The Research Council of Norway
Environment and Development

Biological Diversity – Dynamics, Threats and Management

Programme plan

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Preface

In 1996, the Divisional Board for Environment and Development agreed to put forward biological diversity as a new commitment from 1998, and appointed in December of the same year a programme development committee composed of: **Peter Johan Schei (chairman)**, special adviser at the Directorate for Nature Management, **Olav Gislerud**, adviser, Division for Bioproduction and Processing, Research Council (observer), **Rolf Anker Ims**, professor, Department of Zoology, Institute of Biology, University of Oslo, **Gørill Kristiansen (secretary)**, adviser, Division for Environment and Development, Research Council, **Else Løbersli**, adviser, Directorate for Nature Management, **Øyvind Mårvik**, fisherman, Hasvåg, **Guri Kristin Rosendal**, research assistant, Fridtjof Nansen's Institute, **Anders Skonhoft**, senior lecturer in socio-economy, Norwegian University of Science and Technology, **Tom Skyrud**, Division for Science and Technology, Research Council (observer), **Bernhard Tinker**, professor, Department of Plant Science, University of Oxford, **Wim Vader**, professor, Tromsø Museum, University of Tromsø, **Reidunn B. Aalen**, senior lecturer, Department of General Genetics, Institute of Biology, University of Oslo.

The proposal for a research programme on *Biological Diversity - Dynamics, Threats and Management* was considered by the Divisional Board in March 1997. The Board expressed its gratitude to the committee for preparing a thorough proposal. It had a number of comments which it wished to incorporate into the proposed programme prior to its initiation, and the document was adjusted by Gørill Kristiansen and Kristin Sverdrup before the Board approved the programme on 10 April 1997.

It is important to bear in mind that this programme can be initiated before the structure and amount of the funding is known. The final profile of the programme will depend upon the source of the funding and, in particular, which ministries wish to participate in research on biological diversity. The Divisional Board has nevertheless elected to begin this programme from as early as 1998 because it wishes to ensure continuity in the research since key research programmes on biological diversity end in 1997.

1 Background

Biological diversity may be briefly explained as the variation in life forms on the Earth. The Convention on Biodiversity defines it as: "The variability in living organisms from every source, including terrestrial, marine and other ecosystems, as well as the ecological complexes of which they are a part; this includes the diversity within species, at the levels of species and ecosystems". The sum of different ecosystems such as oceans, lakes, mires, mountains, coniferous forests, etc., constitute the biodiversity at the ecosystem level. All ecosystems consist of many species of plants, animals and micro-organisms, and the sum of these species constitutes the species diversity. The appearance and properties of each and every individual are an expression of the genetic composition of the individual. The genetic diversity is the foundation for all variation.

In all societies, people depend on the diversity of nature to obtain food, wood and fibre, medicines and energy, and opportunities for recreation. The ever-increasing loss of biological diversity is therefore a serious threat to the basis of life for future generations. This threat is further enhanced because the loss of biological diversity may disturb basic functions in nature, such as regulation of water drainage, formation and maintenance of soil, assimilation of waste substances and cleansing of water, as well as the carbon and nutrient cycles. Research which helps promote prudent management and preservation of biological diversity is essential, because loss of genetic resources cannot be reversed.

Nature is dynamic and biodiversity changes at every level. Populations and species die out in the long run (and new ones will arise), even without the influence of man. Not all human activities are detrimental. However, some of our activities are the reason why the biodiversity is being reduced at an ever-increasing rate. In the case of plants and vertebrates, it has been estimated that species are dying out at a rate that is 50-100 times greater than it would have been without human disturbance. It has been calculated that in the tropical rain forest alone, one species of plant, bird or mammal and about 50 other species are being lost every single day. In Norway, several birds of prey and most large carnivores have declined greatly in numbers during the present century, likewise plants associated with cultivated land, such as arnica and moonwort. The Norwegian 'red list' numbers 1839 species, 45 of which are classified as extinct, 150 as endangered and 279 as vulnerable.

Based on the three objectives of the Convention on Biological Diversity, preservation, sustainable use and fair allocation of returns, a broad approach is necessary to acquire the best fundament of knowledge to pursue the objectives. Finding out what is a long-term sustainable use of biological resources that will safeguard the diversity is an outstanding challenge to be met. As regards the problem of allocating the returns from such use, a great deal of research is required into such key aspects as the basis of value and culture, management systems and external socio-economic constraints. The Convention on Biological Diversity requires the drawing up of national strategies for biological diversity. In Norway, the Ministry of Environment is co-ordinating the task of preparing a

National Strategy and Action Plan for Biological Diversity. This will form a major element in the Government White Paper on *Environmental Policy for Sustainable Development*, which will be published in spring 1997. This programme proposal is expected to cover the research needs expressed in the White Paper, but this will have to be looked at more closely when that document is published.

Research directed at the environment is one of four themes given high priority in *Research for the Future*. In the *Strategic Plan for Research on Environment and Development*, which state the premises for environmental research in more detail, biological diversity in itself and the effects of man-made changes are fields that are given high priority. In the same way as the *Strategic Plan*, this programme proposal has been drawn up independently of the Divisions of the Research Council and lies athwart the sectorial divisions of the ministries.

This proposed research programme, in particular, follows up the chapter on programme organisation in the *Strategic Plan for Research on Environment and Development*. To ensure continuity in research, it is recommended that the programme is designed for a 10-year period. Moreover, in line with the objective to have larger and fewer programmes, this programme has considerable thematic breadth. Four programme fields define the programme at its start. To ensure flexibility for a programme of such long duration, and to be certain that it is always up-to-date relative to the research needs which appear, the way should be kept open for including more programme fields in due course.

2 Objectives and target groups

2.1 Main objective

To improve the knowledge base for a sustainable use of biological resources and preservation of the intrinsic value and diversity of nature.

2.2 Subsidiary objectives

Subsidiary scientific objectives

- analyse the composition, function and dynamics of biological diversity
- analyse the effects of damage to habitats
- analyse the effects of introductions of alien species and genotypes
- analyse the causes of threats and the effectiveness of various management strategies.

Subsidiary strategic objectives

- achieve a closer link between research and monitoring
- strengthen multi- and interdisciplinary co-operation as tools to solve problems

- strengthen international research co-operation in this field
- strengthen recruitment to, and expertise in, taxonomic research.

2.3 Target groups

The programme is intended to be implemented by research groups at universities, colleges and institutes. The results are aimed at national and international research groups and at everyone involved in management of biological diversity at local, national and international levels. On the national level, the target group is more than just the Ministry of Environment and institutions under its authority. Other ministries, and external government departments linked to them, in the fields of fisheries, agriculture, transport, trade, industry and commerce, and development aid will be important target groups. Based on the national policy that has been adopted regarding the obligations of the sectors to have regard for biological diversity within their respective fields of responsibility, in line with the obligations laid down in the Convention, it is also taken for granted that the sectors are responsible for acquiring the expertise necessary to meet this obligation. This is particularly linked with research on the impacts of human disturbance.

3 Programme fields

The most important threats to biological diversity can, broadly speaking, be divided into a) destruction of habitats (including fragmentation, pollution and climatic change), b) undue harvesting, c) introduction of alien species and genotypes, and d) indirect consequences of these, for instance through loss of important species in the food chain. The motive forces in society which lie behind these threats are, however, associated with demographic, economic, institutional, cultural, political and technological factors, which include greater population growth, more use of resources by individuals, increased migration of people and more international trade, ignorance, lack of appreciation for the value of the diversity, and so on. We lack the knowledge to develop the best management strategies on local, national and global levels to enable us to turn ecological recommendations to account in practical policy.

The above division has formed the basis for selecting the following programme fields: *3.1 Biological diversity - composition, function and dynamics*, *3.2 Impacts of damage to habitats*, *3.3 Introductions of alien species and genotypes*, *3.4 Management of the diversity*. In contrast to existing activities, it has been decided not to make the problems surrounding undue harvesting a separate programme field. It is important to stress that harvesting of biological resources may have wide-ranging, if unintentional, impacts on biological diversity. However, several research programmes exist which cover harvesting of biological resources, and their objectives give space for studying the impacts on diversity. In practice, it seems that a great deal of attention is being directed at the impact on the resource that is harvested, and less on impacts on the diversity of organisms that

are indirectly affected. It is therefore recommended that existing programmes on harvesting to a greater extent include the impacts on the rest of the diversity (particularly the programmes concerned with marginal land, marine resources and environment, and forestry) and that a possible future programme board evaluates this theme again at a later date. Generally speaking, the desire is that this programme, on the scientific side, shall concentrate more on organisms that are not economically important, since they probably make up 99% of the diversity and have traditionally been given much less priority. The social aspects of harvesting problems should, however, also be covered by this programme. The links between the social motive forces behind excessive harvesting and possible alleviative measures are therefore included in section 3.4.

The research requirements within the four programme fields are not exhaustive, but indicate what must be initiated or strengthened on the basis of an appraisal of ongoing activities in the Research Council and criteria for setting priorities stated in the *Strategic Plan for Research on Environment and Development*. Special emphasis has been put on identifying fields where Norway holds a special position or has a special responsibility due to political, economic, cultural, geographical, natural or resource factors. This means that the research can take place in both Norway and other countries (see the comments on geographical focus in section 5.4 and especially on research in developing countries in section 5.5).

