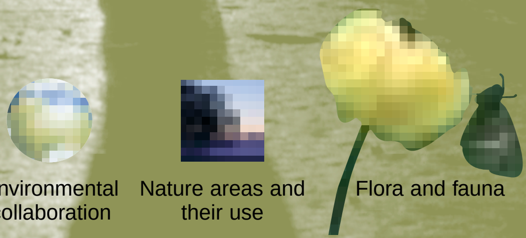
DN Report 2002-1b

Norwegian Millennium Ecosystem Assessment -

Pilot Study 2002



Environmental collaboration | Nature areas and their use | Flora and fauna | Outdoor recreation

Norwegian Millennium Ecosystem Assessment - Pilot Study 2002

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Abstract:

This report puts forward proposals for the content, organisation and financing of a Norwegian full-scale project which can be linked with the global project "Millennium Ecosystem Assessment". The report also presents two examples of results which can be obtained by means of a full-scale project: namely, a simplified assessment of trends and the current condition of Norway's natural environment, and a case study of the Glomma river basin. In the case study, scientific analyses are conducted in which the extraction of goods and services from ecosystems are examined in context. The case study illustrates how the extraction of goods and services from the natural environment in one sector influences the potential for extraction of goods and services required by other interests/ industries.

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Foreword

The Directorate for Nature Management (DN) has produced this pilot study, commissioned by the Norwegian Ministry of the Environment, as a basis for deciding whether or not Norway will undertake a full-scale analysis of the country's natural heritage and environment along the lines advanced by the "Millennium Ecosystem Assessment" model. The original title of the Norwegian project can be translated as "Nature's values and services – an assessment of Norway's natural environment at the turn of the millennium". Results from a Norwegian full-scale project will be incorporated in the global project. Norway will gain a number of benefits by participating in the global project, such as quality control, methodology and free satellite images.

The Section for Environmental Data and Monitoring in the Directorate's Environmental Information and Monitoring Department has had responsibility for the pilot project within DN. An internal consultative committee provided advice during the course of the pilot study's development. The members of the group were: Reidar Dahl, Svein Båtvik, Brit Veie-Rosvoll, Else Løbersli, Jon Barikmo, Peter Johan Schei, and Odd Terje Sandlund (NINA). Signe Nybø has functioned as project leader for the pilot study. Hilde Kyrkjebø has contributed written material regarding economic values.

In connection with the production of chapter 2.2. of the pilot project report, seven meetings were held with potential users of the results of a full-scale study. The following participated: The Norwegian Water Resources and Energy Directorate (NVE), Sabima, WWF, Nature and Youth, The Norwegian National Association for Outdoor Recreation (FRIFO), The Norwegian Tourist Board, Oppland County Council, the Ministry of Agriculture, Norskog, the Norwegian Association of Forest Owners and the Fisheries Directorate. The participants responded with oral and written views on the project, in addition to contributing to the shaping of chapter 2.2. A meeting was also held to inform people working with the monitoring and mapping of clean food, air and water. Representatives from the Norwegian Pollution Control Authority, Public Health Authority and the Norwegian Radiation Protection Authority were present at the meeting.

The Norwegian Institute for Nature Research (NINA) was commissioned by DN to produce chapters 3 and 4, which form the scientific parts of the pilot project. Odd Terje Sandlund had responsibility for this, and the following research scientists have contributed text to NINA's two chapters: Vegar Bakkestuen, Trine Bekkby, Hartvig Christie, Lars Erikstad, Erik Framstad, Christian Nellemann, Odd Stabbetorp and Torbjørn Østdahl. The specialist content in Chapter 3 "Norway's natural environment: a description of its condition, values and services", has been read and quality-controlled by research scientists at the Norwegian Marine Research Institute(Per Solemdal), The Museum of Natural Sciences, Norwegian University of Science and Technology (Asbjørn Moen), Norwegian Institute for Water Research (Anne Lyche Solheim), Norwegian Institute for Land and Forest Research (Wenche Dramstad, Wendy Fjellstad), Norwegian Forest Research (Skogforsk) (Kåre Venn), as well as DN's own experts in the various environmental fields.

The pilot project has provided DN with a number of new points of contact with other sectors and interested groups that work with environmental values. It has been very gratifying that so many have met up and participated in discussions. We would like to express our gratitude to all those who have contributed to the pilot project.

With sincere regards

Ivar Myklebust
Director of the Environmental Information and Monitoring Department

Summary

The Millennium Ecosystem Assessment (MEA) is a collaborative project between the Convention on Biological Diversity, the Ramsar Convention, the Convention to Combat Desertification and a range of organisations. This report is a pilot study which demonstrates how a Norwegian full-scale project linked to MEA can be carried out. The Norwegian project's Norwegian title can be translated as "Nature's values and services – an assessment of Norway's natural environment at the turn of the millennium". This title was given because it is difficult to translate the English title used for the present report into Norwegian.

A Norwegian full-scale study is needed in order to assess how our ecosystems can continue to supply the values and services that we require, both now and in the future. Through participation in this pilot study, various users have pointed out themes which they think should be incorporated in a full-scale study. The pilot study has shown that we have the necessary data which make it possible to carry out a full-scale study. However, this data needs to be prepared to some extent before it can be used. Linkage to the global study ensures access to a shared conceptual framework, methodology, and a number of free satellite images. It also establishes uniform criteria for controlling the quality of the results. By co-ordinating a Norwegian full-scale project with other on-going projects in Norway, other Nordic countries and globally, a win-win situation will arise which will be to everyone's benefit. Examples of this are provided in the report itself.

The methodology in the global project eases communication between diverse institutions, sectors and interest groups. The methodology is based in the individual user's requirements for ecosystem services. This ensures that the project will function as a shared platform for the discussion of ways of approaching problems which are of relevance to a range of involved parties. The initiation of the full-scale study therefore provides a good opportunity to create greater responsibility for comprehensive management of the natural environment in all sectors. The full-scale study should highlight important "trade-offs", in relation to which Norwegian society should have a conscious policy. Such trade-offs will be made apparent in scenarios for future development. At the same time, the full-scale study will identify possible solutions/initiatives which can facilitate comprehensive management. The implementation of such initiatives will ensure that important goods can be obtained and ecosystem services will be taken care of for future generations. The proposals for solutions/ initiatives which emerge in the full-scale report can have relevance for a number of sectors. It is recommended therefore that the project be steered by a cross-sector committee. It is further recommended that the interdepartmental committee with responsibility for following up the parliamentary report on biological diversity act as the project's steering committee, or alternatively, that it appoint another steering group. It is suggested that the full-scale project should be conducted over a period of 4 years, starting in 2002. The total budget for the project is NOK 9.9 million (USD 1.2 million), of which NOK 0.86 million (USD 0.1 million) is required in 2002. The finances suggested for 2002 will be used to identify themes for incorporation in the full-scale study and to prepare data. Should the grant be lower than anticipated, it will still be possible to conduct a study, though modified with respect to the methodology outlined in the international project.

A working group for the full-scale study should be appointed early in 2002, so that the international project's time-frame can be adhered to. In 2002 further work should be undertaken to focus on what the full-scale study can deal with, identify and prepare in terms of data, as well as getting an overview of relevant projects which can contribute to the full-scale study's concrete contents. Reporting from the Norwegian full-scale study to the international project will take place in the course of the winter of 2003/2004. Reporting does not presuppose that the Norwegian project has been completed, but rather that some of the results will be available.

Chapter 3 of the pilot study comprises a simplified analysis of the condition of, and trends within, values and services associated with Norway's natural environment. The study compares the current status with the situation as it was about a hundred years ago. The table presented below summarises the simplified analysis. The analyses are conducted individually for each type of envi-

	Type of natural environment						
Commodity/service	Ocean	Coast	Freshwater	Mires and wetlands	Cultural landscape	Forest	Mountain
Food production	Fair ↘	Good ↗	Fair ↘	Poor ↘	Fair →	Excellent →	Fair →
Fibre	Fair →	Good →	Not assessed	Poor ↘	Poor ↗	Good ↗	Fair ↗
Hydrology/erosion protection/ pollution	Poor →	Fair →	Good ↗	Fair ↘	Poor →	Fair ↘	Poor ↘
Biological diversity	Poor ↘	Fair ↘	Fair ↘	Fair ↘	Bad ↘	Fair ↘	Fair ↘
Recreation	Good →	Fair ↘	Good →	Poor →	Poor ↘	Fair →	Fair ↗

Condition

	Condition
Purple	Excellent
Green	Good
Yellow	Fair
Orange	Poor
Red	Bad
Grey	Not assessed

Developmental trend

→	Stable
↗	Increasing
↘	Decreasing

ronment. This means that it is not immediately possible to compare the colour scale between environment types.

Chapter 4 of the pilot study comprises a case study of the Glomma river basin. This demonstrates how data series from diverse social sectors and activities can be used to analyse the way in which the extraction of products and services from ecosystems simultaneously both depends upon, and exerts influence on, the condition of the ecosystems. The demands of one sector for extraction of services can influence the potential for extraction desired by other sectors. The Glomma river basin exemplifies many of the opposing interests, conflicts and necessary compromises faced by those involved in nature management. Some examples are:

- The construction of infrastructure leads to the fragmentation of the landscape. We know this has a negative effect on species such as wild reindeer, but we lack much information about the other effects of such fragmentation. In the Glomma river basin, the areas south of the line Trysil – Elverum – Hamar – Gjøvik are today devoid of encroachment-free areas, and in the areas north of this line the encroachment-free areas largely coincide with existing or planned conservation areas.
- The areas of old-growth forest have diminished, while at the same time the forests contain a larger volume of timber and have a different structure than they had fifty years ago. This efficient management of forest resources aimed at lumber production has probably led to the loss of biological diversity at species or ecosystem level.
- Economic and political conditions at national and international levels promote changes in farming methods. Larger areas of uninterrupted fields and fewer field boundaries and groves provide for more efficient food production. Changes in the cultural landscape have consequences for tourism and outdoor pursuits in terms of experience and enjoyment value. The homogenisation of the landscape can be detrimental to the tourist industry.
- Along the coast, conflicts of interest continually arise between the construction of holiday cottages or other infrastructure and the public's rights of access to land and sea. This problem also arises along the coast near the mouth of the Glomma.
- The watercourse today supplies diverse services and products such as hydro-electricity, supply of water to households and irrigation, cleansing of drainage water and recreation. Future conflict between different user interests on the watercourse will probably occur in different combinations in each individual case.

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Appendix 1: Methodology for carrying out a full-scale study

1 Introduction

Do you dream of an all-embracing management of our ecosystems, in which people take their natural place, but where nature can also exist on its own terms?

The Norwegian project will try to provide some answers as to how we can manage our natural environment in a comprehensive manner. Sustainable use of the natural environment will in future create a foundation for the Norwegian people's health and well-being. At the same time we will manage to take care of the values in nature which cannot be measured in terms of money. The global project "Millennium Ecosystem Assessment" (MEA) provides a tool for showing how comprehensive and sustainable management can be achieved, also here in Norway.

This report is the result of a pilot project conducted in 2001. The pilot project forms a basis for an assessment by the Ministry of the Environment as to whether Norway will undertake a full-scale study over four years as part of the global project "Millennium Ecosystem Assessment".

The report is divided into three parts. The first part (Chapter 2) looks forward towards a full-scale study – what form can it take, and how might it be organised? Chapters 3 and 4 form the scientific part of the project, and provide foretastes of what a full-scale study might comprise.

The Norwegian project distinguishes itself from some previous work in the sphere of environmental conservation management in that it takes greater account of human needs in relation to the natural environment. The global study provides a concept for how national studies can be carried out. This is described in Chapter 2.1. What are the "goods and services" from the natural environment that we need in order to achieve good health and well-being in a long-term chronological perspective? The pilot project has therefore conducted a survey of the "goods and services" that are required by different interest groups in Norway (Chap. 2.2.). The connection between the production of these commodities and diverse ecosystem services is portrayed in its own table (see Chap. 2.2.). What economic value do these goods and ecosystem services have? Chapter 2 ends by sketching out the organisation, progress and content of a full-scale study. The proposal builds on guidelines outlined in the global project, as well as from experiences derived from contact with interest groups in Norway, work on the case study of the Glomma watercourse (Chap. 4), and an assessment of the condition of Norway's natural environment as it is today (Chap. 3).

Chapters 3 and 4 provide examples of the types of analyses a full-scale study might contain. Here can be found a straightforward assessment of Norway's natural environment based on the requirements we have for goods and services (Chap. 3). This is a simplified assessment conducted by researchers who have studied these ecosystems over an extended period of time. The format follows the one used at a global level in "World Resources 2000-2001. People and Ecosystems" (UNDP, UNEP, the World Bank, World Resources Institute, 2000). The pilot study also provides an example of the kind of analyses a full-scale study might contain (Chap. 4). Constrained as it was by the project's economic limits, the case study of the Glomma river basin does not provide scenarios, as would have been the case for a full-scale study, and does not outline follow-up response options (administrative, economic, legal).

2 Proposals for the content and organisation of a Norwegian full-scale study

2.1 The global project

Organisation and implementation

The Millennium Ecosystem Assessment is a 4-year project financed by a range of institutions (http://www.millenniumassessment.org/). The chief sponsors are the United Nations Foundation, the World Bank, the Global Environment Facility and the David and Lucie Packard Foundation. There are additional contributions, among them a Norwegian-supported sub-regional project in southern Africa. The budget is equivalent to that of the Climate Panel (IPCC), namely 21.1 million dollars (NOK 180 million). The project is steered by an international board, where Norway is represented by Peter Johan Schei (Directorate for Nature Management). The project's final report will be presented in 2004/2005, but the final results from the majority of sub-global projects will emerge somewhat later. Some results from the sub-global projects will, however, be published simultaneously with the global study. The aim of all the projects is to report underway in order to ensure good contact and co-operation between users.

The project is organised so that a number of local and regional projects which have been initiated will primarily have an intrinsic value their own while also contributing to the global study (fig. 1).

Summaries from local projects will be incorporated in the global project. Parts of the local projects will report to the international study. A framework has been designed for structuring contributions from local studies to the global study (see http://www.millenniumassessment.org/en/nominations.outline.pdf). Norway's full-scale study is provisionally one of seven projects which have been asked to apply for approval as a sub-regional entity. There are many sub-global projects on the threshold, and more will appear in 2002. Norway has applied for formal approval, but with the reservation that national financing must be clarified in advance. The Ministry of Foreign Affairs has granted funding for Norwegian participation in activity twinned with the regional study in southern Africa. The aim of this collaboration will be mutual development of expertise. In 2002, Norway will hold the chairmanship of the Nordic Council of Ministers. In connection with this, Norway has advanced a proposal for a Nordic millennium study as one of seven initiative areas in Nordic environmental

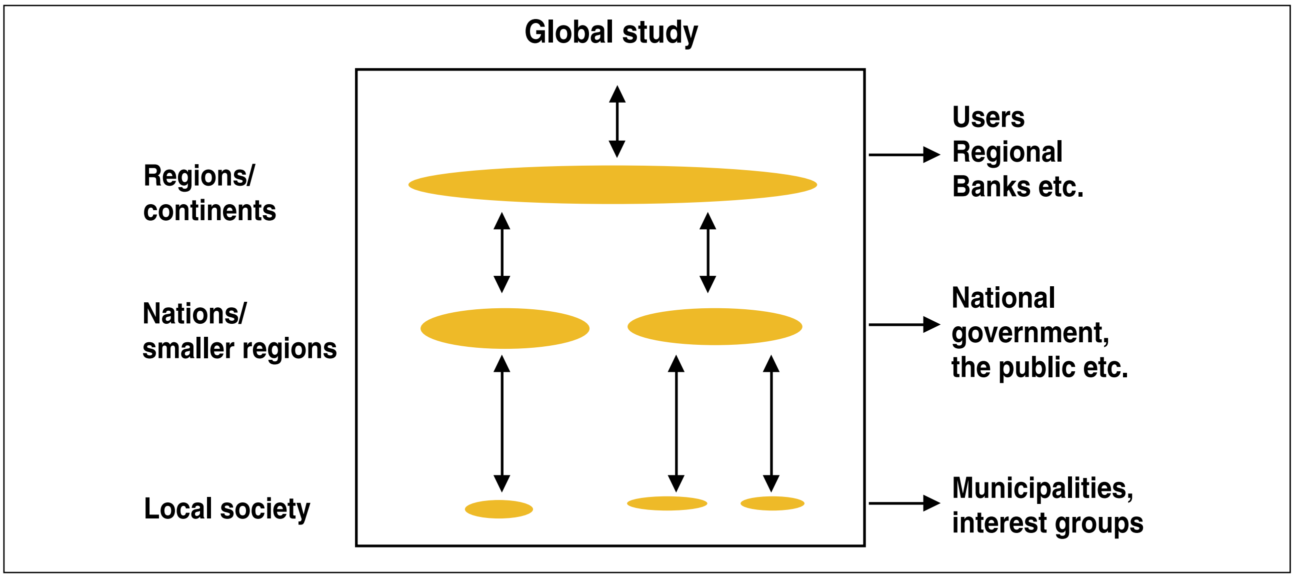

Figure 1. The connection between the local, regional and global studies

cooperation in 2002. A Nordic initiative can therefore contribute to the commencement of a Norwegian full-scale project.

At a global level the main users of the results are the Convention on Biological Diversity, the Convention on Desertification, and the Ramsar Convention, as well as the organisations which support the project economically. These have contributed to formulating the focus and main themes which will be treated in the global project.

For the local projects, local users will contribute to defining relevant themes. Users in Norway comprise sector departments, directorates, industrial and voluntary organisations, and trade and industry. In the course of the pilot project, a number of meetings have been conducted with the most relevant Norwegian users in order to investigate whether there is an interest for a full-scale study in Norway (see Chap. 2.2.). These users have identified particular approaches to problems and themes which can be of interest to them in a full-scale study, within the framework of the global concept (see Chap. 2.2. and table 1).

