Chapter 11
Genetic diversity

The total number of species in Denmark was given as about 30,000 in the previous chapter. As was mentioned in Chapter 3, most of these species have dispersed freely and established permanent breeding populations. These species which, with many or few populations, have adapted to the conditions prevailing in the country are our *natural native species*. It is the *authenticity, dynamics and variation* that the populations of the species represent that we wish to preserve in Denmark, as our contribution to the conservation of global genetic - and thus, biological - diversity. Thus, the introduction of new species and of populations of species that already occur *does not enhance the genetic diversity* that we already have in Denmark.

Natural genetic variation

Local strains

The genetic material of a Danish population of a species can, to a certain extent, differ from populations that occur in our neighbouring countries, in the same way that several, differing, populations can occur within our borders. In some cases this is a question of such large regional differences in characteristics between the populations that it is possible to differentiate them at a certain level, and a *local Danish strain*, with its own genetic resources, has emerged; see Box 11.1. In other words, the regional differences in genetic material are conditioned by the responses of the viable individual populations to the pressure of natural selection exercised in space and time. Thus, the *viable population* is a concept central to the conservation of genetic diversity.

The IUCN (International Union for the Conservation of Nature) has defined the viable population as follows: *It contains a high degree of genetic variation and, thus, preserves its potential for*

Box 11.1

Emergence of strains

Plants that grow on very windy sites, for instance, along the west coast of Jutland, often develop special characteristics, such as reduced height or fleshier leaves, in comparison with inland individuals of the same species. A new strain has emerged once these characteristics become hereditary. On the left is the low strain of the spotted cat's ear at Bulbjerg and, on the right, the normal, inland strain, from Tibirke.

Box 11.2

Artificial introduction and use of wild seed mixtures

Fish

Only one self-reproducing wild salmon population has been ascertained with any degree of certainty in Denmark, i.e. in the River Skjern system. This population is being re-invigorated by releasing fish that are the offspring of wild salmon caught in the River Skjern. As far as can be seen, no other Jutland watercourse contains any residue of the original salmon populations. The salmon found today in these watercourses are either wanderers or the result of releases in recent years. Attempts are now being made to re-establish self-reproducing populations, e.g. in the River Gudenå, from which the salmon vanished in the 1920s.

These attempts use material that is presumed to possess great similarity to the original material. On the other hand, it is appropriate to release broadly varied genetic material, in the form of different strains, e.g. from the River Skjern. After their release, the salmon will be exposed to the forces of natural selection and, with the passage of time, will adapt to the conditions of the Gudenå.

Birds and mammals

Wild birds are released for shooting. Of our original native species, only partridge and mallard duck can be released without special permission. Wild mallard duck hardly exists as an independent strain now as a result of interbreeding with the domestic duck, of which the mallard is the progenitor.

Of our original native species, it is only permissible to breed red deer. The release of stags, which are often imported from abroad, constitutes a threat, in the form of the mixture of genetic material, to the original Jutland population.

Use of wild seed mixtures

Interest has increased over the last 10 years in sowing wild herbs in the open countryside cultivated clearings, road verges, railway embankments, local-council installations and recreational areas), in gardens and in parks.

Because of this interest new plants are being introduced into Danish nature, which are often members of genera or strains that did not previously exist in this country and which are, for instance, sold in packets of so-called "meadow seed mixtures" produced in other countries. They often contain partly improved material of narrow genetic variation. This material can be sown freely throughout the country, wherever sowing is permitted.

A few places in Denmark have started to produce wild seeds based only on material collected from Danish sites. Although the number of these places is at present small and not typical of our countryside, their collections are preferable to imported material. The Danish material has not been improved, but a certain loss of genetic variation must be expected as a result of the cultivation process, unless there is continuous admixture of seeds taken from wild populations.

developmental adaptation; whereas its risk of extinction through fluctuations in population, changes in its environment and human exploitation is small.

Genetic isolation

Many animals range regularly between their feeding grounds and their breeding and nesting grounds. Adult individuals of the same strain of trout return year after year to the breeding grounds where they were, themselves, hatched, thus isolating the different strains from each other. Genetically different local strains, which are associated with individual watercourse systems, develop as a result of reproductory isolation. There is, however, always a certain mutual interchange of genetic material between the more or less isolated trout populations. This happens, for instance, when a few of the adult fish wander up a watercourse other than the one in which they were hatched, and mate with individuals of the local population. This has the effect of a biological safeguard against genetic isolation and, therefore, in-breeding, of which there is more risk in watercourses that have small breeding populations.

Fragmentation of the terrestrial landscape (cf. Chapter 7) has had the effect that many wild plant and animal populations have become genetically isolated. If an isolated population cannot receive new genetic material, the risk of a loss of genetic variation increases. Populations of few individuals and narrow genetic variation are especially vulnerable to new declines in their numbers. This applies particularly to species, the abilities of dispersal of which are limited. In the event of severe fragmentation, the genetic diversity of populations having only few individuals will normally be adversely affected: such populations are more exposed to local extinction, with a concomitant loss of genetic variation and authenticity, while fragmentation obstructs re-immigration from neighbouring areas.

Threshold for survival

A population's viability depends on its degree of adaptation to its environment and on its size. When the size of a population drops below a certain *threshold value*, there is a risk that it will be unable to survive since its genetic variation diminishes rapidly. Random causes can bring about the destruction of a small population, despite protective measures.

We know very little about how few individuals a population can comprise before it passes the threshold between survival and destruction. It is certain that this threshold value varies considerably from species to species. Correspondingly, we know little about how large a population should be, if it is to retain so much genetic variation that it will permanently be able to adapt itself to random changes in its environment.

Man-made changes and natural changes affect the conditions of life of plants and animals and exert influence on the process of natural selection. If the impact of pollution is serious, or if climatic changes occur rapidly in relation to the natural evolution of species, these factors can influence the genetic variation of several species.

Re-introduction of plants and animals

If a plant or animal species is, or is becoming, extinct in an area, e.g. because of genetic isolation, individuals from that area can be bred and their offspring released, or individuals brought in from other parts of the species' range can be released in the depopulated area. Re-introduction can be used, for instance, to counteract in-breeding in isolated populations; see Box 11.2.

But the re-introduction of plants and animals in areas where they have previously lived can result in loss of authenticity. The individuals that are released can possess genetic material that differs from that of the original, or extinct, po-

pulation. But, apart from this, the question of re-introduction is not so simple. The balance between doing something that promotes biodiversity and doing something that is, in reality, an expression for manipulation, is often extremely delicate. In the final analysis, it is questions of this nature that underlie our present restrictive practice.

To maintain this restrictive practice we should, at the minimum, carry out in each individual case in which plant and animal species are to be re-introduced an accurate assessment of the relevant species' potential for spreading into, and surviving in, the area in question. If the conditions of living for a species are optimum in a habitat, or if the chances of the species' survival and propagation are improved, that species can often return by itself. Re-immigration is preferable to re-introduction. This is also the reason why no permission has been granted for releasing such creatures as white stork and white-tailed sea eagle.

We should only resort to re-introduction when there is a serious risk that a species will either become extinct or will be unable to increase its population size within so short a time that other measures (conservation, nature management, etc.) have time to act. Where appropriate, re-introduction should use individuals that are genetically related as closely as possible to the original population, as has been done in the re-introduction of rare amphibian species.

Genetic variation created by man

As is the case with wild plants and animals, local strains have emerged that are adapted to Danish conditions and local conditions from the crops, forest and garden plants and domestic animals that man has used for producing food, frames of buildings, garments, etc. In many cases, local strains have emerged through the selection and breeding of native or introduced species. As in the case of wild plants and animals, there are strains worthy of conservation among the plants and animals that man has bred.

Crops, garden plants and forest trees

Over the centuries, farmers have carried out selection according to flavour, quality and yield in their cultivation of crops. With the passage of time, local varieties emerged that possessed particular characteristics which, in many cases, disappeared again as breeding continued. The scientific breeding of crops, which has been common practice ever since, started at the end of the 1800s.

We wish to conserve the Knapstrup horse as a representative of an old Danish domestic strain.

Box 11.3

The brown bee

About 24 sub-species of honeybee have been described globally. These sub-species can interbreed freely if they are brought together. In Denmark, the yellow bee and brown bee are examples of such sub-species. The latter is naturally native to Northern Europe, whereas the yellow bee comes from Southern Europe.

With the exception of a few populations, for instance, in Scotland, Norway, Sweden and Denmark, the brown bee is disappearing from its entire range through the genetic dilution that has resulted from the artificial introduction of other sub-species. The population on the island of Læsø is now the only one in Denmark.

Apart from the moral and cultural obligations involved in the conservation of native species, there are also genetic reasons. The brown bee has developed different characteristics, which are of interest from the breeding standpoint. It tolerates the winter (i.e. has low mortality during the winter months) and is adapted to the wild Danish flora and Danish climate. Practical experience also indicates that the brown bee is resistant to a disease (Nosema), which is caused by a parasite.

In every beehive there is a queen, which makes only a single or few mating flights in the course of its life. It can fly several kilometres from its hive on mating flights. During these flights, it can mate with up to eight drones within a radius of about 12 km. It can be seen from the foregoing that, on the isolated island of Læsø, which is about 20 km long by 10 km wide, it is possible to maintain a viable population of the brown bee, but also that the presence of other sub-species within the area will mean that there is a clear possibility of the genetic mixture of these sub-species.

Breeding has resulted in high-yield, uniform, disease-resistant varieties. At the same time, agricultural developments have led to the cultivation of few varieties, which are seldom based on native genetic resources. Only a few crops have native relatives, for instance, such plants as root beet and bird's-foot trefoil. Together with developments in agriculture, breeding has reduced the genetic variation of our crops.

