly vegetables. Reports/case studies on the ecosystem distribution of certain species (brassica, cereals etc.) have been presented to scientific fora. Data for the distribution of this germplasm in Greece are also available in the appropriate databases of FAO and the EU. A major attempt to record genetic diversity of domesticated crops in Greece has been undertaken by the Greek Ministry of Agriculture (Directorate of Environmental Protection) between 1995-1998 as a preliminary step towards the implementation of measures for its protection under the provisions of EU Regulation No. 2078/92.

As regards the genetic diversity of domesticated animals, the system used in Greece to classify their genetic diversity is based on the assessment of breeds, made according to the number of the female animals registered by the relevant authorities and in stipulation with EU Regulation No. 2078/92.

*Source: Adapted from Greece’s reply to the OECD Agri-environmental Indicators Questionnaire, 1999.*

For European Union countries EU Regulation No 1467/94 provides a programme for the conservation, characterisation, collection and utilisation of genetic resources in agriculture, while in principle conservation of agricultural genetic resources can be supported through EU Regulation No. 2078/92 (European Commission, 1998, pp. 48-50). The latter EU regulation is applied to promote conservation of threatened farm animal species through provision of support for farmers who undertake to rear local livestock breeds in danger of extinction and to cultivate crops threatened by genetic erosion.  

**Crops**

Overall, there has been an increasing number of crop varieties registered for marketing and as a share in crop production over the past 13 years in OECD countries (Figure 3). This trend suggests that for many countries arable farming has improved its resilience to environmental change and risk through diversifying the number of crop varieties used in production.

The trend in the share of the one to five dominant varieties in the total marketed production for specific crops has also declined in a large number of cases. The share of these dominant crop varieties, however, is still in excess of 70 per cent for most crop categories, although for some countries the dominance of major varieties in crop production is lower, for example, in Germany, Italy, Poland, Portugal and Sweden (Figure 4). These trends are supported by other research, that reveals, over a longer time period than shown in Figure 4, the percentage share of the total area of wheat planted to the dominant cultivar has declined in France, Hungary, Italy, the Netherlands and the United Kingdom (Smale, 1997, p. 1261).
Figure 3. **Number of plant varieties registered and certified for marketing: 1985 to 1998**

![Graph showing the percentage of the one to five dominant varieties in total marketed crop production.](image)

1. Percentages are zero or close to zero per cent for Finland (cereals, oil crops, vegetables), Italy (oil crops), Norway (oil crops), Sweden (vegetables).
2. Percentages are greater than 200% for Denmark (oil crops), Japan (cereals, root crops, vegetables), United Kingdom (oil crops).

Notes: See Annex Table 1. Data are not available for all crop categories and all countries.
Source: OECD Agri-environmental Indicators Questionnaire, 1999.

Figure 4. **Share of the one to five dominant varieties in total marketed crop production: 1985 to 1998**

**Change in the share of the one to five dominant varieties in total marketed production**

![Graph showing the change in the share of the one to five dominant varieties in total marketed production.](image)

**Percentage share of the one to five dominant varieties in total marketed production: 1998**

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1. Percentages are zero or close to zero per cent for Italy (rapeseed), Norway (rapeseed), Switzerland (rapeseed, soybeans).
Notes: See Annex Table 2. Data are not available for all crop categories and all countries.
Source: OECD Agri-environmental Indicators Questionnaire, 1999.
Australia has developed an index of agricultural plant species diversity to track trends in the regional diversity, or genetic diversity of cultivated agricultural plant species (Commonwealth of Australia, 1998). The index is based on the number of different species grown (for major plant groups such as oilseeds, cereals, legume pasture), the area of each species and the number of farms growing each species over the period 1989-1994. An increase in the number of species grown reveals the greater resilience of farming systems to adapt to economic and environmental changes. Although the span of years was too short to draw conclusions about the biological resilience of regional agro-ecosystems, there is no suggestion that diversity has declined in any region.

The most frequently cited cause of the loss of genetic diversity from country reports provided to the FAO (FAO, 1996, pp. 13-14), was the introduction of new varieties of crops leading to the replacement and loss of traditional, highly variable crop varieties. In Korea 74 per cent of varieties of 14 crops grown on farms in 1985 had been replaced by 1993.14 In the United States, a study drawing on information about varieties grown by US farmers in the 19th century revealed that most varieties can no longer be found either in commercial agriculture or any US genebank, with 91 per cent of field maize varieties lost, 81 per cent of tomatoes, and 94 per cent of peas (FAO, 1996, p. 14).

Livestock

The overall trend for livestock, like that for crops, shows an increasing number of breeds registered for marketing and as a share of total livestock numbers in OECD countries since 1985. This indicates a growing diversity of the breeds used for livestock production for most categories of livestock and OECD countries. Examination of changes from 1985 to 1998 in the number of livestock breeds, registered or certified for marketing, shows an increase for nearly all major livestock categories and for most OECD countries, although data for poultry are extremely limited (Figure 5).

These trends are also reflected in the reduction in the share of the three major livestock breeds in total livestock numbers for respective livestock categories (Figure 6). Differences across OECD countries and between livestock categories exist, in particular, the increasing share of the three major breeds of sheep and cattle in respective total numbers of sheep and cattle, in some countries. Also, the dominance of a few breeds in total livestock numbers for respective categories is, in general, higher than for crops, in excess of 80 per cent in most cases.

In the case of the loss of livestock genetic diversity, FAO estimates that globally for over 3 800 breeds of cattle, goats, pigs, sheep, horses and donkeys that existed 100 years ago, 16 per cent have become extinct and 15 per cent are threatened. In cattle breeding, where the Holstein-Friesian breed has become the dominant breed for milk production world-wide, the number of sire-lines is decreasing and for the pig and poultry sectors only a small number of breeds dominate global production. Estimates for Germany show that in 1997 the number of endangered breeds was 12 out of a total of 77 for cattle, 14 out of 41 for sheep, 3 out of 16 for goats, 12 out of 103 for horses, but with no endangered breeds for pigs.15

Interpretation and links to other indicators

Preventing the erosion of genetic diversity and dependence of agricultural production on a relatively small number of varieties/breeds is important for agriculture. Genetic dependence on a small number of varieties/breeds can heighten the risks associated with changes in environmental conditions and susceptibility to pests and disease. Genetic erosion could impair the future potential to raise crop and livestock yields, as genetic material loss is generally irreversible.

The baseline from which this loss should be measured is yet to be determined, although initially the early 1980s is being used as a suitable baseline. Tracking in situ conservation of rare crop varieties/livestock breeds can be important for conservation of certain specific ecosystems. This is also of significance for within-species diversity and the consequent adaptability of the species.

In some cases the increase in particular national varieties/breeds, shown in Figures 3 to 6, is the consequence of the expanding international trade in varieties/breeds. The Hereford cattle breed, for
Figure 5. Number of livestock breeds\(^1\) registered or certified for marketing:\(^2\) 1985 to 1998

![Graph showing the percentage of livestock breeds registered or certified for marketing in various countries between 1985 and 1998.](image)

1. Poultry are not included in the figure as there was no change in the number of breeds registered or certified for marketing between 1985 and 1998, except for Poland, minus 1%.
2. Greece and the Netherlands are not included in the figure as there was no change in the number of breeds registered or certified for marketing between 1985 to 1998, except for cattle, minus 11% in the Netherlands.
3. Percentages equal zero for Austria (pigs), Norway (sheep, goats).