Contents and methodology

The global project focuses on ecosystems, their goods and services, their intrinsic value in terms of biodiversity, and the consequences which ecosystem changes have for human health and well-being, means of livelihood, food safety and other important factors. The development of the global project builds for a large part on thinking connected with the principles for the ecosystem approach towards the management of biological diversity which were endorsed by the Convention on Biological Diversity's COP 5 (Decision V/6; http://www.biodiv.org/decisions/). This was also the theme of the Third Trondheim Conference on Biological Diversity (Schei et al. 1999).

The main focus of the global project can be summarised as follows:

- What effect has ecosystem degradation on human health and well-being?
- What effects do economic growth and globalisation have on ecosystems?
- What constitutes effective policy in relation to ecosystems which will lead to the reduction of poverty?

This means that it is the ways in which ecosystems and their services are important for human health and well-being which will be focused on in this project. How can ecosystems be managed so that human health and well-being can be maintained through the generations? Which of the goods and services required by people can be maintained in the long-term? The global project has dealt with this at a higher level. A conceptual framework has been developed which will form the point of departure for the analyses (fig. 2). All types of ecosystems are included in the study, including those which are man-made.

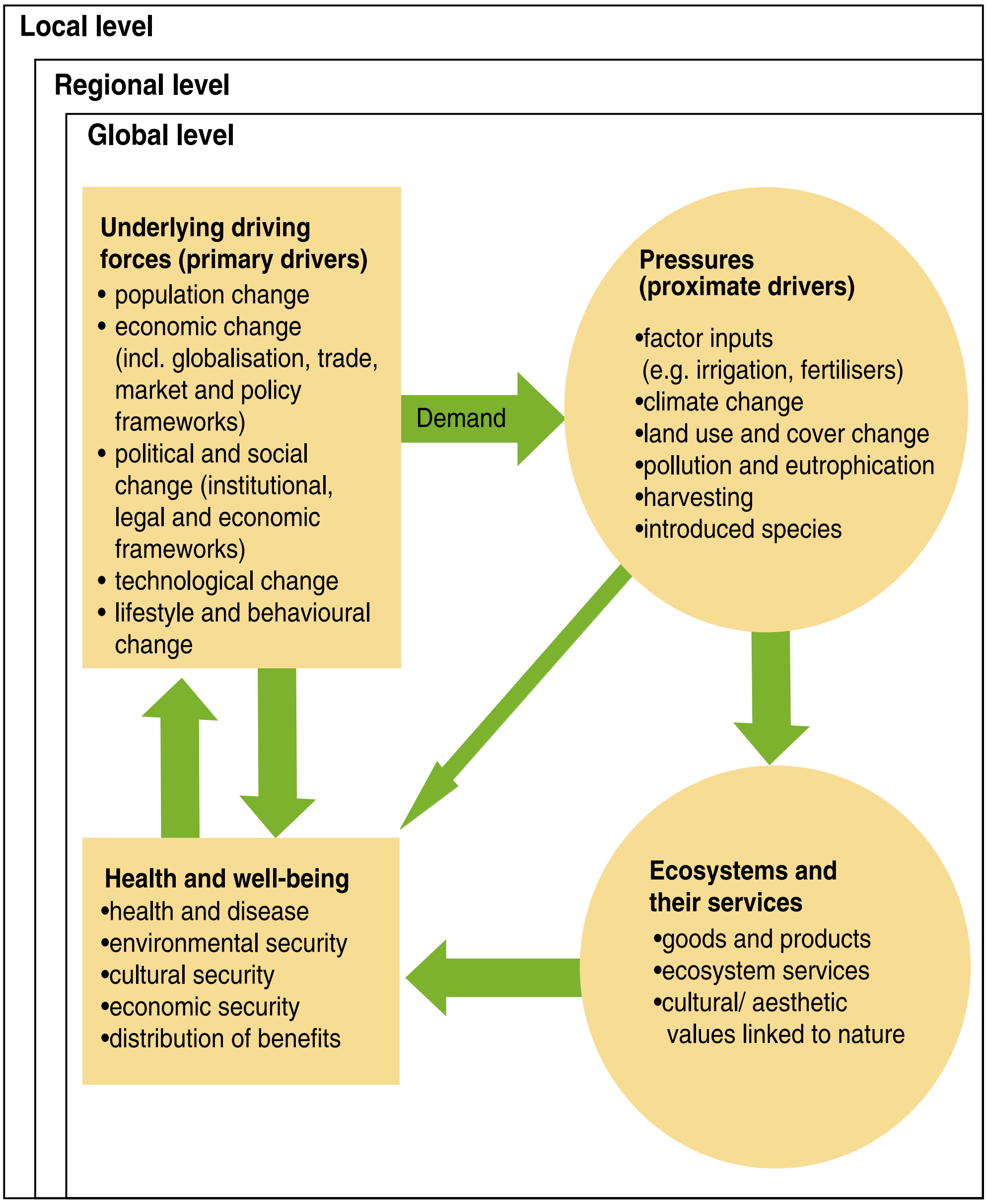

Figure 2. Schematic conceptual framework outlining the relationships between human health and well-being, society (driving forces/primary drivers and pressures/proximate drivers) and ecosystems as they are understood in the "Millennium Ecosystem Assessment". Green arrows indicate directions of influence in this conceptual framework.

The figure shows that ecosystems and the goods and services they supply form preconditions for the attainment of health and well-being. In addition, the underlying driving forces (population structure, politics etc.) have direct significance for human health and well-being. In some instances pressures also have a direct impact on health and well-being, as occurs where climate dictates the kinds of clothing that people wear. This is indicated by a small arrow in the figure.

If things go "wrong", management response actions, or measures, must be implemented. Response actions can only be implemented by changing the level of pressure or changing the underlying driving forces (see fig. 2), and can not be introduced into the ecosystem itself. For example, we cannot alter nature's own cleansing capability. An improved cleansing capability can only be obtained by increasing the factor inputs, either by building cleansing plants or by stimulating nature to increase its own cleansing capability. An example of the latter could take the form of introducing oxygen by pumping in order to increase the breakdown of sewage.

In the Norwegian study, emphasis is placed on the box situated at bottom right in figure 2; i.e. the importance ecosystems and their services have for human health and well-being. The global project has developed a list of the most relevant goods and ecosystem services (see box 1).

Box 1 Ecosystems and their services

Goods and products	Ecosystems and their services
Food from • plants •animals •micro-organisms **Other biological products** •biochemical products/ medicines •energy/ fuel •fibre (e.g. timber, wool, linen) •non-living products (e.g. shell-sand, peat) **Other values connected with nature** •religious and cultural attachment to areas of land •recreational areas •research, education and training	**Supporting functions** •biological diversity •connecting lines in the landscape and landscape structures •areas for differing uses **Regulating functions** •soil formation •pollination •nutrient cycling •natural barriers which impede the spread of disease and introduced species •climatic regulation •regulation of chemical composition in the atmosphere •flood- and erosion control •cleansing of water, soil and air

The list shows that everything is interdependent. It illustrates that production of goods from ecosystems is dependent on ecosystem services – the necessary ecological support functions. For example, biological diversity is a basic supporting function for regulating functions, such as soil formation. Soil formation is in turn necessary for the production of grain (goods/products). The Norwegian pilot project has developed an equivalent list for Norwegian ecosystems and their services (Chap. 2.2., table 1). This is more detailed than the global project's list, and is limited to elements relevant for Norwegian circumstances.

Box 1 shows the many demands which must be satisfied in the future. Among other things, this requires making trade-offs between different needs, i.e. comprehensive (or holistic) management must be developed so that most needs can be covered. The models and conceptual framework (fig. 2, box 1, table 1) will be used to analyse development over time in relation to society's requirements and the ecosystems' ability to supply goods and services. The condition of, and developmental trends in, important ecosystems and goods will be mapped (box 1). With this in mind, scenarios for possible future development will be worked out. This will form the basis for an analysis of how society can formulate response measures designed to impede or counteract an unfavourable development, and which will be incorporated in the final product. Which measures are most effective for counteracting a development which is not sustainable?

- As a result, both the sub-global projects and the global project will contain the following main themes:
- developmental trends and the condition of the natural environment
- scenarios
  •response options

All parts will be linked. This means that, among other things, proposals for effective measures must be based on scenarios of future development. Credible scenarios must be developed on the basis of historical developmental tendencies and analyses of connections between cause and effect. Developmental trends and the condition of the natural environment will be particularly viewed in relation to goods, necessary support functions and other values connected with nature. At a local level, scenarios can be created in relation to different requirements for goods and services, readily shown through different trade-offs. At a global level, the scenarios will probably be directed more towards underlying driving forces, such as e.g. globalisation. This may also be done at a local level.

Each individual project will use the methodology developed in connection with the global project. This methodology is shown schematically in Appendix 1. The study will build on the best scientific data available. The results will as far as possible be illustrated with maps and simplified figures. The methodology demands that inclusiveness, interdisciplinary practice and user direction are central to the process. In other words, different sectors of society and interest groups will be involved. This means that the initial phase can be relatively long before the final choice of themes/focus is made. There is nonetheless a requirement that the project must collaborate with projects at other levels. In the case of Norway, this means co-operation with a Nordic, or possibly a European project. The methodology also contains stipulations regarding the quality-control of results by peer review and procedural transparency. Some meta-data (also called core data) should be made freely available for projects at other levels. Information about this can be found in Annex I in the document which can be downloaded from: http://www.millenniumassessment.org/en/assessments/subglobal.assessment.selection.pdf .
The projects will be interdisciplinary and involve a number of sectors. This is necessary in order to achieve a better grasp of comprehensive ecosystem management. A provisional outline is provided for the sub-global project reports that are to be submitted to the global project. This report outline is to be found at:
http://www.millenniumassessment.org/en/nominations.outline.pdf.

2.2 Goods and services from the natural environment: present and future Norwegian requirements

This section has been discussed with responsible authorities within agriculture (Ministry of Agriculture), forestry (Ministry of Agriculture, The Norwegian Association of Forest Owners, Norskog), fisheries (Directorate of Fisheries), water authorities (The Norwegian Water Resources and Energy Directorate), the tourist industry (The Norwegian Tourist Board), the Norwegian National Association for Outdoor Recreation (FRIFO) , as well as nature conservation organisations working with biological diversity (WWF, Nature and Youth and SABIMA). These organisations have commented on the project, and contributed ideas towards table 1 and relevant questions for the full-scale study (see below). This section was assembled before the global project's conceptual framework and list were available. This is the reason for a slight overlap between chapters 2.1. and 2.2., and the minor divergence in the way goods and services are organised and characterised. This section has nevertheless been adapted to Norwegian circumstances.

Human health and well-being depend upon the nature's ability to provide sufficient goods and services of a particular standard (fig. 3). Clean food, air and water are necessary for maintaining good health, and enough goods must similarly be produced in order to maintain a satisfactory standard of living. Nature also has great value for humanity's quality of life, in which varied recreation and outdoor-life experiences are important. Also bound in with the natural environment are traditions, beliefs, religion and cultural-historical remains. Sustainable management of the natural environment is therefore a prerequisite for future human health and well-being.

In order to obtain a manageable grasp on how nature contributes to human health and well-being, one can look at the production of **goods** (fig. 3, B) and how this is dependent on **ecosystem services** (fig. 3, A). Ecosystem services are a prerequisite for the sustained, long-term extraction of goods, over for example 100 - 1000 years. In order to increase production of goods from the natural environment over and above the levels provided by the ecosystem services, factor inputs are used (fig. 3). For example, we apply artificial fertilisers to fields when the soil does not provide sufficient nutrients for agriculture, or we increase the transport distance to

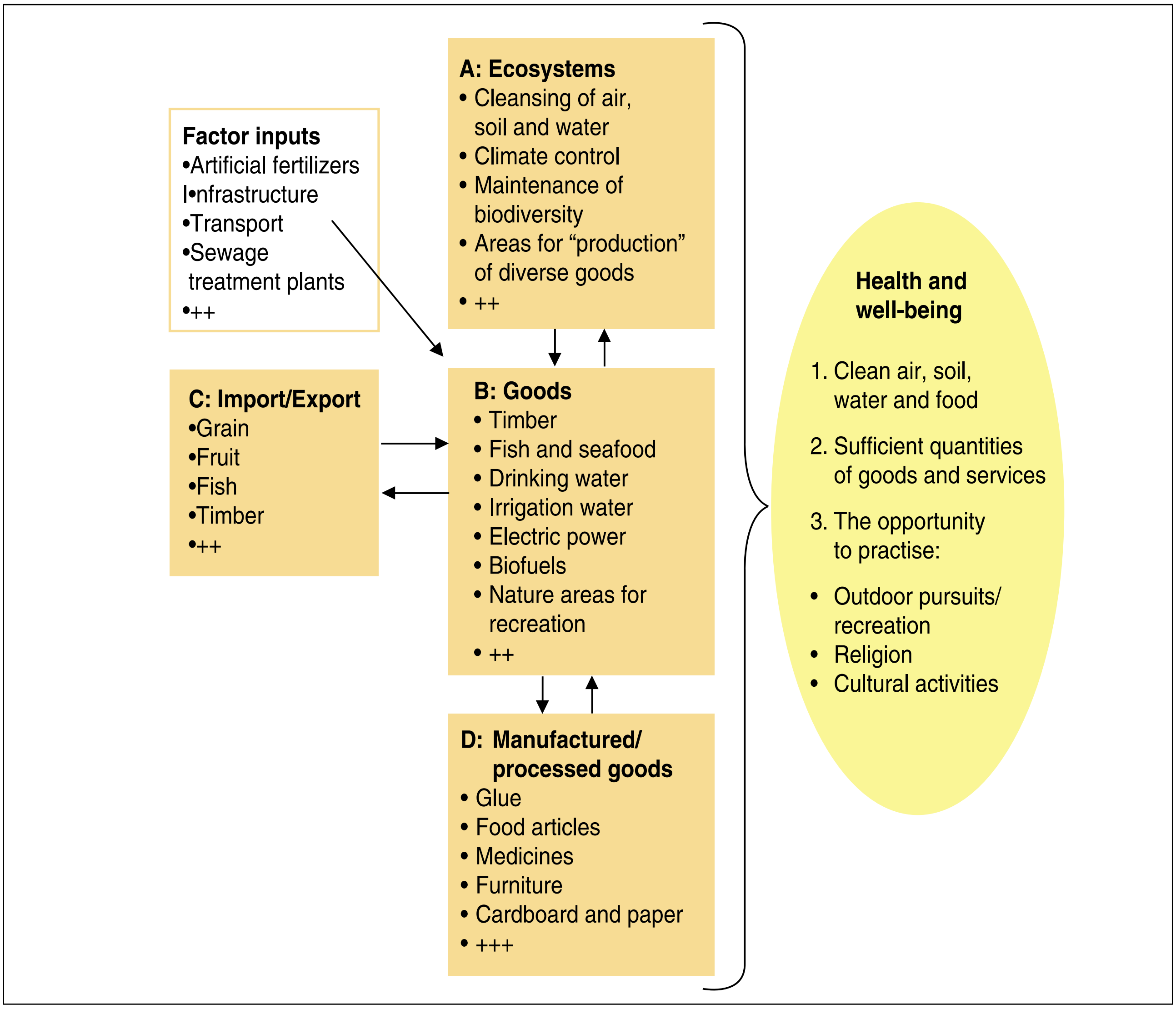

Figure 3. The importance of goods (B), ecosystem services (C) and manufactured/processed goods (D) for human health and well-being. Factor inputs are used to increase production of goods, either because the ecosystem services do not themselves naturally provide sufficiently high yields of goods, or because their capacity is reduced as a result of detrimental influences from human activity.

fisheries when it is no longer profitable in areas closer to hand. If the factor inputs increase over time, this indicates that the ecosystems are not able to deliver the goods we require. The extraction of goods can be too great in relation to what constitutes a sustainable use of nature. The costs of cleaning air, water and soil can also indicate the great degree to which ecosystems are overloaded in relation to their own cleansing capabilities.

Raw materials are the source of **manufactured goods** (fig. 3, D). Together with primary industries, manufacturing and processing industries form the basis for settlement and employment in Norway. A sustainable management of Norwegian ecosystem services is therefore not only a basis for health and well-being, but also for settlement and employment.

The import and export of goods (fig. 3, C) can replace Norwegian goods (fig. 3, B and D). This in turn can have an indirect influence on ecosystem services (A) through change in the extraction of Norwegian goods. For example, the import of foreign apples will reduce the need to produce apples in Norway. As a result, settlement and employment in Norway are influenced by the import and export of goods. At the same time, international trade also has consequences for the ecosystem services in the country which exports the goods to Norway. Both international trade agreements and the way in which Norwegian ecosystem services are managed are therefore decisive for determining the future character of settlement and employment in Norway, and the population's health and well-being.

Overview of nature-based goods and services in Norway in 2000

Human health and well-being is dependent upon the stable extraction of goods and the functioning of ecosystem services (fig. 3). This pilot project has consequently prioritised the production of an overview of important goods and showing how they are dependent upon the ecosystem services in Norway (fig. 3, A and B). The overview will form a basis for choosing the most important ecosystem services and goods which will be prioritised in the full-scale study. The overview is relatively crude, but nonetheless expresses what we think are important Norwegian goods and ecosystem services (cf. Chap 2, Box 1), and which of these are important for maintaining values and the production of goods in the future.

Future requirements for nature-based goods and services in Norway

Future requirements for the maintenance of health and well-being in Norway are linked to clean air, water and soil, sufficient quantities of goods and services, and the opportunity to take part in outdoor pursuits, and religious and cultural life (fig. 3). In order to satisfy these demands, the ecosystem services must function in the best possible way.

Clean air, water and soil are sustained by maintaining nature's cleansing capability, perhaps by building a cleansing plant when nature's cleansing capability is exceeded. Natural cleansing processes take place when, among other things, organisms (and abiotic processes) decompose pollutant chemicals into more harmless materials. New chemicals of the future will require other natural decomposing processes than are in use today. Variation in life forms creates the possibility that such "new" biochemical decomposing processes can be found in one or more organisms. The maintenance of clean air, water and soil in the future distinguishes itself from other requirements for goods and services in that these services cannot be imported, but must be produced at home.