This programme plan is motivated by the social objective of preserving biological diversity. Just what "preserving" means is not unequivocal. Do we wish to preserve the diversity as it is now, as it was at a given moment in the past, or in some other defined state in the future? The answer to this question will probably vary with both time and place. It is not realistic to act out of the wish to preserve nature without any influence from human beings, because there is extremely little so-called undisturbed nature in populated parts of the world, including Norway. Most of this country has been or is influenced by human activity, and large segments of the countryside have been shaped through interaction between nature and culture. It has been estimated that without human influence, 80-90% of Europe would have been covered by woodland and forest. This means that when reference is made in future sections to natural ecosystems and landscapes, this means areas that are widely looked upon as being natural today and which perhaps more correctly should be called semi-natural. Nor should it be taken for granted that all human influence consequently reduces biological diversity. One example is traditional cultural landscapes, where the work of the farmer results in landscape that has greater biological diversity than the original one. What is desirable cultivation has largely to do with choice of values, but research is also needed to find out what human influence is required to maintain particular types of cultural landscape. This kind of research is not specified in detail in this document. The Research Council is undertaking an investigation of the research requirements linked with the cultural landscape, and the results can perhaps be applied later to specify the link with biological diversity.

Preservation of biological diversity applies to all levels from genes via populations and species to ecosystems and landscapes. The four programme fields dealt with below largely consider more levels than the species level, which is the most traditional one.

Norway's biogeographical location means that it has special landscapes and ecosystems linked with its long coastline (and thereby adapted to influence from the sea on the land), and its extensive mountainous areas and proximity to polar tracts. Norway has relatively few species, and only a small number are indigenous to Norway. Moreover, many species are at the very limit of their range and populations here can differ considerably in genetic terms from populations in more central parts of the range of the species. Norway therefore has many local populations which represent a significant bonus for the genetic diversity of the species. This gives us a special responsibility and important research tasks on the genetic level.

3.1 Biological diversity - composition, function and dynamics

To understand what impact the changes caused by man have on nature, it is necessary to have broad knowledge of the processes of nature without 'modern' human influence. This particularly applies to the responses of ecosystems to natural variations in climate and other ambient conditions, but also to the relations between the organisms (within and between species). Results of research into effects are often limited by poor knowledge about nature as such. Little pure research on ecology and taxonomy is currently being done, but many applied research programmes need fundamental data and knowledge. In relation to practical problems regarding preservation and monitoring of biological diversity, pure research is faced with the following four challenges.

3.1.1 Taxonomy

The biological diversity of organisms is an expression of the variation in their genetic composition. This concerns variation between and within populations, and between and within ecosystems. Taxonomy is the science that studies the variation between organisms, and classifies it so that kinship between different groups can be identified. This classification is fundamental for all biological research, and taxonomic expertise can substantially enhance the efficiency of such research.

It is calculated that science knows about 10-20% of all species now living on the Earth. In the Tropics, where the threats to biological diversity are far more acute than in Norway and where the diversity is significantly greater, there are virtually no taxonomists. Such countries are completely dependent upon taxonomists from the industrialised nations. Norway has a responsibility to help to strengthen national expertise in developing countries, and collaboration between Norwegian research workers and those in developing countries should be stimulated. The scientific body charged with following up the Convention on Biological Diversity is now making an effort to strengthen taxonomy internationally. The status of taxonomy in Norway has also been significantly reduced in recent years and there is a lack of taxonomic expertise within many groups of plants and animals. Not least many micro-organisms and other organisms belonging to the soil fauna, many groups of insects, crustose lichens, most algae and many groups of marine

invertebrates are extremely poorly studied and mapped. It is not realistic to have the aim that this programme will acquire taxonomic expertise for all these groups, but there is a great need to strengthen expertise in, and recruitment to, modern taxonomy, which is the fundament for all research and management that relates to biological diversity in Norway and in developing countries. In 1997, the Research Council's Division for Science and Technology will investigate the number of recruits to taxonomic research and the need for taxonomists in the university and college sector during the next 20 years. The result may provide a better basis than has been available for this document for determining more specific priorities for the commitment on taxonomy.

Classical taxonomy is the basis for understanding diversity at the species level. In the last few decades, it has evolved from superficial conjecture to different schools with a much more stringent character, of which cladistics is at present by far the most widespread. Molecular taxonomy has also brought new and very promising methods for studying kinship and 'evolutionary distance' between organisms.

Taxonomy, i.e. scientific classification, must not be confused with floristics and faunistics, i.e. mapping of plants and animals. The building-up of taxonomic expertise has a natural place in a research programme concerned with biological diversity, whereas mapping and monitoring tasks, which are also extremely important, must be covered elsewhere. The connection between these is, however, vital and must be improved (see Chapter 5).

3.1.2 Identifying the inherent dynamics of natural ecosystems

There are usually large natural fluctuations in the composition of ecosystems. This applies particularly to northerly ecosystems where periodical fluctuations in the numbers and distribution of animals and plants occur on different time scales. The fluctuations may reveal themselves at decadal intervals (e.g. warm and cold periods in the Barents Sea, herring peaks), in cycles covering several years in a number of organisms (e.g. grouse, ptarmigan and small rodents), as seasonal variations, or still shorter intervals. Long-periodical, natural fluctuations are particularly problematical for research into, and monitoring of, biological diversity, because they may easily be misunderstood as unnatural trends if they are studied for too brief an interval. The causal factors behind such natural fluctuations are still poorly understood. A challenge to pure research is to identify natural, dynamic changes in the sizes and genetic structure of individual populations in space and time, and in the composition and mutual proportions of species communities over longer periods of time. Both palaeo-ecological studies and analyses of data that have already been collected will be relevant for such research tasks.

3.1.3 Strategic studies of natural stress gradients

One of the greatest challenges to pure research in ecology is to provide predictions on how scenarios for changes in environmental parameters (climate, pollution, size of habitats, alien species) will result in changes in biological diversity. Predictions about

which species are expected to be specially sensitive and which environmental changes have the greatest effects will provide valuable guidelines for management measures. There is obviously little point in a situation where predictive research follows in the wake of the environmental changes. This will first and foremost be in the nature of an enquiry and provide passive documentation. Predictive research relative to changes in biological diversity can, on the other hand, take place through strategic studies of ecosystems that are exposed to natural stress gradients. For instance, knowledge about species compositions in ecocommunities and variations within species (genetic variation and population fluctuations) along natural climatic gradients will be able to provide predictions about which species (characterised on the basis of aspects of their life history and breadth of genetic variation) will die out and which may perhaps appear (invade the system), if major man-made climatic changes take place. Moreover, ecosystems which vary with regard to how highly fragmented they are under natural conditions will be capable of providing predictions of which species are always absent from highly fragmented systems and which will therefore be expected to disappear with increased fragmentation and destruction of habitats. Climatic changes brought about by man, and habitat destruction, will probably take place simultaneously and this is likely to have a synergistic, negative impact on the biological diversity. It will therefore be a challenge to design stress gradient studies in such a way that such 'simultaneous effects' can be identified. Norway covers geographically important gradients in climate and in the degree of the fragmentation of ecosystems. Hence, Norwegian ecologists and taxonomists should be particularly well equipped for providing valuable contributions.

3.1.4 The function of biological diversity

It has been claimed that biological diversity at different levels (genes, species and ecosystems) has an essential function in relation to the stability, productivity and resistance to disturbances (both man-made and natural) of nature. Surprisingly little research has been done to verify this claim. The question of the function of biological diversity is, however, so closely linked with the crux of the scientific, administrative and political credibility of the biodiversity concept that it has to be given priority on the research agenda. Key hypotheses that remain to be tested are:

(1) *Does biological diversity promote the stability, productivity and power of resistance of nature?* It has recently been shown that this hypothesis can be tested experimentally in natural ecosystems. Such experiments should be repeated in a number of different ecosystems. In ecological research, it is impossible to generalise on the basis of single experiments. Emphasis should be put on finding systems that are suitable for controlled experiments where biological diversity can be manipulated in a realistic manner. Another key hypothesis in this context predicts that intraspecific diversity (genetic variation within species) enhances the resistance of the species to various forms of environmental stress. It is at any rate common for large, widely distributed populations to have greater diversity than small, local populations. The large populations will frequently have greater resistance to stress owing to both their distribution and their diversity. Research on the effect of genetic variation for the vitality of populations is important basic research for

understanding the effects of damage to habitats (3.2), the effects of introductions (3.3) and the development of systems for managing diversity (3.4).

(2) *Is diversity at different levels (genes, species and ecosystems) interconnected?* What, for example, is the relationship between genetic diversity within species (intraspecific variation) and species diversity (number of species)? It has been suggested that natural paucity of species is 'compensated' for, at any rate to some extent, by each species having greater genetic variation and occupying larger ecological niches. This question is important in relation to the discussion about which levels are relevant for preservation, monitoring and management of biodiversity and whether the various levels can be evaluated independently of one another. Very little empirical research has so far been undertaken in this field.

(3) *Do key species and indicator species exist?* Even though there are many grounds for looking upon the ecosystem as the most relevant unit for managing biological diversity, ecosystems are frequently extremely complex units that are not very easy to handle for either research or management purposes. It is therefore desirable to identify simpler, more manageable units, which at the same time 'detect' much of the complexity of the dynamics and stability of the ecosystem. Such *key* and *indicator* units may be species or functional groups and links in the food chain, which are of particularly great importance for the function and power of resistance of the system. Notions like key species and indicator species, as well as species and functional redundancy, are extremely controversial topics among researchers, and new research is essential to be able to clarify their practical usefulness. There may be considerable benefits to be had in the shape of improved scientific understanding and opportunities for monitoring biological diversity if instances can be found where such reductionistic approaches are valid.