Selective breeding has correspondingly reduced the genetic variation of Danish fruit trees and bushes. However, this reduction is balanced to some extent by the fact that varieties and hybrids that contain older genetic resources still thrive, for instance, in hedgerows and on barrows. Old apple, pear and plum trees, as well as gooseberries, black and red currants, still occur in hedgerows and coppices, especially around farms and villages.

Corresponding, but less obvious, selective breeding has taken place in the case of a number of introduced forest trees.

Domestic animals

Domestic animals have their origins in wild species, which have been tamed and used as domestic animals, i.e. have become *domesticated*, since the times of the earliest farming cultures. No large, original, native animals have been domesticated in Denmark. The first domestic animals were brought here by migrating tribes or suchlike. Widespread introduction of domestic animals also took place during the first half of the 1800s.

Pure-line breeding of domestic animals became the preferred breeding method by the mid-1800s. Breeding became more systematic, with the emphasis on specific characteristics. More uniform strains of domestic animal, that were associated with individual countries or local areas, gradually emerged. Most Danish strains of domestic animal also have their origins in this period.

Much local character has disappeared in modern, scientifically-based breeding. Most of the old, traditional Danish domestic animals have lost their significance as breeding animals.

There are 24 strains of old Danish domestic animal, counting dogs, pigeons and the brown bee; see Fig. 11.3. The Frederiksborg horse has existed for over 300 years whereas others, such as the white Danish rabbit were bred at the beginning of the century. Individual foreign strains, such as the Jersey cow, were introduced over 100 years ago, since which they have been bred without any significant importing of breeding animals and we can now speak of a special strain, the Danish Jersey.

9 of the old Danish strains of the most important production domestic animals, i.e. horses, cattle, pigs, sheep, goats and fowl, are endangered; see Fig. 11.4. A

Fig. 11.4.
Status of populations of old Danish domestic animal strains, 1993.

Strain	Number	Need for conservation
Jutland horse	350 mares	average
Frederiksborg horse	500 mares	safeguarded
Knapstrupp horse	300 mares	average
Jutland black and white cattle	60 cows	great
Black and white Danish dairy strain, type 1950 to 1970	50 cows	great
Danish shorthorn	200 cows	great
Red Danish dairy cattle	1000 cows	great
Black and white pigs	100 sows	great
Danish pig strain	20 sows	great
Danish sheep	100 ewes	great
Danish goat strain	2500 nannies	safeguarded
Danish goose	250	average
Danish duck	500	average
Danish hens	5000	safeguarded
Jacobin pigeon	500	safeguarded
Tumbler pigeon	500	safeguarded
Danish suabian pigeon	500	safeguarded
White Danish rabbit	30,000	safeguarded
Danish bird dog	2000	safeguarded
Broholmer dog	180	average
Danish farmyard dog	1500	safeguarded
Hertha pointer		great
Strelluf hound		great
Brown bee	275 societies	safeguarded

Note: the figures given for some of the above families are only rough estimates.
(Source: „Committee for conservation of the genetic resources of Danish domestic animals.")

newly-conducted FAO study shows that 25% of 4,000 strains of domestic animal are threatened with extinction. Of these, more than a quarter occur in Europe.

Half of the animals that could be found in Europe at the turn of the century are now extinct. In addition, a third of the remaining animals are in danger of disappearing in the course of the next 20 years.

Genetically modified organisms

Developments in the field of gene technology have made it possible to alter the genetic material of living organisms and, thus, to create *genetically modified organisms*. Genetic modification consists of the insertion of specific characteristics into the genetic material of organisms or of removing some of the organism's own genetic material. The material inserted, for instance, into a plant, can be taken from another plant species, an animal or a micro-organism. Gene technology can be used to produce human hormones or other substances that can be used in the production of pharmaceuticals.

So far, plants have been the main objects of genetic modification. Genetically modified culture plants, with increased resistance to virus and fungus infection, with increased tolerance for specific weed-killers or cold, can be used to increase the productivity of agriculture and in horticulture and forestry.

If a genetically modified organism has received a characteristic that increases its competitive ability, experience with other alien species show that it will be able to establish itself and spread out into our nature. If it also has wild relatives, a mutual interchange of genetic material is also possible through cross-breeding. In this way, inserted characteristics can be transmitted to individuals of the wild species and increase its competitive ability. These individuals are capable of defeating other, less competitive individuals. Rape and root beet are examples of genetically modified crops that have wild Danish relatives, in which plants that possess increased resistance to chemical weed-killers are being tested out of doors in Denmark.

The Danish Ministry of Environment and Energy has issued 10 permits for the release of genetically modified rape, root beet and potato plants. Permission for the production of genetically modified mice has been applied for, and granted, although the Minister of Environment and Energy has not yet granted permission for releases.

The Minister has also approved about 50 different genetically modified micro-organisms, mainly for the production of pharmaceuticals. Several of these permits also permit a certain level of discharge of the micro-organisms in waste water, air and solid waste. In connection with all decisions concerning the discharge of micro-organisms, risk assessments have shown that the organisms cannot survive and grow outside the laboratory.

Current protection performance and conservation initiatives

Legal protection

The protection of nature types under the Nature Protection Act, Forest Act and other acts has been done to promote the protection of natural native plant and animal species in their natural surroundings. By ensuring viable populations of native plants and animals, we also protect their genetic diversity. The regulations of the Nature Protection Act and Act on Hunting and Game Management that prohibit, for instance, the release of species that do not naturally occur in the wild in Denmark, are mentioned in Chapter 10.

Species conservation orders are used to protect particular plant and animal species generally, but not in selected areas; see Chapter 10. Conservation orders are used to protect selected areas of land and water; see Chapter 7. The provisions of recent area conservation orders make

it possible to carry out a specific form of management.

The possibility of including provisions on the protection and management of the habitats of populations of specific plant and animal species worthy of conservation in a conservation area has only been used to a modest extent. Area conservation orders will therefore be suitable for protecting genetic diversity *in situ*, if an appropriate method of management is included in the provisions.

In situ and ex situ conservation

The programme for the conservation of genetic resources is being conducted according to two principles, i.e. through conserving the relevant species or population in its natural habitat, *in situ conservation*, or through conserving it in other places, *ex situ conservation*. Although the latter is a secondary approach, we cannot dispense with it.

In situ conservation is the overall goal of nature management. When applying the means of nature management, species can develop in their natural environments and natural evolution can continue. However, safeguarding a few individual habitats of a species is not sufficient to safeguard that species' genetic diversity.

The *in situ* conservation programme can be reinforced by nature management of the relevant habitat and by establishing ecological corridors to it. This makes immigration possible from other *in situ* areas. All species-specific nature ma-

Box 11.5

In situ conservation of the large blue butterfly

The large blue butterfly is a good example of in situ, goal-oriented species conservation. In earlier times, this species occurred at about 40 sites in the Islands, Djursland and in Vendsyssel. Today, it is only known at a couple of localities at Jammerbugt and the island of Møn.

The species' habitats are uncultivated dry grassland or heath-like areas, which are often situated near the coast. The individual populations are very tied to their localities. For this reason, they are only rarely encountered outside their clearly delimited habitats.

The breeding biology of the large blue butterfly involves complex interaction between egg-laying in the flowers of Breckland thyme and the larvae spending the winter in the nests of a particular species of ant, which cares for the larvae through the winter.

As a result of purposeful monitoring during 1991 to 1992, it was observed that the number of large blue butterfly on Møn was reduced and that populations were otherwise seriously threatened. This was not due to a shortage of host ants or to the collection of butterflies. The cause was a marked decline in the numbers of the thyme plant. It was feared that the large blue butterfly would disappear from Møn.

Vegetation management, including the cutting of high herbs and bushes, was carried out to help the population of large blue butterfly to regain its strength. The ex situ cultivation of larvae and the releasing of fully developed larvae into their habitats were also practised for two seasons. Moreover, thyme plants grown from seeds taken from nearby sites have also been planted.

Continued monitoring will reveal whether or not this method has succeeded in raising the population.

Box 11.6

Gene bank

The most important use of a gene bank is for collecting, storing, documenting and making available genetic material. The conservation of plant and animal material, i.e. seeds, cells and tissue cultures, including sperm and eggs, is carried out ex situ by cooling, cryo-preservation or some other form of storage.

The Nordic Gene Bank (NGB), an institution under the Nordic Council of Ministers, located at Alnarp in Sweden, is the centre for work on the conservation of genetic resources in the Nordic countries.

Conservation is primarily carried out ex situ, at seed stores in Alnarp and on Svalbard (emergency stock), but also in situ. Information on the properties of the material is stored in the NGB data base and is freely available. Information from other gene banks can also be obtained through the NGB.

nagement can be considered as *in situ* conservation; see Box 11.5.

One advantage of several forms of *ex situ* conservation is that considerable genetic diversity can be safeguarded, with relatively low demands for space, work force and cost. Significant disadvantages of *ex situ* conservation are the risk of a lack of natural evolution in the genetic material selected and the risk that species and populations will be subjected to changed selection pressure. Thus, *ex situ* conservation should always be considered in the context of a general strategy, which also safeguards species' or populations' genetic variation in nature.

The importance of, and effort towards, *ex situ* conservation of Danish genetic resources has increased significantly over the past 10 years. The effort is concentrated primarily on the genetic resources of agriculture, forestry and horticulture, although an understanding of the potential of *ex situ* conservation of the genetic resources of wild plants and animals is growing, even if it is something of an *ambulance service.*

Wild genetic resources

So far, only a few conservation programmes have been conducted in Denmark to safeguard endangered species *in situ*. However, several individual actions have been carried out over the past 10 years, to strengthen local populations of the common spade-foot frog, green tree frog and fire-bellied toad against extinction resulting from human intervention in their habitats. These rescue actions have included the cleaning of ponds, establishment of new ponds and transferring of adult individuals and tadpoles. In a few cases, the tadpoles were hatched and raised *ex situ* and then released. These rescue actions are a combination of creating and safeguarding new habitats and improving and invigorating established habitats, and of releases and re-introduction from other populations.