The production of **sufficient quantities of goods** in the future will be based mainly on existing commodity production. In addition, we will get new development of goods. At present there are high levels of consumption of non-renewable resources which can seldom be recycled or re-created. Collectively, the consumption of non-renewable resources creates more waste than nature's ecosystems have the capacity to deal with. These conditions require that in future one must lay greater emphasis on producing goods based on renewable resources, as well as retaining the services which support the production of these goods. Goods produced from renewable resources frequently produce little in the way of harmful waste. Rich biological diversity will provide a good potential for developing new goods. New medicines can be developed with the help of genes in plants, animals and micro-organisms, and in naturally occurring materials. Wide-ranging bio-prospecting is already taking place ie. the search for genes or biochemically active materials in natural organisms which can be used in the pharmaceutical or biochemical industries (cf. coral reefs). The development of new agricultural products, other biological products and new seafood products are also based on the selective breeding of species, which depend on the availability of a varied genetic material. This means that genetic diversity, species diversity and variation in the ecosystems inhabited by the species are necessary prerequisites for the production of new goods. It is a cross-sector responsibility to ensure that ecosystems continue to function well enough to allow the extraction of goods to be maintained at a level consistent with the sustainable use of the natural environment. The use of factor inputs to increase the extraction of goods should be moderated, so that one avoids over-exploiting ecosystems to the extent that nature's ability to heal itself is damaged.

Our ability to **practise outdoor pursuits, religion and cultural activities** connected with nature is based on access to areas in which these activities can take place. It is a prime social responsibility that such areas should be available for use. Access to such areas in the vicinity of towns and urbanised areas may be restricted. Distances to nature areas will increase unless these needs are secured through land management and land disposal. The preservation of such common areas will often conflict with industrial interests and housing development. Conscious policy-making and good methods of implementation are necessary to deal with such conflicts and secure these "goods" in the future.

The maintenance of a clean environment, the production of goods and the opportunity to take part in outdoor pursuits, religious and cultural activities are all dependent upon the functioning of ecosystem services. Examples of such critical ecosystem services are nutrient cycling and climate control. As shown above, the maintenance of ecosystem services is vital for the long-term health and well-being of the people of Norway.

Focus on critical ecosystem services

Critical ecosystem services are those which are exposed to major negative pressures from human activity and which at the same time are absolutely essential for the maintenance of clean air, water and soil, sufficient amounts of goods, and for the practise of outdoor pursuits, religion and cultural activities. The identification of negative pressures therefore provides an indication of what constitute critical ecosystem services (see also fig. 2). In a European context, MIRABEL forms a standardised tool for comprehensive analyses of pressures on biodiversity. In modified form this tool can be of use in our own context, and indicates, among other things, different pressures on ecosystem services. The development of MIRABEL is based on the thinking behind the "Drivers-Pressure-State-Impact-Response" (DPSIR) model (NERC 1995) which includes the following concepts:

Box 2

A: Drivers – underlying driving forces, such as population increase, consumption increase, globalisation.

B: Pressures (proximate drivers)

- •Climate
- •Pollution
  - -acidification
  - -eutrophication
  - -other pollution
- •Land use
  - -urbanisation
  - -flood precautions
  - -watercourse regulation
  - -forestry
  - -rough grazing
  - -intensification, agriculture
  - -closing down, agriculture
  - -transport – infrastructure
  - -recreation – disturbance
  - -resource extraction (mines, quarries)
- •Harvesting
- •Introductions (of alien invasive species/genes)

C: State – condition, description of current situation.

D: Impacts – changes of condition as a result of pressures.

E: Responses – initiatives, agents; can be legal, economic or information-related.

Table 1 shows the most important ecosystem services in the main types of natural environment in Norway. The ministries, institutions and organisations who have been involved in the preparation of this chapter have pointed out, among other things, that the following ecosystem services are of critical importance for them: land for the cultivation of grain, climate control, biodiversity as a basis for many of the ecosystem services, as well as natural barriers for animal and plant diseases. The list is not exhaustive. Critical ecosystem services should be prioritised in the full-scale study.

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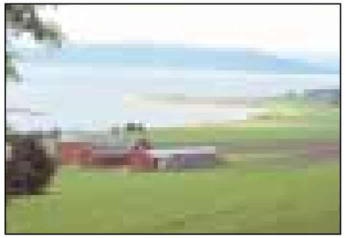
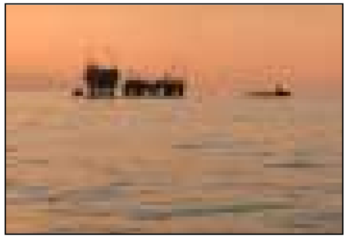
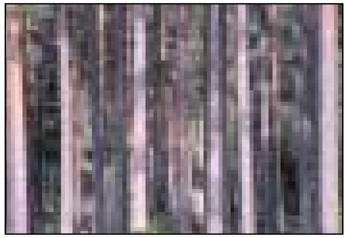




Ecosystems	Goods	Ecosystem services
The Cultural Landscape		
cultivated food: harvested food: other biological products: water: energy: tourism: other: common goods:	grain, meat, fruit, vegetables, eggs and milk roe deer hides, biofuel, fertiliser, decorative greenery etc. irrigation water, drinking water geothermal, biofuel (straw, oil plants) farm tourism green care foodstuff security (self-sufficient), culture and traditions, archaeological and architectural sites and monuments, culturally determined biodiversity, living countryside communities	• cleansing of water, soil and air • exchange of nutrients in the soil • erosion protection • rough grazing for farm animals • wild organisms which are important for agriculture (bees, soil organisms etc.) • land resources; areas for the cultivation of goods; particularly the scarcity of grain areas • areas for wild animals and plants which are harvested and for organisms which form part of the diversity of the cultural landscape • areas for infrastructure, industry and buildings
Mountains		
"cultivated food": harvested food: energy: tourism: common goods:	tame reindeer, grazing farm animals wild reindeer, grouse, hare, cloudberries wind power musk-ox safari, hunting, skiing facilities, snow-scooter safari, glacier tours, alpine dairy farm tourism, holiday cottage tourism biodiversity, recreation such as hunting, fishing, mountain walking, rambling, cross-country skiing, cycling, mountaineering,, photographing etc.	• water reservoirs • rough pasture areas (tame reindeer, sheep) • areas for recreation • pasturing resources for harvested wild animals • areas for wild species which form a part of the biological diversity
Bogs and wetlands		
harvested food: other biological products: common goods:	berries, ducks, geese peat biodiversity	• water reservoirs • pasture resources for harvested wild animals • areas for wild animals which form part of the biodiversity • areas for infrastructure, industry and buildings
The Ocean		
harvested food: other biological products: energy: tourism: common goods:	80 commercial fish species, minke whale, prawns, Iceland scallop chitin, sealskins oil and gas whale safaris, fishing excursions biodiversity	• cleansing of seawater • carbon retention in the ocean (climate control) • feeding resources for harvested wild animals (including fish) • areas for wild species which form part of the biodiversity • areas for oil and gas installations, transport corridors for ships



Ecosystems	Goods	Ecosystem services
Forests		
harvested food:	moose, red deer, roe deer, capercaillie, berries, fungi	• retention of carbon (climate control) and local climate control
Other biological products:	decorative materials, timber from spruce, fir and deciduous trees	• exchange of nutrients • stabilising the hydrological cycle, e.g. filtration, cleansing, flood control, and erosion prevention
energy:	biofuels	• water reservoirs
tourism:	hunting, fishing, skiing facilities	• building-up of the soil
common goods:	biodiversity, recreation such as hunting, fishing, cross-country skiing, rambling, cycling, photography etc.	• pasture resources for harvested species (e.g. moose, capercaillie) • areas for harvested wild animals and plants (including forests) and other species which form part of the biodiversity • areas for infrastructure
Freshwater		
cultivated food:	rainbow trout	• cleansing of water and reduction of pollution
harvested food:	salmon, trout, char, beaver etc.	• feeding resources for harvested species (e.g. salmon)
water:	drinking water, industrial water, irrigation water	• hydrology/ flood modification
energy:	water power	• areas for harvested wild animals and plants and other species which for part of the biodiversity
tourism:	salmon, trout, char, canoeing, rafting, kayaking	• areas for recreation
common goods:	biodiversity, recreation such as hunting, fishing, paddling, boating, swimming, camping	
The Coast		
cultivated food:	farmed fish and shellfish	• cleansing of water, soil and air
harvested food:	shellfish, sea urchins, seals, seabirds	• reduction of pollution
other biological products:	knotted wrack, kelp	• areas and pasture/feeding resources for harvested species and other species which form a part of the biodiversity
energy:	wind power, wave power,(in the future?)	• areas for recreation
tourism:	"food-garnering tourism", sports fishing	• areas for breeding/rearing
common goods:	recreation such as fishing, boating, swimming, hunting, biodiversity, camping	• areas for infrastructure, including industry, ports, sea lanes

Relevant approaches for a Norwegian full-scale study

The Directorate for Nature Management has invited the same organisations/ government departments involved in the preparation of table 1 to suggest their most pressing or important issues which might be taken up in a full-scale study. The list below is a result of different individuals' professional positions and experiences, and therefore provides an initial indication of where they feel the "shoe pinches" in relation to their own industry/ organisation and its relationship to the natural environment. The list provides examples of themes which can be dealt with in a full-scale Norwegian study. Abbreviations are explained at the beginning of chapter 2.2 (DN: Directorate for Nature Management).

<u>All types of natural environment</u>

- What is the value of Norwegian nature as a trademark for the Norwegian export industry? (WWF)
- What importance do shopping centres and settlement patterns have for sustainable development and nature values? (SABIMA)
- What are the costs to the Norwegian tourist industry of Norwegian policy regarding wild predators vis-à-vis the cost benefits of sheep farming? (WWF)
- How can one reveal the costs of numerous small encroachments on biodiversity? (Nature conservation organisations)
- How can one strike a balance between total costs and profits of a new industrial concern or a new road between different geographic areas or across generations? For example, what are the costs of the construction of flood precautions in the upper reaches of a watercourse for biodiver sity in the lower reaches? (Nature conservation organisations)
- Is it profitable for the nation's health to protect nature areas solely for the pleasures of outdoor recreation? (FRIFO)
- What impact does noise from motorised traffic in nature areas have upon enjoyment of outdoor recreation? (FRIFO, DN)
- What are the costs of not having restrictions on the introduction of alien organisms to Norway versus the costs of having such restrictions? (DN)
- To what extent are the chances of enforcing public rights of access reduced in the light of various scenarios for the construction of holiday cottages in mountain areas or along the coast? (FRIFO, DN)
- What importance for children's health and well-being has the provision of recreational areas by local municipalities? (DN)
- What are the effects of the fragmentation and reduction of coherent nature areas on biodiversity and outdoor recreation? (DN)

<u>The cultural landscape</u>

- How does the reorganisation of farmland influence future food security in Norway? (Ministry of Agriculture)
- Rural Norway is changing in structure; how does this influence Norway as a tourist-marketing trademark (ie. "Norway as medicine for Europeans")? (tourist industry)

<u>Forests/ the cultural landscape</u>

- How will ownership structure in Norwegian forests influence logging in the future? (Norskog)
- How will major investment in industry in nature areas or rural areas profit from rich biodiversity? (Norskog?)
- How will a large-scale changeover to bioenergy influence biodiversity in Norway? (Norskog)
- How do forests and the use of forest products influence the net release of greenhouse gases? (Norwegian Association of Forest Owners)
- Changing consumption: How is the climate influenced when consumption turns from renew able resources (forest) to the increased use of non-renewable energy resources and energy-demanding materials, such as steel, oil and aluminium? (Norwegian Association of Forest Owners)
- Regarding current forestry – how will the forest develop as a basis for biodiversity over time? (Norwegian Association of Forest Owners)
- What effects do different forms of forest man agement have on ecosystem services? (DN)
- What importance do forests have for water resources? (Nature conservation organisations)

<u>Freshwater</u>

- Norway is based nearly 100% on hydro-electric power: what will happen should one opt for gas power? (The Norwegian Water Resources and Energy Directorate)
- What consequences have the conservation plan for watercourses had for Norwegian water man agement? (The Norwegian Water Resources and Energy Directorate)
- How great a loss for income from salmon fishing has been caused by *Gyrodactylus salaris* (intro duced parasitic species)? (DN)
- In 10 years time, what will be the value of fish from Norwegian aquaculture compared to the value of the wild fish used as fodder to produce the farmed fish? (WWF)

Mountains
- What importance has organised tourism for outdoor-life and biodiversity, and for tourism itself? (tourist industry)
- What is the effect of comprehensive rough grazing/ over-grazing by reindeer and sheep on biodiversity, and what constitutes sustainable grazing exploitation? (DN)

The coast
- Will numerous wind-power installations along the coast reduce the enjoyment value of travel ling on the express coastal steamer? (tourist industry)
- How will comprehensive investment in industrial development and increased value-creation in the coastal zone (notably aquaculture, hereun der new species) influence biodiversity, land use, outdoor pursuits and public rights of access? (DN)

The ocean
- How large will future income from fishing be in the northern part of the Norwegian Sea (off Lofoten) and in the Barents Sea, calculated on the basis of differing scenarios regarding the exploitation of oil and fish? (DN, Fisheries Directorate)

2.3 The economic value of goods and services from the natural environment

Sustainable development is defined as a development which satisfies the current generation's demands without compromising the ability of future generations to satisfy their requirements (Government white paper 58, 1996-1997).

The fulfilment of human requirements in the future is dependent on access to resources. The total economic value of all the resources which society can use for value-creation constitutes a national asset (see box 3). According to the long-term programme, the important components in Norway's national wealth consist of the values represented in human resources, real capital, net foreign claims, and natural and environmental resources.

The value of environmental and natural resources

Humans cannot survive without a sufficient basis in nature and a satisfactory environmental situation. We live directly by harvesting biological resources, and living standards are dependent upon, among other things, access to mineral resources and our ability to process them. The biological resources (i.e. plants and animals) are dependent upon proper environmental conditions for their survival. Plants, animals and humans all need sufficiently clean air, water and soil. Humans are part of the ecosystem, with the capability to influence the ecosystem, but in the worst instance also the capability to destroy it. This capability is possessed by no other species.

Box 3 Environmental resources and natural resources and the focus in the project

The Commission on Green Taxation drew the following distinction between environmental and natural resources: "It is possible to distinguish between *environmental resources* (or condition resources) and *natural resources* (or material/ harvesting resources).

Natural resources are those which can be extracted or harvested from nature, and consist of:
- Mineral resources which are non-renewable ie. elements, minerals, fossil fuels, stone, gravel and sand
- Biological resources, such as living animal and plant species, which are renewable under certain circumstances (often called conditional renewable resources)
- Influx resources, which are continuously renewed (also called permanent resources) i.e. solar energy, water circulation, wind and ocean currents

Environmental resources are condition resources, which require a certain minimum quality as a precondition for production, and where the quality of the resources (the condition) can influence both value-creation and living conditions. Environmental resources, which include air, water, soil and land area, are also conditionally renewable".

In the Norwegian assessment focus will particularly be placed on:

Biological resources which can be harvested – cf. goods and services in figure 2

Environmental resources – and particularly that part which deals with ecosystem services - cf. figure 2 and box 1

The influx resources and mineral resources which are defined above under Natural resources are not dealt with to any great extent in the Norwegian study.

The value of *natural resources* will in principal be reflected in market prices, at least in part. In the case of the the Norwegian study, this concerns the biological resources which can be harvested (cf. goods and services).

Nature provides humans with an array of *ecosystem services*, which in principal can be considered in the same way as other services generated in the ecosystem. For example, air and water have the characteristic that they can function as recipients of waste products from human activities, though within certain limits. If one exceeds these limits, the functions of air and water as elements important for life and growth will be diminished or destroyed. Pollution can therefore have a cost in the form of diminished biological production and reduced human health and well-being.

There is a basic imbalance in the way in which the economy works, in that most of these ecosystem services are "free" to their users. While the prices of manufactured goods and services in principle reflect levels of input of labour and capital, there is at the outset no market for, and no price on, nature's ecosystem services. Similarly, neither will the market prices on produced goods and services reflect the costs of production in the form of damage to the natural foundation or the condition of the environment (ecosystem services), unless measures are taken to make visible the costs which society inflicts through their use.

That the ecosystem as a whole has no market price does not mean that the condition of the environment (which is regulated by the ecosystem services) is without importance for the extent or quality of the goods and services which are sold in the market. The weakening of the condition of the environment can influence the conditions for production in different sectors. Air pollution can lead to faster destruction of buildings and capital equipment, and to deterioration in the workforce's health. Reductions in biodiversity can undermine the basis for effective food production and the development of new medicinal products. Reduced water quality can weaken the basis for the tourist industry.

Likewise, weakened ecosystem services can lead to the direct reduction in human well-being and welfare, over and beyond the effect on the production of traded goods. When a watercourse is developed for hydro-electric power, the production of electric power is increased and consequently creates a basis for increased material living standards. At the same time, the watercourse will diminish as a source for recreation and the enjoyment of nature. The value of the electricity will be expressed in the market price, but not so the costs caused by the loss of a natural area. Clean air and water are sources for well-being which are not given a value in the market place. For many people, the knowledge that vulnerable animal and plant species, and biological diversity in general, are being taken care of to the greatest possible extent, also forms a source of well-being and quality of life.

The full value of environmental resources should also reflect their *future* value, both for our own and future generations. Particularly when faced with alternatives which might and do create *irreversible* changes, an intrinsic value should be added by choosing a solution where irreversible damage is avoided and consequently choice alternatives are kept open for the future. The eradication of species or genetic variants, for example, cannot be reversed once it has occurred. This situation is the point of departure for the formulation of the "precautionary principle", which is central to environmental policy in Norway and other countries.

Biodiversity is defined by the Norwegian study as a basic condition for regulating functions (e.g. soil formation, pollination, cleansing), which is furthermore necessary for the production of goods and services (Chap. 2.1., boxes 1 and 2). This basic premise is difficult to measure in terms of economic value because it only indirectly affects commodity production. Nonetheless, the direct value of goods which are based on biological diversity can be measured. Major economic values and genetic information contribute to food and medicinal aid to an increasingly ageing population. For example, the cultivated ecosystems are dependent upon diversity at the levels of species and genes in order to provide stable secure food production. Biodiversity at the genetic level is also important for the maintenance of individuals' vitality in the short term, and the vitality of stocks in the long term. Species which contain significant genetic variation have a great potential for evolution and adaptation to new environmental conditions. The natural ecosystems contain a wide range of functions relating to, for example, the climate, hydrological and nutrient cycling, as well as the formation and protection of soil.