Source: OECD Agri-environmental Indicators Questionnaire, 1999.

Figure 6. Share of the three major livestock breeds in total livestock numbers: 1985 to 1998

<table>
<thead>
<tr>
<th>Change in the share of the three major livestock breeds in total livestock numbers</th>
<th>Percentage share of the three major livestock breeds in total livestock numbers: 1998</th>
</tr>
</thead>
<tbody>
<tr>
<td>Points</td>
<td>Cattle</td>
</tr>
<tr>
<td>Austria</td>
<td>93</td>
</tr>
<tr>
<td>Finland</td>
<td>87</td>
</tr>
<tr>
<td>Germany</td>
<td>90</td>
</tr>
<tr>
<td>Greece</td>
<td>88</td>
</tr>
<tr>
<td>Italy</td>
<td>94</td>
</tr>
<tr>
<td>Netherlands</td>
<td>91</td>
</tr>
<tr>
<td>Norway</td>
<td>91</td>
</tr>
<tr>
<td>Poland</td>
<td>98</td>
</tr>
<tr>
<td>Sweden</td>
<td>82</td>
</tr>
<tr>
<td>Switzerland</td>
<td>88</td>
</tr>
</tbody>
</table>

1. Percentages are zero or close to zero per cent for Finland (pigs, goats), Greece (goats), Norway (goats), Sweden (goats).
2. Percentage is greater than —20% for Norway (pigs).

Notes: See Annex Table 4. Data are not available for all livestock categories and all countries.

Source: OECD Agri-environmental Indicators Questionnaire, 1999.
example, while previously a dominant breed in the United Kingdom, is now becoming more common in Norway.

Some caution is required, however, in using and interpreting indicators that measure genetic diversity by the trends in numbers of crop varieties, shown in Figures 3 and 4. First, the genetic structure of the varieties in current use is likely to be similar, independent of the number of varieties grown. In other words, twenty main varieties grown in 1998, for example, may not have more genetic diversity than two main varieties grown in 1985. Second, varieties for certain crops are not registered in some OECD countries, in particular, this applies to fruit and vegetables and forage plants. Third, and perhaps most importantly, these indicators only account for what is grown or registered for marketing at any given time. The available gene pool is much wider.

For some countries the information on livestock breeds in Figures 3 and 6 may underestimate the "real" situation, as not all livestock are registered, and in some cases registered animals represent the elite breeding population and not "commercial" animals. These indicators could also be improved by providing a breakdown by sex, which registration statistics often neglect, and providing information on the number of livestock breeds considered threatened because of low population numbers. The FAO is now in the process of developing the international Domestic Animal Diversity Information System (DAD-IS) database to address the issue of the loss of animal genetic resources and their better use and development (FAO, 1998).

The genetic diversity between livestock breeds, as well as within breeds, is also important. So far exterior characteristics, e.g. coat colour, have been used to distinguish breeds. This is, however, a rather crude measure and does not sufficiently distinguish within breeds. Productivity levels may also be used as breed characteristics, but that would not represent genetic progress in production potential made, for example, in rare breeds. Moreover, productivity levels also fail to take account of other desirable traits in domestic animals such as hardiness to cold or drought, behavioural traits, meat quality (e.g. taste, nutritional value, etc.).

Indicators of ecosystem diversity are also important in assessing genetic resources, because the plant varieties and livestock breeds have generally developed within specific agro-ecosystems. It is the adaptation of these breeds to these ecosystems that can make their conservation desirable. Ecosystem structure may, in this respect, not be an assessment variable, but a descriptive variable, linking adaptation traits with specific ecosystems.

Related information

Crop genebanks

Ex situ crop gene banks, which are now well established for crop genetic resources. They preserve and make available samples of heritage and unused cultivars, traditional landraces, wild and weedy relatives of cultivated varieties, and special genetic stocks (including many breeders' lines and mutants), in addition to the cultivated varieties in current use. All of this genetic diversity is readily available for use in plant breeding programmes. It is a well established practice that when a variety or landrace is no longer grown by farmers, for whatever reason, efforts are made to preserve that genetic diversity ex situ.

The world-wide number of genebanks has grown rapidly since the early 1970s, when there were fewer than 10 genebanks holding about a half million plant genetic accessions. Now there are more than 1 300 collections with in excess of 5 million accessions, and the major part of these accessions are held in the collections of OECD countries (FAO, 1996, pp. 20-25). Even so, it has recently been estimated that about 90 per cent of plant breeding material used by private breeding companies are from their own or other private company collections (Kate and Laird, 1999, pp. 135-37).

There are also examples, in some OECD countries, of in situ conservation of plant genetic resources (e.g. farmers fields and uncultivated pasture), such as in Germany (fruit trees), Mexico (Maize), and Turkey (wild relatives of cereal plants), and the European Union which provides support to in situ...
conservation (see previous discussion). Switzerland also has a national in situ programme based on the FAO plan of action (FAO, 1996, pp. 16-19). Most in situ programmes are more limited than the development of ex situ genebanks, although often countries link programmes covering the two.

Transgenic crops

The new and increasing use of transgenic crops, developed through genetic engineering, has raised concerns that this could threaten landraces and wild relatives of the world’s plant genetic resources for agriculture and also adversely affect other wild plant species (Table 1). However, genetically modified crops also present the possibility of improving agriculture’s environmental performance by, for example, making plants more pest resistant, thereby, reducing reliance on pesticides.

Table 1. Agricultural area under transgenic crops: late 1990s

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>&lt; 0.03</td>
<td>0.05</td>
<td>0.1</td>
<td>0.1</td>
<td>&lt; 1</td>
<td>&lt; 1</td>
</tr>
<tr>
<td>Canada</td>
<td>0.1</td>
<td>1.3</td>
<td>2.8</td>
<td>4</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>France</td>
<td>0</td>
<td>0</td>
<td>&lt; 0.1</td>
<td>0.1</td>
<td>&lt; 1</td>
<td>&lt; 1</td>
</tr>
<tr>
<td>Mexico</td>
<td>0</td>
<td>0</td>
<td>&lt; 0.1</td>
<td>0.1</td>
<td>&lt; 1</td>
<td>&lt; 1</td>
</tr>
<tr>
<td>Portugal</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>&lt; 0.1</td>
<td>&lt; 1</td>
<td>&lt; 1</td>
</tr>
<tr>
<td>Spain</td>
<td>0</td>
<td>0</td>
<td>&lt; 0.1</td>
<td>0.1</td>
<td>&lt; 1</td>
<td>&lt; 1</td>
</tr>
<tr>
<td>United States</td>
<td>1.5</td>
<td>8.1</td>
<td>20.5</td>
<td>28.7</td>
<td>16</td>
<td>72</td>
</tr>
</tbody>
</table>

2. The global area of transgenic crops in 1999 was approximately 40 million hectares.
3. The US Department of Agriculture estimates differ from the above industry estimates as follows: 1996: 3.2 million hectares; 1998: 20.23 million hectares.


There is now a considerable research programme underway in a number of OECD countries to determine the effects of genetically engineered crops. Several European governments have called a moratorium on commercial planting of these crops pending further assessment of possible health and ecological risks.