The process of safeguarding and improving habitats includes the cleaning of ponds, goal-oriented protection of specific plant and animal species, and laying out fodder to improve the conditions of specific animal groups. Thus, the Ministry of Environment and Energy has drafted a strategy for the feeding of birds of prey in its own areas.

Large-scale releases of freshwater fish can be considered as *in situ* conservation, even if these actions primarily satisfy angling interests.

In order to safeguard local strains of wild fish, the Ministry of Agriculture and

Fisheries has conducted studies within the last 5 years of the genetic variation of wild populations of salmon and trout. Moreover, a major programme has been started to study the effect of releasing commercial fish (mainly reared trout) into the natural trout population of the River Karup system.

The Ministry of Agriculture and Fisheries and 6 Jutland counties have prepared the *Action Plan for the Release of Salmon*, the purpose of which is to build up and re-establish a self-reproducing Danish salmon population, based on Danish and foreign genetic resources, for instance, in the River Gudenå; see Box 11.2. This plan has been incorporated into the Ministry of Agriculture and Fisheries' *Action Plan for Fish Conservation* as of 1994.

In 1994, the Ministry of Environment and Energy prepared a report on the possible implementation of controls on fishing in Ringkøbing Fjord and the River Skjern, in order to strengthen the populations of salmon and trout, in particular.

Domesticated genetic resources

Work on plant conservation includes primarily crops that originate in Denmark and that have been cultivated widely here or associated with breeding. Wherever possible, the material is stored as seeds at the Nordic Gene Bank (NGB); see Box 11.6. The seed samples include improved varieties, old local varieties and populations of cultivated crops of the following main groups: corn, grasses,

Box 11.7

Examples of ex situ conservation

The „Pometum," under the Royal Veterinary and Agricultural University:
Founded: 1956
Area: 10 ha
Stocks: apples, pears, plums, cherries, black and red currants, gooseberries, strawberries, bilberries, elder.
700 varieties of apple, of which 200 are old Danish local varieties.
The variety collections are also stored in the Nordic Gene Bank.
Data base containing all varieties of apple in Denmark.

Orchards in Ulborg State forest district
Founded: 1980
Area: spread in glades in the district's plantations.
Stocks: apples, pears, bird cherries, plums, cherry plums, sloes, blackberries.
About 100 varieties of apple, of which many are local varieties.

Valby Park Rose Garden
Founded: 1964
Area: 1.5 ha
Stocks: 12,000 roses, including about 120 bush varieties, 60 polyanthas, 60 large-flowered hybrids and 30 climbing varieties.
Trial plot for new varieties of rose.

Gerlev Rose Garden
Founded: 1982
Stocks: 2,000 roses, including old, only slightly improved varieties, lightly improved varieties of native species and highly improved varieties from well-known Danish rose cultivators.

Box 11.8

*A **seed source** is the stand or the parent trees from which the seeds for cultivation are harvested. It could comprise a natural or planted stand. Seed sources are designated by the Seed Source Committee.*

*In the case of forest trees, the designation **provenance** (origin) is used, which is the locality in which a given stand grows.*

*In the official definition, a **stand** is „a population of plants that is so homogeneous in its composition, structure and distribution that it can be distinguished from its neighbouring stands."*

*A **clone bank** or clone depot is a collection of clones, for instance, in the form of grafts.*

*In **clones**, all plants have been produced vegetatively, from a single parent plant. Thus, all individuals of a clone have in principle the same hereditary properties.*

root vegetables, oil plants, pulse, potatoes, green vegetables, fruits and berries.

Moreover, fruits and berries are stored as either clones, in which the NGB cooperates with national institutions, such as the Danish Research Service for Plant and Soil Science and the Pometum, at the Royal Veterinary and Agricultural University.

The Pometum disposes over an extensive collection of the common old Danish fruit trees and berry bushes. Certain museums have collections of fruit and berries, as well as old culture plants. The old medicinal herbs and potherbs are primarily preserved in convent gardens and public gardens. To some extent, rose varieties have also found their way to these refuges; see Box 11.7.

In 1985, the *Committee for Conservation of the Genetic Resources of Danish Domestic Animals* was appointed under the Danish Ministry of Agriculture and Fisheries. The Committee also has representatives of the Ministry of Cultural Affairs and of the Ministry of Environment and Energy, together with associated animal specialists. The purpose of the Committee is to promote work on tracing, collecting and conserving populations of our old traditional strains of domestic animal. This is carried out in cooperation with societies, associations, agricultural museums and interested individuals.

The Committee has prepared a list of Danish domestic animals worthy of conservation (see Fig. 11.4) and has helped to establish conservation centres at a number of farms, where economic support is given for conserving large traditional domestic animals, in particular. The Committee is drafting breeding plans for established populations of domestic animal, so that in-breeding and genetic mixing with other species can be avoided.

Forestry

For a number of years, the Ministry of Environment and Energy, the Ministry of Agriculture and Fisheries and *The Arboretum*, under the Royal Veterinary and Agricultural University, have conserved some of the most commonly-used species of forest and landscape tree and bush, in connection with breeding activities and seed source work. Conservation activities were preceded by the establishment of seed sources, provenance collections and clone banks; see Box 11.8.

Some of the Ministry of Environment and Energy's established installations for the production of tree seeds also function as genetic conservation areas. The tracing and designation or selection of seed sources has been carried out by State selection committees (a few species) and

the Seed Source Committee (many small trees and bushes). Both committees are appointed by the Ministry of Agriculture and Fisheries.

In 1994, the Ministry of Environment and Energy issued its *Strategy for Conservation of the Genetic Resources of Trees and Bushes* in Denmark. This strategy proposes the designation and establishment of about 1,800 ha of genetic conservation stands embracing 75 species. 1,500 ha will be conserved *in situ* and 300, *ex situ*. Designation has already started. The area sizes and numbers of conservation stands are only very approximate, as they will be adjusted during the designation phase and in step with increases in our knowledge of the species' hereditary variation. The designated areas are known as *genetic resource areas*.

Subsidies can also be granted for conservation of the genetic resources of trees and bushes in forests. Similarly, subsidies for nature management can also be used for safeguarding genetic resources.

Botanical gardens

The primary contribution of *botanical gardens* is the conservation of populations of rare and endangered species, of economically important species and of ecological key species that are crucial to the maintenance, function or restoration of ecosystems and of scientifically important species. One vital area is conservation of the material of original crop strains. The genetic resources of botanical gardens can be used as a basis for breeding and re-introduction projects.

The Botanical Gardens in Copenhagen have established a *gene bank* in which the seeds of herbs are stored, also including wild Danish herbs collected from nature; see Box 11.6.

The purpose of storing Danish seeds is the goal-oriented *ex situ* conservation of genetic diversity and maintenance of Danish seed material, for exchange with related institutes abroad. The Botanical Gardens' gene bank contains about 5,000 collections, representing about 700 species. It is vital in this context that we know something of the *in situ* occurrence of these genetic resources. To satisfy this need, a register is being established of the original localities of the material in the Botanical Gardens' seed and gene banks.

An international basis on which to unite the world's botanical gardens in a global network, with a view to conserving vascular plants and their genetic diversity, has been established through the organisation *The Botanic Gardens Conservation International*.

Zoological gardens

Zoological gardens assume a central role in the conservation of biodiversity through the international cooperation on the conservation of endangered animal species. This cooperation is organised as regional breeding collaborations for the purpose of building up healthy animal populations, which can be used where necessary when re-introducing them into the countryside and, thus, which serve as a reserve for the natural populations.

This breeding collaboration is carried out within the framework of the IUCN which, through a specialist group, the CBSG (Captive Breeding Specialist Group), coordinates the conservation efforts made in zoological gardens with work done in the field.

In association with the breeding collaboration, zoological gardens participate in the preparation of Global Animal Survival Plans (GASP), which give priority to conservation efforts according to the methods to be used and the species to be conserved.

Zoological research is also conducted in support of this conservation work. This research concentrates especially on genetic, physiological and behavioural matters and is a necessary adjunct to both breeding and field work.

The numbers of visitors to zoological gardens (an annual 600 million, at the global level) offer excellent opportunities for presenting our scientific knowledge of conservation work.

Culturing centres for algae

In 1986, Copenhagen University established a culturing centre for algae, which has collections of marine algae and, to a limited extent, freshwater algae. The collection contains about 200 species.

Genetically modified organisms

To avoid undesired effects on the environment, the Environment and Gene Technology Act (lov om miljø og gentek-nologi) states that an ecological risk assessment be carried out prior to the issuing of permission to release genetically modified organisms. This act is based on EU directives governing the release of genetically modified organisms. The EU directives require that all matters concerning the release of genetically modified plants and animals in a single country be reported to the other member states. This requirement takes into account the fact that living organisms do not respect national borders.

The Ministry of Environment and Energy has, in connection with *tests of the artificial re-introduction of plants* that have been carried out so far, emphasised the importance of preventing spreading of the hereditary characteristics of genetically modified plants through pollen, seeds and vegetative parts; see Box 11.9. This has been done as a result of the *ecological risk assessment* (see Box 11.10) and by setting conditions on the procedure of the tests, such as the isolation distance to the nearest crops of the same species and to wild relatives. Moreover, some permits set requirements on the sowing of specific plants in the zone around the test land. This protective zone is intended to ensure as far as possible that the pollen from genetically modified plants does not leave the test field, but falls out in the protective zone.