Biodiversity has economic value in that, among other things, it provides raw materials for the production of food, medicines, clothes, energy and housing. For example, the annual global market value for medicines developed from plants stands at more than NOK 350 billion. Today, humans exploit only a small proportion of the diversity in connection with agricultural production and the biotechnology industry, and we lack knowledge regarding those elements relating to biological diversity which will reveal themselves to be especially valuable.

Biodiversity can also be seen as a form of insurance for future survival. In keeping with this terminology, genes are the species' insurance, the species are the ecosystems' insurance, while the ecosystems are the planet's, and, consequently, humanity's insurance. This means that diversity of genes within a particular species ensures that it can adapt to future changes in the living environment, such as new pollutants. With a diversity of species, ecosystem services may be maintained even if the external conditions for life change (see box 1). For example, variation of soil organisms will ensure that nutrient cycling in the soil will continue even if the climate gets warmer. With diversity of ecosystems, the biosphere will have greater resistance to changes in the physical and chemical environments. This means, furthermore, that humans will also have a greater chance of survival in the future, precisely because ecosystems will survive. We cannot predict which genes, species or ecosystems are necessary for adaptation to new life conditions. Consequently, variation in genes, species and ecosystems is necessary to ensure that species, ecosystems, the biosphere and humanity can survive in the future.

The challenge is to make the value of ecosystem services visible

The demonstration of ecosystem service values (see box 2, chap. 2.1) is important to ensure that this knowledge is integrated in cross-sector management.

This is nevertheless a challenging process in a socio-economic perspective since values have no market price. However, ecological functions are economic functions because humans benefit directly or indirectly from the service. We need methods for revealing these economic values, and methodology has been developing during the past decades. However, the methods are generally still not good enough to capture the entire value of the services. The results can nonetheless provide indications, and it will be important to clarify the economic values associated with ecosystem services where this can influence trade-offs relating to factor inputs. One way of placing a value on services is to ask what the consequences will be if the ecosystem services do not function (or if there is a significant loss of ecosystem functions). Some examples of ways in which ecosystem services can be evaluated are given below:

- Analyse the effects of environmental deteriora tion on the workings of the national economy.
- Analyses of production processes – which factor inputs are used and how are they changing?.
- The costs of mitigating measures (e.g. removal of pollution to protect human health) or factor inputs to increase production (artificial fertilisers, machines, fuel). These resources (workforce and investments) could have been used for alternative activities associated with value-creation.
- Costs connected with restoring ecosystems ("replacement cost").
- Analyses of the potential for future non-destructive exploitation of biodiversity (biotechnology and medicines).

2.4 Proposals for the content, organisation, costs and progress of a full-scale study

Norwegian policy background

The government white paper entitled “Biodiversity. Sector responsibility and co-ordination” (no. 42, 2000-2001) is a cross-sector report in which 14 ministries have prepared plans for the protection and use of biodiversity. Under the collective initiatives in the report (chapter 17) it is stated: “It should be considered whether Norway should conduct a national millennium assessment. It should also be discussed what such a possible assessment will embrace”. The Millenium Ecosystem Assessment prepares the way for an environmental analysis which in many ways is a pioneering work. Through a comprehensive process conducted in 2001, the global MA project prepared a methodology for carrying out the project. Norway has taken part in this work, and the models, conceptual apparatus and methods are, with small modifications, well suited to a Norwegian assessment. It is important to note that sector-related considerations are so well integrated into the analyses that the project cannot be conducted without full sector participation. A full-scale project will provide support for future work aimed at getting all sectors to include environmental considerations in their activities, i.e. by contributing to a shared understanding of concepts and agreed models and analytical methods.

The Millennium Assessment is anchored in the Convention on Biological Diversity, the Convention to Combat Desertification and the Ramsar Convention on Wetlands. A full-scale study will consequently serve to support Norway’s work in following up the recommendations of these Conventions.

A full-scale Norwegian assessment will furthermore support work for the International Year of the Mountains (FAO) and Ecotourism (UNEP) in 2002, as well as the Ocean Environment report. This requires, however, that the main themes are chosen with this in mind (see under “content” below). The Norwegian Tourist Board is currently marketing Norway as a “brand” internationally under the slogan “Norway as medicine for Europeans”, where natural and cultural values are central. How this “medicine” can be maintained over time is a theme which can be included in the Norwegian full-scale study.

Content

The aim of the Norwegian full-scale study is to prepare the ground for Norwegian political decision-makers with a view to the comprehensive and sustainable management of the natural environment. Politicians and those employed in nature management have to make daily decisions in which they balance conflicting interests in society. The full-scale project will contribute to a more holistic and less “bit-for-bit” management of Norwegian ecosystems and their services.

Through the work undertaken in connection with the global project, it has become clear that three themes will be included in all projects connected with the Millennium Assessment process:

- trends and current conditions
- scenarios
- response options

All three themes will shed light on important goods and ecosystem services, and balances between their uses. For example, what is the current condition of the cod stocks and their development viewed in relation to the extraction of oil in the North Sea and Barents Sea, an economically profitable process which can cause pollution and damage the fish stocks? What are the scenarios for these two “goods” in the future, and what initiatives can be taken to achieve sustainable management so that we can achieve desired yields of both goods over time? If possible, the long-term value of these goods should be described.

With a background in themes raised in meetings with different interest groups (Chap. 2.2), the Norwegian policies described above (Chap. 2.4), and the case study of the Glomma river basin (Chap. 4), a number of relevant themes for the full-scale study are suggested below. The proposals are intended to form a source of ideas for a steering group which will decide the focus of the full-scale study. The themes are so-called “trade-offs”, or compromises, between different interests in society, and they are pushed to extremes in order to make the approaches to the problems explicit. By making scenarios for future development, one can clarify the ways in which these diverse activities can co-exist, i.e. a holistic, or comprehensive, ecosystem management.

- **Polluted oceans or commercial fishing?** What are the future costs and benefits associated with fishing contra oil extraction in the northern part of the Norwegian Sea (off Lofoten) and in the Barents Sea? (relevant for the white paper on Marine Environment in 2002)

- **Intensification of agriculture or the tourist industry's marketing of Norway as "medicine for Europeans"?** What importance has the decline of traditional rural communities in Norway for the tourist industry's future income ? (the tourist industry's investment in "brand Norway", possible ecotourism – UNEP)
- **Development of infrastructure or wilderness areas?** How can a balance be achieved between the need for further infrastructure and the conservation of the last remaining areas of wilderness? (the Year of the Mountains, FAO)
- **Outdoor recreation or unrestricted development?** What is the significance of local and national governmental regulations for protecting the interests of outdoor recreation, and what are the health-related benefits of such regulations measured in monetary terms?
- **Ecotourism in forest areas and biodiversity.** How will major investment in nature-based tourism benefit from rich biological diversity? (ecotourism – UNEP)
- **Nature values or shopping centres?** How will the existence of important natural areas be influenced by centralisation, increased mobility and consumption?
- **The use of coast and ocean.** What are the long-term costs and benefits of different forms of management in fisheries and aquaculture. How do different forms of management in fisheries and aquaculture influence nature values?

Data sources

Data for the full-scale study will be obtained from on-going research projects, monitoring programs, mapping authorities, national statistics, and the global Millennium Assessment project. This is briefly described below.

A win-win situation. Co-ordination with on-going and completed projects.
A number of research and monitoring projects of relevance to a full-scale study are being conducted in Norway. The full-scale study must build on such projects, and an exchange of methods and results between the full-scale project and the research and monitoring projects is necessary. This will strengthen both the full-scale study and individual projects. The individual projects can thus also become part of a comprehensive evaluation of the use of the natural environment, and consequently gain greater importance for prospective political decisions. The development of scenarios for possible responses through this process will also add an extra dimension over and above that which each project will provide individually.

Among major issues or activities of special relevance for the full-scale project are the development of the Norwegian Government's Ocean Report and the implementation of the European Union's Water Directive. Both these documents have as their main targets the comprehensive and sustainable management of nature values and natural resources. The activities related to both documents can contribute knowledge and analyses to the full-scale study. Conversely, both the work connected with following up the Ocean Report and the implementation of the EU Water Directive will benefit from analyses and scenarios developed in connection with the full-scale project.

In addition, a number of completed and on-going research projects, some funded by the Norwegian Research Council, could contribute knowledge to the full-scale study . The relevance of individual projects depends on the main themes chosen in the full-scale study. It is nonetheless necessary to have expertise within the areas of the natural and social sciences in order to describe both current condition and development, develop scenarios and to propose effective responses. Where possible, economic analyses should also be incorporated at all levels of the study. The use of methods for the valuation of nature values and ecosystem services can contribute towards shedding light on the consequences of different scenarios regarding trade-offs. Examples of projects concerning valuation are "Valuation of recreation areas", a European project under the Water Directive, and "Valuation of environmental damage, economic quantification of the usefulness of reducing air pollution".

The development of an agreed system for registering impacts/proximate drivers on ecosystems has taken place in connection with two European projects: the further development of Mirabel and a project under the EU's Water Directive. The Norwegian full-scale study should utilise the same concepts/frameworks relating to impacts as these two projects in order to compare the results of a given impact across national boundaries. With regard to changes in land-use, which is an important pressure incorporated in Mirabel, a precondition is that an international classification system for surface cover be used.

The results from long-term statistics, monitoring and mapping of natural resources and biodiversity will be important for the description of condition and developmental trends. The data from mapping and monitoring programmes must be adapted to the correct data format before they can be used directly in connection with this project. In addition, the surface cover project and satellite monitoring will contribute to the development of scenarios for changes in land use. Linkage with the global Millennium Assessment project provides free access to new satellite data.

Relationship to new research projects
The aim of establishing a comprehensive management of Norwegian ecosystems (including man-made systems) will never be fully achieved, and will therefore demand continuous effort. Newly initiated research on values connected with nature and environmental resources, and the sustainable exploitation of the natural environment in different sectors, will in this instance contribute new knowledge. However, research is by its very nature long term. Given the four-year perspective for a full-scale project, it is obvious that relatively few results from newly initiated research will be incorporated in the final report. New research programmes focusing on sustainable use of the natural environment will probably be initiated (cf. Open Research Forum, White Paper 42, 2000-2001). It may be feasible to present new results from this research in annual reports subsequent to the presentation of the full-scale study report in 2005.

Contributions from the global project
The global project will provide free access to NASA satellite image files (1990 and 2000), as well as some fully analysed satellite images. The images can be used free of charge in the Norwegian study. In addition, the global study contributes methodology (Appendix 1), and a system for peer-review and transparency (see Chap. 2.1). The Norwegian full-scale study will submit reports to the global project according to closely defined report outlines.

Organisation, progress and costs
Cross-sectoral steering and co-operation are preconditions for a successful full-scale study. Collaboration between professional institutions and research groups in natural sciences, economics, and social sciences is necessary to identify developmental trends, scenarios and effective response options.

Collaboration with the Nordic countries and with southern Africa
Nordic collaboration funded by the Nordic Council of Ministers will strengthen the proposal below (see Chap. 2.1). All Nordic countries may be in a position to start working on the preparation of data in 2002.

The "twinning project" with southern Africa which is funded by the Norwegian Ministry of Foreign Affairs (Chap. 2.1) will include exchange of knowledge and expertise between the Norwegian full-scale project and the sub-regional project in southern Africa. In the eventuality of the Norwegian full-scale project not being funded, collaboration with southern Africa must be reconsidered and resolved in another way.

Organisation of the Norwegian project
Steering committee: The Ministry of the Environment has appointed an interdepartmental committee to follow up the collective initiatives set out in the White Paper on Biological Diversity, Co-ordination and Sector Responsibility (Chapter 17). The committee's task is to secure good co-ordination between the white paper's collective initiatives: legal work, economic means, information and research, the species database, mapping, and monitoring. It is therefore natural that this committee should function as the steering group for the full-scale project, or alternatively that they in turn appoint a steering group composed of representatives from relevant departments, non-governmental organisations and highly qualified researchers. This should ensure good co-ordination and a mutual exchange of information between the different areas connected with responding to the white paper and the full-scale study. The results of the legal work, and an examination of economic means will be of importance for the proposal of specific initiatives in response to the scenarios. Work connected with the full-scale study will also provide suggestions as to whether or not the monitoring programmes gather the correct kind of data for use in comprehensive management.

In the early spring of 2002 the steering group should decide on the main themes that are to be examined. This is necessary in order to prepare the dataset for analyses which can commence early in 2003. Proposals for the main themes in Chap. 2.4 and Chap. 2.2 are meant to be a source of ideas for the steering group. An outline of the main themes/ subprojects should be developed. A working group will conduct the practical work connected with the project. It is proposed that this consist of a project leader and 4-6 members. The working group members should be in charge of the subprojects on the main themes, including current condition, developmental trends and scenarios. In addition, a separate subproject concerning response options should be established. This should deal with proposals for initiatives to be taken in connection with all the main themes. The leader of the working group should not be a leader of a subproject. The leaders of the subprojects should represent different sectors, or have different professional backgrounds. The person who leads the twinning project with southern Africa should also be a member of the working group.

As soon as the steering committee has selected the themes for the full-scale study, the working group should begin identifying data sets and preparing them for analyses. This work should take place during 2002. During this year, the working group should also identify relevant research projects which can support the chosen main themes. Reporting to the international study should begin already during the autumn of 2003 – this can comprise interim experiences and results.

Progress and costs

The project's costs are presented below. If the project is to be carried out in a satisfactory manner, it is necessary to concentrate on a restricted number of main themes (3 to 4). Possible major media initiatives, such as a TV programme, for example, will require extra funding.

End products

Annual reports/ bulletins presenting the results should be produced in order to build up an interest in society for comprehensive management of the natural environment. The working group will evaluate which items will be produced. Custom-made reports for different user-groups, TV programmes and media reports should be considered. Reporting to the international study will take place during the autumn of 2003/ spring 2004. The entire project does not have to be completed before reporting takes place. Experiences from the project are included in the report to the global project, as well as some results.

Table 3 Progress and costs for a Norwegian full-scale study (in NOK 1000).
x: activity which will be carried out this year.

Activity	**2002**	**2003**	**2004**	**2005**
Choice of main themes (3-4) for the subprojects	x			
Working group established	x			
Identify relevant knowledge, prepare data for				
analyses in subprojects	x	600		
Work with developmental trends, nature condition,				
scenarios for 3-4 subprojects		x 2500	x 2000	x200
Work with proposals for possible initiatives		x 400	x 900	x 700
International reporting		x 300	x 300	x
Running of secretariat	x 100	x 100	x 100	x 100
Sum excl. VAT	700	3000	3000	1300
Total sum incl. VAT; c. NOK 9.9 million	**806**	**3720**	**3720**	**1600**

3 Norway's natural environment: a description of its condition, values and services

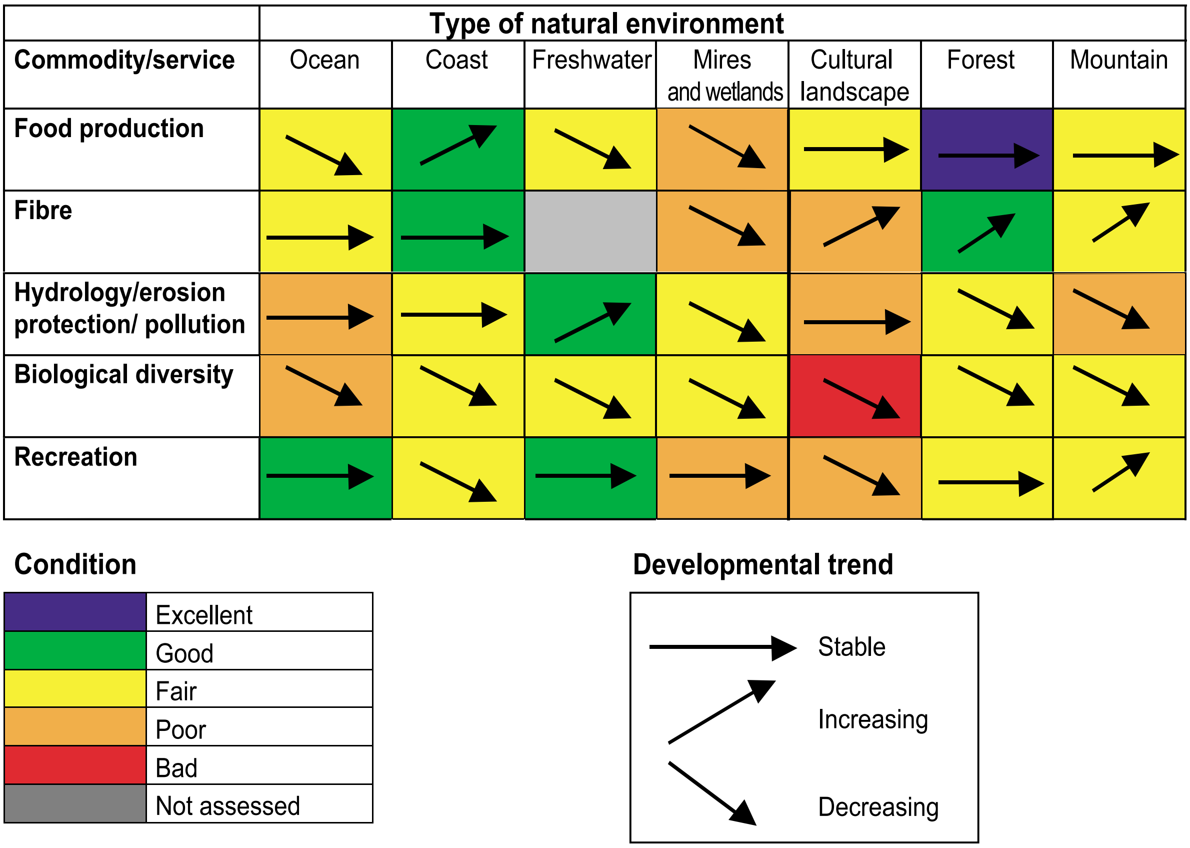


Fig. 3.1

Graphic summary of the assessments presented in the following text. The colour codes for condition and the arrows for developmental trends are intended to summarise the main content of the text. The evaluation of condition is conducted in relation to the situation as it was up to 100 years ago, depending on the availability of information of the situation as it was in the past. It is considered impossible to establish the "pristine state" for Norway's natural environment types. This also means that the individual types of natural environment are evaluated independently, i.e. the classification does not indicate the condition of the various natural environment types in relation to each other. This evaluation does not compare the status of Norwegian nature with that of other countries.