Biogeographical considerations based on the notion that the ocean consists of quite distinct regions where the physical conditions, biological communities, fish populations, etc. are so closely linked with one another that they should be managed as an entity have formed the background for the concept of "Large Marine Ecosystems" (LME). Examples of LME's are the Norwegian Sea, the Barents Sea and the North Sea. In these marine areas, some of the large fish populations are key species in that their size is of great significance for which prey are eaten and which direction the energy goes or which food chains dominate. We know, for example, that the key populations in the Barents Sea can vary a great deal. Considerable basic knowledge and many time series exist for these areas and they can be used to analyse such factors as the fundamental links in the ecosystems, such as stability. Studies of structures (e.g. species composition) and processes (e.g. transport of carbon through the food chain) in such systems will be important, if LME's are to form the basis for management on the ecosystem level that also ensures diversity on the species level.

Irrespective of the type of ecosystem, it is important to increase our knowledge about functional changes arising from the removal of species from ecosystems. What

significance does it have for maintaining a desirable 'service', a desirable function, in an ecosystem if individual species or populations disappear?

3.2 Effects of damage to habitats

Today, impacts from land use are considered to be the most important threat to biological diversity in terrestrial ecosystems. This is not least the case in developing countries where the proportion of the total land area that is being transformed into commercial agricultural land is rapidly increasing. The physical impact of land use constitutes a more obvious threat to animals than to plants. In the case of marine ecosystems, pollution and excessive harvesting of biological resources are regarded as the most important threats. Pollution and introductions cause the greatest damage to limnic ecosystems. *For the future*, however, it is predicted that global climatic changes will affect the biological diversity more than any other single factor, and most in terrestrial systems.

This is the background for the priority given to the following subsections on land use, pollution and climatic changes. Within each subsection, emphasis is put on research that can potentially contribute most to management, which represents new problems or approaches, and on which there is at present or in the near future little major activity.

3.2.1 Fragmentation and changes in land use

Fragmentation means that the habitats are split up into ever smaller entities which become more and more isolated from one another. The consequence of such a trend is that more and more populations occur in smaller numbers. When fragmentation leads to the creation of barriers, this can have major consequences for migrating species, for example. This has been a "classic" theme for research on biological diversity. However, the establishment of *conservation biology* and *landscape ecology* as scientific fields directed specifically at research into threats to biological diversity did not take place before the mid-1980's. There is therefore still a great need for research that focuses upon the effects of fragmentation from the viewpoint of traditional methodology and theory. Traditional research on conservation biology focuses upon problems such as smallest critical habitat and population sizes, edge-zone effects between habitats and disturbed or destroyed areas, and measures such as provision of corridors to create links between isolated habitat fragments. Habitat destruction caused by changes in land use are not only a threat which splits up the habitats. When large areas become built up, entire ecosystems may be destroyed and on a national scale this will reduce the extent of suitable areas for populations and species to live in. Such building activity, and also schemes that make land areas uniform, for example through cultivation, therefore represent a threat to diversity from the genetic to the landscape level. We have both too little knowledge about the impacts of the building activity that has already taken place and the potential impacts of future building work on important habitats.

New technology and methods are appearing at a furious rate, offering this research new opportunities. Particularly useful for understanding and predicting the effects of habitat

destruction are methods which can quantify such destruction taking place on the large scale. New mapping and modelling techniques in landscape ecology[1] provide better

[1] Such an approach is not limited to terrestrial systems (as it might appear). Marine biologists are increasingly adopting it, for instance in round fjords with narrow inlets and in certain fjord systems.

opportunities than traditional methods for predicting changes in the biological diversity on scales which correspond to those on which nature operates. These new techniques have so far largely remained unused in Norwegian research on biodiversity in both the North and the South. The following themes will be relevant areas for research.

(1) *What effect do fragmentation parameters like habitat size and isolation have on various levels of biological diversity (e.g. genetic structure, species composition)?* This question is founded on classical theories (metapopulation theory and source-sink theory). A landscape ecological approach focusing on parameters mapped on a large scale may provide more realistic predictions about the dissemination of disturbances (e.g. invasion of alien species). Such an approach will also give better indications of how the fragmentation - destruction scale has an impact. Taxonomic and ecological expertise should be brought in here.

(2) *Research directed at identifying spatial scales for natural variations in biological diversity.* This concerns natural fluctuations in the size of the ranges of animals and plants (expansions and retractions), as well as the scale and frequency of natural disturbances (e.g. fires, erosion and pest outbreaks). Not least the last-mentioned aspect provides an essential background for predicting the ability of the organisms to withstand the scope of our own encroachments and disturbances (e.g. fragmentation and habitat destruction). For management purposes, knowledge about these matters is fundamental for the appropriate design of monitoring programmes (duration and extent of area covered) and in relation to determining the size of reserves and the distance between reserves (see Chapter 5 on monitoring and section 3.4 on management).

(3) *Latency (sluggishness) in systems following habitat destruction and fragmentation.* The natural sluggishness found in many ecological systems (i.e. the time it takes before the effects of a disturbance reveal themselves) will lead to the present-day situation being beset with a hidden "debt" in the form of a latent loss of biological diversity which will first manifest itself in the future. Analytical studies which can identify and predict this latency in different systems will be an important research contribution.

(4) *Quantification of the probability for extinction.* Such knowledge is of great value for the management of endangered and vulnerable species, and also as an objective basis for understanding the effect of various disturbances. It may be advantageous to view this type of prediction in connection with scenarios for changes in communities. Many of the models used today are based on assumptions which make them of little use for many important taxa. This applies, for example, to classical metapopulation models, which can usually not be applied to either plants or vertebrates. It is therefore important to evolve

general models based on more realistic assumptions for populations which have been fragmented as a consequence of habitat destruction. It will be specially vital to test the ability of such models to describe the dynamics in these kinds of populations. Such studies should be done for several taxa. This mode of attack will enable important data to be acquired concerning which elements in the landscape (isolation, size of habitat islands, etc.) are most important for ensuring viable populations of various kinds of taxa. Computer programs for viability analysis are now commercially available. However, many of the parameters which enter into such analyses are unfortunately still unable to be estimated from the data. To develop such analyses into efficient tools for management purposes it is essential that new methods are evolved to estimate the parameters in the models and to acquire precise input data.

3.2.2 Pollution

Pollution stresses ecosystems and may depreciate the value of habitats and reduce populations of sensitive species. Acid precipitation has made fish populations and freshwater invertebrates extinct in large parts of Norway. Examples are known from several countries where DDT, PCB, atmospherically transported nitrogen and water eutrophication have greatly affected biological diversity. In Norway, reductions in the species diversity of demersal fauna owing to discharges from oil installations have been recorded up to 5 km from platforms. The threat to biological diversity from toxic discharges is increasing, not least in developing countries where industrial and agricultural developers pay no concern for the environmental consequences in the absence of environmentally-friendly technology, know-how and environmental legislation. It is known that substances found, for example, in industrial effluent, household sewage and composition (to prevent fouling of boat hulls) disturb hormone production in fish and snails. This contamination has led to disturbances in coastal ecosystems elsewhere in the world and occurs in such concentrations along the Norwegian coast that it will be capable of creating problems in Norway, too.

Pollution that spreads over large areas, is bio-available and persistent, and is thought to constitute the greatest threat to the biodiversity of nature since it is capable of endangering many species and habitats. Stable substances occurring in toxicologically effective concentrations for long periods (e.g. PCB), or leading to protracted abiotic changes (e.g. acidification), represent greater risks for biological diversity than just brief episodes of pollution.

The impacts on biological diversity of environmental toxicants and atmospherically transported nitrogen are included in other programmes (Nitrogen and Ground-level Ozone, Ecotoxicology, Radiation Protection). The following themes lie athwart different impacting factors and fall outside existing programmes.

(1) *Interaction between several kinds of contamination and interaction with other stress factors*. Most earlier research on pollution focused upon the effects of a single source of contamination on abiotic factors and separate individuals. However, there are two key

questions. When does a contamination impact represent a risk for biodiversity? If some individuals of one or more species respond negatively, how serious and extensive does this reaction have to be before the biodiversity is affected? This research requires a more comprehensive approach, where biotic factors like access to food, competition and predation are evaluated, in addition to abiotic factors. This means that complex biocommunities and entire ecosystems are studied first, and pollution is then considered in the context of these. The various forms of pollution have different, often greater, effects in combination than when they act alone.

(2) *Loss of genetic diversity as a response to chemical stress*. If exposure to pollution is so serious that it becomes lethal, or reproduction among the most sensitive individuals in a population is hindered, populations that are more resistant to the pollution will gradually evolve. Little research has been done on the effects of pollution on genetic diversity in natural populations. Extensive use of pesticides in agriculture has developed resistance in some target organisms. The development of resistance is also well known from aquaculture (antibiotic-resistant bacteria). Little work has been done on genetic effects on non-target organisms. Selection of resistant populations can lead to other important properties being lost, so that the ability of the populations to tackle other stress situations (e.g. cold or drought) is reduced.

(3) *Chronic effects of diffuse discharges from petroleum activity*. In marine ecosystems, large increases in the discharge of production water (which contains oil components and chemicals) are expected from petroleum activity in the years ahead. This continuous flow may change the phyto- and zooplankton communities. Long-term impacts are particularly important.

3.2.3 Climatic changes

A great deal of research on climatic effects is being done in other countries and much general information can be acquired from abroad. However, Norway's geographical location means that only a limited amount of this information can be directly transferred to Norwegian conditions. Relative to the far-reaching changes which nature is expected to undergo as a consequence of climatic changes, Norwegian efforts in this field must be characterised as relatively modest. Climatic models evolved at the Hadley Centre for Climate Prediction and Research in England suggest that the winter temperature in Scandinavia around 2025 will be 1-2° C higher than today, and an increase of 3-4° C is expected by 2065. The expected changes in precipitation and wind conditions, and in the frequency of extreme events, are at least as important, but the predictions for these are very uncertain. Without research on impacts, we will lack any basis for putting in measures to alleviate them. For instance, protected areas that have already been established may not necessarily serve their original purpose in the future, and their function should be re-assessed.