Farmers in the United States sowed their first transgenic crops in 1994, followed by other OECD and non-OECD countries in 1996 (Table 1). By 1998, nine countries world-wide were growing transgenic crops, and that number is expected to reach 20 to 25 countries by 2000 (Brown et al., 1999, pp. 122-123). While there are more than 60 marketed transgenic crops, the principal crops in terms of the total area under transgenic crops include maize, soyabees, canola and cotton.

Species diversity

Wild species

Definition

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

Method of calculation

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. Thus, at this stage of the work it is not possible to develop a consistent method of
calculation across OECD countries. Instead, it is only possible to report on the state and trends of wild species in relation to agriculture, according to different country approaches, such as in terms of measuring species abundance, species richness, species distribution, key species, endangered species, or groups of species having similar functions (i.e. species guilds). These different approaches have varying advantages and disadvantages in terms of accuracy, sensitivity, feasibility and cost.

Most OECD countries do not have specific monitoring systems to track wild species populations and numbers on agricultural land. Background information is available, however, for a number of species and species groups related to agriculture, but usually this is not collected in a systematic manner. Many OECD countries, and some international organisations, however, report on a regular basis the total number of known and threatened species of mammals and birds, and to a lesser extent fish, reptiles, amphibians invertebrates, vascular plants, mosses, lichens, fungi and algae, but none of this information relates specifically to agriculture (OECD, 1998).19

In some countries, Norway, Sweden and the United Kingdom, for example, biological records are maintained by government organisations and volunteer groups for various species groups, typically mammals, birds and vascular plants.20 More commonly nearly all countries have Red Lists of endangered species, although these lists are not specific to agriculture, but some countries have been able to identify Red List species particularly associated with agriculture (e.g. Finland, Germany, Netherlands, Norway, Switzerland).

A few countries have begun to establish monitoring systems specifically to track wild species trends in agro-ecosystems. Canada, has started to examine the issue of monitoring wild species on agricultural land (Box 4). Some countries also use hunting statistics as proxies for the likely impact of agriculture on wild species (e.g. Denmark; hares; Norway, roe deer, rooks, blackheaded gull and partridge, since the 1940s). Germany, is developing a system that will involve monitoring the occurrence and frequency of 100 selected species through periodic sampling for defined ecological areas, including agro-ecosystems.

In the Netherlands, for example, a monitoring programme exists, and is being further developed, covering plants, birds, butterflies, dragonflies, amphibians, mammals, fish, aquatic macro fauna and soil

**Box 4. Canadian System to Monitor Wild Species Diversity**

There is no comprehensive national system in place in Canada to monitor the diversity of wild species on agricultural land. Available data focus on economically important species (such as selected beneficial and pest species in agriculture), economically valuable species for which specific management programmes are in place (e.g. waterfowl; see also the North American Waterfowl Management Plan, see Box 6), some songbirds, and migratory birds subject to the Canada-US Migratory Birds Convention. In cases where population and diversity data exist, species are usually also influenced by factors other than agriculture or even factors in other countries (Mexico, United States).

Information is collected by the Committee on the Status of Endangered Wildspecies in Canada (COSEWIC) on endangered, threatened and vulnerable species. A study conducted for Agriculture and Agri-Food Canada (AAFC), completed in May 1998, found that 223 of the 268 species then classified by COSEWIC as endangered, threatened or vulnerable overlap into the Canadian agricultural landscape. The results of this study do not indicate a cause-effect relationship between agriculture and species at risk.

In part, due to sparse data, the difficulty of determining “key” species, and because in most cases factors other than agriculture also affect species populations, AAFC has not developed a national indicator of wild species diversity on farmland. Instead, AAFC has developed an indicator that combines information on agricultural land use and information on how different vertebrate species use agricultural land as habitat to develop an indicator of habitat availability on farmland (see the Habitat matrix indicator in the Wildlife Habitats chapter).

Source: Adapted from Neave et al. (2000).
fauna (e.g. nematodes, worms, mites, fungi etc.). Measurable species within these groups are selected, providing a representative cross-section of the agro-ecosystem, and consist of rare species as well as more common species. Species are measured under the Dutch system in various units, such as distribution, presence/absence, density, total numbers, breeding pairs, or area coverage, depending on what is feasible in sample areas or plots. The United Kingdom is another example, involving a national periodic random stratified sample survey of plant species, including agro-ecosystems.

There remains an active discussion amongst biologists as to the merits of using the species abundance or species richness in monitoring biodiversity. Species abundance measures both the decline or increase of populations, which may result from human activities, such as agriculture. Species richness refers to the total number of a specific taxonomic group or functional groups associated with key ecosystems per site. Species richness measures presence/absence of species and is, therefore, a relatively insensitive variable compared to species abundance (Figure 7).

The decrease in abundance of three original species, symbolised by the three oval shapes in time period $t_0$ in Figure 7, and the introduction and increase of one other species in one particular area over time $t_1$–$t_2$ is typically a common process of biodiversity loss, resulting from changing farming practices in a particular agro-ecosystem. The decrease of species abundance is a far more sensitive indicator than species richness, as the latter initially increases from 3 to 4 (in $t_1$) while the average species abundance of the “traditional” species dramatically decreases in $t_1$ and $t_2$ (Figure 7). As a result the policy message could be the opposite of what is expected. While traditional species may become extinct at the local level they may not be extinct nationally (e.g. due to conservation of specific habitats), while new species are easily introduced. The result is an increase of species richness at the national level while the loss of species abundance is totally ignored.

**Figure 7.** Theoretical change in species abundance and richness over time

*Note: Shaded areas show different species, “species richness” (e.g. 3 species in $t_0$) while area of each shaded part shows “species abundance” (e.g. decline of species from $t_0$ to $t_2$).

*Source:* Adapted from Ed Van Klink (National Reference Centre for Agriculture, The Netherlands), presentation to the OECD Workshop on Agri-environmental Indicators, York, United Kingdom, September, 1998.
Concerning population trends for wild species using agricultural land as habitat, there is considerable work completed on the status of birds on agricultural land, especially in Europe (Figure 9 and Box 5). A comparison of different habitat types (e.g. agriculture, forests, wetlands, etc.) reveals that
across Europe agricultural habitats account for the highest proportion of birds with an unfavourable conservation status (Tucker and Heath, 1994; and Tucker and Evans, 1997). Much of the adverse impact of agriculture on bird populations has been attributed to pesticides (EEA, 1998, p. 166; and see also the Pesticide Use and Risks chapter) and changing land use patterns in agriculture, especially the loss of extensive grazing land (see Contextual Indicators and Wildlife Habitat chapters).

In Finland, over one-third of the country’s vascular plants are found on pasture (MAF Finland, 1996, pp. 4-6). With the reduction in the pasture area in Finland over the past few decades and large-scale structural changes in the agricultural sector, it is estimated that these changes have threatened the disappearance of almost 290 species of flora and fauna, and, in addition, thousands of other species have declined (Table 2).