3.1 The Ocean

Main features of development

- Norway's ocean areas together comprise 2.2 million km^2, or c. 7 times greater than the land area. The ocean areas cover large tracts of the Skagerrak, North Sea, Norwegian Sea, Barents Sea and the ocean around Svalbard.
- Norway has a long coastline, and marine resources are important for Norwegian settlement, infrastructure and economy. At the end of 2000 there were c. 20,240 registered fishermen in Norway, 71% of whom had fishing as their chief occupation.
- In the year 2000, fishing, hunting and fish farming contributed NOK 9.9 billion to the GNP (i.e. 0.7%). The fishing industry's proportion of national employment was 0.8%.
- Commercial fishing and hunting of 80 species takes place off the Norwegian coast e.g. fish, minke whale and shellfish. In addition to more traditional food products which are harvested in the sea, chitin, fish for fishmeal and feed for fish farming and farm livestock can be mentioned, as well as sealskins and raw materials for the medicinal and cosmetic industries.
- The extraction of oil and gas also take place in the ocean, and is of great importance to the Norwegian economy. The export value from Norwegian oil and gas installations has increased during recent years and in 2000 stood at 46% of total export income (23% of GNP). Significant areas on the continental shelf are occupied by oil and gas installations.
- The ocean is also a tourist area (e.g. whale safaris), and the ocean provides areas for transport in the form of shipping lanes.
- The ocean contains feeding areas for a wide variety of animals, including those that are harvested.
- The ocean outside Norway harbours a rich biodiversity, including deepwater coral reefs.
- The ocean acts as a CO_2 reservoir. The ocean currents are important for the movement of animal larvae and other plankton as well as for climatic conditions (the Gulf Stream).

Social driving forces

- Population growth
- Increased demand for raw materials, food and products
- Increased interest in expanded petroleum prospecting
- Increased tourism
- Increased consumption and trade leading to increased ocean transport
- Insufficient knowledge about ecosystems
- Subsidies and quota policies

Environmental pressures

- Global climate change, ocean temperatures and ocean climate
- Over-fishing/over-harvesting
- By-catches
- Pollution (e.g. radioactive emissions, oil spillages)
- Introduction of exotic species (e.g. Japanese drifting kelp, *Sargassum muticum*)
- Disturbance caused by human activity (e.g. oil drilling, fisheries)
- Boat traffic
- Fragmentation and destruction of biotopes, e.g. coral reefs

THE OCEAN		
Commodity/ service	**Current condition and developmental trends**	**Data quality**
Food production	•Stocks of capelin have remained at a low level for many years following the collapse of 1986/87, but have increased significantly over the past few years. During 2000 the total catch of capelin reached c 370,000 tonnes, in contrast to 160,000 tonnes in 1997. A small reduction in the capelin stocks from 2000 levels has been observed in the Barents Sea during 2001, and few spawn have been found. •The herring stocks in the Barents Sea/Norwegian Sea were reduced during the 1960's, but have developed positively since then, and are at present strong. The stocks of North-Sea herring increased steadily from 1980 to 1990, but decreased from 1990 to 1996 due to over-fishing. There has been a certain increase in the stocks towards 2000. In 2000 the total catch of herring stood at 800,000 tonnes, which is less than in 1997 (c. 920,000 tonnes), but the stocks are still good. • The stocks of Norwegian-Arctic cod lay at a low level throughout the 1980's, but increased towards the beginning of the 1990's. Since 1993 the stocks have been in continuous decline. From 1991 to 1997 the cod quotas were exceeded by 10%, and from 1998 to 2001 by 54%. The spawning stock was below secure biological limits in 1998, and has continued to fall. In 2000 the catch of cod comprised 220,000 tonnes, in contrast to 400,000 tonnes in 1997. The increase in the capelin stock is positive for the cod stock. • Haddock stocks are harvested beyond secure biological limits. The 1999 year class is strong and can carry the stock in the short-term, but it is presently the only year above average. ICES recommends a quota for next year equivalent to fishing only for human consumption, i.e. lower than 94,000 tonnes. • The saithe stocks in the North Sea are within biological limits. ICES recommends a catch of less than 135,000 tonnes of saithe in the North Sea for 2002. • Mackerel in the north-eastern Atlantic: the total stock lies below biological limits.	• The major fish stocks are monitored annually. However, it has been difficult obtain good estimates for the fish stocks, and the quality of the data has been open to discussion. Annual quotas are allocated on the basis of the estimates, and catches are reported annually. However, unreported over-fishing occurs, which makes the data quality poor. • In the case of saithe a lack of information regarding young year classes entering the catches makes the basis for projection of the stock uncertain. • In the case of mackerel from the north-east Atlantic, the stock levels and stock projections are made even more uncertain because three years have elapsed since the spawning stock was last estimated. • Catches of marine seal species are reported, and the quality of the data is good. However, there is uncertainty regarding the status and development of the marine seals (harp and hooded), partly because estimates are based on old mark-recapture experiments, and partly because they are uncorrected minimum estimates. • The harvesting statistics for Iceland scallop provide a good indication of the status of the stock. • Annual counts are carried out in sub-areas for minke whale, so that in the course of a six-year period the entire Norwegian distribution area for the whales will be covered. A new stock estimate will be presented in 2002.

Food production	ICES recommends a catch of no more than 694,000 tonnes in 2002. • Iceland scallop is harvested close to the coast, and the quota lay at 250 tonnes for the 2000/2001 season. The harvest rate has been constant since 1997, indicating a stable stock. The areas around Jan Mayen are closed to Iceland-scallop harvesting, and observations made around Svalbard indicate a reduction in catches. • Norwegian sealing is based principally on the harp seal (Eastern Ice) and the hooded seal (Western Ice). The catches of seal have remained at a low level since the 1980's after a dramatic decrease since the 1950's and 1960's. The yield is presently at between 10,000 and 40,000 animals per season (in 2000: 1,871 hooded seals and 12,321 harp seals), and appears to have stabilised at this level. The catch value for the 1980's was annually between NOK 10 and 40 million, but in 2000 lay at c. NOK 2.7 million. • Commercial exploitation of whales is limited to the minke whale, which is caught in the central and north-eastern Atlantic. Whaling has continued since 1993, after being stopped in 1987. The quotas have increased from 226 animals in 1993 to 549 animals in 2001, also including the Jan Mayen zone. The most recent stock estimate is from 1995, with 112,000 animals in the north-eastern stock, and 12,000 animals in the Jan Mayen stock. The stocks appear to be increasing, but there is great international pressure against increasing the quotas. It is therefore uncertain whether the exploitation of this resource will increase.	
Fibre	• There are major stocks of seal which yield sealskin (particularly harp seal and hooded seal) in our northern ocean area. The stocks have been increasing, but it is uncertain whether the exploitation of this resource will increase.	• Stock estimates and catch reports are carried out for the marine seal species, and the data quality is good. The yield of sealskins is reported. However, there is uncertainty regarding the status and development of the stocks, partly because estimates are based on old mark-recapture experiments, and partly because they are uncorrected minimum estimates.

Hydrology/ erosion protec-tion/ pollution	• Oil production brings with it both uncontrolled (acute) emissions and permitted operational emissions. The latter dominate and these have increased significantly since 1992 in step with oil production. Acute emis-sions have in general decreased during recent years. • Radioactive particles are transported into our ocean areas, right up to the Arctic. The two most important sources have been fallout from the nuclear test explosions during the 1950's and 60's, and emissions from reprocessing plants in Europe. The relatively high amounts of radioactivi-ty in organisms at that time declined towards the 1970's. Since then, a number of accidents and emissions have introduced radioactivity to our waters. Sellafield on the Irish Sea is today the single largest contributor of radioactivity to Norwegian waters. Emissions have been reduced, but the radioactive materials remain in the ecosystem for a long period of time. • Many organic pollutants are intro-duced by atmospheric long-distance transport, ocean currents and rivers. Organic pollutants are often stable compounds which accumulate in organisms. Investigations show that, compared with other waters, fish in Norwegian waters are of good quality with low pollution levels.	• Monitoring is taking place around petroleum installations in order to docu-ment emissions and biological impact. Monitoring of radioactivity and environmen-tal pollutants is also taking place in our ocean area. Research is done on the impact of a number of pollution types along the Norwegian coast and in our Arctic areas. • The quality of the monitoring data on radioactivity and organic pollutants is good for our marine areas.
Biological diversity	• Our ocean areas cover a large geo-graphical gradient with great varia-tions in depth, currents, salt content and temperature. This provides for a number of ecosystems. Over-fishing, pollution and different activities may negatively influence biodiversity.	The pelagic systems are investigated as areas for the growth and nourishment of our major fish stocks. Animal life on the shelf is researched in connection with petroleum-related activities. There is other-wise little data available relating to biodi-versity in the ocean. Our knowledge about the impact of over-fishing, pollution and various activities on biodiversity is insuffi-cient. •
Recreation	• Compared with the coast, the ocean's importance for recreation is very limited. This is not an area which is undergoing any particular change.	

Sources: Havets ressurser 2001. Havforskningsinstituttets statusrapport for 2001.Naturressurser og miljø 2001, Statistisk sentralbyrå. St. meld. nr. 24 (2000-2001). Regjeringens miljøvernpolitikk og rikets miljøtilstand .

3.2 THE COAST

Main features of development

- The Norwegian coastline is some 25,000 km long, equivalent to half the length of the equator. If one includes all the islands, the coastline's length reaches c. 67, 000 km. Over 2/3 of the population lives along the coast, and 280 of the country's municipalities are bounded by salt water.
- The coastal zone has rich resources of fundamental importance for future industrial development and settlement along the coast. The coast has historically been important, and many archaeological and historical sites and monuments are to be found here.
- During the last 15-20 years aquaculture has grown into one of our most important industries. Aquaculture's production volume has grown from a modest 8,000 tonnes in 1980 to c. 500,000 tonnes today, equivalent to 1/5 of the Norwegian fisheries yield. Fish products formed 15% of Norway's traditional commodity exports in 2000.
- The coast has great diversity of types of natural environment and species. Production of farmed fish and shellfish takes place along the coast, and molluscs, sea urchins, shellfish, seals, seabirds and fish are harvested. Other products include sealskins, knotted wrack, kelp, sand, gravel, shell-sand, as well as raw materials for the medicinal and cosmetics industries. The coast is also an important breeding ground for marine fish stocks.
- Over recent years there has been an increase in the production of energy from wind power. In future, wave power may also become an energy source.
- The coast is increasingly being used in connection with tourism (e.g. ecotourism), outdoor life and recreation (e.g. fishing, boating, swimming and hunting).
- Along the coast one can find areas and grazing resources for harvested species, areas for fish-farming, areas for wild animals and plants which are harvested, as well as for other species which form part of the biodiversity, areas for infrastructure, including industry, harbours, shipping lanes, military activity, harbour construction, settlement, and areas for recreation, tourism and touring.
- In Norway as a whole, 22% of the coastline lies less than 100 m from the nearest building. Between 1985 and 2000 new construction or renovation of buildings took place along 1.2% of the coastline. The increase is greatest in the southernmost counties.
- 2% of the land area is protected under the Nature Conservation Act. The national target is to protect about 15% of the total area within the base-line (including sea and land).
- The coast contributes towards reduction of pollution, and acts as a CO_2 reservoir. Coastal currents are important for the existence of larvae and other plankton, as well as for the climate.

Social driving forces

- Population growth
- Increased demand for raw materials, food and products
- Increased tourism
- Increased consumption and trade leading to increased transport along the coast
- Urbanisation
- Insufficient knowledge about ecosystems
- Subsidies and quota policies

Environmental pressures

- Global climate change, ocean temperatures and ocean climate
- Over-fishing/over-harvesting
- Fish farming (escape, fish diseases)
- The over-grazing of seaweed and kelp over significant areas due to high densities of sea urchins
- Kelp trawling
- The spread of parasites via fish farms
- Pollution (e.g. radioactive emissions, oil spillages, heavy metals, organic pollutants)
- Eutrophication (e.g. through over-fertilisation)
- Introduction of exotic species (e.g. American lobster and King crab)
- The increase in introduced/exotic species (e.g. Chattonella)
- Disturbance caused by human activity (e.g. outdoor activities)
- Boat traffic
- Fragmentation and destruction of biotopes (e.g. sea meadows and river deltas), directly through building development and activity, or indirectly through neighbouring activity

THE COAST

Commodity/ service	Current condition and developmental trends	Data quality
Food production	• The large increase in volume within aquaculture has taken place over the past 20 years and total production is at present nearly 0.5 million tonnes, or almost 1/5 of the Norwegian fisheries yield. Prognoses point towards continued annual growth of around 10-15%. An optimistic scenario suggests that the production value can reach NOK 150 million in 2020 i.e. 20% of Norway's total value creation. This production will take place in areas near the coast and will include a number of species. • Salmon farming is the dominant aquaculture in Norway. Production has increased strongly since the 1970's, and in 2000 it stood at 420,000 tonnes. Production of sea trout reached 50,000 tonnes. Questions have been raised regarding the availability of sufficient fodder if there is an increase in fish farming. This is a challenge which must be addressed before growth in value creation within aquaculture can be realised. • The mollusc-farming industry (notably mussels, but also scallops and oysters) is expanding. This industry is still small, but it is thought that the potential is great. Production of mussels stands at 3-400 tonnes per year. It has been suggested that production will reach 200,000 tonnes in 2020. Sea urchins are also of interest in this connection, but at present only in modest terms. • Lobster is caught along the Norwegian coast, but catches are low. The stock is weak, and this situation will persist if strong conservation measures are not introduced. • Norway lobster catches have increased during the last decade, chiefly in the Skagerrak. There are relatively few Norwegian waters with suitable conditions for Norway lobster, and the potential for increase in this industry is relatively small.	• Estimates of future potential in aquaculture are somewhat uncertain, and information about the impact of factors such as fodder limitations and pollution is insufficient. There are little or no data regarding food production and the extraction of goods over and beyond commercial fishing. • We know little about the number of farmed salmon which escape from farms and the effect this has on wild stocks. • There has been variable success in the farming of molluscs and sea urchins. We have insufficient information regarding factors which are important for optimal growth and factors which influence mortality. • Catch statistics for lobster are regarded as very unreliable. Both the size of the population and catches of crabs are unknown. We know little about the population size of the Norway lobster. • The population of coastal seals is monitored and counted regularly and minimum estimates are available. The data quality is now good, following a significant improvement of the counting method.

Food production	• Two seal species are hunted along the coast: the grey seal and common seal. The common seal population stands at 7,666, that of the grey seal at 4,413 animals. Both populations are increasing. The hunting quotas are set for each county for the common seal, and regionally for the grey seal.	
Fibre	• Goods: e.g. knotted wrack, kelp. The kelp forests are harvested commercially in Norway, and the alginate is exported. Norway has the world's largest alginate industry, with an annual production of 6,000 tonnes based on the harvesting of 160,000 tonnes of kelp. The total amount of harvested kelp has shown an increase since the 1970's, but has levelled out in recent years. An average of 20,000 tonnes of knotted wrack has been harvested over the past five years. The knotted-wrack forests are trawled every five years, with the exception of areas which are protected for seabirds. Some of the seaweed forest areas have been depleted by over-grazing by sea urchins. This means that even if there is a potential for an increase in the extraction of seaweed in outlying northern areas, this potential is limited. • Two seal species are hunted along the coast for their skins, namely the grey and common seals. Both populations are growing.	• Statistics for the extraction of kelp and other seaweed are available. However, our knowledge of the areas covered in kelp and other commercial sea weed is insufficient, and our information regarding the areas affected by over-grazing by sea urchins is poor. • The seal yield is reported and information on seal skins is available.
Hydrology/ erosion protection/ pollution	• Compared to more central parts of Europe, the Norwegian coastal zone has a major advantage due to its good water quality and the relatively small impact of various forms of human activity. • From 1985 to 1989 the man-made emissions of nitrogen and phosphorus along the Norwegian coast have been reduced by 8% and 41% respectively. The major reduction in phosphorus is principally the result of more efficient cleansing of waste water from industry and households. It is also partly due to altered farming methods. It has been difficult to reduce nitrogen discharges. In 1999, aquaculture was responsible for 66% of phosphorus discharges and 33% of nitrogen discharges in the Norwegian ocean area as a whole. • The health situation for farmed salmon has been improved significantly, and the use of antibiotics in Norwegian fish farming has been reduced considerably. The use of antibacterial agents reached its peak in 1987 (49 tonnes), while consumption in 2000 was 685 kilograms.	• There are good statistics for discharges of phosphorus and nitrogen along the Norwegian coast. Monitoring of environmental pollutants and radioactivity are carried out regularly, often in compliance with international agreements.