The effects on plants should be given priority for research on biological diversity, because plants largely determine where animals live. Very little research on the effects of

global climatic changes on animals has been done in other countries, and existing investigations mostly concern interactions with plants. There are abundant opportunities for breaking fresh ground with research in this field, and zoological studies should therefore be included. The biodiversity of the soil is important because of its special significance for the migration of vegetation. Particularly important questions are related to how the turnover of organic material in the soil is changed.

The effects on plants of changes in temperature and precipitation are quite well known from controlled laboratory experiments. The results of such studies cannot, however, be transferred to natural conditions, and very few studies on natural vegetation exist. The greatest and most rapid changes will take place in ecotones (marginal zones), and migration, invasion and local extinction will be observed most easily in such areas. Alpine and northerly species will probably be specially at risk. The vegetation may respond by adapting if the population has a substantial genetic diversity. The alternatives are migration or extinction. An important question in this context is whether present-day ecosystems will be maintained (or change their extent as systems), or whether species will behave individually.

The effects of climatic changes on our northern marine ecosystems will first and foremost depend upon whether and how the changes affect the direction and strength of the Gulf Stream and the North Atlantic Current. Because the organisms, particularly in the free water masses, generally speaking are very mobile, often have long-living, pelagic, larval stages and shorter generation spans than on land, and the habitats are, moreover, much less fragmented, the effects of the climatic changes may perhaps be far less wide-ranging than on land. Research will nevertheless be needed in the coastal zone, in areas with episodic water exchange (many fjord habitats), and in the very important kelp forest belt, because such areas are vital for the rest of the production in the sea.

Research must consider both the impacts of the climatic changes in themselves and the effect of these when combined with pollution. For instance, it will be important to study the combined impact of increased CO_2 and nitrogen on the species composition and the primary production. Research on the community and ecosystem levels should also be given priority. This means that research must take place in several directions simultaneously and be integrated through the use of dynamic ecosystem models.

The geographical location of Norway offers ideal opportunities for longitudinal transects. In 1996, the Norwegian IGBP committee held a workshop to plan a possible Scandinavian transect. This programme should co-operate with the IGBP committee with a view to putting such plans into effect.

3.3 Introductions of alien species and genotypes

A large number of alien species are deliberately introduced from other countries; in Norway, this concerns not least cultivated plants. Many species are fortuitously spread to new countries; seeds, for instance, are dispersed by road transport and marine organism in ballast water. In the case of both deliberately and accidentally introduced species, there are many examples of the species having spread in an uncontrolled manner in the new

environment (e.g. the Iberian forest slug *Arion lusitanicus*, Canadian pondweed in Norwegian lakes, Japanese drifting kelp in Norwegian coastal waters, and Nile perch in Lake Victoria in East Africa. A drastic increase in the introduction of alien species and genotypes is expected in the future due to more 'natural' dispersal occasioned by, for instance, climatic changes. In Norway, more marine introductions are also expected because of substantial increases in the volume of ballast water reaching Norwegian waters, which is already being experienced owing to the huge rise in the export of petroleum products. The deliberate introduction of new, cultivable species will probably increase and the release of genetically modified organisms will become actualised. When new genes are introduced into the environment, the original (dynamic) balance may be upset. Alien species may affect indigenous ones by spreading parasites and diseases, being competitors, predators or herbivores. Introductions of alien populations of a species may also affect the biodiversity, first and foremost on the genetic and population levels. Mixtures of populations can lead to homogenisation of the genetic structure and thereby perhaps to fewer local adaptations. This is known, for example, from the conflict concerning the impact of farmed fish on wild salmon populations.

The Gene Technology Act in Norway emphasises the need for the release of genetically modified organisms (GMO's) to be advantageous for sustainable development. Documentation of possible ecological impacts from the use of GMO's is therefore required. Lack of legislation and knowledge about biotechnology in developing countries has important implications for distribution and management (see section 3.4).

Current models are inadequate for predicting the effects of introduced organisms. Once undesirable species or genotypes have entered a system there are generally no known methods for removing them again. Both natural dispersal and deliberate and accidental introductions are traditional research fields in ecology, and such projects should continue. There is an outstanding need for more knowledge to form a basis for research into the effects of genetically modified organisms (GMO's). Nowadays, the technical possibilities for constructing new GMO's lie far ahead of our knowledge about the ecological impact of their release or accidental escape. During the coming decade, we must expect that an ever-increasing number of genetically modified organisms will be brought into use, above all genetically modified plants in agriculture, micro-organisms in the food and drinks and chemical industries, and recombinant viruses for medical and veterinary purposes. Not many years ago (e.g. when the present programme on Environmental Impacts of Biotechnology began), no GMO's had been approved for commercial use. By March 1997, seven had been approved and 11 were being considered by the EU, and the number of new applications seems to be growing exponentially. Work is also taking place to develop genetically modified farmed fish, domestic livestock and micro-organisms that can be used for various environmental purposes. Problems linked with the production of GMO's are particularly important in a North-South perspective, because developing countries have a weaker control apparatus for preventing damage to health and the environment. International efforts to adopt regulations for the control of biotechnology (the Biosafety Protocol) are intended to protect the developing countries from becoming an arena for experiments. In Norway, distances are generally short between natural and semi-natural ecosystems and land used by the primary industries. Climatic conditions

here, and working methods in the primary industries, mean that little is to be gained from transferring experience acquired from trials with transgenic organisms on the Continent or in the USA, because the results of such investigations are dependent upon the local environment. Potential impacts must therefore be studied in our own ecosystems. It is thus supremely important to obtain better baseline data in the fields of gene exchange, potentials for invasion and establishment, and competitiveness in natural populations. This presupposes pure research in systematics, evolution and ecology, including such research topics as studies of species diversity, population genetics, population ecology, and demography. Better mathematical models should be designed.

Statutes and regulations controlling the release and use of GMO's presuppose risk assessments that must be based on qualified insight into the general biology and ecology (including reproductive biology) of the species concerned, knowledge about the newly introduced genes, the genome and the environment, survival of DNA and horizontal gene dispersal. Better methods of detection and control in connection with monitoring released GMO's are essential.

Research into the risk of changes in host specificity in naturally occurring viruses through recombination with transgenic viruses, and into the effects on health and the environment through the possible dispersal of antibiotic resistance from transgenic organisms, is also desirable from a management viewpoint. Research concerning the effects of the introduction of alien species and genotypes is complicated and demands efforts from, and co-operation between, several disciplines. Research on molecular biology, genetics and ecology is necessary to improve the level of knowledge. The complexity of the ecosystems means that empirical and theoretical studies are inadequate; good experimental research should be given priority.

3.4 Managing the diversity

The most important threats to biological diversity have largely been identified and scientists are continually advancing new recommendations for how they may be reduced. To be able to turn these scientifically founded, ecological recommendations to account we need to know more about how we can best develop and organise measures and models to acquire solutions.

The motive forces in society that lie behind detrimental human activities are well known from the literature. Emphasis is not being put on studies of motive forces *per se* in this programme; instead, it is desirable to put more focus on measures. However, it is necessary to map out the links to the causal relationships when studying management measures, and an important aspect is strengthening the *connection* between knowledge of motive forces and evaluation of possible measures. This line of thought dominates the first subsection, concerned with harvesting and habitat loss.

A limitation in much of the research effort to date is that it limits the selection of causal factors and measures to *one* of the levels for managing biological diversity. For instance, a number of studies of local management systems exist which fail to view these in the context of national, not to mention global, structures. The same applies the other way.

Anthropologists and others who study local micromechanisms should be stimulated to take an interest in how the structure of incentives for the agricultural population in a specific part of the country is influenced by meso- and macrophenomena - and ultimately by global markets. Those who study international regimes should be encouraged to study links with lower levels. This line of thought lies behind most of the subsection on institutional factors and the management level.

Even though the links between the levels are important, this does not mean that studies which mainly deal with one of the levels should be excluded. When it comes to national and local studies, Norwegian conditions should be given priority in addition to studies in developing countries. Such countries are important because of their great richness in genes and the role Norway has played and plays as a spur and bridge builder in relation to the developing countries during the process of developing and implementing the Convention on Biological Diversity.

3.4.1 Harvesting and habitat loss - motive forces and measures

Harvesting may be both a threat and a factor that help to safeguard biological diversity. On the one hand, the existence of things that are valuable to harvest provides the owner(s) of resources with incentives to household them and, on the other hand, there is always a risk of biologically excessive harvesting. The existence of harvestable species and things that have a high harvest value (direct utility value) often has a different effect on land and at sea. On land, the objects that have high harvest value may counteract habitat degradation and loss of biodiversity. It is of interest to obtain analyses which investigate the validity of this and, not least, there is a need for empirical investigations. Is there a link between high harvest value and a modest degree of habitat degradation?

A great deal may be gained from studying how the interaction between population growth, technology and changes in markets influences the extent and character of the use of natural resources and land. With sustained high population growth and more need for food, land use in developing countries will continue to change, but the trend can be curbed if alternative ways of using land and alternative opportunities for income can be identified and introduced. On average, the area of land used for agriculture in developing countries has risen by 17% per decade since 1960. Trends show that the financial return from following the classical road of economic development, where specialised agriculture holds an important place, is declining. The relative increase in the value of agricultural production as a consequence of an increase in agricultural land has dropped continuously. It is, however, expected that the trend of bringing into cultivation former areas of forest and woodland and intensifying the cultivation of areas that are already in use will continue. There is therefore a great danger that the soil will be destroyed because of a considerable rise in the use of agricultural chemicals. Moreover, adjustment to markets, with ever-more concentration on monocultures in agriculture and forestry may lead to an increase in genetic impoverishment. It will therefore also be important to study how, in co-operation with the local population, the biodiversity may be preserved simultaneously with the changes in land use, and how zones that are less intensively used can function as buffers to totally protected areas. Alternatives to shifts in land use should also be sought.