Thus, Denmark follows the precautionary principle, in cases where approval of the release of genetically modified organisms is concerned. In Denmark, it is still the Minister of Environment and Energy who approves the release of genetically modified organisms.

International cooperation

Many wild relatives of our culture plants are invaluable for breeding purposes and have been collected, and are still collected, in parts of the world that have great native biodiversity. The countries involved have, themselves, little chance of undertaking extensive gene conservation. Danish aid programmes make an im-

Tests on genetically modified sugar beet

portant contribution to the effort to conserve global biodiversity.

The five Nordic countries support the establishment of a regional gene bank for a number of countries in Southern Africa. The NGB is responsible for the practical implementation of the project and for providing technical assistance. The NGB also cooperates with the Baltic countries.

The *Nordic Gene Bank for Domestic Animals* (NGH), which is associated with the Royal Norwegian Veterinary and Agricultural College, was established in 1984. Its primary task is to establish a common Nordic data base for domestic-animal resources and to stimulate and coordinate practical conservation activities. The actual work of conservation is carried out in the individual countries.

The Nordic Council of Ministers has decided to place a five-year readership at

Box 11.9

Introduced species

In contrast to species that have immigrated naturally, introduced species have been brought in by man. The ground elder and giant hogweed are among the best known. These species were introduced respectively as vegetables by monks, in the Middle Ages, and as ornamental plants in the last century. Of more recent introductions, we can mention the South-American shaggy soldier, which was first observed in Denmark in 1929 and has now been observed in all parts of the country. There is also the East-Asian giant knotweed, which was first observed in Denmark in 1950. The giant knotweed can now be found in most parts of the country, as a conspicuous and particularly expanding plant.

The reason why some introduced plants are highly visible in the Danish landscape is that they possess a combination of characteristics that is new to the region. Introduced species can spread and establish themselves, for instance, when their original enemies and competitors have not accompanied them, or if they possess unique morphological or reproductive properties.

A comparison between introduced and genetically modified species will illuminate the problems of the arrival of new characteristics or genes in an area. Tolerance of frost, drought, salt, attacks by insects and disease are examples of the characteristics that can increase the competitiveness and survival of a species in the countryside. Gene technology is being used to insert, or in attempts to insert, such characteristics into plants.

the Royal Veterinary and Agricultural University, as a phase in the expression of its action plan for the conservation of genetic resources. This is expected to yield scientific knowledge to support the research effort and education in this field.

A programme for the conservation, description and use of the genetic diversity of crops and domestic animals has been planned under the auspices of the EU. This programme prepares the reinforcement and increased coordination of work on the genetic diversity that is significant to agriculture within the EU.

Forthcoming efforts

The purpose of our forthcoming efforts for the conservation of genetic diversity is to safeguard the breadth of genetic variation of naturally occurring plants and animals and of culture species.

Specialist committee

Hitherto, the protection of natural assets has traditionally proceeded through the application of nature conservation and species' protection. One important section of the Convention on Biological Diversity is the safeguarding of variation within species.

Consideration should therefore be given to the appointment of a committee of specialists to advise the Ministry of Environment and Energy and other authorities on matters concerning the preservation of Danish genetic resources. It would be the task of such a committee to draft guidelines for the preservation of genetic diversity in Denmark, to designate areas for the necessary research and educational efforts and to advise the authorities in specific cases.

Box 11.10

Testing of genetically modified organisms

Each release of genetically modified organisms shall proceed in phases. Phased test releases mean that the genetically modified organism is first cultivated in a growth chamber, then in a greenhouse and, finally, out of doors. The modified characteristic of the genetically modified organism is studied during the release process.

An ecological risk assessment is performed in each phase. This means that different characteristics of the genetically modified organism are compared with the corresponding characteristics of unmodified individuals; see Box 11.9. Its capabilities for establishing itself, dispersal and hybridisation are studied. The knowledge gained in each phase of the organism's ecology is taken into account in the decision of whether or not to continue with the next phase of the release procedure. The effect of the genetically modified organism on the environment is assessed against this background.

Permission for marketing can only be obtained after the effects that the genetically modified organism can or will have on the environment have been accurately described. When granted, such permission extends to all EU countries.

Another principle of testing is the case-by-case procedure, which requires an individual assessment of each artificial introduction. Two individuals of the same species, which have both been given the same new characteristics, are thus studied as two separate cases.

Gene conservation orders

Consideration should be given to the need for supplementing existing conservation orders, so that they also cover the *in situ* preservation of genetic diversity in wild plants and animals, not least when considered in the light of implementation of the EC Habitats Directive; see Chapter 4. It has been noted in the current designation of habitat areas that many populations of plants and animals in need of special protection live in areas that are already the subject of conservation orders, without this becoming apparent from the relevant conservation provisions.

More specifically, increased conservation of genetic diversity can be promoted through including to a greater extent the conservation of individual wild plant and animal populations in current and future conservation orders relating to sea and land areas, so that nature management appropriate to these areas is specified in the conservation provisions. Consideration should be given to extending the scope of the *Action Plan for Conservation Orders* (terrestrial) to give consideration to populations of plants and animals that require special protection, or it could be supplemented with a special action plan intended to preserve genetic diversity.

Extending scientific knowledge of genetic variation

Additional knowledge of the range and genetic variation within Denmark, of wild plant and animal species is a crucial issue in the preservation of genetic diversity. For instance, our available knowledge on the magnitude and distribution of species' variation among native trees and bushes is limited. This knowledge is the foundation on which we decide whether or not there is a special need for safeguarding the genetic diversity of a species and, possibly, can designate genetic resource areas for such species.

The contribution of Danish genetic resources to overall global biodiversity should be identified. The scientific knowledge acquired could form a basis on which to draft conservation programmes for safeguarding vital Danish genetic resources *in situ*, as well as *ex situ*.

Important phases of such programmes will be to focus on the realistic opportunities for safeguarding authenticity in the naturally-occurring genetic material, such as ecotypes, and for safeguarding the evolutionary and adaptive potential of this genetic material in the future. This should be compared to the need for safeguarding and restoring our nature types and our natural ecological relationships.

Efforts for the *in situ* protection and conservation of Danish genetic resources have hitherto been scattered and uncoordinated. Conservation efforts often bear the random stamp carried by projects for the preservation of populations of individual species and of local interests; see Box 11.5. These projects, the foundations of which are commercial and, thus, economic, interests, have carried the greatest weight so far.

In each individual case, the implementation of conservation action, for instance, in the form of nature management, shall be weighed against the biological interests that occur in the habitat. We need basic knowledge of the living patterns and interaction with the environment of the individual species - linked to thorough investigations of the habitats and population dynamics of species worthy of conservation.

Research and education in taxonomy, ecology, population biology and dynamics at the universities and other institutes of higher education should therefore be promoted, with the simultaneous inclusion of the conservation and use of the genetic diversity of crops and domestic animals. Not least necessary is an increased research effort, since the conditions for safeguarding species and populations *in situ* are, as has already been mentioned, often dependent on access to an exten-

sive body of scientific knowledge. This knowledge can be acquired in part through studies of the genetic variation of *ex situ* material. Studies of population biology and dynamics are vital to our future understanding and safeguarding of viable populations across excursions over the threshold of population collapse.

There is a need for increased scientific knowledge on the cryo-preservation and thawing of seed and egg cells, in conjunction with the *ex situ* preservation of mammals, in particular.

Wild plants and animals

The Ministry of Environment and Energy has started to prepare the *Strategy for Conservation of the Genetic Diversity of Wild Herbs in Denmark*. The goal of this strategy is to establish a relationship, which is compatible with considerations of nature protection, between conservation of the genetic resources of wild herbs and the need to be able to use home-produced plants and seeds in Denmark. This strategy shall therefore include the designation of genetic-resource and seed-harvest areas, as well as guidelines for breeding and cultivation for commercial and practical applications.

As mentioned in Chapter 10, the Ministry of Environment and Energy has produced a draft of the *Management Plan for Denmark's Reptiles and Amphibians* (in 1993). The need for plans for conservation of the genetic diversity of other groups of wild plants and animals should also be identified. This could be done, for instance, in connection with the preparation of species management plans for the species for which such plans have yet to be drafted.

Botanical gardens

Our botanical gardens' strategy for the conservation of genetic diversity has four main goals. The first goal is to identify high-priority tasks for botanical gardens,

Old varieties of apple, which are adapted to Danish conditions, are still being cultivated - but for how long?

with a view to implementing the World Conservation Strategy. The second goal is to prepare proposals for how botanical gardens can cooperate effectively to complete these tasks. The third goal is to draft a set of cohesive principles and methods that will enable our botanical gardens to plan individually their own part of cooperation with other institutes, so that the greatest number of species and populations can be preserved in the long term. Finally, botanical gardens must be able to focus public attention on plant and nature conservation through programmes of training and information.

Forestry

The Ministry of Environment and Energy's *Strategy for Conservation of the Genetic Resources of Trees and Bushes* should be implemented according to the following time schedule: *in situ* populations shall be designated and safeguarded before the end of 1998, whereas *ex situ* populations shall be designated and established before the end of 2003.

Agriculture and horticulture

Work on conservation of the genetic diversity of plants and animals in agriculture and horticulture should be promoted. The preservation of these assets is a vital stage in the safeguarding of our future potential for production. This will also contribute to fulfilling international obligations concerning the preservation of genetic resources and to the development of international cooperation. Old Danish crops and domestic animals are a part of our cultural heritage and are of significance in research, as they can contain valuable genetic material that could benefit future breeding activities. Such characteristics as frugality and robustness, or reproductive capabilities, can become significant as a result of new forms and goals of production.