Biological diversity	• Our long and complex coastline has a high degree of diversity in types of natural environment and species. The rich primary production found along the coast forms the basis for a rich faunal life (e.g. much animal plankton, rich fish stocks and a rich bird life). In addition, large stocks of fish migrate from the ocean to the coast to spawn. • However, the rich biodiversity along the coast is affected by human activity in the form of boating, discharges, the presence of fish farms, etc. The strong growth of fish farming and harvesting along the coast, as well as the increasing use of the coast for recreation, outdoor pursuits and tourism, probably have a negative impact on biodiversity.	• There is scarce information about biodiversity in marine areas, including the coastal areas. Local and regional mapping demonstrates what can be found within diverse habitats, but great complexity of habitats, together with a coastline which includes a number of biogeographical regions, implies that information relating to biodiversity relates to a large area. In the case of many habitats, only dominant species are known. It is probable that our concentration on the research of marine fish resources is a reason why our knowledge of biodiversity in systems near the coast is poor compared with other European countries.
Recreation	• Tourism along our coast is an important investment area, and each summer over 90,000 tourists come to Norway expressly to fish. More than 350,000 pleasure boats are located along the coast. This industry is regarded as being on the increase. • It is thought that increased recreational fishing can lead to a reduction in coastal stocks of many species of fish and shellfish.	• Information about all publicly approved building activity is registered. The problem with this information is that it is inadequate, since it does not include illegal extensions or extensions which do not require official approval (e.g. flag staffs, patios). In some areas it is particularly this type of activity which has increased in the coastal zone. • The impact of fishing tourism on local fish stocks is unknown.

Sources: Havets ressurser 2001. Havforskningsinstituttets statusrapport for 2001. Naturressurser og miljø 2001, Statistisk sentralbyrå. St. meld. nr. 24 (2000-2001). Regjeringens miljøvernpolitikk og rikets miljøtilstand .

3.3 FRESHWATER

Main features of development

- Norway has over 400 watercourses with a collective freshwater area of 17,505 km^2, i.e. 5.4% of the total land area. The watercourses have many user groups and are vulnerable to a range of encroachments and impacts. Historically, the encroachments and impacts have changed over time in step with the predominating user interests (e.g. timber floating, hydro-electric power production, flood precautions).
- Hydro-electric development has had a major effect on the freshwater ecosystems in Norway. The largest developments took place between 1970 and 1985, while expansion during the 1990's has been low.
- There are currently 857 hydro-electric power plants on Norwegian watercourses. These production plants have an installed effect of 27,470 MW and annually produce c. 130 TWh. This constitutes over 99% of Norway's total energy consumption. At 1st January 2000, the total of economically viable hydro-electric resources in Norway stood at 180.2 TWh, of which 35.3 TWh is permanently protected. Seven of Norway's ten highest waterfalls are today exploited for hydro-electric power.
- The theoretically available volume of freshwater in Norway is 112,500 m^3 per person per year. This is more than 100 times higher than in the Netherlands, for example. Water consumption in Norway is currently 500 litres per person per day. This is c. 10 times higher than personal consumption in India, for example, but a little lower than in the USA (630 litres per person per day). 90% of the population connected to the public water system is supplied from surface water sources, while 10% is supplied from groundwater sources.
- There are almost 2,800 known animal species in Norwegian freshwater. In comparison, c. 14,500 known freshwater species are to be found in Europe as a whole.
- The number of known plant species in Norwegian freshwater stands at c. 2,150 (c. 2000 algae species, 100 vascular plants – not including helophytes, 20 charophytes, 50 mosses).
- 258 freshwater animal species are registered in the national list of threatened species in Norway. Also included are 82 freshwater plant species (charophytes, mosses and higher plants).
- Pollution in the form of nutrient salts and organic matter from agriculture, industry and settlement led to the significant pollution of Norwegian freshwater sources during the 1970's and 80's. Sewage disposal reorganisation and initiatives taken within agriculture have reduced the total impact of nutrient salts and organic matter, but the impact is still too high in many watercourses, particularly in low-lying parts of Østlandet, Rogaland and Trøndelag.
- Long-range pollution (sulphur, nitrogen, etc.) led to increased acidification of lakes and rivers, especially in Sørlandet, during the 1960's and 70's. After 1980, the levels of European sulphur emissions have been significantly reduced. In Eastern Europe, emission reduction is primarily the result of economic depression, the decline of industry and reduced power production. In Western Europe the reduction has most often been caused by the installation of cleansing plants. European nitrogen emissions have not been reduced to the same extent.

Social driving forces

- Urbanisation, infrastructure development, private industrial activity and general public interests.
- Hydro-electric development is the single most economically beneficial use of watercourses for society.
- Increased water consumption in the private and public sectors. Increased demand for water due to intensified agriculture.
- Intensification of agriculture, changes of land-use in the river basins, lack of political will to implement expensive measures in the sectors of effluent management and agriculture.
- Consumption of fossil fuels in industry, transport and private households.

Environmental pressures

- Hydro-electric development, gravel and sand extraction, land-fill, embankment-building, channeling and lowering, road-building along watercourses.
- The removal of riparian vegetation and the introduction of pollutants are the encroachments which have had the greatest impact on the natural condition of the watercourses.
- Hydro-electric development causes changes in the natural pattern of water flow during the course of the year, reservoirs have major fluctuations in water levels, dams form physical barriers in watercourses, and river stretches downstream from hydropower dams receive reduced amounts of water. All this contributes to changes in habitat which affect a range of freshwater animal and plant species.
- 58% of Norway's population receives satisfactory water supply from public waterworks. The largest waterworks consistently supply water of the best quality. In the case of smaller water-

works in particular, groundwater sources are regarded as the most advantageous, in terms of good and stable water quality, simple water management, good protection against pollution, simple technical installations, and low investment and running costs.

- Many freshwater localities are small “relict biotopes” with a large number of plant and animal species and a large proportion of threatened species. At the same time these freshwater biotopes are small in area and form types of natural environment which have been drastically depleted during the last 30-40 years as a result of encroachments and impacts. In 1999 watercourse regulation was seen as one of the biggest threats to salmon in 113 of 668 Norwegian salmon rivers. Parasites, acidification and genetic contamination from farmed fish also comprise threats to wild salmon in many rivers.
- Despite a reduction in the impact of nutrient salts and organic matter, concentrations are still too high in many watercourses. Due to internal fertilising in a number of lakes, water quality can still be unsatisfactory even where the impact has been reduced. Bacteria growth and strong algae development in watercourses and the blooming of potentially poisonous cyanobacteria (“blue-green algae”) still create major user conflicts in lakes and rivers used for drinking-water and swimming.
- Norwegian freshwater ecosystems are sensitive to acidification. Areas in southern Norway in particular have low tolerance levels for acidification because the soils in the river basins are thin and the bedrock consists of acidic rock types such as gneiss and granite. Acidification of watercourses has led to the depletion or loss of many fish populations. Other plant and animal species in the watercourses are also affected by acid rain. Increased nitrogen supply through precipitation has contributed to an increase in the growth of plants and algae in Norwegian mountain lakes.

FRESHWATER

Commodity/ service	Current condition and developmental trends	Data quality
Food production	• The total catch of exploitable freshwater fish species lies in the region of 8,000 tonnes a year. Of this, commercial fishing took 180 tonnes, recreational fishing for salmon and sea trout 630 tonnes, and recreational fishing for trout and other freshwater fish 7,000 tonnes. In addition to fish, the annual catch of freshwater crayfish lies at 11 tonnes. • Fish farming in freshwater is insignificant compared to seawater, but it has local importance e.g. the production of rainbow trout for the delicacy known as *rakfisk* (half-fermented trout). The production of young fish for stocking in regulated waters contributes to the yield from recreational fishing in such areas. • Acid rain, physical encroachments in watercourses and diseases connected with fish farming, as well as the spread of European minnow, *Mysis relicta* and other introduced species have all reduced the production potential for exploitable freshwater fish species.	• Good data exists for catches of anadromous salmon fish in rivers. Data at a national level for other freshwater fish catches are much poorer, though satisfactory for limited areas. • For fish farming in freshwater the data basis is poor in that official statistics do not distinguish between farming in freshwater and farming in saltwater.
Water quantity	• Climatic and topographic conditions ensure that Norway has plenty of freshwater compared to most other countries, and Norway has sufficient water for drinking, recreation, industry, power and agriculture. For some types of water use, such as drinking and recreation, for example, the available water quality may be unsuitable without appropriate treatment/measures. • Water consumption in Norway currently lies at 500 litres per person per day. This is 10 times higher than in India, for example, though lower than the USA (630 litres per person per day). • Water consumption is on the increase in both households and agriculture, and total capacity is in slow decline. • Global climate changes can produce changes in the volume of precipitation and lead to increased surface run-off during parts of the year.	• The data basis for water consumption in households is satisfactory for households connected to public waterworks. • Statistics for agricultural irrigation contain no information about the size of irrigated areas or the volume of water used, but only what size of area can theoretically be serviced by individual irrigation plants.

Water quantity	• Water quality in Norwegian watercourses is generally good compared with most other countries, but discharges from settlement and agriculture has affected the quality of water in rivers and lakes. The result has been a reduction in the quality of drinking-water, an increase in fish mortality and reduced recreational value (swimming and other forms of outdoor pursuits). Over-fertilisation in freshwater has also led to algal blooms in large lakes such as Mjøsa, and to a large extent affects rare and vulnerable biotopes containing many threatened species. Water quality has been significantly improved over the past 20 years as a result of comprehensive cleansing initiatives in the municipal sector, agriculture and industry, but the impact is still too high in many watercourses, particularly in low-lying parts of Østlandet, Rogaland and Trøndelag. Bacterial growth, strong algae development and algal blooms still create major user conflicts in lakes and rivers connected with drinking-water and bathing interests. Long-range pollution led to increased acidification of lakes and rivers in southern Norway, especially in Sørlandet. The influx of long-range pollutants, particularly sulphur, has been reduced since 1990, and this has resulted in improved water quality in many parts of southern Norway. However, the acidification situation is still critical for fish over large areas. Nitrogen from foreign sources still leads to large nitrate run-off in many areas, causing delay in the restoration of the acidified ecosystems. Long-range transport of environmental pollutants has received increased attention in recent years.	• The data basis regarding the acidification situation in Norwegian watercourses is satisfactory. • With regard to other types of pollution: the monitoring investigations which have been conducted have to a large degree been response-orientated and limited to localities where the pollution situation has been very serious. The data basis is fragmentary and insufficient, particularly with regard to biological parameters. • Time-series which may indicate long-term changes in water quality are rare, particularly concerning nutrients/ eutrophication.
Biodiversity	• Compared with most European countries, the status of Norwegian freshwater ecosystems is good. This concerns first and foremost water and watercourses in high-lying areas and in the north. In low-lying areas and in the south, biodiversity in freshwater is affected by changes in habitat quality and the fragmentation of habitats as a result of physical interventions and pollution. In addition, the influx and spread of exotic organisms has had increasingly negative consequences for the original flora and fauna in the watercourses.	

Biodiversity	• Among introduced species in freshwater are a number of disease-carrying organisms which have caused much damage, among them the crayfish pest, the bacterium causing furunculosis in salmonids, and the salmon parasite *Gyrodactylus salaris*. The latter has wiped out salmon stocks in a number of rivers, and has so far cost society almost NOK 100 million in attempts to combat the parasite. • Vegetation-rich and biologically highly productive lakes, ponds and other stationary waters, as well as freshwater localities without fish, are of particularly major importance in terms of listed threatened freshwater species.	• General information about the effects of encroachment and pollution is reasonably good for most groups of freshwater plants and animals. • An overarching description of the state of biodiversity in Norwegian watercourses, and figures which quantify the effects of human impact on biodiversity in freshwater at a national level are not available. • The Norwegian list of threatened and vulnerable freshwater species provides a good overview for groups of organisms such as fish, amphibians, molluscs, dragonflies, mayflies, stoneflies and sedge flies. The overview is less comprehensive for other taxonomic groups.
Recreation	• About half the adult Norwegian population fishes once or more a year. In 2000, 224,000 people paid government fishing fees. • Around 500,000 fishing permits are sold annually in Norway; in 1995 this comprised a value of NOK 40 million. The economic effects of inland fishing are about 10-20 times the income from fishing permits, and consequently provide significant economic benefits for rural districts. • In 1996, 23% of the adult population between the ages of 16 and 79 stated that they had been on a paddling or rowing trip in freshwater in the course of the year. 27% stated that they had fished for inland fish (apart from salmon, sea trout or sea char). • Additional outdoor pursuits include rafting, canyoning, swimming, sailing and use of motorboats. The variety of freshwater activities collectively make this a very important type of natural environment for recreation.	• There are few data on long-term trends in the extent of the various recreational activities connected with freshwater.

Sources: See bibliography

3.4 MIRES/WETLANDS

Main features of development

- Mires and wetlands currently comprise c. 10% of Norway’s total land area. Of this, mires form c. 7%.
- There is uncertainty regarding areal information, but it is estimated that more than 6,500 km^2 of the 21,000 km^2 of mire under the timber line has been destroyed by drainage ditches, building encroachment, etc. The area of mire above the timber line is estimated at 9,000 m^2, and is less exposed to encroachment.
- Wetlands include rare natural habitat types such as river deltas, eutrophic lakes and diverse relict biotopes on alluvial plains (oxbow lakes, ponds). Such wetland areas have often been reclaimed for agricultural purposes, either by drainage, in-filling, or lowering of groundwater, and the total area is still diminishing.
- Ditch-digging and the drainage of wetlands and mires for forestry and agricultural purposes and for peat extraction have had the greatest impact on these habitat types.
- An area of 20-30 km^2 is currently drained annually, while at the beginning of the 1960’s this figure was around 120-150 km^2.
- 360 species associated with mires and wetlands are registered on the 1998 Norwegian list of threatened species.
- Norway has around 280 river deltas larger than 25 ha. Around 40 of these are severely affected by encroachments. About 100 deltas are almost untouched, but only 30 of these are in southern Norway.
- Surface run-off and localised emissions have led to significant accumulations of nutrient salts and organic matter in wetlands located near intensive agriculture and urban areas.
- Long-range pollution has particularly affected nutrient-deficient bogs. Even though European sulphur emissions have been significantly reduced since 1980, the influx of nitrogen from foreign sources is still high.
- The mires are carbon stores; they are formed by peat mosses which assimilate and store the greenhouse gas CO_2, and they are therefore important for the carbon cycle.

Social driving forces

- Urbanisation and infrastructure development.
- The increased efficiency of agriculture and forestry.
- Following the removal of economic subsidies in 1980, ditch-digging in forest mires has been significantly reduced.
- Industrial development, road building and flood precautions.
- The consumption of fossil fuel in industry, transport and private households.
- As part of the process of reducing emissions of greenhouse gases, it is important to protect intact mire ecosystems and other wetland types which store dead plant material.

Environmental pressures

- Mires and wetlands have been exposed to a range of encroachments and impacts, such as in-filling, ditch-digging, drainage, eutrophication, acidification and the spread of exotic organisms. In lower-lying areas and the southern parts of the country, all types of mire, especially the rich fens, are severely depleted. In formerly mire-rich districts, such as Jæren and Lista, there are no surviving mire systems.
- Ditch-digging in mires and the drainage and in-filling of wetland areas reduces the water-storage capacity in the river basins and affects the course of flooding and the flow of water.
- Nutrient-rich mires and wetlands are types of natural environment with high levels of biodiversity. At the same time, the environments are small in area and are exposed to a number of threats, and they contain many threatened plant and animal species.
- River deltas comprise a small area in total, but contain important and rare types of natural environment and landscapes which are very important for a number of species. The areas are especially important as nesting grounds and resting areas for birds during spring and winter migrations.
- The influx of nutrient salts and organic matter has resulted in a fertilising effect in wetland areas, with increased growth of algae and macro-vegetation. The rate of overgrowth in wetland areas has consequently accelerated.
- The influx of nitrogen to nutrient-poor bogs leads to a fertilisation effect and changes in the species inventory.
- The importance of mires for the carbon cycle is made complex by the fact that some mire ecosystems emit significant amounts of the greenhouse gas methane.

MIRES/ WETLANDS Commodity/ service	**Current condition and developmental trends**	**Data quality**
Food production	• In the hunting season 1999/2000, 59,200 ducks were shot in Norway. The majority were shot in wetland areas, inland and along the coast. • The picking of cloudberries is the most important form of food harvesting on mires. Harvesting is almost exclusively a recreational activity. In Nordland and Troms, cloudberry-picking on private property is reserved for the landowners, while in Finnmark picking is reserved for local residents.	• There are relatively good figures for yields from duck shooting. • There are no available figures for the quantity or value of either recreational or commercial cloudberry picking.
Fibre and fuel	• Peat extraction employed 22 people in Norway in 1999 and had a production value of c. NOK 18 million. During the 1990's there has been a marked decline in employment associated with the extraction of peat products, and production value has halved in the period 1993-99.	• Powdered dry peat was formerly used in cattle sheds, and as insulating material in houses, etc., but is currently used mainly as a compost fertiliser. The current peat industry has a production area of c. 25 km^2. • Peat was formerly an important fuel, particularly in coastal areas, and large amounts of peat were harvested from mires and moors. A lack of resources and information led to very negligent management, and in many cases only naked bedrock was left following peat removal. This led to the adoption in 1949 of a Parliamentary Act for protection against soil destruction. More than 290 km^2 of mire is estimated to have been affected by the production of peat for fuel and horticultural purposes, but the total affected area is probably higher.
Hydrology/ erosion/ pollution	• Mires and wetland areas have great importance as water reservoirs which delay precipitation run-off and dampen the variation in water flow in rivers. Ditch-digging and drainage of mires and wetlands have reduced the water storage capacity and resulted in faster and higher floods in rivers during periods of high rainfall, and reduced minimum water flow in dry periods. • Wetland areas can reduce the impact of pollution on watercourses by functioning as buffers or filters against localised emissions and surface run-off.	• Quantitative data on water storage capacity in mires and wetland areas are only available for limited parts of some catchment areas. • Data on the importance of wetland areas as pollution buffers are similarly only available for small, delimited catchment areas.