Table 2. Number of species threatened to disappear and dependent on agricultural habitats: Finland, early 1990s

<table>
<thead>
<tr>
<th>Agricultural habitat</th>
<th>Vertebrates</th>
<th>Invertebrates</th>
<th>Vascular plants</th>
<th>Cryptogams</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh meadows</td>
<td>1</td>
<td>18</td>
<td>8</td>
<td>6</td>
<td>33</td>
</tr>
<tr>
<td>Woodland pastures</td>
<td>0</td>
<td>34</td>
<td>13</td>
<td>22</td>
<td>69</td>
</tr>
<tr>
<td>Dry meadows</td>
<td>1</td>
<td>122</td>
<td>27</td>
<td>23</td>
<td>173</td>
</tr>
<tr>
<td>Fields</td>
<td>4</td>
<td>7</td>
<td>3</td>
<td>0</td>
<td>14</td>
</tr>
<tr>
<td>Total</td>
<td>6</td>
<td>181</td>
<td>51</td>
<td>51</td>
<td>289</td>
</tr>
</tbody>
</table>

1. Mammals, birds, fish, etc.
2. Annelids, molluscs, butterflies, beetles, and other insects, arthropods, and invertebrates.
3. Non-flowering plants, such as algae, mosses, ferns, etc.

Source: MAF Finland (1996).
A study has been undertaken in Germany, by the Federal Ministry for the Environment, to examine the various human and natural factors that have caused declines in plant species over the past 10 years, including the impact of agriculture (Figure 10). Intensified agricultural land use, cessation of use, fallowing and natural succession, appears to have been the major cause of the decline in plant species, although the destruction of habitats and afforestation also has been important. It is also evident from Figure 10 that the causes of plant species decline in agriculture have had less effect in recent years.

Monitoring of the Peregrine Falcon (Falco peregrinus) population in Ireland, showed a decline in numbers between the 1940s to the 1970s because of contamination by organochlorine pesticides. With restrictions on the use of these pesticide compounds there has been a recovery in the population from 225 breeding pairs in 1981 to 350 in 1991 (Environmental Protection Agency, 1999).

The destruction and fragmentation of habitat of agricultural land in Luxembourg is considered to have had a negative impact on biodiversity in the country (OECD, 2000b). The eutrophication of rivers and lakes caused by agricultural inputs has also threatened amphibian species.

Almost a half of the bird species using farmland as habitat in the United Kingdom have declined in population size over the past 20 years (UK Department of the Environment, 1996, pp. 120-121). Within

Source: Adapted from Commission of the European Communities (1999, pp. 16-18).
farmland habitats the decline in numbers of species was higher on cultivated arable land (about 60 per cent of the bird species) than in grazing land (about 40 per cent). The decline in UK farmland birds shown in Figure 9 is a cause of concern. At the same time, some bird species benefit from intensive farming and their populations are not decreasing, for example, the stock dove (Columba oenas) and jack-daw (Corvus monedula) (MAFF, 2000). However, some rare species not included in the UK indicator, such as the corncrake (Crex crex), stone curlew (Burhinus oedicnemus) and cirl bunting (Emberiza cirlus), are responding well to conservation efforts.23

The marked reduction in UK bird populations occurred in the late 1970s and early 1980s and can partly be linked to the declines in farmland habitat quality as a result of intensification of agricultural practices. Pasture (a good source of invertebrate food) has been lost from the arable areas in the east and cereals from the pastoral areas in the west of the country. Most unimproved grassland has been lost since

---

**Figure 10.** Decline in plant species due to various human and natural factors: Germany, 1998

<table>
<thead>
<tr>
<th>Causes of decline in species</th>
<th>Number of species affected</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Agricultural impacts</strong></td>
<td></td>
</tr>
<tr>
<td>– Intensified agricultural land use</td>
<td></td>
</tr>
<tr>
<td>– Cessation of use, fallowing and natural succession of shrubs and trees</td>
<td></td>
</tr>
<tr>
<td>– Ceased cultivation of old and traditional crops</td>
<td></td>
</tr>
<tr>
<td><strong>Destruction of plant habitats</strong></td>
<td></td>
</tr>
<tr>
<td>– Irreversible destruction of habitats</td>
<td></td>
</tr>
<tr>
<td>– Reversible destruction of habitats</td>
<td></td>
</tr>
<tr>
<td>– Treading on, sailing across, forces of waves/pounding of waves</td>
<td></td>
</tr>
<tr>
<td>– Taking/removal and destruction of plants</td>
<td></td>
</tr>
<tr>
<td>– Water engineering</td>
<td></td>
</tr>
<tr>
<td><strong>Change of habitat conditions</strong></td>
<td></td>
</tr>
<tr>
<td>– Nutrient inputs – uncontrolled shifting of natural ecosystem balance</td>
<td></td>
</tr>
<tr>
<td>– Suppression/failing of natural dynamic processes</td>
<td></td>
</tr>
<tr>
<td>– Effects of pollutants – damage to vegetation</td>
<td></td>
</tr>
<tr>
<td>– Displacement by alien species</td>
<td></td>
</tr>
<tr>
<td><strong>Silvicultural impacts/Forestry impacts</strong></td>
<td></td>
</tr>
<tr>
<td>– Afforestation of non-wooded areas</td>
<td></td>
</tr>
<tr>
<td>– Silvicultural measures</td>
<td></td>
</tr>
<tr>
<td>– Cessation of traditional woodland systems</td>
<td></td>
</tr>
<tr>
<td><strong>Biological risk factors</strong></td>
<td></td>
</tr>
<tr>
<td>– Low production of seed, and hybridization</td>
<td></td>
</tr>
<tr>
<td><strong>Impacts of gamekeeping and hunting activities</strong></td>
<td></td>
</tr>
<tr>
<td>– Losses caused by browsing and grazing game, cultivation of feeding areas</td>
<td></td>
</tr>
</tbody>
</table>

Notes: The horizontal bars indicate the number of species affected by each respective cause of endangerment. The dark blue parts of each bar show the number of those species for which respective causes of threat are still active or became more active over the past 10 years. (The assessment is based on 756 species/1 670 common names).

Source: German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety.
the 1930s, thus reducing the variety and numbers of birds, especially in the west. Most cereal crops are now planted in the autumn, not the spring. As a result there are substantially fewer stubble fields, which are a good source of food for bird populations over the winter. Both hedgerow removal and the loss of other uncropped habitats have also reduced nesting and feeding opportunities for some species.

Pesticide use is another factor implicated in the decline of farmland birds in the UK. Concern has focused on whether pesticides, by removing insect pests and weed species, may have an indirect effect on some bird populations by reducing food sources. The UK Ministry of Agriculture has recently commissioned a 5-year research project, involving collaboration with various conservation bodies, specifically to investigate the role of pesticides and other factors in the decline of farmland bird species.

Recent surveys by the United Kingdom Mammal Society, also reveal the reduction in mammal species that use agricultural land as habitat, such as voles (Arvicola), shrews (Sorex) and field mice (Mus rylvaticus). The main causes for these declines over the period since the 1970s have been attributed to the loss of rough grazing land and small habitat features on farmland such as ditches, hedges, etc. Also the removal of field margins, by ploughing as close to field edges as possible, and spraying field margins with pesticides has also led to the reduction in habitat and feeding areas for mammals and other wild species.

North America

Over the past 15 years in Canada, many farmers have begun to replace conventional tillage practices with conservation tillage, including no-till (see the Soil Quality chapter). In Canada, studies have shown that wild species benefit from conservation tillage. Invertebrate numbers have been shown to rise as a result of the protection afforded by crop residue cover and reduced mortality caused by ploughing. Many species of birds become more common as their prey, invertebrates, grow in numbers. Deer mice (Hesperomys), too, may become more abundant, possibly because of higher survival rates or greater mobility of the population than is the case in conventionally tilled fields. The impact of agriculture on Canadian waterfowl is also examined in Box 6.