Up to the year 2000, Denmark should continue with its work on conservation of the genetic resources of crops and other utility plants in the Nordic Gene Bank, and of domestic animals, in the Nordic Gene Bank for Domestic Animals and within the Committee for Preservation of the Genetic Resources of Danish Domestic Animals.

The EU is working on a programme for the conservation and use of genetic

Danish hen, with chickens

diversity in agriculture. We should endeavour to obtain economic support for Danish conservation work from this programme.

In the long term, the survival of populations of the most important of our national domestic animals should be safeguarded, under public auspices if necessary. This could be carried out, for instance, in connection with agricultural and regional museums which, to this end, could animate to a greater extent their collections and environments with our old domestic animal varieties. The Minister of Cultural Affairs has presented a proposal for the establishment of a small centre for the preservation of domestic animals at the Danish Agricultural Museum.

We should also consider whether or not the counties' subsidisation of hedgerows could be combined with nature management, e.g. of conservation areas, in which the old Danish domestic animal varieties could be used thanks to their frugality and robustness.

Ecological landscape planning

In future, ecological landscape planning through the establishment of ecological networks (as described in Chapter 7) should be given higher priority and made binding. This is a question of creating more ecological corridors, which are vital if isolated populations are once more to be able to interchange genetic material. This can be done through conservation orders, afforestation (see Chapter 8) and through the inclusion of ecological landscape planning in physical planning, for instance, by safeguarding ecological corridors for plants and animals. Fauna passages should be established when roads are constructed.

Re-introduction

As has already been mentioned, plant and animal species that are close to extinction can be safeguarded through re-introduction. The precautionary principle is, however, of great significance here. Thus, we must ensure that requirements continue to be set at least on the thorough preparation of each re-introduction, and that some form of centralised approval and control is exercised over such re-introduction. Guidelines should be drafted for the possible use and breeding of species that are still extant in the country, and that are considered to represent genetic material that is deserving of preservation.

The consequences of re-introduction must be considered carefully prior to undertaking such re-introduction. It is vital to bear in mind the fact that the release of a species or variety is often irreversible. Once an organism has been released, it is possible that the population can spread to other areas, in which it may be less desirable, or even directly unwanted. When considering re-introduction, it is also necessary to consider the species' possibility of re-immigration and re-establishment in the relevant habitat in order to preserve Denmark's hitherto restrictive attitude to re-introduction.

When planting is carried out in connection with the protection of landscapes, nature conservation and deciduous afforestation, native species and local strains of plants should, as a basic point of departure, be used in preference to alien species and strains.

Continued stringency of conservation provisions when releasing genetically modified organisms

We have no tangible experience of the effects of spreading and establishing genetically modified organisms. However, experience from the introduction of alien species indicates that it is vital to be attentive to possible risks.

Whether or not a genetically modified organism will have effects detrimental to the ecology depends to a great extent on how capable it is of spreading and establishing itself in the landscape and wheth-

er its hereditary characteristics can be transmitted to wild relatives.

The effects of cultivating genetically modified plants will perhaps not become apparent until after the passage of many years. Thus, the release of insect-resistant plants can, for instance, mean reductions in the populations of not only harmful insects, but also beneficial insects. Another effect can be that the inserted characteristics increase the natural range of a species, thus affecting its ability to invade natural plant societies, so that it is perhaps able to defeat wild species.

Genetically modified organisms can have an impact on biodiversity, either through the genetic modification enhancing the organism's ability to compete or through the relevant characteristic being transmitted to wild species, which thus gain an increased competitive ability. This means that wild species can be defeated in competition or become restricted to marginal areas, thus reducing biodiversity in general.

If genetically modified organisms affect key species or processes, they can alter the balance of the ecosystem and, thus, exert a highly detrimental influence on biodiversity.

Today, we apply strict security procedures in conjunction with the release of genetically modified organisms. These procedures, which are sanctioned in the EU directive and in Danish legislation on the environment and gene technology, are based on the *precautionary principle*.

Other EU countries have expressed a desire to see the procedures eased that are specified in the EU directives.

Denmark wishes to work in the EU for the continued maintenance of a high level of security in conjunction with the release of genetically modified organisms.

Nordic cooperation

In 1994, the Nordic Council of Ministers appointed a strategy group for genetic resources. This group consists of two members from each Nordic country, one from the environmental sector and one from the agricultural sector. The strategy group has the task, for instance, of assessing and presenting proposals on policy, tangible measures and priorities concerning matters of genetic resources. Moreover, it shall assess the latter matters in conjunction with research and investigatory projects.

A review of Nordic cooperation on genetic resources can be found in *Cooperation on Genetic Resources - Nordic Action Programme, 1994-1997*. Denmark should follow up the recommendations and goals of this action programme that are concerned with strengthening Nordic cooperation on the conservation of genetic diversity through increased efforts in research, education and international cooperation.

Chapter 13
Information and public awareness

Man needs experience and recreation. Nature plays a central role in satisfying these needs.

Personal experiences in nature and knowledge and experience of the interaction between plants and animals and their physical surroundings are fundamental to man's understanding of nature. This also motivates man to assist in preserving biodiversity. An active population that has an interest in nature is probably Nature's best defence.

Authorities and organisations are becoming increasingly aware of the fact that information and the creation of satisfying frameworks in which to experience nature are important instruments in overall nature policy. Consideration for the population's opportunities for outdoor activities, nature experience and knowledge is receiving steadily increasing priority.

In the Ministry of Environment and Energy's areas, in counties and districts, at museums and in the Danish Open Air Council's member organisations, higher priority has been given to the presentation of nature, through the employment of environmental interpreters, nature kindergartens, eco-schools and nature centres in recent years. The presentation of nature has, thus, become an integrated part of work on the areas in which people are employed on nature management and popular information; see Box 13.1.

The education sector also considers it important to introduce *a „green" bias* into all subjects and educations.

Status of environmental education in Denmark

The primary purpose of environmental education is to give the population an increased understanding of the importance of protecting nature and the environment. We attempt to do this through direct experience and presentation of natural and environmental relationships.

Box 13.1

Article 13 of the Convention on Biological Diversity, 5 June 1992:

The Contracting Parties shall:

(a) Promote and encourage understanding of the importance of, and the measures required for, the conservation of biological diversity, as well as its propagation through media, and the inclusion of these topics in educational programmes; and

(b) Cooperate, as appropriate, with other States and international organizations in developing educational and public awareness programmes, with respect to conservation and sustainable use of biological diversity.

The presentation of the conditions of our primary industries, first and foremost agriculture, forestry and fisheries, and of culture-historical relationships is also an important area.

Environmental Interpreter Service

The Environmental Interpreter Service is based on the Danish tradition of popular education and nature activities in the relevant organisations. In order to support these initiatives, the Ministry of the Environment established the Environmental Interpreter Service in 1986, under which environmental interpreters were employed in the State forest districts, in counties and districts, as well as at museums and recreational nature centres. A programme of further training for environmental interpreters has also been developed and granted subsidies for experiments in rangership.

One of the environmental interpreter's most important tasks is to take people out into the countryside - and also in their more immediate surroundings - and draw their attention to its nature content. Direct presentation, personal experience and activities give an understanding and insight that cannot be attained through the media, such as television and books. The presentation of urban nature and ecology under the Environmental Interpreter Service have also been given priority in several places.

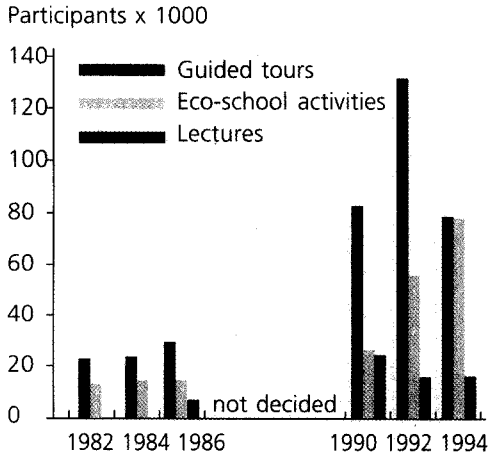

Fig. 13.2
Presentation of nature in our state forests. (Source: Ministry of the Environment 1994e)

77 people are employed today in the institutions mentioned above. There are another 66, who are primarily teachers, biologists, educationalists, foresters, forest workers, etc., but whose work also entails a considerable amount of rangering. All 143 persons have completed, or are in the process of completing, the Danish Forest and Nature Agency's 3-year supplementary course in rangership.

This course, together with the environmental interpreters' association, seminars and regional cooperation, has made it possible to establish a network in which educational methods can be developed, that have already resulted in first class rangership.

Even though the environmental interpreter programme is aimed at the whole of society, children and families with children receive especially high priority. A large part of the environmental interpreter's time is, therefore, spent in rangering activities for schools, camp schools and kindergartens. Environmental interpreters are used as teachers on courses for teachers, educationalists, volunteers from associations and others who are engaged on environmental education as part of their everyday employment or leisure activities.

The interest for, and scope of, these activities is increasing steadily. The population already has an awareness of the Environmental Interpreter Service. According to a survey of 1993, 52% of all adult Danes are aware of the service. In 1993, over 8,000 arrangements were held, with more than 300,000 participants. Of these, 16% have participated in several arrangements. In addition, many activities are arranged by private organi-

sations for their own members and for the general public; see Fig. 13.2.

Eco-schools, projects and courses

60 eco-schools, of which 27 are in the Ministry of Environment and Energy's areas and 33 are operated mainly by local councils in connection with other nature areas, have been established since 1972, in an effort to give our school children better opportunities to learn about nature outside the normal framework of schooling. The eco-schools in the Ministry of Environment and Energy's areas are established and operated in cooperation with one or more of the neighbouring local councils.