Biological diversity	• Many mires today undergo an anthropogenic succession, as areas that were previously drained by ditches or stripped of peat are now overgrown by forest. The same also occurs on mires where formerly hay was harvested or grazing occurred. Hay production and grazing were particularly associated with rich fen. A range of plant species, and probably also animal species, are threatened because of changes in use and the subsequent forest cover development of mires. Rare and threatened species associated with mires are found mainly on rich fen, but poor fen can also contain species which are regarded as rare in regional terms.
	• Mires are of vital importance as functional areas for wild species such as the crane, the broad-billed sandpiper and great snipe, and are important for spring grazing and as mating grounds for wood fowl.
	• Vegetation-rich wetlands, river deltas, beach meadows and alluvial-plain biotopes, such as ponds and oxbow lakes, are types of natural environment with high levels of biodiversity. Twelve bird species on the Norwegian red list are associated with wetlands, of which the osprey is thought to be under most threat. About 10 mammal species on the red list are regarded as being more or less periodically dependent on wetlands. Of the red-listed species, 61 vascular plant species and 56 mosses grow on mires/wetlands, as well as 15 fungi and 6 charophytes.
	• The list of threatened types of mire includes three vegetation types and three types of complex:
	  • Rich (incl. intermediary) wooded/shrub-covered fen
	  • Open and intermediary mires and rich fen in lowland areas
	  • Extremely rich fen in higher areas
	  • Raised bogs with marginal forest and lagg
	  • Blanket bog and other oceanic bog
	  • Palsa mire
	• Lowland springs are regarded as a habitat type under severe threat.
	• The following types of freshwater shore vegetation and freshwater vegetation are threatened:
	  • Rich isoëtid vegetation
	  • Rich sedge swamp
	  • Rich elodeïd vegetation
		• Information regarding the species inventory of plants on different types of mire is relatively good. Information is sparse with respect to invertebrates, fungi and algae.
		• Norway has an unusually wide diversity of mire and wetland types harbouring a varied plant and animal life.

Biological diversity	• *Chara* lake-bottom vegetation • Bryophite lake-bottom vegetation • Threatened wetland types are also found in seashore environments. • Norway seeks to establish a network of protected mires and wetlands representing a variety of vegetation types. At present, 240 mire reserves have been set up, and a comparable number of other reserves and protected areas contain important mire and wetland areas. We estimate that currently 3-4% of the total area of mire is preserved, with an equivalent figure for other wetland types.	
Recreation	• Mire and wetland areas are rarely directly used for recreation in many parts of the country, but form important types of natural environment which can be enjoyed for their landscape value, due to their open terrain (in forest landscapes) and their rich diversity of species. In wintertime, the mires, wetlands and other open landscape types are much-used for ski tracks, such as in forest areas around the large cities. In addition, wetlands often comprise small relict biotopes which form small-scale landscape elements regarded as aesthetically beautiful. Consequently, the wetland habitat types contribute significantly to the general impression of the landscape.	• Data on different recreational activities are not related directly to the types of natural environment in which they take place.

Sources: see bibliography

3.5 THE CULTURAL LANDSCAPE

Main features of development

- The agricultural landscape, i.e. land which is clearly influenced by cultivation and harvesting associated with food production, comprises a small part of Norway's total surface area. Cultivated and cultivable land together comprise c. 19,000 km^2, i.e. barely 6% of the land area, while agricultural land which has been in active use has fluctuated around 10,000 km^2 over the last 50 years. In addition to cultivated agricultural land, there is also a significant area of extensively used forest, mire and mountain habitats which to some extent has been, and still is, used for grazing and other forms of harvesting.
- The distribution of agricultural land among forms of production has varied much over the last 50 years: the area used for grain production has more than doubled, and surface-cultivated meadowland and fertilised pastureland was nearly halved, but has increased somewhat again during the past decade.
- Livestock numbers have also changed significantly, with horses, goats and dairy cows showing the greatest fall (-87%, -54%, -55% respectively), and an increase for sheep and pigs (+34%, +94%).
- A major rationalisation of agriculture has taken place during the past 50 years, with increased intensification, capital investment and mechanisation; the number of farms has been reduced by 2/3, and the area of land per farm has trebled, while at the same time production on each farm has become increasingly specialised.
- A policy of differentiation of the subsidy system in order to promote grain production in the lowlands of Østlandet and Trøndelag and animal production in other parts of the country, has led to a high degree of specialisation in agricultural production, also regionally.
- The environmental challenges in the agricultural landscape are principally connected with changes in the prevailing conditions within agriculture and the consequences of this for farming methods. Economic driving forces lead to increased rationalisation and the abandonment of marginal operations, while environmentally-orientated subsidies and initiatives in agricultural policy modify this.
- There is strong pressure on agricultural land which can be converted to other uses connected with urbanisation and infrastructure development.
- There are still major challenges connected with pollution and erosion caused by agriculture, both in the form of soil erosion, and the run-off of nutrients and environmental pollutants.
- Global climate changes can lead to unpredictable problems with increased environmental stress and diseases.
- Agriculture has long been responsible for a significant import and introduction of exotic species into Norway's natural environment; this is a challenge which can increase with the use of genetically modified organisms in agricultural production.

Social driving forces

- Population growth, both in Norway and internationally.
- Increased economic growth; increasing industrial production and transport.
- Falling real prices and heightened demand for agricultural profitability.
- Urbanisation, infrastructure development, changes in consumption patterns.
- Agricultural policy: subsidies and controls connected with different initiatives related to production; generally falling subsidy levels and increased adaptation in line with environmental initiatives.
- Conflicts between differing uses, especially connected with ordinary agricultural production, alternative industrial activity and nature conservation.

Environmental pressures

- Climate changes, with rising winter temperatures and increased precipitation over much of Norway can lead to a longer growing season, but also to increased damage and disease.
- Changes in land-use connected with intensification of production on the most productive agricultural land; reduction in quality and increased fragmentation of remaining natural habitats.
- Changes in land-use related to abandonment of agriculture on less productive land; the reduction in habitat diversity and the fragmentation of cultivated fields influenced by previous production methods.
- The conversion of agricultural land to forest, or decline connected with urbanisation and infrastructure development.
- Erosion and surface run-off connected with environmentally damaging production forms and the addition of fertiliser and insecticides.
- The introduction of exotic species and genotypes (incl. GMO).
- Changes in the amount and quality of relict biotopes and landscape elements which are important for biodiversity, for the reduction of run-off/erosion, and the values associated with people's enjoyment of the landscape.

THE CULTURAL LANDSCAPE

Commodity/ service	Current condition and developmental trends	Data quality
Food protection	• In the context of economic and other framework conditions within agriculture, there is no lack of land for agricultural production in Norway today. • The most productive agricultural land, particularly land suitable for the production of food cereals, can be limited in relation to potential demand. • Grain yields have quadrupled over the last 50 years and meat production is 2.5 times higher. • Current production is high and reasonably efficient, but with new technology and better locally-adapted production this can probably be increased substantially in terms of both quantity and quality. The course of development will be determined by the world market and agricultural policy. • Operating within current frameworks, an adaptation to more extensive food production combined with the production of environmental and other collective benefits form a better strategy than increased production in itself.	• There has been an approximately tenfold increase in land used for ecological/organic agriculture over the last ten years, but still only 2% of agricultural land is used for this purpose. • There are extremely good data for agricultural production connected with actively farmed agricultural land, but it is more difficult to get an overview of pasture and other farming-related harvesting in more marginal areas.
Fibre	• The most important agricultural fibre production today takes the form of wool from sheep and pelts and hides from fur-bearing animals, cattle and reindeer. The production of fur pelts in particular has varied according to market conditions. • There is significant potential for exploiting some agricultural land for the production of bioenergy and biological products other than food.	• There are good data for farm-animal products and fur-bearing animals in agricultural statistics. • There are data for agricultural land which is deliberately converted to forest, but no available data for land which is abandoned or used for the production of bioenergy (such as oil plants or biomass).
Hydrology/ erosion p rotection/ pollution	• Ditch-digging and other forms of drainage of wet fields for agricultural purposes has taken place over hundreds of years in parts of Norway. • The intensification of agriculture over the last 50 years has led to homogenisation of the landscape structure through the removal of marginal zones, levelling of land, the burial of streams in culverts, and other changes in hydrological conditions. • Intensification has also led to increased working of the soil, autumn ploughing, run-off from silos and manure storage, as well as the input of artificial fertilisers and pesticides, all of which have led to increased surface run-off, erosion and	• There are good figures for the range of activities connected with different subsidy schemes. • In connection with the programme for status monitoring and result checking in agriculture, some data have emerged regarding the condition of land-use and landscape structure, as well as for pollution pressures on watercourses. • There is, however, a need for better data on the condition of different areas in catchment areas and impacts in connected watercourses. • The EU's framework directive for water management represents a clear challenge for monitoring and result checking of these environmental aspects in the agricultural landscape.

Hydrology/ erosion protection/ pollution	pollution (in the form of nutrient salts and environmental pollutants), in both down-stream water systems and surrounding areas. • Changed regulations and subsidy schemes have been introduced during the last 20 years in an attempt to reduce these problems; further initiatives will be necessary in order to maintain and develop marginal zones and wetlands in the agricultural landscape, so that a better balance can be created between productive activities and nature's limits of tolerance.	
Biological diversity	• Alterations within agriculture over the past 50 years have led to two changes which are unfavourable for biodiversity in connection with agricultural land, i.e. intensification of the most productive land and the abandonment and subsequent reforestation of more marginal agricultural land, including land marked by traditional farming practices. • The reduction in range and quality, as well as increased fragmentation of relict biotopes, marginal zones and land used as unploughed meadows and pasture, have led to poorer living conditions for many species, and to changes in ecological processes, resulting in a reduction in the sustainability of the production system. • Almost 30% of threatened and vulnerable species in Norway are associated with cultural landscapes and a substantial number of these species are threatened by farming methods. • The support for environmental initiatives and more locally adapted forms of farming can reduce some of the problems for biodiversity associated with intensively worked farmland. It is, however, difficult to see how biodiversity connected to traditional farming methods can be maintained with the restricted economic resources available. • There is consequently every reason to assume that the condition of biodiversity in agricultural landscapes will continue to decline in future years.	• The programme for status monitoring and result checking in agriculture provides some data for land cover and landscape structure which is of relevance for biodiversity, although the collection of data is restricted to a statistical sample of areas. • There are also good data for the range of subsidy schemes for different environmental initiatives. • There is nonetheless a major lack of good data for the actual development of species diversity and ecological processes in the agricultural landscape.

Recreation	• The restructuring of agricultural production, with the intensification of productive land and the setting aside of marginal land, has reduced the attraction and accessibility of the agricultural landscape for most people. • A varied agricultural landscape comprising marginal zones, relict habitats, and extensive meadows and pasture, and with livestock and rich species diversity, contribute to high levels of appreciation of the countryside; extensive meadows and pasture, and traditional paths and tracks, also provide the possibility of good access to the agricultural landscape. • Changes in agricultural policy during the last 10 years, with greater emphasis on the collective good in landscape management, provide certain possibilities for reversing the current trend towards a simplified landscape. • Large areas of marginal agricultural land will revert to secondary forest or forest plantations.	• The programme for status monitoring and result checking in agriculture provides some data for land cover and landscape structure which is of relevance for people's enjoyment of the countryside. • Research results that will throw better light on these relationships will soon be available. • There is, however, no systematic collection of data regarding people's enjoyment of, and interest in landscape with varied visual qualities, or data that throw light on the accessibility of the agricultural landscape; some insight can possibly be derived from data relating to landscape structure.

Sources: See bibliography

3.6 FOREST

Main features of development

- Almost 37% of Norway's surface area is covered by forest and other wooded land; productive forest makes up c. 24% of land area; forest is on the increase in Norway, particularly as a result of planting on marginal agricultural land.
- The standing biomass of forest trees is increasing and has almost doubled since the 1920's; the increment is currently double the annual timber harvest.
- The increment of forest trees is equivalent to an annual net fixing of CO_2 amounting to 40% of Norway's man-made emissions.
- The strongest environmental pressure on Norwegian forests is caused by modern intensive forest management, involving clear-felling, planting, intensive care of stands and the construction of forest roads for forest machinery, all of which have altered forest dynamics and landscape structure over extensive areas. At least 50% of productive forest land is affected by this type of forestry. There is a current trend towards more subtle and locally adapted forest management, and the construction of forest roads is diminishing.
- Long-range pollution from other countries affects Norwegian forests through the influx of, among other things, sulphur, nitrogen and ozone; while acidification is decreasing, the fertilising affect of nitrogen is still increasing.
- Global climate changes can lead to major and unpredictable consequences for forest ecosystems.

Social driving forces

- Population growth, in Norway and internationally.
- Increased economic growth; increasing industrial production and transport.
- Urbanisation, infrastructure development.
- Forestry policy: subsidies for road building and other production-related initiatives, and in time also for environmental initiatives.
- Falling real prices and heightened demand for profitability in forestry.
- Conflicts between different uses, particularly connected with industry (forestry, agriculture, tourism), nature conservation and values associated with the recreational experience of natural forests.

Environmental pressures

- Climate changes, with rising winter temperatures and precipitation over much of Norway, may lead to a longer growing season, but also the possibility for increases in storm damage and diseases.
- An increase in long-range pollutants (particularly nitrogen and ozone); acidification of forest land still occurs, particularly in the south-west.
- Shortening of the forest's natural rejuvenation cycles, reduced maximum ages of stands and trees.
- Changes in habitat quality (forest structure, tree species, landscape elements, hydrology, as well as localised pollution – acidification, metals, nitrogen) which result from intensive felling.
- Fragmentation and change in the forest's natural landscape structure as a result of clear-felling and road construction.
- The conversion of forest land to other uses occurs mainly in thermophileous deciduous woodland, and through planting of spruce in birch- and other deciduous forests.
- Too heavy culling of large predator species.
- The introduction and establishment of non-native species and provenances.

FOREST		
Commodity/ service	**Current condition and developmental trends**	**Data quality**
Food production	• There has been a strong increase in production and harvesting of wild ungulates (moose, red deer, roe deer) since the 1960's. For example, the moose yield has quadrupled. The hunting yield of roe deer has fallen somewhat over the last 10 years. • The production of woodland birds (capercaillie, black grouse, etc.) and other small game varies much according to factors such as weather and the population densities of small rodents and predators; hunting yields vary accordingly. • The picking of berries and fungi in forests is much lower than production and probably shows a decreasing trend. • Pasture for livestock in forests is not as extensive as it was 100 years ago, but sheep-grazing still takes place to a great extent, particularly in high-altitude forests. • Due to increasing predator stocks, the utilisation of grazing resources in forests by both deer and sheep may decline in coming years.	• There are good data for hunting yields of wild ungulates, but figures for stock levels are somewhat poorer, particularly for roe deer. • Figures for yields of woodland birds and other small game are less satisfactory, and generally poor regarding stock levels, even though assessments are carried out by local game managers and associations. • Data for the production and picking of fungi and berries are almost non-existent. • There are good data for farm animal stocks generally, but not for the animals' use of forest grazing, and in particular the distribution of grazing intensity and fodder extraction in time and space.
Fibre	• Felling rates of forest trees have fluctuated between 7 and 11 million cubic metres annually over the last 50 years. • Of this, about half goes to the sawmill- and wood-products industries, and about a third to the cellulose and pulp wood industries. The use of timber and waste for energy purposes comprises less than 5% of total domestic energy consumption. • Net forest biomass production is now more than twice as high as felling rates. • Global climate changes will probably lead to increased growth, but also more extensive damage and disease. • Based on market trends, with falling real prices for timber and increasing environmental requirements, particularly with regard to biodiversity, it is unlikely that the total felling volume will increase significantly in the foreseeable future. However, increased intensity of forest management, particularly in productive forest areas, may lead to local balances between increment and felling. More niche markets may lead to rising prices on special sorts of timber.	• There are good statistics for forestry production and felling in data from the National Forestry Audit, industry and individual forest owners' operational plans. • There are no particularly good data available for populations, production and CO_2 assimilation for other than the most important tree species. • There are no good available figures for the extraction of timber for household firewood.

Hydrology/ erosion protection/ pollution	• Drainage of marshy woodland and marshy fields took place on a relatively large scale up to about 20-30 years ago. More recently, extensive clear-felling and road construction have led to great changes in the forests' hydrological regime, with a resulting increase in surface run-off, erosion and pollution. • Extensive extraction of the biomass also contributes towards increased acidification of the soil and chemical effects on the run-off water.	• National programmes for the monitoring of forest damage and water quality provide data connected with forest pollution. • There is, however, no systematic data collection for forestry's impact on hydrology and surface run-off, and knowledge must be based on extrapolation from limited research projects.
Biological diversity	• Modern intensive forestry management has caused changes in the forests' natural age structure, distribution of tree species, the incidence of important habitat elements, the fragmentation of old-growth forest, and changes in landscape structure. • Around 800 km^2 of forest have been planted with exotic tree species since the 1940's. • This has a negative influence on the forests' original species diversity, particularly species associated with forest with long continuity and incidence of special habitat qualities, as well as on the forests' ecological processes. • According to the National Forest Audit, c. 50% of the forested area comprises felling classes IV and V (i.e. "mature forest"). When this type of forest is allowed to stand untouched it is beneficial for rare species associated with old-growth forest and dead wood. • About 50% of threatened and vulnerable species in Norway are associated with forests, and at least 50% of these are probably threatened by the forestry industry. • Initiatives aimed at showing more concern for biodiversity in forests through protection and special forestry initiatives are not extensive enough to deter further negative development in the coming years.	• General information about the effects on biodiversity of different forms of operational practices in forestry is reasonably good, but precise studies of effects (dose-response) are almost completely lacking. • Apart from forest trees and individual habitat elements of importance for biodiversity, there is no representative collection of data for the status of biodiversity in forests. • Programmes for intensive monitoring in model areas, however, provide significant insight into the status of a number of common forest species. • Similarly, the mapping of key biotopes and environmental surveys in forests will provide an overview of a number of forest environments and habitat elements which are important for threatened and vulnerable species. • We lack basic information about the dispersal capabilities of many species groups e.g. lichens, fungi, mosses and insects.

Recreation	• Modern forestry management also has clearly negative effects on the general public's experience of old forests. • Both natural qualities and access to areas of forest are impeded by clear-felling and various forestry operations. • However, the road-building associated with modern forestry has also increased access and improved other forms of forest recreation (cycling, riding). • Clear-cut areas may also be perceived as a positive aspect in the forest land-scape, , and different types of felling classes provide variation in the forest landscape. • In order to be environmentally certified, a forest owner is required to adhere to the standards for aspects of forest manage-ment related to recreational values set out in The Living Forest's standard for sustainable forestry.	• Data relating to access via forest roads are readily available, and there are overviews of parts of the footpath net-work. • There are also good data available for hunting yields, especially for large game. • On the other hand, there is no systemat-ic data collection in the form of surveys of the values relating to the public's experience of forests, or of qualities in forests which can influence these values. In this case we are dependent on results from limited research projects. There is, however, an increasing amount of research into qualities of experience connected with outdoor life, including, among other things, forestry in areas close to towns.