Agricultural activities in the United States are considered to affect 380 of the over 660 wild species listed as threatened or endangered in 1995 (USDA, 1997, pp. 17-18). The main threats to wild species from agriculture in the US originate from converting land to cropland and grazing, with exposure to farm chemicals also important. The competition between agriculture and endangered species for land was heightened in the US with the introduction of the Endangered Species Act in 1973, which has the express objective of protecting ecosystems on which threatened and endangered species depend. Several agricultural programmes include measures that are designed to reduce the conflict between agriculture and biodiversity loss, including the Conservation Reserve Program and the Wetlands Reserve Program.

Interpretation and links to other indicators

Where agriculture is the dominant land use activity, as is the case for many OECD countries, then it is to be expected that agriculture is likely to provide the major habitat area for wild species. In this context, Figure 8 needs to be interpreted with some care, as it is unclear if forests or other ecosystems were re-established on agricultural land what the relative share of wild species on different land uses would be.

The interpretation of wild species indicators is not straightforward, and caution is required in relating species reductions or increases to agriculture, where other external factors, such as changes in the weather or populations of natural living organisms and predators, may have an important influence. It will also be necessary to take care in interpreting such indicators across countries, as the number of species will tend to be greater in large countries than for small countries, hence, the possibility of expressing the indicator according to a standard area unit could be considered.

Defining baselines is an important step in calibrating, comparing and interpreting indicators of biodiversity, but in practical terms baselines will usually be limited by available data. Baselines can be useful as objective measures of status at a given point in time against which changes in status can be compared. However, irreversible ecosystem and climate changes may prevent restoration of pre-existing
species populations. In these cases progress towards agreed targets may be more useful for policy decision-making than measuring distance from baselines, especially when it is difficult to establish common baselines across OECD countries.

Setting baselines is a complex and often an arbitrary process, with many alternative baselines possible, and with each alternative generating different results and policy information. A number of baseline options with respect to wild species can be considered. These include first, setting the baseline at the time of the CBD’s agreement in 1992; second, determining a baseline that represents the evolution of biodiversity in an ecosystem that has been unaffected by any significant human influence, i.e. the original “natural” state; and third, establishing a baseline, in the case of agriculture, prior to the intensive use of inputs in agriculture, which for many OECD countries is around the early 1950s.26

Measurement against the conditions at the time of CBD ratification is likely to be an attractive alternative, but assessing biodiversity using 1992 as a baseline would be perceived as giving a biased result, because at that time OECD countries had already achieved a high level of socio-economic and agricultural development partly at the expense of biodiversity.

Comparing an agricultural area with the original “natural” baseline, e.g. a forest or wetland, is of little value in that it will simply show that the majority of the original biodiversity has disappeared. However, the original natural state baseline is the relevant baseline in the case of clearing additional forests for agricultural use. It can also be of interest to potential resilience, if an area is no longer cultivated or if agriculture becomes less intensive. The so-called “climax” baseline, on the other hand, characterises the developing natural state after human activities on an area have ceased, and can be an important baseline in the case of a potential change in land use from agriculture to another use.

Establishing a baseline for agriculture in terms of the period before the intensive use of inputs, also raises a number of questions. For example, how to define “intensification”, at what point this is considered to begin (which can also vary for regions across a country), and what are the impacts of agriculture on biodiversity under different systems of input intensity (e.g. intensive use of machinery and chemicals, organic, and extensive “low” input farming systems, etc.)?27 For many countries, which

Box 6. North American waterfowl and agriculture

In the 1980s, waterfowl populations in North America began dropping at an alarming rate. Concern for this situation led Canada, United States, and Mexico to co-operate in restoring these birds to 1970 levels and improving the habitat for these and other wetland-dependent wildlife. Signed in 1986 and called the North American Waterfowl Management Plan, this agreement has resulted in a major conservation programme.

In Canada the plan focuses on the Prairies, which provide breeding habitat for almost 40 per cent of the North American duck population. Goals of the programme include the restoration and protection of wetlands and grasslands. To achieve these goals, a landscape approach is taken and agreements made with farmers to modify their land use and agricultural practices. Another major component of the programme is the reform of land use policy to remove the pressure to put marginal land into agricultural production.

Ten years into the programme, dabbling duck populations had nearly reached the 1970s average, and diving duck populations had far surpassed it. Provincial surveys of the socio-economic impact of the plan show that farmers and the general public have a positive attitude toward wetland and waterfowl conservation and that communities benefit economically through jobs associated with the plan and greater tourism opportunities.

Note: For the Canadian website of the North American Waterfowl Management Plan see: www.cws-scf.ec.gc.ca/nawmp_e.html; and for the United States website see: http://northamerican.fws.gov/nawmpphp.html.

Source: Adapted from Neave et al. (2000).
have only just begun to establish wild species monitoring systems, the only practical baseline will be
the first year of the monitoring programme.

In terms of species diversity, links to the wildlife habitat indicator area are clearly critical, in
particular, the habitat matrix indicator, which is a surrogate for species diversity. Farm management
indicators also are of importance in terms of the choices farmers make in their use of farm chemicals,
especially pesticides. Farm management practices are also important to wild species in terms of soil cover
and crop harvesting practices. An example is the different influences of early grass silage production as
opposed to haymaking later in the year on the development of insects and dependent bird populations.

**Non-native species**

**Definition**

Trends in population distributions and numbers of key “non-native” species threatening agricultural
production and agro-ecosystems.

**Method of calculation**

Indicators of non-native species threatening agricultural production and ecosystems are being
developed in some countries (Saunders et al., 1998, p. 23; and New Zealand Ministry for the
Environment, 1998, pp. 56-58). This can cover the abundance and distribution of non-indigenous
species identified as pests, *i.e.*, plants, vertebrates, invertebrates and pathogens, that cause economic
losses to agriculture by damaging crops and competing for forage.

These indicators are being developed in terms of tracking the changing pressures on agricultural
production, and biodiversity more widely. This involves collecting information about the distribution or
range, and abundance where possible, of different invasive species. In general, the range of non-native
species is the aspect most important for agriculture.

**Recent trends**

Non-native species have been reported as a concern across European countries, causing problems
for agriculture as well as forestry and fisheries, and nature conservation (EEA, 1998, p. 152). In Denmark,
mink are a menace to poultry and fish farms and in Germany, the muskrat (*Fiber zibethicus*) has damaged
water banks and endangered cultivated plants. Problems elsewhere include those from rats and locusts
in Greece, crabfish (*Procambarus clarkii*) in rice fields, and the Norwegian rat (*Rattus norvegicus*) in Portugal.

Certain invasive weeds are also common across Europe, including in Denmark damage to pasture by
*Heracleum pubescens* and *rosa rugosa*; in Germany, imported crop species, such as tobacco, potatoes and
tomatoes have been accompanied by specific pests and viruses. Greece has reported *Ipomoea hederacea*
(*ivy-leaf morning glory*) and *Eleusine indica* (wire grass); while in Portugal, there is concern with *Microphyllum
aquaticum* and *Eichhornia crassipes*; and in Switzerland with *Lyriomyza spp.*

Invasion by non-indigenous species is considered in the United States as one of the most important
issues at present in natural resource management and conservation biology (Mac et al., 1998, pp. 117-129).
The major concern in the US has been the loss of native biodiversity, ecosystem changes due to alien
species invasions, and economic losses resulting from the introduction of non-indigenous species,
although some of these species can be beneficial. A US government study estimated that of the 6 500
non-indigenous taxa in the US, about 15 per cent are considered economically or ecologically harmful
(Office of Technology Assessment, 1993). Economic losses were conservatively estimated over the
20th century at US$97 billion, and this does not include damage from agricultural weeds for which there
is little or no data.