These are examples of a type of research where interdisciplinary and multidisciplinary approaches are important because the original processes are social and economic whereas the impacts are biological or physicochemical. This type of study is particularly important in developing countries.

Certain activities, like agriculture, forestry, tourism and biodiversity prospecting (screening of genetic resources for potential, new areas of use in, for instance, pharmacy and agriculture), involve a use of biodiversity that may be sustainable or pose a threat. The research should aim to identify structural factors that are of significance for whether the use is sustainable or not. For instance, it is important to study existing practices in biodiversity prospecting, since this may help in an appraisal of international measures to regulate the access to and distribution of the returns when genetic resources are used. Developing countries frequently lack the necessary legislation and infrastructure to be able to control the removal of genetic resources by outside companies. Comparative analyses are a useful approach to this kind of study.

Another important factor which is poorly clarified by existing research is the relationships between pressure on resources, loss of biodiversity and lack of food on the one hand, and social and political disquiet on the other. Stability in politics and the population is in many ways a prerequisite for preservation of biological diversity, particularly in vulnerable areas. It is obvious that high diversity countries like Colombia in a continual state of internal, armed conflict and waves of violence, and Zaire suffering civil war, are incapable of taking care of their biological resources. It is also obvious that armed conflicts and disasters to humanity may have an extremely negative effect on biological resources. For Norway, it will be a challenge to find ways of safeguarding the biodiversity in development collaboration and humanitarian aid work. Examples exist where farmers (particularly women), even during famines and civil wars, have put priority on setting aside a selection of seed (local gene banks) so that agriculture can recover more quickly with the help of cultivated plants that are adapted to local conditions.

The relationship between harvesting, biological diversity and land-ownership conditions should also be studied more closely. Habitat areas may be privately owned, state-owned, or be common land. Rights to common land may be held by many or a few people, and these may be extremely alike or extremely different. Studies which investigate how the numbers and their homogeneity affect the use of resources would be useful for various kinds of regulatory and management measures.

Institutional factors, the management level and the distribution of benefits and costs have an impact on biodiversity. The benefit gained from preserving and using biological resources differs on the local, national and international levels because their value is realised on different markets and often falls to different participants. Generally speaking, the value of a bioresource can be grouped as follows: direct utility value (e.g. harvesting), non-consumable utility value (e.g. outdoor recreation and research that does not alter the populations), indirect utility value (e.g. forest may prevent soil erosion) and non-utility value where both the opportunities for future use ('option') and the situation where

resources have a value in themselves are included. The direct utility value via harvesting is often realised locally, whereas other values are only realised nationally and/or internationally. It will often be the case that if the resources have no harvesting value, they will have no value locally either. It will therefore not be unusual for conflicting interests with regard to utilisation of resources and habitats on the local and the national and/or international levels. Damage to the environment often arises as (unintentional) side effects of other activity at the same time as different opinions exist on how the values should be divided. A local management authority that pays no regard for non-utility values will, then, generally speaking give too little attention to biodiversity and generate too much habitat degradation compared with a more central management authority. This brings us over to the relationship between management measures at different levels.

3.4.2 Institutional factors and management level

Loss of biodiversity affects every management level from the local to the global one. Better knowledge of international environmental agreements is required, from their drafting and implementation to their following-up and effectiveness. This applies especially to the Convention on Biological Diversity, which raises fundamental questions concerning efficiency and fair distribution in the implementation of measures locally, nationally and globally. Here, it is a prerequisite that the various levels are viewed in context. Good analyses are lacking regarding extremely important questions in this connection. How are global management signals transplanted through national decision-making bodies down to the local level, and how does the response go back to corresponding global fora?

The effectiveness of management measures will often depend upon the local communities obtaining a direct benefit or economic return from them. Differing views on management locally and nationally, between the national and the local community, often originate in quite fundamentally different perspectives of values in a more general sense, whether these concern protection of woodland or the place of large carnivores. It is therefore vital to acquire an understanding of local opinions on values linked with nature and bioresources. The premises and opportunities for local participation in management and possible local advantages to be had in the establishment of protected areas should be examined more closely. Against this background, it is important to study i) how different measures on the local level have worked, ii) what are the most effective means of organising local biodiversity projects, iii) what kind of local knowledge is relevant for different protection measures, and iv) how can international measures be formulated so that local adaptations are possible? Such studies are relevant both in Norway and developing countries.

On the national level, it is important to look at the development of action plans in different countries, appropriate decision-making levels for various questions and scales for the effective observance of the Convention on Biological Diversity. In Norway, it will be relevant to examine whether changes and adjustments in economic and legal measures can ease the implementation of the action plan. That the legislation is not satisfactory is

apparent from the White Paper, St. prop. 56 (1992-93) regarding the ratification of the Convention on Biological Diversity, where it is stated that new legislation may be called for to extend and co-ordinate statutes and ensure that "in separate policies and programmes consideration is given to environmental consequences that may be detrimental to biological diversity".

The preservation and use of biological diversity are characterised by mutual dependence. For instance, biotechnology in the North may depend upon access to genetic resources from the South. This applies, for example, to the direct utility value in the pharmaceutical and agricultural industries, and more generally in relation to safeguarding the diversity with a view to its future usefulness. Structural premises in the form of power and interests will set limits for what can be achieved through international environmental co-operation, although to some extent the development can nevertheless be steered through the organisation of this work. One important aspect is how the relationship between politics and science will develop as deliberations regarding the Convention on Biological Diversity proceed. How much importance is attached to scientific advice in this process and where does it stand in relation to the development of common international norms in this field?

The Convention's aim to have fair distribution between North and South will meet considerable difficulties when it comes to drawing up national and international regulations, and it is important at this stage to study existing practices and proposals that have been put forward and help to draft solutions. The concept of "fair distribution" itself can be expected to have different implications for national and international distribution (identification of recipient) depending upon whether it concerns, for example, return or advantages deriving from ecotourism or return from the pharmaceutical or agricultural industries. Questions concerned with distribution hold a key position whether they refer to distribution between or within nations, and call for great care in the designing of mechanisms for the transfer of financial and technological resources. What importance do institutional factors like rules for decision making, patterns of participation, building of coalitions, and monitoring, incentive and control mechanisms have within the framework of the Convention on Biological Diversity for the efficient and fair distribution of returns from biological resources?

Biological diversity is a wide-ranging field which has associations with many other fields. The Convention on Biological Diversity must therefore be considered in the context of other international agreements and activities. Climate problems, international efforts for sustainable forest management (IPF), and not least trade and environment within the framework of the World Trade Organisation (WTO) and the Convention on the International Trade in Endangered Species (CITES) are specially important. The forestry problems illustrate how the same resource can be the object for different, and in part irreconcilable, interests on, respectively, the global (biological diversity, climate regulation), national (tourism and timber) and local (food, medicines, local water regulation, etc.) levels. This can easily result in, sometimes conflicting, proposals for solutions. Even though, from a climatic perspective, one would be satisfied with reforestation in the form of monotonous plantations, this can lead to loss of biological

diversity when the old forest is replaced. In the relationship between the Convention on Biological Diversity and the WTO it is particularly the various approaches regarding ownership rights (patents and national sovereignty) that have helped to intensify the North-South conflict surrounding the distribution of earnings from the use of biological resources. It is important to study these processes and find out whether and under which conditions they are overlapping, contradictory or compatible.

4 Closer links between research and monitoring

It is important to distinguish between mapping and monitoring on the one hand, and research on the other. The former is, and must remain, a task for management authorities, whereas the Research Council must take responsibility for research. Nonetheless, it is important to achieve a closer link between these two activities, as is also underlined in the *Strategic Plan for Research on Environment and Development*.

Both research and monitoring will benefit from closer links. Monitoring is dependent upon research to identify objects requiring monitoring and to develop methods and models to analyse and interpret data. Research can provide significant contributions to make monitoring more efficient. Research on its part can benefit from long time series of data generated by monitoring. Such data are admittedly extremely variable with respect to how far they are worked up and their suitability for research, but it is important that they are made available for possible use in research concerned with biological diversity. This programme should provide a stimulus for several scientific groups to collaborate on projects based on such data. It is also intended that monitoring shall help to assess the effect of measures implemented by management authorities, and researchers should be able to help with such evaluations. Important tasks for research are:

- To establish expertise on natural patterns of variation in time and space which can serve as reference bases to distinguish between natural and unnatural changes.
- To find indicators that are robust and expedient for monitoring programmes (e.g. for endangered and vulnerable species and to monitor the biodiversity of coastal ecosystems).
- To provide knowledge to design sampling methods for monitoring in time and space which offer a basis for statistically tenable estimates of changes at different levels of biological diversity.
- To obtain knowledge as a basis for using remote sensing and geographical information systems (GIS) in nature management. What qualitative and quantitative content must such systems have to be expedient for managing biological diversity and natural resources more generally? Specifically, it is vital to know which parameters should be quantified and mapped, and to what degree of detail and scale in time and space.

5 Plan for implementation and means

5.1 Organisation of the programme

The programme should last 10 years. A long-term programme is important to be able to understand the variations in the function and dynamics of the ecosystems. This requires empirical approaches of considerably longer duration than has so far been normal (3-5 years) in Norwegian research. Research into the effects of management measures also require longer time periods to be able to draw conclusions. The programme should be evaluated after five years.