Eco-schools supplement the teaching of our primary and secondary schools, where teaching methods encourage the curiosity and desire for discovery of the children. This opens up opportunities for children to find stimulation for their interest and love of nature, which is a vital condition if our adults are to become involved in protecting it.

Eco-schools are one of several opportunities available to our schools' natural science teaching. The teaching sector has been largely responsible for a large number of projects in the area of teaching on the environment. Several other organisations, including the Danish Open Air Council, have made major contributions on behalf of our school children, in the form of projects and courses, such as *Plant and Learn* and *Green Flag - Green School*.

Nature kindergartens

It is also important that children of below school age receive satisfying experiences of nature. Many forests are the daily point of departure for kindergartens, nature kindergartens and children's forest groups. Forest personnel help to find suitable areas and can, to a certain extent, make premises, etc., available and assist with inspiration and getting started. Kindergarten forest groups and nature kindergartens are often established on the initiative of parents and educationalists who take an interest in nature.

Nature centres

Nature centres have been established in many parts of the country in recent

Assembly in the woods

years, in part with funds granted for nature management pursuant to the Nature Protection Act and from the receipts from the State football pools. In particular, these centres house exhibitions on the local countryside and its content of nature types, plants and animals, cultural history and farming industry. Thus, they offer the public the opportunity of increasing their enjoyment of the local countryside.

Pamphlets for outdoor recreation
The Ministry of Environment and Energy and Denmark's counties produce a large number of pamphlets, with maps and suggestions for marked routes.

The Ministry of Environment and Energy's series of pamphlets, which first appeared in 1964, contain information on the unique aspects of our forests and other natural areas, as well as history of nature and cultural history, etc. They are in great demand and about 2 million of the (at present) 97 different pamphlets are distributed annually, free of charge.

Ministry of Environment and Energy publications
The Ministry of Environment and Energy issues a large number of publications, for all target groups, on subjects relating to nature protection.

Forthcoming efforts

Denmark has an established tradition of nature protection - a tradition that offers a firm foundation for presentation and teaching on biodiversity and the many interests that are linked to its preservation.

The educational goals of our future environmental education and teaching are to contribute to enhancing people's common sense, so that they are in a better position to adopt an attitude in questions of nature and the environment. This is to be achieved through personal experience of nature and programmes of information on nature and the environment. It is especially vital to strengthen the presentation of nature to children and families that have children, and methods of marketing and presentation must be developed that can reach people who find nature alien.

One task will be to integrate to a greater extent the presentation of urban nature and the Danish and global environments into our enjoyment of nature.

Subsidies for developing environmental interpretation
Subsidies for experiments in rangering (financed with nature management funds and receipts from the State football pools) will enable us to continue to launch projects and activities that can contribute to the continuing development of nature-presentation methods and the activities in which eco-schools and environmental interpreters participate and initiate. The development of courses on presentation will be given high priority, so that all who are involved in environ-

mental interpreter activities gain a more solid background against which they can include a broader range of aspects of the protection of nature and the environment in their presentations. The Ministry of Environment and Energy has established a nature-presentation workshop for a three-year period, subsidised from the proceeds of the State football pools.

Moreover, we will work for the closer integration of environmental education in tourism, local administration, the organisations of the Danish Open Air Council, primary and secondary schools, kindergartens, folk high schools, youth centres, etc.

Parliament adopted the Green Fund Act in 1994. The purpose of this act is to make possible economic support for activities that entail changes of lifestyle, with a view to reducing our consumption of resources and of paying more attention to nature and the environment. This also includes support for information activities, etc., that can encourage us to behave in an environmentally-oriented fashion.

Part of the receipts from the State football pools, which are administered by the Danish Open Air Council, goes to support outdoor-activity projects that focus on work on nature and the environment, including environmental education.

Environmental presentation in schools

It is important to lay a foundation of understanding for nature and the environment as early as possible. Since there is no sign that our residential pattern will change, most children will continue to grow up in cities and towns, with their concomitantly reduced potential for gaining insight into natural and environmental relationships, at any rate, outside urban areas.

The new Primary Education Act of 1994 contains the following section in its objects clause: *Primary schools shall familiarise pupils with Danish culture and contribute to an understanding of man's interaction with nature.* The Act introduces a new subject, *Nature and Technology*, into the school syllabus from the first to the sixth year.

Against this background, the Minister of Environment and Energy has taken the initiative in cooperation with the Ministry of Education and Research on, for instance, education on the environment and the adoption of a „green" approach. With its long background of presenting nature experience and information on nature and the environment, the Ministry of Environment and Energy wishes to participate actively in the development of education on the environment, for instance, by offering to participate in the supplementary education of teachers.

More eco-schools, nature centres and increased information effort

The Ministry of Environment and Energy has the goal of contributing to the establishment of an additional 20 eco-schools in Denmark before 1998, so that the total number reaches 80. The eco-schools that are established in our State forest districts will continue cooperating with the Danish Open Air Council and interested local councils. The establishment of more eco-schools will make it possible to integrate to a greater extent the presentation of nature and the environment in the syllabus of our schools.

The Ministry of Environment and Energy will also continue to establish nature centres in order to heighten our awareness that nature must be protected and used in sustainable ways.

The individual State forest areas are in favour of cooperating on outdoor activities and environmental education, as well as making available relevant and exciting areas.

The use of other tools, such as radio, television, the daily press and target-oriented information aimed at the farm-

Environmental education

ing industry and decision makers, etc., must also be reinforced as a vital part of a heightened effort on behalf of an increased understanding of nature and the environment.

The responsibility of participating in the necessary, on-going debate is incumbent on every citizen and organisation. The public sector can stimulate and enhance this debate and, for instance, strengthen public understanding for the consideration necessary for the preservation of biodiversity.

Consumer councils in State forest areas

Denmark has a long tradition of engaging its population in the general effort on behalf of nature protection, e.g. through the special right of the Danish Society for Nature Preservation to initiate actions on conservation issues. The Danish Society for Nature Preservation and local associations are entitled to make complaints relating to decisions pursuant to the Nature Protection Act.

The Minister of Environment and Energy has decided that *user councils* shall be appointed in our State forest districts in order to give the population clearer insight and influence over how the Ministry of Environment and Energy's areas are used.

Danish names for animals

A necessary prerequisite for understanding the value of preserving biodiversity outside the circle of specialists is that our species have usable Danish names. In *Project Danish Animal Names*, work is in progress under the auspices of Danish post-graduate training colleges on proposing Danish names for our „nameless" species of invertebrate.

Chapter 12
Accumulation of scientic knowledge

Effective conservation of biodiversity is based on a sound knowledge of species and their habitats. An awareness of the range of genetic variation within each species, the geographical range of each species, as well as the functions of ecosystems, their variation, balancing mechanisms and range, are all fundamental to optimum conservation; see Box 12.1.

Moreover, a knowledge of the socio-economic causes underlying loss of biodiversity is necessary. There is also use for a knowledge of the means (technical, juridical, pedagogical, etc.) that can be applied with a view to counteracting the processes that lead to the loss of nature types, species and genes.

Protection performance to date

Today, our scientific knowledge is scattered and its structure is to some extent uncoordinated. Some of the most vital areas of the research related to the conservation of biodiversity have been neglected for the sake of research that is immediately connected to combatting problems of pollution.

In the field of natural resources, our accumulation of knowledge has been financed in part with project funds from the Ministry of Environment and Energy. However, these funds have only been sufficient to cover the most necessary, long-term monitoring of nature. No national research programmes have been implemented, for which reason our institutes of higher education and sectoral research have given little priority to the acquisition of scientific knowledge.

Nature monitoring

The purpose of nature monitoring is to give an up-to-date review of the state and trend of populations of wild plants and animals and the nature types in which they occur.

A number of organisations have worked with nature monitoring. Special interest organisations have made significant contributions to future, more systematic nature monitoring. Several associations have implemented nation-wide mapping projects through the voluntary efforts of their members. Some of these projects have resulted in sound knowledge of the state of several groups of species and, in particular, have illuminated the causes of the decline of many plants and animals; see Boxes 12.2-12.4.

Our institutes of higher education

Box 12.1

Article 7 of the Convention on Biological Diversity, 5 June 1992:

„Each Contracting Party shall, as far as possible and as appropriate, ... (b) Monitor, through sampling and other techniques, the components of biodiversity ...“

Box 12.2

Botanical monitoring

The Danish Botanical Society started to map the distribution of vascular plants in Denmark in 1906. This was given the name ***„Topographic-Botanical Investigation" (TBI).***
42 treatises were published between 1931 and 1980, which describe the frequency and distribution of these species. ***„Rostrup's Flora"*** *has included the results of the TBI since its 16th edition, of 1943.*

The Botanical Locality Register *was established in 1971, in cooperation with the Danish Botanical Society and the Ministry of the Environment. The register was completed in 1991. The goal of the project was to collect and process information from the body of botanical literature and from unpublished sources, such as flora lists. Information on about 6,850 localities in Denmark has been collected and published in 11 reports on these localities.*

The project „Heaths and Uncultivated Dry Meadows" *was a nationwide flora mapping project, the goal of which was to obtain current information on the states and ranges of heaths and uncultivated dry meadows. This survey was conducted over the period 1980-1989 and was initiated by the Field Botany Club. It is estimated that between 60 and 70% of the country's heaths and uncultivated dry meadows were covered by the survey.*

„Atlas Flora Danica" *is a nationwide survey of the wild flora of Denmark. It was started by the Danish Botanical Society in 1992, in cooperation with Copenhagen University, and is expected to proceed over a period of 10 years. The goal of the survey is to illuminate the current distribution of wild flora within the country's borders.*

„Orchid Monitoring" *was started by the Ministry of Environment and Energy in cooperation with the counties, voluntary observers and private consultants. Its goal is to attain in time a reliable index on an annual basis, of the population sizes of the various species of Danish orchid, in a number of selected localities. This project runs continuously and its results are published every five years, with the next issue due during 1996.*

Vegetation on raised bogs *is monitored on 21 of the most intact Danish raised bogs. This monitoring programme was started by the Ministry of the Environment in 1987. Its goal is to follow the growth of vegetation on our raised bogs, which are extremely sensitive to the input of airborne nutrients. These surveys will be carried out at regular intervals.*

The counties of Denmark *are carrying out botanical recording in conjunction with the assessment of nature management.*

Vegetation trends have been monitored since 1948 by the Ministry of Environment and Energy, at Geological Survey of Denmark, in Draved Forest. The Copenhagen and Århus Universities conduct studies of vegetation trend at a number of localities throughout the country, while the Århus Museum of Natural History is studying vegetation trends in Mols Bjerge.