**Australia and New Zealand** are acutely affected by the impact of non-native species on agriculture and
ecosystems because of the evolution of their distinctive biota prior to European settlement. About
17 per cent of the total flora in Australia are non-native species, with about a quarter of these having the
potential to be serious environmental weeds (Commonwealth of Australia, 1995, pp. 40-47). Also at least
18 exotic mammals have established feral populations in Australia, such as cats, dogs, foxes and rabbits. They have inflicted economic losses to farmers through damage to crops and competition for livestock forage, and through predation leading to the destruction and decline of native species.

While exotic mammals damage agricultural production and harm ecosystems, in part, these species have spread and become abundant in Australia because of agriculture itself. This has occurred through clearing native habitat and, with respect to feral animals, through cropping and grazing activities providing them forage and water (Commonwealth of Australia, 1996, p. 23). New Zealand has also had a similar experience to that of Australia with respect to non-native species and their effects on agriculture and native ecosystems (New Zealand Ministry for the Environment, 1998, pp. 56-58).

**Interpretation and links to other indicators**

For non-native species an increase (decrease) in abundance or range of the species would be interpreted as increasing (decreasing) the threat of damage to agricultural production. However, any changes in the number of non-native species must be interpreted with care, as it may indicate either an increase in the number of threatening species or research that has found more pests exist (ANZECC, 1998, p. 26). Also, it is not always evident from different studies whether non-native species, or instead native pest species, are being monitored. Further information is required here to identify the key non-native species that are causing significant problems or threats to agricultural production and ecosystem balance.

A significant constraint in developing both non-native and wild species indicators, is that surveys of species populations can be very expensive and may require highly specialised skills. Methods for cost-effective and statistically reliable sampling have yet to be established for many species groups. Even so, databases both nationally and internationally, have been, or are being, established that may help to provide information on species distributions and population trends (see endnote 19).

**Ecosystem diversity**

Indicators of ecosystem diversity include the proportion of semi-natural and uncultivated natural habitats on agricultural land, and the extent of changes in agricultural land use. Ecosystem diversity indicators represent the “quantity” aspect of biodiversity shown at the base of the rectangle in Figure 2. These indicators are examined in the Wildlife Habitats chapter, and the Contextual Indicators chapter under the section concerning agricultural land use.

3. **Related information**

**Biomass production**

An important aspect to the link between biodiversity and agriculture, is the relationship between biomass production from agriculture (i.e. crops and forage) and species diversity as set out in the CBD (Box 1). This relationship is important as it can have implications for future sustainable land use management decisions, for example, determining how much of the world’s land surface can be set aside for conservation.28

There is evidence to suggest that in agricultural systems plant biomass production increases rapidly with the first 5 to 10 crop species, and adding more species may bring diminishing returns. However, in grasslands there is mostly a negative relationship between biomass and biodiversity. Also on semi-natural agricultural habitats, under low intensive systems of management, there can be an “optimum” biodiversity and not a one-dimensional relationship. Research into the relationship between biomass and biodiversity, however, is still at an early stage of development.

There are also important links between biomass production in agriculture and productivity, such as the possibilities of increasing plant biomass through technology to provide energy.29 In other cases data on biomass production are also of use in evaluating agricultural production potential under different environmental conditions. Norway, for example, through its Agro-Ecology Programme,
is collecting geographically referenced data on altitude, climate and soils and, in the longer term, data from plant biomass experiments will be included. The aim is to develop a standardised and objective means of measuring agricultural production potential to enable evaluation of agricultural land in cases of expropriation, for example, compensation payments for loss of agricultural land during road and rail development.

4. Future challenges

Understanding 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. This work will also benefit in the future from further co-operation internationally with efforts concerning biodiversity and agriculture underway in FAO, and more broadly through the Secretariat to the Convention on Biological Diversity. 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.

While the emphasis of indicators of genetic diversity in agriculture, has been on the in situ diversity of domesticated crops and livestock, further work could examine in situ indicators of wild relatives for genetic improvement, especially for cultivated crops. As in situ indicators measure only a very small proportion of existing and available genetic diversity and can severely underestimate real available genetic diversity, ex situ indicators might be further developed. The key to future work on ex situ indicators should involve drawing on FAO work already underway in this area (see FAO 1996; and 1998). Also, in the future, using molecular “fingerprint” genetic marker data to measure genetic diversity could allow more precise assessment of genetic diversity of domesticated species. For example, using different named varieties of maize could be misleading, as they may have very similar germplasm.

To improve monitoring of the state and trends in wild species diversity in agriculture across OECD countries, may require developing a standardised methodology for indicators of wild species on agricultural land. One possibility, being explored by some countries, is to develop species diversity indicators for agriculture through a Natural Capital Index (NCI) framework. The NCI is calculated as the product of the quantity of the ecosystem (e.g. agro-ecosystems) multiplied by the quality of the ecosystems (i.e. the average of changes in wild species numbers from a baseline period). This approach has similarities with the habitat matrix indicator discussed in the Wildlife Habitats chapter.

Comprehensive data on species distribution and population numbers are unavailable for most countries, although certain indicative wild species (e.g. birds) could serve as a useful proxy of biodiversity quality in agriculture. A pragmatic approach will be needed to choose indicative (endemic) species, or groups of species that are important to the functioning of particular agricultural ecosystems. In this context, it will also be necessary to distinguish between indicators of wild species that help support agricultural production, such as pollinators and pest controlling organisms and predators, and wild species that use agricultural habitat or are affected by farming but use other habitats (especially for those farming systems that have been established over long periods of time).

Baselines from which to interpret changes in biodiversity, can be important for valuing the state and trends in biodiversity. A number of baseline options can be considered for biodiversity, and setting such a baseline is a complex and often a relatively arbitrary process. 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. 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.

As targets and baselines are established it will also be useful for policy makers to improve understanding of the spatial distribution of biodiversity in agriculture. This may also require better understanding of the significance of particular species distribution patterns and how to interpret changes in these distributions over time. Knowledge is also poor of species numbers and distribution patterns in relation to different agricultural land use types and farm management practices and systems. A feasible approach
to this is to link biodiversity and agro-ecosystems into a matrix, an approach that is discussed further in the Wildlife Habitat chapter.

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.³¹ 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.³²

This area of work 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 (Box 1 and also see the discussion on the valuation of wildlife habitats and landscapes in the relevant chapters of this report). 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.³³
NOTES

1. Further details of the FAO inter-governmental Commission on Genetic Resources for Food and Agriculture are available on the FAO website at: www.fao.org/ag/cgrfa/.

2. For details of the Biosafety Protocol visit the CBD Secretariat website at: www.biodiv.org/.


4. This section on the environmental context of biodiversity draws, in particular, on Day (1996) and Pagiola and Kellenberg (1997).