Within the broad thematic framework of the programme, which is indicated by the title "Biological diversity - dynamics, threats and management", there should be substantial flexibility and the need for knowledge must be continuously assessed. In other words, action plans for research needs should be drawn up at regular intervals, for example prior to the application deadline each year. During the term of the programme, new fields should be able to be drawn in and existing ones concluded. For instance, it should be possible to take into this programme parts of other programmes which are to continue while the programmes themselves are brought to a close (cf. the objective of Environment and Development to have fewer, but larger programmes).

The part of the programme that deals with the natural dynamics and range of diversity constitutes the core of the programme and must deliver results to, and answer to the needs for knowledge that arise in, the more practical parts of the programme. The budgets for the individual programme fields should form given proportions of the total budget. In addition, there should be a 'free' proportion to be divided among the fields, based upon the quality and scope of applications received. This will ensure that the quality criterion for approving applications does not become subordinated to the relevance criterion.

In addition to the research needs, the other means outlined in this chapter should be assessed from year to year. To make the attainment of goals more effective and ensure an appropriate division of attention to different programme fields, it is recommended that the programme board itself acquires results which are necessary in relation to existing action plans. This means that projects can be 'commissioned', even though the majority of the funding must be allocated on the basis of open advertisements of the programme.

5.2 Interdisciplinary approach

Problems concerned with biological diversity require an all-embracing approach. Individual disciplines will provide an important contribution in a larger perspective, but it is important that a significant portion of the funds supports interdisciplinary projects. It is vital to underline that it is the *research* which should be multi- and interdisciplinary, not

necessarily the individual researcher. Inter- and multidisciplinary approaches are not goals in themselves, but tools to solve problems. This has been acknowledged for a long time, but has often been difficult to attain in practice. There is a need for new means for such co-operation, to increase both the scope and the value of the results. The following means are recommended (cf. the *Strategic Plan for Research on Environment and Development*):

- All other terms and conditions being equal, give preference to project applications involving multi- or interdisciplinary co-operation.
- Establish postdoctoral and senior scientist grants for researchers wanting to take part in multi- or interdisciplinary co-operation.
- Approve larger scale projects and allocate additional time when their multidisciplinary nature calls for it.
- Create meeting places for representatives of disciplines that do not usually meet, in an effort to resolve common problems and methodological challenges.
- Impose the same high standards for multi- and interdisciplinary research as for research based on a single discipline. This includes requirements for publication in recognised, international journals.

5.3 International co-operation

International research fora have put considerably more focus on biological diversity in recent years, and increasing numbers of formalised co-operative projects have appeared in both established and new bodies. Norway is relatively little involved in such co-operation, but has a great deal to gain from increasing its international involvement. A large amount of the knowledge generated in international co-operation is of a general nature and is applicable to Norway, too. Giving priority to international co-operation will consequently be an efficient use of resources. We also need this kind of co-operation to maintain the quality of our national research.

It will be neither practicably possible nor appropriate to participate in everything that takes place internationally. The most important international programmes in this context will be *Diversitas* and *IGBP (International Geosphere-Biosphere Programme)*, particularly *GCTE (Global Change and Terrestrial Ecosystems)*, and *IHDP (International Human Dimensions Programme)*. For work in tropical areas, co-operation with CGIAR (Consultative Group on International Agricultural Research) may be valuable. Moreover, it is obviously important to participate in EU programmes, but at the moment it is not certain whether biological diversity will be given priority in EU's fifth framework programme. Special means are required to strengthen the international co-operation. Two of the means mentioned in the *Strategic Plan for Research on Environment and Development* may be particularly emphasised:

- All things being equal, give priority to projects that are international in scope.
- Finance fellowships for Norwegian scholars and researchers to study at accredited institutions abroad.

5.4 Geographical and ecosystem focus

The *Strategic Plan for Research on Environment and Development* states that environmental research must focus "... on environmental challenges in Norway, global environmental challenges, and environmental problems in developing countries, newly industrialised countries and countries with transitional economies. Priority will be given to environment-related research in other industrialised countries only if it is directly relevant to Norwegian conditions. Norway's geographical location and traditions also imply a special responsibility for environmental research in the polar regions, where the effects of environmental changes will be rapidly apparent and have a particularly strong impact."

There should be a corresponding geographical breadth for a programme on biological diversity, but the prime focus should be on Norway and the northern regions, and on specially selected developing countries. The latter are dealt with separately in the next subsection. Much of the research on biological diversity related to Norway's special responsibility for the northern regions (sub-Arctic and Arctic) already forms part of marine, and particularly terrestrial, research programmes dealing with Svalbard and the actual polar regions (middle- and high-Arctic and Antarctic waters). Some of these programmes have had a bias towards research concerning processes that are important in a biodiversity context (e.g. the former TERRØK (terrestrial ecology) and current ALV (arctic light and heat) programmes). However, the Norwegian coast, and the low-Arctic and sub-Arctic regions of northern Fennoscandinavia have largely fallen between two stools as regards research on biological diversity, and many important tasks remain to be tackled in this part of the Barents Region. One of the features found here are important, large-scale ecotones (marginal zones) which comprise boundary areas between sea and land, and between tundra and boreal coniferous forest (e.g. the sub-Arctic birch woodlands). Such zones are expected to be very sensitive to environmental changes.

Nor should the programme preclude research on delimitation of ecosystems (types of environment). For many of the more general problems that hold a key place in this programme, the suitability of the individual system relative to the goals and the funds available for the research will be most important. It is nevertheless necessary to stress the need for research on biological diversity in coastal zones and the marine environment. Norway has a very long and extremely varied coast, stretching from the Arctic to the boreal zone and having a rich selection of habitats along a gradient from exposed to very protected. The coastal biotopes both on land, on the shore and in the sublittoral zone (e.g. kelp forests) form excellent areas for comparative studies of biodiversity in habitats with large natural fluctuations and clear north-south gradients. The shore in Norway is a very imperfectly studied area, and biotopes that are special for Norway such as rounded fjords with narrow inlets, and the relict Arctic area in Indre Porsangen (north-east Norway), are virtually unknown biologically. The Norwegian coast represents a marginal zone on the large scale, and may be specially prone to environmental changes. The majority of marine research has traditionally been concerned with the management of economically important species. Research that does not focus on resource exploitation is inadequately

covered by the Research Council's marine programmes, and knowledge of a more general nature forms an important basis for resource exploitation.

Both marine and polar environments are given priority in *Research for the Future*, where separate programmes exist (Marine Resources and the Environment, Arctic Light and Heat). If it is desired to give real priority to these types of environment, it is important that this priority is also followed up in other programmes. If not, the result may be a commitment that is smaller than it was before the priority was made.

5.5 Special comments on research in developing countries

Norway has taken upon itself to help developing countries in the task of acquiring better global environmental management, for instance through the conventions on biological diversity, climate and desertification. Biological diversity holds a key place in the Government's environment-related aid (cf. St. meld. 19, 1995-96. *A Changing World*).

Summary of challenges for research in developing countries

Most of the scientific approach in this programme plan is independent of a geographical context. This means that where the research needs do not refer specially to Norwegian conditions, the way will be open for projects in developing countries. There is a special need for expertise on the management of biological diversity, where research in the short term will probably be at least as important as ecological research to preserve the diversity. The following points sum up the relevance of the individual fields of the programme for research in the South.

3.1 In tropical regions, where threats to biological diversity are more acute than in Norway and the diversity is substantially greater, there is a paucity of taxonomists. Research co-operation that helps to strengthen national expertise in taxonomy in developing countries is important (see 3.1.1).

Studies of the inherent dynamics of ecosystems are also of relevance in selected developing countries; likewise, research concerning natural stress gradients as a basis for management measures (see 3.1.2 and 3.1.3). There are also opportunities for research on topics associated with the function of biological diversity (see 3.1.4).

3.2 Fragmentation and changes in land use are topics presented earlier without reference to any specific geographical area, and are relevant in both the North and the South.

The section on pollution describes the research challenges in detail to avoid overlap with existing research programmes (NOBOZ (Nitrogen and ground-level ozone), and Økotoks (Ecotoxicology), which deal with Norwegian conditions). Less is known about pollution in developing countries than in Norway. It may therefore be relevant to begin projects on biological diversity and pollution in developing countries which do not confine themselves specifically to the three themes to which priority is given (interactive effects, genetic diversity and response to chemical stress and diffuse

discharges from petroleum activities; the last-mentioned theme is most relevant for Norway).

Climatic changes will probably take a different course in northern areas than in the South. Warmer regions are expected to experience smaller changes in temperature and these will have less impact. Changes in precipitation conditions and the frequency of extreme events will probably be most important at lower latitudes. Norway has little expertise (few researchers) on the impacts of climatic changes and little knowledge about how the changes will reveal themselves under Norwegian conditions. Research on the impacts of climatic changes should therefore first and foremost give priority to northerly conditions and less to tropical regions.

3.3 Present models are inadequate for predicting the effects of introduced organisms. When undesirable species or genotypes have entered a system, there are generally no known ways of removing them again. Both natural dispersal and deliberate or accidental introductions (including GMO's) are traditional research fields in ecology which suffer from a great lack of fundamental data and models. Such research is relevant in both the North and the South.

Problems associated with the production of GMO's are specially important in a North-South perspective, because developing countries have a weaker control apparatus to prevent health and environmental damage. The environmental effort to establish regulations governing biotechnology (the Biosafety Protocol) is intended to protect the developing countries from becoming an arena for harmful experiments. The production of GMO's has important implications for management and distribution, which are specially relevant for developing countries. For instance, it is important to study existing practice for biodiversity prospecting. Developing countries often lack necessary legislation and infrastructures to control the extraction of genetic resources by external companies.