Box 12.3

Monitoring of mammals

In 1994, the North-Sea Museum at Hirtshals started „Project North Sea Whales", with a view to ascertaining the species of whale that occur in the North Sea, and where they occur. It is estimated that there have been about 25 species of whale in the North Sea within the last 100 years.

The Ministry of Environment and Energy monitors the total Danish population of otters and seal continuously. Moreover, the populations of game mammals are monitored indirectly through our official game-bag statistics. Similarly, it has been possible to obtain information on squirrels and badgers from these statistics, until they were taken off the hunting list in 1993/1994 and 1994/1995, respectively.

France, Belgium, Holland, Germany, Denmark, Sweden and Norway are cooperating on the initiative of Great Britain in a common project (SCANS) for the purpose of determining the range and numbers of several species of small whale in the North Sea, inner Danish territorial waters and parts of the Baltic Sea. This project reported its results to the Commission of the European Community in June 1995.

Monitoring of birds

The New Danish Atlas and Bird Site Survey was launched by the Danish Ornithological Society in 1993 and is to run for a three-year period. This project maps Denmark's birds, including the counting of breeding and resting birds at one or more localities in a grid square, and of studies of occurrences of birds in the small biotopes of agricultural land.

The Ministry of Environment and Energy is conducting a number of bird monitoring projects, in cooperation with private consultants, the Danish Ornithological Society, et al. The scope of this monitoring includes the recording of breeding and resting birds at six field stations, as well as Tøndermarsken and in the Wadden Sea. Moreover, the total Danish population of geese, sea ducks and cormorants is also being monitored. Annual point counts are carried out at over 100 localities, in forests, meadows, agricultural land and towns throughout the country.

The Ministry of Environment and Energy monitors game-bird species and harmful species through hunting statistics and wing collection.

The Århus Museum of Natural History observes the avian fauna in a natural forest area of Mols Bjerge.

Monitoring of fish

The Danish Institute for Fisheries Research (DIFR), under the Ministry of Agriculture and Fisheries, conducts continuous monitoring of population trends for the commercially-exploited species of fish.

There is no systematic monitoring of non-commercial species of sea fish. In 1989, the Ministry of Environment and Energy and the Zoological Museum joined forces to launch the „Rare Marine Fish" campaign, in order to obtain information on the occurrence of rare fish in our territorial waters. This has resulted in a couple of hundred reports. New species, such as the ribbon fish, have been recorded. Other species, such as the thick-lipped grey mullet, have become more common in recent years. This project is permanent and reports annually as of 1995.

Freshwater fish are recorded in connection with county surveys of watercourse quality and the information is collected by the DIFR. There is no real monitoring programme for rare freshwater fish.

have traditionally engaged themselves in monitoring tasks, in association with fundamental research. Several such research projects touch on practical nature monitoring and are, therefore, of value in this context.

Sectoral research (in connection with agriculture, forestry, hunting and fishing) has the longest, most systematic observation series of monitoring character. These series represent invaluable contributions to the total body of scientific knowledge.

As a whole, however, nature monitoring has been scattered and uncoordinated. For this reason, the responsibility for such monitoring has increasingly been assumed by the public sector - primarily through a purposeful effort on the part of the Ministry of Environment and Energy and the counties.

Nature monitoring programme of Ministry of Environment and Energy

Pursuant to the Nature Protection Act, the Ministry of Environment and Energy

Box 12.4

Monitoring of insects

Since 1992, the Ministry of Environment and Energy has monitored butterflies by transect surveys at four field stations. The monitoring of moths using traps will be started at the same locations in 1995 as part of a Nordic/Baltic cooperation. Selected, conserved species of insect will be monitored with a view to protecting their habitats.

The Ministry of the Environment, the Danish Research Academy and the Zoological Museum conducted „Atlasprojekt Danmarks Dagsommerfugle" (the national Danish butterfly mapping scheme). The goal was to obtain up-to-date information on the range and frequency of Danish butterflies, to cast light on the change in frequency that has occurred during this century and to relate the decline of selected species to the changes that have taken place in Danish nature.

The Århus Museum of Natural History is observing trends in insect fauna in selected rivers and at a number of localities in Mols Bjerge. The museum is also mapping and monitoring the range of May fly, stone fly and black fly.

The counties are undertaking extensive recording of aquatic insects, in connection with studies of water quality.

Danish entomological associations are documenting the range of Danish insects by issuing annual lists of observations, for instance, of butterflies and beetles. Some of the rarer insects are monitored on a voluntary basis and the information is sent to the Zoological Museum in connection with catches of moths.

Individuals have prepared status reports and studied the range of other groups of insects, the ranges of which are roughly correlated with the individual parts of the country (11 areas). These studies have primarily yielded an instantaneous view and, to a varying degree, information on changes in frequency. Such projects have been conducted, for instance, for ground beetles, certain families of click beetle and butterflies.

Surphids have been observed by individuals over a considerable number of years. This has yielded detailed information on their frequency, living patterns and range, as well as changes in their occurrence.

is obliged to monitor the status of our nature in cooperation with the counties and other concerned public authorities and institutions.

Our State nature monitoring programme is conducted by the National Environmental Research Institute within the framework of the program for national monitoring, for the period 1987-1996; see Fig. 12.5. This programme is concerned with supplementary nature monitoring in relation to other monitoring and supervision.

The part of the program that has already been implemented includes the total recording, about every five years, of selected, rare types of vegetation, as well as monitoring population trends of selected indicator species and groups of species, in a selection that is as representative as possible of the nature types in which they occur. Every five years, moreover, the programme records the small biotopes occurring in selected landscapes and urban areas, in which are carried out counts, index calculations and detailed studies of bird life on ecological and conventional farms; see also Chapter 7.

Of the international conventions and other agreements by which Denmark is bound (see Chapter 14), some impose direct national obligations within the frameworks of the agreements to carry out nature monitoring. Such obligations are not formulated directly in other agreements, but derivative nature monitoring is necessary for the purpose of reporting regularly the manner in which the provisions of each individual agreement are satisfied.

Another field is the establishment of coherent information on our species of aquatic birds that impose responsibility, e.g. as a part of the trilateral cooperation on the Wadden Sea; see Box 12.6.

The Ministry of Environment and Energy has proposed a strategy for national monitoring of our environment. Out of special consideration for the environment, it is proposed that nature monitor-

Table 12.5
Ministry of Environment and Energy monitoring programme, 1987-1996.

	1987-1993	1994	1995	1996
Nature type				
Coastal meadow	+	+	o	o
Heath	+	-	o	-
Bog	+	-	o	o
Lake	+	+	o	o
Watercourse	+	+	o	o
Sea	+	+	o	o
Forest	+	+	o	o
Meadow and uncultivated dry grassland	+	+	o	o
Arable land	+	+	o	o
Urban	+	+	o	o
Species				
Algae	+	+	o	o
Fungi	-	-	-	-
Lichens	+	-	-	-
Vascular plants	+	+	o	o
Insects	+	+	o	o
Fish	+	+	o	o
Amphibians	+	-	o	-
Reptiles	-	-	-	-
Birds	+	+	o	o
Mammals	+	+	o	o
International directives, conventions and agreements				
EC Bird Protection Directive	+	+	o	o
EC Habitats Directive	-	-	o	o
Ramsar Convention	+	+	o	o
Bonn Convention	+	+	o	o
Berne Convention	-	-	o	o
Biodiversity Convention	-	-	o	o
Wadden Sea agreements	+	+	o	o

Legend
+ = monitoring carried out
o = monitoring shall be carried out
- = monitoring will not be carried out

ing and environmental monitoring be integrated, that centralised and decentralised monitoring be established through economically binding agreements that run over several years, that terrestrial monitoring be generally reinforced, and that monitoring be organised in a way that facilitates the preparation of nationwide status descriptions. Finally, *scientific data centres* shall be established, e.g. for terrestrial nature data.

The Ministry has published the results of our nature and environmental monitoring in the publications *„Environmental Indicators"* and *„Facts and Figures on Nature and the Environment"*, published in cooperation with the Bureau of Statistics, and *Environment and Society*. The latter summarises our scientific knowledge on certain crucial trends in the state of nature and the environment, and links these trends to developments in the sectors of society that contribute to the load on the environment.

The newly completed monitoring programme, *Sea '90* (see Chapter 4), is linked to the Aquatic Environment Plan. The Ministry of Environment and Energy is considering launching a monitoring and research programme based on experience gained from Sea '90.

In 1987, the Ministry of the Environment started a pesticide research programme, which was an offshoot of the *Action Plan for Reducing the Consumption of Pesticides*; see Chapter 7. This supports research into the effects of pesticides on the environment and public health, including their effects on the diversity of plants and animals in the open countryside. This work is coordinated with the interministerial pesticides research programme that was launched in 1994.