5. The impacts on biodiversity from changing agricultural land use to other land uses is discussed in the Wildlife Habitats chapter, but see also Fjellstad and Dramstad (1999); Hunziker (1995); and Ilse (1995).

6. The recent developments in biotechnology as they relate to agriculture are also discussed below, but for an examination of biotechnology in relation to plant genetic resources see Spillane (1999); and in relation to animal genetic resources see Cunningham (1999). Also for an examination of the commercial use of genetic resources from agriculture, see Kate and Laird (1999).

7. Estimates of world species numbers range from 5 to 100 million, moreover, the richness of individual countries in biodiversity varies greatly according to the parameter chosen. Some European countries and Turkey are rich in wild and local varieties of livestock and food crops, while Australia, Mexico and the US are amongst the world’s top ten countries in terms of species richness (in part because of their size and location). Japan and New Zealand, however, are not high in terms of species richness, but they have a distinctive fauna and flora (OECD, 1996, pp. 25-28).

8. In Australia, for example, the biological condition of the soil is also considered to cover elements such as, feral animal and pest invasions, woody shrub infestations and clearance of native vegetation (Industry Commission, 1996).


10. The trade-off between agriculture, production and biodiversity and improved wildlife management practices are discussed by Wossink et al. (1999). See also Montgomery et al. (1999) concerning the concept of biodiversity management policies to help inform decision-making to prioritise biodiversity conservation efforts.

11. For a bibliographic review of the impact of climate change on biodiversity, see Burns (2000).

12. Unless stated otherwise the information in this section draws from the responses to the OECD Agri-environmental Indicator Questionnaire 1999. For reviews of possible indicators related to biodiversity see Reid et al. (1993); and specifically related to agriculture see Tucker and Evans (1997).

13. For a discussion of the EU Regulation with respect to rare breeds, see European Commission (1999, p. 131); and ECNC (2000) for a broader assessment of the EU Agricultural Action Plan for Biodiversity.

14. The data on genetic erosion of crop plants in Korea are drawn from Ahn et al. (1996).

15. The list of endangered domesticated breeds in Germany are those for which support under EU Regulation No. 2078/92 would be granted.

16. FAO is developing a monitoring system, the Domestic Animal Diversity Information System (DAD-IS), to track the state of the world’s animal genetic resources, see: www.fao.org/dad-is/.

17. The Mexican experience of conservation of maize varieties is examined by CEC (1999, pp. 163-167).

18. For a recent review of economic issues related to genetically modified crops see OECD (2000a).

19. There is an increasing availability of data and information related to biodiversity at an international level, see, for example, the IUCN, the UNEP, BirdLife International, the European Environment Agency Topic Centre on Nature Conservation, and in the United States the Smithsonian Society databases.
20. Other examples here include: Greece, mid-winter counts of waterfowl since 1969; Denmark, populations of certain birds since 1976; Norway, breeding bird survey, since 1995; Sweden, a breeding bird survey established in the 1970s and a project “flora guardians” monitoring mainly vascular plants; Switzerland, regular bird surveys; and United Kingdom a breeding birds survey established in 1970.

21. Figure 8 should be interpreted cautiously as definitions and the measurement of wild species using agricultural land as habitat vary across countries.

22. A detailed study of agriculture and biodiversity, with emphasis on the policy aspects in Europe, has recently been prepared for the IUCN (1999).

23. Trends in UK bird species, including those on farmland, are annually monitored by the RSPB (1999).

24. Information regarding UK mammal population trends can be found at the UK Mammal Society website at: www.abdn.ac.uk/mammal.

25. This text draws from Neave et al. (2000).

26. The baseline of 1950 has been chosen in the Netherlands because first, data from that period are available or can be derived from research; second, in 1950 agricultural ecosystems are considered as having still a very high biodiversity; third, from 1950 industrial management practices were rapidly introduced and the loss of biodiversity was accelerating fast; and, fourth, 1950 has been proposed by the CBD as a postulated pre-industrial baseline to provide a common denominator across countries.

27. Increasingly in the public policy debate on environmental issues, including biodiversity, the precautionary principle and the safe minimum standard, are being invoked as a policy guideline to help ensure that the level of biodiversity that future generations inherit is no less than that available to present generations. The precautionary principle and safe minimum standard in relation to biodiversity is examined by Barbier (1997).

28. These issues are discussed by Holmes (1998), and see Lewandrowski et al. (1999) for an estimate of the cost of setting aside land to protect ecosystem diversity.

29. This issue has been explored by, for example, Haberl (1997). For an estimate of biomass production in Switzerland see Paulsen (1995). Australia is also considering developing an indicator of the net primary productivity of biomass, see Hamblin (1998, pp. 79-80). The biomass for energy issue is also discussed in the Greenhouse Gases and Wildlife Habitat chapters.

30. The Netherlands, for example, have been actively researching the possibilities of developing a NCI for agriculture, see RIVM (1998).

31. For a more complete discussion of the use and non-use values of biodiversity, see OECD (1999).

32. Work by Cooper (1999) has attempted to develop indicators of the economic value of plant genetic resources for agriculture, but on this subject see also Smale (1998) and Zohrabian and Traxier (1999).

33. See, for example, OECD (1997, pp. 42-45); OECD (2001, forthcoming); and Steffens and Hoehn (1997).
Annex Table 1. **Total number of plant varieties registered and certified for marketing: 1985 and 1998**

<table>
<thead>
<tr>
<th></th>
<th>Cereals</th>
<th>Oil crops</th>
<th>Dried pulses/beans</th>
<th>Root crops</th>
<th>Fruit</th>
<th>Vegetables</th>
<th>Industrial crops</th>
<th>Forage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>...</td>
<td>160</td>
<td>...</td>
<td>27</td>
<td>...</td>
<td>31</td>
<td>...</td>
<td>83</td>
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<tr>
<td>Canada¹</td>
<td>539</td>
<td>725</td>
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<td>332</td>
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<td>130</td>
<td>76</td>
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<td>Denmark²</td>
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<td>109</td>
<td>33</td>
<td>107</td>
<td>16</td>
<td>46</td>
<td>62</td>
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<td>Finland³</td>
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<td>57</td>
<td>7</td>
<td>7</td>
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<td>...</td>
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<td>Greece⁵</td>
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<td>723</td>
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<td>15</td>
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<td>Japan⁷</td>
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<td>...</td>
<td>11</td>
<td>42</td>
<td>5</td>
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<td>Portugal¹⁰</td>
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<tr>
<td>United Kingdom¹²</td>
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<td>55</td>
<td>184</td>
<td>59</td>
<td>103</td>
<td>188</td>
<td>164</td>
</tr>
</tbody>
</table>

4. For each crop category (e.g., cereals), the number of varieties for specific crops (e.g., wheat, rice, barley, maize, etc) are added together to form total number of varieties.
   - Not available
   - Negligible
1. Data for 1985, 1998 refer respectively to 1986, 1995. Number of varieties registered for sale. A registered variety does not mean that the seed of each variety is sold annually.
2. Data for 1998 refers to the year 1999. Forage: Seeds for sowing (perennial ryegrass, red fescue, smooth meadow grass). The species included in each category are the 3 dominant species in terms of area in 1997.
3. Forage: seeds for sowing (ryegrass, fescue, meadow grass, etc) and nitrogen fixators (clover, alfalfa, etc).
4. Data are for registered and certified varieties. Forage: seeds for sowing (ryegrass, fescue, meadow grass, etc) and nitrogen fixators (clover, alfalfa, lupin, vetch).
5. Vegetables: data for registered for Plant Variety Protection at the end of the year.
7. Number of varieties registered for Plant Variety Protection at the end of the year.
8. Fruit: data for 1985 are number of varieties grown.
10. Vegetables: data refer to brown kidney beans.
11. Forage: data refer to velvet kidney beans.