3.4 This section considers the management levels from local to international and focuses specially upon the links between these levels. It is desirable to concentrate on the measures, at the same time as links are drawn with the causal relationships. For developing countries, the following research challenges (at national and local levels) can be summarised:

Research linked with the implementation of the Convention and how Norwegian development co-operation can help conservation and sustainable management is important. The premises and possibilities for local participation in management and possible local advantages in the creation of protected areas should be examined more closely. It is important to gain an understanding of local opinions about values linked with nature and bioresources, and to analyse the kinds of conflicts between conservation and exploitation of natural resources. Research is encouraged that includes studies of the value of alternative forms of land use in and around protected areas in developing countries, and which views this in the context of the local basis for income and regard for distribution.

Links between ownership conditions, local and national regulations and harvesting methods are important for the management. It is, moreover, desirable to obtain analyses which investigate the validity of the claim that harvesting values are capable of counteracting habitat degradation.

Studies of how the interaction between population growth, technology and changes in markets influences the scope and nature of the use of natural resources and land will be important. How is it possible, in co-operation with the local people, to preserve biodiversity during changes in land use? Moreover, studies of how different groups of users, and competition between different sectors in local communities, influence the use of resources, will be useful for various types of regulations and management measures.

The connections between pressure on resources, loss of biodiversity and shortage of food on the one hand, and social and political disquiet on the other are too poorly clarified. Relevant research topics will exist connected with how regard for biological diversity can be safeguarded in humanitarian aid.

Where possible, stimulus will be given for multidisciplinary projects which link research and comprehension in the natural sciences, described in points 3.1-3.3, with studies of management measures.

Criteria for projects in developing countries

To be successful, projects in developing countries usually require established co-operation between institutions, substantial resources and a long-term effort. Norway has long traditions of providing aid to developing countries. This aid should also include expertise and research concerned with biodiversity. However, co-operation with developing countries is not just aid, it is necessary for solving global, environmental and development problems. The selection of areas and systems for this research should be allocated priority in relation to the following criteria:

- Systems with high biodiversity that are particularly exposed to man-made impact (e.g. rain forests and coral reefs).
- Systems where we already have an advantage in the form of expertise and experience with the conditions bestowed by nature and culture. Research in many developing countries often meets special problems in relation to logistics and co-ordination with local authorities and cultures. It seems natural to give priority to areas where Norway has undertaken a special donor responsibility in a development context.
- Systems where Norwegian researchers and Norwegian-funded projects can form part of an international collaborative effort on major programmes linked with problems concerning biological diversity.

5.6 Budget

Through the ratification of the Convention on Biological Diversity, Norway has taken upon itself extensive obligations with respect to research and monitoring of biological diversity. Both Article 12 (on research) and Article 7 (on monitoring) will demand resources on quite another scale from the present one, and it is necessary to have a far more solid fundament of knowledge than we have today to be able to assess the impact of disturbances. The three goals of the Convention also require great breadth and a large measure of interdisciplinary approach in a research context - and an interdisciplinary approach requires considerable resources. To be able to advance further in research on the function and dynamics of the ecosystems requires experimental studies on quite another scale than we are used to, and such projects also demand substantial resources. Modern taxonomic methods are more effective, but also much more costly. These are examples which indicate the need for a more long-term commitment and one on a completely different scale than hitherto if the goals are to be attained.

During the Divisional Board's discussion (Nov. 1996, ITEM 109) of a commitment to biological diversity from 1998, information was given that funding from the Research Council that was relevant for research on biological diversity amounted to an estimated NOK 42 mill. in 1996 and that a 10% increase was needed. The programme development committee considers this proposal to be realistic as a total figure, but the need for an increase is appraised more specifically. Owing to the deadline for this document, the committee has based its assessment on current activities in the Division for Environment and Development and estimated the need for an increase on the basis of factors that increase costs. The committee recommends, however, that specific subsidiary objectives are subsequently priced separately so that better information is available of what suffers if grants are smaller than the apparent needs if the objectives of the programme are to be attained. It is important to have an awareness that reduced budgets means that objectives cannot be attained.

This programme proposal is wide-ranging, but can nevertheless not include all research carried out under the auspices of the Research Council that is relevant to biological diversity (cf. the above estimate of NOK 42 mill.). The proposal sets priorities within each sub-topic, and the proposed budget covers only this programme. The proposal is nonetheless higher than has traditionally been the case in Environment and Development. The committee recommends an annual budget of NOK 25-27 mill. to attain the objectives stated in Chapter 2. This sum is calculated on the basis of budgets for those parts of the proposal that are new or should be strengthened relative to the current situation (1). The programme must also take into account that interdisciplinary activities, research on social and ecosystem levels, and also research that views threats in context, are specially resource demanding (2). The existing activities which this proposal is intended to replace (though with new problems) are stated in (3).

(1) Expertise in taxonomy has been greatly reduced, whereas the need is growing; consequently, reinforcement relative to the current situation is recommended. Practical

studies of the impacts of man-made changes have been limited by paucity of knowledge about natural dynamics. Consequently, greater effort is recommended on the fields dealt with in sections 3.2.2-3.2.4. Knowledge regarding management of diversity (3.4) is so limited that a special effort to encourage recruitment is recommended. It seems, moreover, that research on the impact of climatic changes is particularly limited in Norway relative to international activity in the field and is considered to be inadequate for essential 'preparedness research'. Pollution, i.e. the problems defined in section 3.2.2, is a new area of research. Marine research (which has not been significantly covered by previous research on biological diversity) should be focused upon more strongly (cf. *Research for the Future*). These fields of research require a budget (*beyond that which exists in 1997 in Preservation of Biological Diversity and Environmental Impacts of Biotechnology*) of NOK 6 mill. This proposal takes into account that the individual research needs are thematically broader than the two former programmes. For instance, this programme proposal includes some expertise requirements that were not covered by marine pollution or cultural landscape (landscape ecology), which previously had separate research programmes.

(2) Interdisciplinary research costs more than monodisciplinary research, because the projects must necessarily take longer since co-operation requires a learning phase. Interdisciplinary projects have a greater chance of being unsuccessful, but the risk can be reduced by making the budget limits more realistic than is often the case today. Moreover, this programme plan recommends more comprehensive research than is traditionally practised. This means that more focus has to be put on impacts on biological communities and ecosystems than on individuals. In addition, the time is ripe to view the various impacts in context with one another. This often calls for experimental research, which is extremely resource demanding and difficult. The programme development committee nevertheless considers this justifiable, based on the knowledge obtained in recent years and because the results will help to considerably improve management. This type of research requires that the budget is raised by NOK 4 mill. over and above the sums stated under (1) and (3).

(3) Together, the Preservation of Biological Diversity and Environmental Impacts of Biotechnology programmes received approximately NOK 9 mill. per year during their operational phase. It is primarily these programmes the present proposal is intended to replace. It is important to emphasise that the programme proposal is thematically much broader than the two former programmes combined. This is taken into account in (1).

This entails a budget requirement of NOK 19 mill in the *starting-up year*. The committee considers this to be a conservative estimate, but it has been chosen because of a wish to be realistic. It should, however, be stressed that if the objectives of the programme are to be attained considerably greater resources will be required for subsequent years. The table below shows the budget proposal drawn up by the committee for the entire duration of the programme, from 1998 to 2007, inclusive, in million NOK. The funding plan has been set up with an eye to when other, relevant programmes are

brought to a conclusion and newly-developed programme fields should be able to be incorporated into this programme.

Table 1: Budget requirements for the research programme on Biological Diversity: Dynamics, Threats and Management

Yr.	1998	1999	2000	later yrs./yr.	Total
Budget[1]	19.0	22.0	25.0	27.0	255.0

[1]The parties to the income settlement for farmers have previously asked the Research Council to organise research on the genetic diversity of domesticated species. Contact will be taken up again with a view to including this as a possible field in the programme. If so, a budget for this will come in addition to this one.

Appendix 1: Relevant existing Research Council activities

This appendix lists the activities taking place under the auspices of the Research Council which the programme development committee has taken into consideration and attempted to avoid overlap with when planning the programme proposal for biological diversity.

Preservation of biological diversity (1993 - 1997)

Budget: 1996: NOK 5.0 mill., 1997: NOK 3.5 mill.

Objective: To contribute towards preserving biological diversity by acquiring new knowledge, as well as by organising and utilising existing knowledge, in order to describe the diversity, document the significance of the diversity, estimate the threats to the diversity, and suggest scientifically well-founded action plans for how the diversity should be managed in the short and long terms, both in Norway and globally.

Taxonomy

In 1997, the Division for Science and Technology will find out how many research recruits exist in taxonomy and determine the need for taxonomists in the university and college sector in a 20 year perspective.

Environmental impacts of biotechnology (1992 - 1997)

Budget: 1996: NOK 3.8 mill., 1997: NOK 3.0 mill.

Objective: To obtain knowledge, expertise and methods that can be used to assess the effects of the release or accidental escape of genetically modified organisms (GMO's).

Climate and ozone research (1989 - 1998)

Budget: 1997: NOK 13.0 mill.

Objectives:

- Increase insight into processes which may change the climate and ozone layer of the world.
- Increase insight into the impacts of changes in climate and the ozone layer.

- Improve the basis for taking decisions on national and international measures for reducing discharges and detrimental effects of changes in climate and the ozone layer.

Marine resources and the environment (1995 - 1999) (Bioproduction and Processing, Environment and Development, Science and Technology)

Budget: 1996: NOK 25.8 mill.