Research considered in relation to nature resources

To a certain extent, research in this area has been carried out at institutes of higher education, financed by basic funding and by the Danish Natural Science Research Council, through sectoral research institutes, e.g. in the Ministry of Environment and Energy (the National Environmental Research Institute, Geological Survey of Denmark and the Research Centre for Forests and Landscape) and in the Ministry of Agriculture and Fisheries (the Danish Research Service for Plant and Soil Science and the

Box 12.6

International cooperation on migratory birds

The Wadden Sea is one of the most important wetlands in the world, as millions of birds stay in the area for periods of the year. Many of them breed in Siberia and migrate via the Wadden Sea to their winter grounds in West Africa. To safeguard these bird populations, Denmark, Germany and Holland have started cooperating within the framework of the trilateral Wadden Sea cooperation with Russia, in the north, and Guinea-Bissau, West Africa, in the south. Research, monitoring and nature protection stand on a far weaker footing in these countries than in West Europe. This multilateral cooperation is based on assistance with the accumulation of scientific knowledge, through locating in cooperation with the local authorities and their experts the most important occurrences of aquatic birds in each country, and through the implementation of training, information and nature protection programmes.

Danish Institute for Fisheries Research).

As a part of the Biotechnological R&D Programme, the *Biotechnological Committee* (a committee composed from across the board of our research councils) has drafted a framework programme that aims directly at illuminating the risks of releasing genetically modified plants. This programme, which expires in 1996, has already reported some of the results of its research.

Work is also in progress in the field of gene technology within the Ministry of Environment and Energy. This work is financed in part by the Ministry of Environment and Energy alone and, in part, through the participation of the Ministry in the EU BAP (Biotechnological Action Programme) and BRIDGE.

The *Strategical Environmental Research Programme* was started by the Government in 1991 against the background of an international assessment of Danish environmental research. This programme runs from 1992 to 1996. It is financed by 11 ministries, including the Ministry of Environment and Energy.

The Environmental Research Programme now consists of 9 subordinate programmes linked to a number of centres. The acquisition of scientific knowledge on biodiversity is in progress at the Centre for Biodiversity of Agricultural Land, the Centre for Strategical Environmental Research in Fresh Waters and the Centre for Strategical Environmental Research in Marine Areas.

Several of the nine programmes are to be continued, thereby contributing to the accumulation of knowledge that has been built up in the field of the environment by our national research programmes over the past 10 years. This has had the effect that subjects in the field of the environment have been assigned higher priority at our institutes of higher education and in sectoral research.

The Danish Natural Science Research Council has organised the research programme *People, Landscapes and Biodiversity*, which will run over the period 1995-1999. This programme is concerned with man's impact on, and formation of, the landscape, the expressions of our

view of nature and our personal values associated therewith, and the consequences of this relationship to biodiversity.

The aims of the research programme are to stimulate interdisciplinary research on the relationships that concern man's ideas and impact on the development of our countryside. In the long term, this research effort will contribute to making us aware of the factors that affect the countryside and their effect on the very foundations of nature, including biodiversity. This gives a better knowledge base for physical planning, as well as for nature management and restoration and an understanding of the mutual interaction of culture and nature. This programme is our first attempt to coordinate the research taking place in this field up to the year 2000.

The *Centre for Extensively Used Terrestrial Ecosystems* (DaFoLa) was established under the Ministry of Agriculture in connection with the Danish Forest and Landscape Research Centre, which was transferred to the Ministry of Environment and Energy in 1994. The goal of DaFoLa's work is to increase the body of scientific knowledge on extensively used terrestrial ecosystems, to make the existing body of knowledge usable and to contribute to the development of sustainable forms of production in agriculture. It is also DaFoLa's goal to recommend gentle methods of use, management and restoration of nature areas and to reinforce the knowledge foundation on which planning and legislation in the fields of nature protection and nature management rest.

DaFoLa's research effort shall be coordinated and of an interdisciplinary character and shall have the aim of providing the know-how necessary for gentle use of terrestrial ecosystems. This means that the research is oriented towards the individual nature areas, and not towards specific fields of science. The latter is implemented through DaFoLa involving several institutes in interdisciplinary cooperation and building bridges between applied and fundamental research, in order to ensure that the results of research are accessible to its users, as well as to a broader public.

So far, living Nature has carried no great weight in *EU research programmes*, since nature resources have been considered to be areas of national responsibility. In recent years, however, this area has received greater attention, e.g. in connection with the Biodiversity Convention and, not least, as a result of the remodelling of agricultural policy in the EU, with the use of set-aside to limit production. As a consequence of this, the EU adopted a fourth framework programme for research and technological development in 1994, and special programmes under this have been decided during 1994-1995. ENVIRONMENT and AIR are two of these special programmes

that are particularly relevant to the preservation of biodiversity and the cultural landscape.

The Ministry of Environment and Energy and relevant sectional ministries have launched a cooperation on investigatory work in connection with the input of substances alien to the environment into nature. This initiative prepares the way for the development of models and tools for use in strategic environmental research - a development task that demands an extensive research effort and, in parallel with it, the target-oriented extension and coordination of data collection.

Forthcoming efforts

The foundations of better conditions for conserving biodiversity in Denmark are, for instance, the steady improvement of our knowledge of the ranges, conditions and dynamics of our strains, species and nature types.

The accumulation of scientific knowledge can take its point of departure at the gene, species, ecosystem or landscape levels. There is considered to be a particular need for translating the concept of sustainability into practical applications in the fields of area management, natural forestry, set-aside, nature management and restoration, biodiversity and international aspects.

In the long term, it is necessary to accumulate scientific knowledge at the gene, species, ecosystem and landscape levels. The necessity is especially great at the latter levels. For instance, the localisation of marginalisation in the countryside is of greater interest than are the living patterns on set-aside of the individual species, when the question arises of guiding the marginalisation of agriculture in a more nature-oriented direction.

Simple recording activities will often be of greater interest than a programme of scientific research, for instance, when trying to ascertain whether or not the herbal flora of a locality is threatened with overgrowth by willow scrub, and whether clearing the scrub and grazing would be sufficient to avert the threat.

However, in certain other cases, the recording of range and condition are obviously inadequate. This was the case in the 1950s, for instance, when birds of prey declined due to falling breeding capabilities. It was not possible to reveal this circumstance through monitoring. The reason behind the decline of birds of prey was first found and documented later. It was shown that environmental poisons, such as DDT, were being concentrated in the food chain, with the result that birds of prey were laying thin-shelled eggs which, in turn, resulted in fewer chicks being hatched.

In other words, broad monitoring cannot stand alone, but must itself be *monitored* and supported by goal-oriented research. Only in this way can we provide information on possible causative circumstances and the knowledge that is a requirement of the optimum utilisation of the resources available for the task.

Indicators for biodiversity

It is in practice impossible to undertake a thorough investigation of an ecosystem's total biodiversity. Even a rough investigation of a small system's total diversity of species would be unrealistic, and if the genetic variation of all of the species represented is also to be investigated, the task becomes insurmountable. In theory, moreover, all functions and relationships of the ecosystem should be included.

It is, therefore, crucial that we develop a system of indicators for biodiversity. Such a system shall embrace Danish conditions, but it shall also be possible to link it to the biodiversity indicators now being developed internationally.

In Denmark, the National Environmental Research Institute has the general responsibility for the development and maintenance of environmental indi-

cators, which also includes biodiversity indicators. A development programme is in progress in the Nordic Indicator Group (NIG, under the auspices of the Nordic Council of Ministers) in cooperation with the OECD, which has drafted the guidelines for understanding the term „environmental indicator". EUROSTAT and the European Environment Agency are also working on biodiversity indicators.

In principle, such indicators should represent the ecosystem, species and gene levels.

At the level of the ecosystem, developments in selected ecosystem processes and conditions can give general indications of how well a system is functioning.

At the level of the species, the sizes of selected populations, or the number of species in selected groups, can indicate the overall trend of species diversity in an area.

A number of indicators have already been developed for these two levels. Some represent narrow sets of conditions (development in populations of individual species, as an indicator of general conditions), whereas others take a broader point of departure (assemblages of tree species in forests). It must be possible to compare such indicators to obtain a still more general picture of conditions, and it must also be possible to process them so that they can function together with indicators from other sectors, so that the pressure exerted by society on nature, the condition of our nature and development and society's subsequent reaction can be chained together.

We lack information on biodiversity indicators at the gene level. In many cases, our knowledge of the hereditary variation in populations of selected species can hardly give general indications on trends in the hereditary variation of other species. On the other hand, it will probably be possible to indicate general changes in ecological conditions.

Coordination of data

It is necessary to support the accumulation of our scientific knowledge of the functioning of aquatic and terrestrial ecosystems. Our efforts should be intensified from the standpoints of species' requirements on habitats, degradation of nutrients and ecotoxicology in the aquatic environment, as well as the nutrient balance of the marine environment, forest environment and in the open countryside. Moreover, we must gather information on the significance of area use and outdoor recreational activities to the functioning of species and ecosystems.

The accumulation of scientific knowledge must be organised so that it supports the development of planning tools, including models and computerised information systems for our terrestrial and marine ecosystems. This development work requires large quantities of data, which are collected in coordinated nature and environmental monitoring programmes.

Part of the data has already been gathered in current monitoring programmes and it could prove relatively inexpensive to increase data acquisition through the use of telemetering in a number of areas. Detailed information on habitats and biological processes is essential, although it is often costly to accumulate.

Improved coordination of, and the establishment of clear guidelines for, our nature monitoring efforts should be implemented through information and the extension of cooperation between the Ministry of Environment and Energy and the counties. But the NGOs should also be involved to the greatest extent possible, in order to gain a broad popular understanding of, and participation in, our nation-wide programme of nature monitoring for the benefit of our biodiversity.