Source: OECD Agri-environmental Indicators Questionnaire, 1999.
### Annex Table 2: Share of the one to five dominant varieties in total marketed crop production: 1985 and 1998

<table>
<thead>
<tr>
<th></th>
<th>Canada¹</th>
<th>Denmark²</th>
<th>Germany³</th>
<th>Greece</th>
<th>Italy⁴</th>
<th>Japan</th>
<th>Norway</th>
<th>Poland⁵</th>
<th>Portugal⁶</th>
<th>Sweden⁷</th>
<th>Switzerland</th>
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<tbody>
<tr>
<td></td>
<td>Nb % share</td>
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<tr>
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<tr>
<td>Wheat</td>
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<td>Wheat - Winter</td>
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<td>Durum</td>
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<td>Sugar beet</td>
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<td>Peaches (industrial)</td>
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<td>Cerises</td>
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<td>Apricot</td>
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</table>
Annex Table 2. Share of the one to five dominant varieties in total marketed crop production: 1985 and 1998 (cont.)

<table>
<thead>
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<th>Nb</th>
<th>% share</th>
<th>Nb</th>
<th>% share</th>
<th>Nb</th>
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<th>Nb</th>
<th>% share</th>
<th>Nb</th>
<th>% share</th>
<th>Nb</th>
<th>% share</th>
<th>Nb</th>
<th>% share</th>
<th>Nb</th>
<th>% share</th>
</tr>
</thead>
</table>

Vegetables
- Tomatoes 5 50 30
- Cucumbers 5 30 20
- Watermelons 5 6 4
- Lettuce 5 50 50
- Melons 5 8 5
- Asparagus 5 4 3
- Aubergine 5 3 3
- Pepper 5 3 3
- Brown kidney beans 1 94 56

Industrial crops
- Tobacco 5 70 80

Forage
- Perennial ryegrass 3 34 29
- Red fescue 3 90 30
- Smooth meadow grass 3 92 71
- Lucerne 1 100 80
- Vetch 3 86
- Red clover 3 100 95
- Timothy 3 90 90
- Fodder clover 5 41 34
- Grasses 5 76 73

Notes:
- See Annex Table 1. Table shows, for Canada and wheat for example, that for 3 wheat varieties their share in total production declined by 6 points from 80% in 1985 to 74% in 1990.
- Not available.
- * 1995 data.
- Nb Number.
2. Data are on weight basis for cereals and on an area basis for other crop categories.
3. In Germany, the cultivated area or the share of the varieties in total marketed production is not directly recorded: the numbers are calculated by seed multiplication areas.

Source: OECD Agri-environmental Indicators Questionnaire, 1999.
### Annex Table 3. Number of livestock breeds registered or certified for marketing: 1985 and 1998

<table>
<thead>
<tr>
<th></th>
<th>Cattle</th>
<th>Pigs</th>
<th>Poultry</th>
<th>Sheep</th>
<th>Goats</th>
<th>Horses</th>
<th>Other</th>
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<tbody>
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<td>Austria</td>
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<td>7</td>
<td>17</td>
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<tr>
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<td>13</td>
<td>..</td>
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<td>4</td>
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<tr>
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<td>9</td>
<td>11</td>
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<tr>
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<tr>
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<td>4</td>
<td>5</td>
<td>6</td>
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<td>18</td>
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<td>5</td>
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</table>

Not available.

5. Pigs: numbers refer to purebred, excluding cross-bred categories. Other: reindeer.

Source: OECD Agri-environmental Indicators Questionnaire, 1999.
Annex Table 4. Share of the three major livestock breeds in total livestock numbers: 1985 and 1998

<table>
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<tr>
<th>Country</th>
<th>Cattle</th>
<th>Pigs</th>
<th>Poultry</th>
<th>Sheep</th>
<th>Goats</th>
<th>Horses</th>
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<tbody>
<tr>
<td></td>
<td>% share</td>
<td>Points change</td>
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<td>85</td>
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Not available.

3. Cattle: beef breeds. Pigs: percentages include purebred and cross-bred categories. Poultry: chicken, duck, goose, quail, and turkey and percentages are estimated from breeding animals.
5. Goats and Horses: data for 1985 refer to 1990. Goats: as percentages for 1985 and 1998 refer respectively to 99.9% and 99.8%, the change equals −0.2.
8. Data refer to the major two breeds. Goats: percentages refer to one breed of goat.
10. Pigs: data refer to the major two breeds.

Source: OECD Agri-environmental Indicators Questionnaire, 1999.
### Annex Table 5. Percentage share of all wild species that use agricultural land as habitat: 1998

<table>
<thead>
<tr>
<th>Country</th>
<th>Mammals</th>
<th>Birds</th>
<th>Reptiles</th>
<th>Invertebrates (butterflies)</th>
<th>Amphibians</th>
<th>Fish</th>
<th>Vascular plants</th>
<th>Other</th>
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<tbody>
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<tr>
<td>Japan</td>
<td>7 (0)</td>
<td>28 (25)</td>
<td>42 (20)</td>
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<td>50 (45)</td>
<td>37 (37)</td>
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<td>60</td>
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</tbody>
</table>

1. Not available.

* Except marine species.

1. This table should be interpreted with care as definitions of the use of agricultural land as habitat by wild species can vary. Species can use agricultural land as "primary" habitat (strongly dependent on habitat) or "secondary" habitat (uses habitat but is not dependent on it).

2. It is estimated that about 90% of all wild species (animals and plants) depend on agricultural habitats.

3. Figures in brackets show species that use paddy rice fields as habitat. Japan does not have scientifically reliable data on invertebrates and vascular plants.


5. Percentages refer to the number of species that are associated with agricultural land but degree of dependence can vary. Birds: 10% of 250 species depend on agricultural habitats of which 3% are believed to have declined due to changes in agricultural landscapes. Invertebrates: day-flying butterflies, 70% of 94 species. Other: threatened mosses, 16% of 250 threatened moss species/red-listed fungi, 25% of 763 red-listed species.

6. Invertebrates: butterflies, beetles, aculeata hymenoptera, a number of smaller groups, plus an estimate of flies (diptera) and other hymenoptera. Overall the Swedish estimate is based on about one third of the known number of invertebrate species in Sweden. Other: mosses/fungi/lichens.

Source: OECD Agri-environmental Indicators Questionnaire, 1999.

**Numbers of species**

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<td></td>
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<td>– Cropland</td>
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<td>6</td>
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<td>– Fertile Grassland</td>
<td>11</td>
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<td>– Infertile Grassland</td>
<td>22</td>
<td>19</td>
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</table>

¹ Not available.
² Denmark: Measured as abundance of 7 key bird species.
² United Kingdom: Birds: Population index (1970 = 100) for 20 breeding birds associated with farmland.
Vascular plants: Average number of species per 200 m² random plots. Data for 1985 refer to 1978.

Source: OECD Agri-environmental Indicators Questionnaire, 1999.
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