The programme consists of 4 sub-programmes with the following subsidiary objectives:

Sub-programme I:	Basic biological and population studies
Subsidiary objective:	Acquire basic knowledge about marine organisms and populations.
Sub-programme II:	Basic oceanography and ecology of systems
Subsidiary objectives:	Establish basic knowledge and understanding concerning the significance of marine systems and resources, and identify mechanisms which control the production and quantity of important marine resources.
Sub-programme III:	State of the environment in the ocean and in coastal waters
Subsidiary objective:	Enhance knowledge about the effect of activity on marine resources and the environment in Norwegian waters.
Sub-programme IV:	Develop technology
Subsidiary objective:	Help to develop technology to acquire the data necessary for research and monitoring of marine resources and environment.

Forestry - environment, industry and society (1995 - 1999) (Bioproduction and Processing)

Budget: 1996: NOK 13.5 mill.

Objective: To build up knowledge that helps to adjust the forestry sector to the demands of the market and society, including knowledge which promotes value creation within the limitations of a sustainable management of resources.

Plants and the soil (1995 - 1999) (Bioproduction and Processing)

Budget: 1996: NOK 23.8 mill.

Objectives: Develop plant production (food, fodder, ornamental and useful plants) that:

- takes care of demands regarding the quality of products, productivity and profitability
- takes care of the concern for natural resources, environment, cultural landscape, health and quality of life
- exploits the competitive advantages which Norway has for agriculture and horticulture.

Arctic light and heat (1996 - 2000)

Budget: 1996: NOK 2.9 mill., 1997: NOK 5.3 mill.

The ***main objective*** is to bring together biological and geophysical disciplines with the aim of elucidating phenomena which are genuinely arctic, such as light and temperature regimes that are extremely variable and control biological processes far more strongly than at lower latitudes. On the basis of this and additional priorities, the objectives of the programme are to enhance our knowledge of:

- natural and man-made variations in climate and radiation
- the effects of climate and radiation on organisms, populations and interactions between populations
- feedbacks between arctic biota and climate.

Nitrogen and ground-level ozone (1996 - 2000)

Budget: 1996: NOK 3.6 mill., 1997: NOK 5.4 mill.

Objectives: The main objective of the programme is to increase our knowledge of the inflow, effects and cost-effective reduction of nitrogen and ground-level ozone. The following subsidiary objectives have been defined:

- Learn more about the inflow of nitrogen and key parts of the nitrogen cycle in terrestrial ecosystems linked with impact mechanisms and ecological effects.
- Learn more about ground-level ozone and the mechanisms of ozone damage on vegetation. Find out the links between ozone concentrations, physical and biological parameters and the extent of ozone damage.
- Develop models for analysis and impact-based, cost-effective strategies for reducing discharges.

Ecotoxicology (1995 - 2000)

Budget: 1996: NOK 6.5 mill., 1997: NOK 7.5 mill.

Objective: The main objective of the programme is to improve our understanding of the most important factors, mechanisms and processes in ecotoxicology.

Fisheries research related to developing countries (1996 - 2001)

Budget: 1997: NOK 5.5 mill.

Objective: The objective of this programme is to improve our knowledge of the resource base and management of fisheries in developing countries to ensure a long-term and sustainable exploitation of the resources as food, and also to help to develop viable fishing communities in developing countries. Important problem areas are fishery resource systems in developing countries, viable fishing communities, ecological sustainability, increased exploitation of aquatic, biological resources as food.

Sustainable use of shared biological resources (1992 - 1997)

Budget: 1996: NOK 3.9 mill., 1997: NOK 2.0 mill.

Objective: Enhance the knowledge that provides the basis for sustainable management of renewable, shared resources by increasing our understanding of the interplay between man and the environment, and which social and economic systems contribute to or work against ecologically justifiable resource exploitation on Finnmarksvidda and in the Barents Sea.

Measures in environmental management (1992 - 1997)

Budget: 1996: NOK 4.3 mill., 1997: NOK 3.0 mill.

Objective: This programme is intended to obtain knowledge about links between development of society, environmental problems and possibilities for management, and to help to fulfil a fundamental need in public management and the business community regarding environment-related measures and comprehensive solutions for managing the flow of materials and the problems of waste.

Environment, power and management (1994 - 1998)

Budget: 1997: NOK 4.0 mill.

Objectives: The aims of this programme are to help provide enhanced insight into the possibilities for the management of environmental policy and find out which strategies

can be effective and realistic. A principal objective is to find out how the development and use of measures in environmental policy are affected by the manner in which the political and administrative systems function and the experience gained from the use of various measures. Analyses of how sectorial responsibility functions as an institutional framework for the management of environmental policies are a particularly key feature.

Quality of life determined by the environment (1993 - 1998)

Budget: 1996: NOK 4.0 mill., 1997: NOK 5.0 mill.

Objectives: The principal objective of the programme is to increase our basic understanding of links between the natural environment and the well-being, health, quality of life, attitudes and actions of people. Nature conservation to a large extent has to do with human behaviour. It is therefore important that research on nature conservation also includes research oriented towards psychosocial, sociological and cultural aspects. Demands are placed on both the quality of the research and its relevance for management within the framework of a interdisciplinary programme.

Cultural heritage objects and the environment (1994 - 1999)

Budget: 1996: NOK 4.0 mill., 1997: NOK 4.0 mill.

Objective: The research carried out in this programme is intended to form an arena for multi- and interdisciplinary co-operation within the fields of cultural heritage and environmental conservation, in such a way that researchers from different disciplines work on the same themes and problem areas with a view to achieving an understanding that is greater than the sum of that which the individual disciplines can contribute. Developing of methodology and valuation will be important aspects of such work. Important problem areas are cultural understanding as a basis for environmental conservation and the way in which various sections of the population experience the quality of life as determined by cultural and environmental factors, the relationship between cultural heritage objects and landscape, and the basis for values and criteria.

Social external constraints and measures in Norwegian energy and environmental policy (1996 - 2000)

Budget: approximately NOK 9.5 mill. per year.

Main objective: to build up and maintain the basic knowledge needed to design Norwegian policy to promote sustainable development linked with the use of energy in Norway and in a regional and global perspective.

Subsidiary objectives:

- The research should provide more knowledge about the conditions and measures needed for an efficient policy in the sphere of energy and the environment.
- The programme should build up expertise on these themes at Norwegian research and educational establishments so that they, in addition to the research directly carried out under the auspices of the programme, may provide good candidates for research expertise which the users require in their everyday work.

Use and management of marginal land (1996 - 2000) (Environment and Development, Bioproduction and Processing)

Budget: 1996: NOK 6.0 mill., 1997: NOK 8.5 mill.

Objectives: To acquire new knowledge about sustainable biological management and optimal economic utilisation of the resources of marginal land for the benefit of both the owners and the public at large. The building-up of expertise should be founded on the interdisciplinary nature of the management of marginal land and the need for a means-oriented approach. The programme should also aim to find and initiate ways of using the land that are sustainable and forward-looking.

Sustainable production and consumption (1996 - 2001)

Budget: 1997: approximately NOK 5 mill.

Objectives: The main objective of the programme is to develop expertise on how it is possible to achieve sustainable production and consumption in Norway. Three subsidiary objectives have been defined.

1. The programme should help to increase insight into theoretical and ethical aspects of the concept of sustainable production and consumption.
2. The programme should help to develop analysis tools and measures which public management can use to pave the way for sustainable production and consumption.
3. The programme should help to increase expertise on how it is possible, in practice, to move a system in a direction of sustainability.

Appendix 2. Mandate of the Programme Development Committee

- The Committee must prepare a proposal for a research programme by 10 March 1997, for consideration by the Divisional Board on 20 March 1997. The Committee is free to obtain advice and use expertise from beyond its own members.

- The programme must include a thematic framework, a geographical framework and the organisation of a possible, new research programme. The proposal must be based on the *Strategic Plan for Research on Environment and Development* and the proposal of the Division for Environment and Development for a major commitment on the theme *Biological diversity - natural processes and effects of man-made changes* (see ITEM MU 109/96). The committee should, moreover, use the following documents as a basis:
  - After Rio... Report no. 3. The Research Council's contribution to a National Action Plan for Biological Diversity (Research Council, 1994)
  - The need for expertise in the management of environmental conservation (reported in letters to the Research Council dated 9 October 1995 and 22 October 1996
  - Global Biodiversity Assessment (UNEP, 1996)
  - Diversitas Operational Plan (IUBS (International Union of Biological Sciences), SCOPE (Scientific Committee on Problems of the Environment), UNESCO, ICSU (International Council of Scientific Unions), GCTE (Global Change and Terrestrial Ecosystems), IUMS (International Union of Microbiological Societies)).

- It is a prerequisite to have close co-operation with the programme development committees for Environmental Impacts of Biotechnology and Preservation of Biological Diversity, both of which can advise on the continuation of projects within their themes.

The proposal must take other ongoing activities into consideration, especially the following programmes: *Ecotoxicology (including part of Nitrogen and ground-level ozone), Climate and ozone (including part of Nitrogen and ground-level ozone), Arctic light and heat, Global environmental changes, Marine resources and the environment (Bioproduction and Processing, Environment and Development, Science and Technology), Plants and the soil (Bioproduction and Processing), Forestry - environment, industry and society (Bioproduction and Processing), and Pure research in ecology (Science and Technology)*. The proposal must be viewed in the light of the objective to have fewer and larger research programmes in the future (see ITEM MU 88/96 on organisation of programmes).

- The proposal should include advice on geographical delimitations for research projects and measures to enhance international co-operation in this field.

- Various sub-themes of the proposal should be suggested in ranked order, to be able to meet alternative budgets.