Sources: see bibliography

3.7 MOUNTAINS

Main features of development

- The natural-environment type “mountain” is not easily defined, but we most frequently consider the areas above and north of the climatic timber line to be alpine. Consequently, the total alpine area is not easily estimated, but a maximum of 47% of Norway’s surface area is provided by land categories such as “permanent open ground” and “other land types” (Naturen i tall 1994). Land above and north of the timber line (i.e. the alpine vegetation zone) comprises 32%.
- The character of the mountain areas exerts a strong influence on the Norwegian landscape and our conception of Norway as a physical reality; the alpine areas have a strong symbolic power.
- The area above the timber line will gradually diminish somewhat due to overgrowth following the abandonment of alpine dairy farms and pastures and climate change. As a result, the landscape and species diversity in large parts of the alpine area will change character.
- In addition to climate change, long-range pollutants still pose a threat to alpine areas in southern Norway and parts of eastern Finnmark.
- The strongest, most extensive and immediate environmental threat in alpine areas today is the development of infrastructure for transport and hydro-electric power production, as well as holiday cabins and other tourist facilities. Areas of wilderness have diminished drastically in extent; in the country as a whole, such areas have been reduced from c. 48% to 12% of land area during the last century, and most of what survives is to be found in the mountains.

Social driving forces

- Population growth, in Norway and internationally.
- Increased economic growth; increasing industrial production and transport.
- Infrastructure development.
- Conflicts between different uses, especially those connected with different types of industrial activity and nature conservation.

Environmental pressures

- Climate change; rising winter temperatures and precipitation over much of Norway will probably change the landscape and biodiversity in mountain areas.
- Increased pollution (particularly nitrogen and ozone), particularly in southern mountain areas; long-range environmental pollutants, including radioactivity resulting from the Chernobyl accident.
- Local pollution from mining still takes place, even though most mines have been closed down.
- Fragmentation of alpine areas through the development of infrastructure and facilities for transport, power production and tourism/recreation, as well as reindeer fences.
- Disturbance and wear-and-tear on the terrain from motor traffic off the roads.
- Over-grazing of reindeer pasture, particularly in Finnmark, but also in some areas with wild reindeer.
- The abandonment of alpine dairy farms and the reduction of alpine pastures in many mountain areas.
- The over-harvesting and culling of large predators and game populations.

Mountains

Commodity/ service	Current condition and developmental trends	Data quality
Food production	• Traditional alpine dairy farming has practically disappeared. • There is still extensive sheep-grazing in some mountain areas. • Even though extensive mountain areas offer rich possibilities for harvesting of fodder and grazing resources, it is probable that the extent of such harvesting will diminish in the coming years as a result of prevailing economic conditions within agriculture and increased conflict with regard to predators. • There can be resource-related grounds for increased long-term extraction from reindeer herding and wild reindeer stocks if better management of these stocks can be achieved (cf. other wild deer and tame reindeer in the Southern Saami areas), although such increased production can have negative effects on stocks and other aspects of biodiversity. • Stocks of small game, such as grouse and hare, will vary greatly in accordance with natural dynamics in the ecosystems, and climate change will probably increase unpredictability in these stocks. • Berry production will also display a large degree of natural variation and sensitivity to climate change, and yields will depend greatly on the public's level of motivation with regard to harvesting such resources.	• There are good figures for industrial forms of agricultural production (even though it can often be difficult to separate out figures specific to alpine areas). • It has been difficult to obtain sufficiently good data for tame-reindeer herding, as well as for stocks and production of wild reindeer (there is significant disagreement about data quality). • There are rough figures for hunting yields for small game, but poor data regarding stocks. • The data concerning berries etc. are extremely poor.
Fiber	• Production of fibre etc. in alpine areas is limited in extent and is potentially mainly connected with hides and wool from reindeer and sheep (insofar as these products are taken care of). • In addition, a certain amount of harvesting of lichen and other plant products for various handicraft activities takes place. • The extraction of such products can probably increase without any appreciable negative effects on the ecosystems, but will be limited by markets.	• Wool and hides are currently by-products of meat production; even data associated with agricultural production will not be precise with regard to these products. • There is unlikely to be any data available for other yields of fibre etc. from alpine areas.

Hydrology/ erosion protection/ pollution	• Hydro-electric power development carries with it a massive impact on the natural hydrology of the alpine areas, both in the form of dam constructions, tunnels and pipe systems, and in addition, occasionally fundamental changes in the flow of water in watercourses (both volume and frequency). • The construction of roads, cottages and other facilities, as well as some motor traffic, will also affect local hydrology associated with alpine mires and wetlands. • Existing and abandoned mines cause changes in hydrology and introduce environmental pollutants (heavy metals). • Since hydropower development is coming to an end, and mining has by and large been abandoned, further disturbance of alpine hydrology will probably be caused by future development of infrastructure and facilities associated with tourism.	• There is a good overview of the incidence of buildings and various types of installation; a certain amount of information regarding effects of hydropower development has accumulated over time. • There is only a limited supply of data and information about the effects of other encroachments on hydrology and pollution, connected mainly with limited studies conducted in local areas.
Biological diversity	• Alpine biodiversity is characterised by a few species which are adapted to quite extreme climatic and environmental conditions, by simple food chains and vulnerable ecosystems. • A fair number of bird species have important nesting grounds in mountains. • Species and ecosystems are often characteristic of, and unique to alpine areas, and in a European perspective Norway has a responsibility for taking care of such species (e.g. arctic fox, wolverine, wild reindeer, snowy owl) and ecosystems. • Threats to alpine biodiversity are principally connected with the development of infrastructure for transport and hydropower, and the building of holiday cabins and other tourist facilities. • This leads to the fragmentation of large unbroken areas of wilderness and living areas for larger mammals, as well as increased disturbance of animal life generally, and wear-and-tear on vulnerable ecosystems. • Power lines and fences can have a direct impact on local bird populations. • The over-harvesting of some species (notably larger predators) is a major threat to the viability of populations.	• There is a good overview of the incidence of buildings and most types of installations, but data and information about the effects of such encroachments on biodiversity are limited, though possibly best developed for wild reindeer, large predators and gallinaceous birds (grouse, ptarmigan). • There are generally no good overviews available for the current condition and development of alpine species and ecosystems, but there are data for selected animal groups (wild reindeer, large predators) or localities associated with intensive monitoring or research projects. • There are particular problems in gaining precise information about the potential effects of climate change.

Biological diversity	• In the near future the continued development of infrastructure and facilities for transport and tourism will lead to further pressure on biodiversity in alpine ecosystems. • Climate change represents a major potential threat to alpine biodiversity, and pollutants from local and long-range sources still contribute to increased pressure on species and ecosystem functions.	
Recreation	• Alpine areas became very important for recreation and tourism during the course of the last century. • Hunting, fishing and other forms of exploiting alpine resources have always been important, but during the past 50 years these have increasingly changed from being productive activities to recreational pursuits. • There is an accelerating development towards more organised recreation based on extensive construction of roads, cottages, amenities etc. • This leads to conflict with more traditional forms of recreation and enjoyment of alpine nature. • The development of more organised and amenity-centred forms of recreation will probably increase in the future.	• There is a good overview of the incidence of buildings and different types of installation, but data and information are lacking about the effects these encroachments have on the public's experience of mountains and attitudes towards constructions and adaptation in relation to alternative uses. • Sources: (INGRID- Som de norske!!!!!!!)

Sources: Naturmiljøet i tall 1994, Statistisk årbok 2000, Naturressurser og miljø 2001, Jordbruksstatistikk 1994 (SSB), Naturskogar i Norden (NORD 1994:7), Nordens miljø - tilstand, utvikling og trusler (NORD 1993: 11)

4 The Glomma river basin: a case study

Summary

The case study will demonstrate ways in which data series for different sectors and activities in society can be used in an integrated analysis of how the extraction of products and services from ecosystems is both dependent upon and influences the condition of the ecosystems. How will one way of using nature influence other ways of utilising, or harvesting from, the same ecosystem? Based on selected data from the Glomma river basin, the intention is to gain experience with a view to conducting this kind of analysis at a national level. In a full-scale study, information about trends and development up to the present day will also be used for developing scenarios for the future, and proposals for measures designed to stop unfortunate courses of development. The limited frameworks for this case study prevented the development of scenarios. Nonetheless, the historical development in the Glomma river basin can indicate possible future areas of conflict. We point to these in the summary, and we have employed the phrase “this may mean that…” when assessments are established on judgements based on scientific data on trends and development.

Norway has good available data for many of the parameters which are important for an analysis based on the methodology developed by the Millennium Assessment Project. Research and assessment projects are currently being conducted which in the near future will be of great value for such an analysis. At present, however, few existing Norwegian data sets are sufficiently organised and detailed enough to allow immediate use. A full-scale study should start with a thorough examination of relevant and available data sets, and an assessment of the effort which is required to prepare the data for such a study.

The Glomma river basin illustrates many of the incompatible interests, conflicts and necessary compromises faced by the authorities responsible for the management of natural resources.

Underlying driving forces

- The underlying reasons for change in natural conditions comprise population development, the population’s consumer patterns and the prevailing economic conditions in society. A characteristic of development during the last hundred years is that local conditions at parish or municipality level appear to play an increasingly smaller role, while national, and even more so, international conditions, are becoming more and more important for development, also at a local level.

This may mean that…

a comprehensive and sustainable policy cannot be developed at local levels if national and international policy does not cater for this. National policy must therefore ensure that the interests and values of local communities are safeguarded, and that values which cannot be measured directly in economic terms are secured.

- In the Glomma river basin, population has grown significantly in the vicinity of Oslo, while less central districts have maintained more or less stable population levels. Construction work associated with hydropower production and transport is largely determined by the needs of the population in central areas. Nevertheless, disagreement regarding such projects often cuts across both small, local communities and larger, centralised communities, rather than between them.

Proximate drivers

- The construction of infrastructure, such as roads, railways, power stations and power lines, is an important proximate driver, or pressure, which causes changes in the natural landscape and the living conditions for vegetation and fauna in natural ecosystems.
- Infrastructure construction leads to fragmentation of the natural landscape. We know that this has a negative affect on species such as wild reindeer, but we lack a good deal of information about the effects of this fragmentation.

This may mean that…..

threatened species which are dependent on wildlands (encroachment-free areas) suffer poorer living conditions as a result of additional infrastructure development. Such species can include wolverine, arctic fox, birds of prey and wild reindeer. One consequence may be a reduction in yields from the hunting of wild reindeer.

• Roads carry activity with them, such as settlement and forestry. This leads to roads being surrounded by a broad band of nature that is strongly influenced by humans. In the Glomma river basin, the areas south of a line between Trysil-Elverum-Hamar-Gjøvik are today devoid of encroachment-free areas, and in the areas north of this line encroachment-free areas coincide largely with existing or planned protection areas.

This may mean that…

we have already lost many nature-related values in the southern part of the Glomma river basin. We probably face a comparable development in the northern part of the basin, where the encroachment-free areas will continuously diminish or disappear unless specific measures are implemented.

Ecosystems and their services

- Road building and forestry operations have caused changes in forest areas. Old-growth forest has been reduced, while at the same time forest-covered land contains a greater volume of timber and a completely different stand structure compared to the situation 50 years ago.

This may mean that…

while we have good timber production and a better timber resource base than previously, this efficient form of forest management aimed at timber production has probably led to a loss of biological diversity at species and ecosystem levels.

- The hunting of large game entails both the production of meat and important values connected with recreation and tourism. The moose yield in particular has increased strongly since 1970, in close step with the moose population's size. The growth in the moose population is thought to be a result of the improved culling regime and new forestry practices which have created better feeding conditions for moose.

This may mean that…

the interplay between management of the moose population and forest management has led to an artificially high moose population. This is chiefly perceived as being beneficial in economic and recreational terms, but it also has negative effects on other biological diversity in forests.

- Landscape structure has changed much over the past 50 years, particularly as a result of changes in farming methods. Economic and political conditions, at both national and international levels, encourage changes in farming methods. We now have larger areas of uninterrupted fields, and fewer field boundaries and patches of woodland . This leads to more efficient production i.e. greater production of food per unit of cultivated land. Recent research results show that this reduces the landscape's suitability for recreation and outdoor pursuits.

This may mean that…

Values connected with landscape and recreation diminish as a result of reduced variation in the cultural landscape caused by the increase in uninterrupted fields and less variation in farming methods. In addition to its primary function as productive land for food, the cultural landscape contributes significant values in terms of aesthetic experience and enjoyment to the tourist industry and outdoor life, and a homogenising of the landscape as outlined here is detrimental to this relationship. It can lead to reduced economic returns for tourism.

- Measures taken in recent years to reduce erosion and run-off from cultivated land, for example by conserving and restoring vegetation along the edges of watercourses and elsewhere in the landscape, have positive effects, both on the attractiveness of the landscape and upon biological diversity.

This may mean that…

Measures for improving agricultural production through, for example, reduced surface run-off of fertilisers and soil erosion, also contribute to the improvement of the cultural landscape's value in terms of species diversity and aesthetic experience.

- Along the coast, confrontations between different interests are continually arising due to the construction of holiday cottages or other infrastructure coming into conflict with the public's right of access to both land and sea. These problems also occur along the shore at the mouth of the Glomma.

This may mean that…

recreational values connected with unrestricted access in the coastal zone can be lost in the future if measures to secure them are not implemented.

The watercourse itself has historically supplied many different services. While today its roles as transport artery and food producer are small, the production of electricity, the supply of water to private households and for irrigation, the cleansing of waste water and recreational fishing are currently the most important products and services. Hydropower development has led to a number of changes in the watercourse. New environmental conditions have been created which will probably constitute the new permanent condition since the hydropower potential of the Glomma is almost fully exploited. The supply of irrigation water to agriculture leads to reduced water flow, which is mainly a problem for aquatic environments in smaller tributaries and streams. The watercourse's ability to supply this service to agriculture is dependent primarily on water quantity, while the quality of the water is less important. This means that the watercourse can be a recipient of waste water (supplying the service "decomposing pollutants") while also supplying irrigation water. The extraction of drinking water from a watercourse is, however, to a large extent dependent on water quality. This means that the services "cleansing of waste water" and "drinking-water supply" are difficult to combine.

This may mean that…

Conflicts between user-interests in the watercourse will in future occur between recreational use, extraction of water for households and irrigation, and recipients of waste water, in various specific combinations.

- Certain aspects of the watercourse's natural dynamics are perceived as being negative and costly by society. This includes erosion and flooding, for example. The complex technical measures for reducing erosion and flooding have both negative and positive effects on different values and services. The measures are aimed at the protection of buildings, agricultural land or infrastructure. They are often implemented at the cost of types of natural habitat that are rare or worthy of protection, such as oxbow lakes, swamps, and alluvial vegetation. We are therefore faced with choosing between protection of material values in the cultural landscape and protection of valuable elements connected with biological diversity.

This may mean that…

A comprehensive assessment of the remaining flood-dominated ecosystems in the river basin must be made, so that species or biotopes are not unintentionally eradicated through the piecemeal development of flood and erosion precautions.

4.1 Background

The aim of the pilot project's case study is to show how data series for different social sectors and activities can be employed in an integrated analysis of the ways in which the extraction of goods and services from ecosystems both depend upon and influence the condition of ecosystems. This reveals the problem areas which can be highlighted in a full-scale (national) project.

The project focuses the extraction of products and services from the natural environment or modified ecosystems and how this is dependent on the influence of different factors in nature. The natural environment is constantly being influenced by natural and man-made processes and activities which decide the ecosystems' functions and characteristics, and with that the products and services which nature contributes. Since these influential factors, or pressures, have changed in the course of history and are expected to do so in the future, it is important to identify what kind of effects different factors have on the ecosystems and the products and services we take from them. The intention behind the case study is therefore to demonstrate that a similar analysis conducted at a national level can contribute feasibly to a better integrated, sector-transcending management of the natural environment and its resources.

While a full-scale analysis will encompass different scenarios for future development and a discussion of potential managerial responses with regard to initiatives and framework conditions, this case study has not had sufficient resources to undertake such an analysis.

The demand for a comprehensive look at the condition and function of ecosystems and the goods and services we extract from them means that we can to only a limited degree expect to have relevant datasets with a sufficient time span and extent to allow the implementation of a formal analysis. This case study is for practical and economic reasons based on datasets which have been relatively readily available, and on expert assessments of these datasets and relationships between different parameters and conditions of ecosystems. Different methods or tools have been developed with the aim of conducting such a comprehensive analysis in a systematic way. One example is MIRABEL (Petit et al. 2001), which is an analytical framework developed by European research and management institutions for the purpose of assessing changes in biological diversity which result from changes in the environment across the various regions in Europe. We have to some extent applied a modified version of this method. We have also made use of the GLOBIO approach for parts of the analysis (UNEP 2001).

4.2 Geographical limits

The case study centres on the Glomma river basin (including the River Lågen in Gudbrandsdal). The reason that this area was chosen is that there is a relative abundance of information which is available in a format that can be used in a pilot project with limited resources. The datasets comprise both the entire basin and smaller parts of it. Over the past 10-15 years, a number of assessments and research projects have produced material which we have been able to use in this analysis. It is apparent, however, that also the available data series for the Glomma river basin have either insufficient resolution or cover time periods which are too short to provide good opportunities for analysing development over time. A full-scale project should therefore begin with a more detailed investigation of what datasets are to be found in Norway, and an estimation of what kind of effort is needed to prepare the datasets for the type of analysis we are referring to here.

4.3 Approach/Methods

The global Millennium Assessment Project (MA) (www.millenniumassessment.org) began in 2002. Development of methods and procedures took place in 2001. This development will be of great importance for a Norwegian full-scale MA. This particularly concerns the work which is being done to improve the so-called “sub-regional assessments”. MA will incorporate three main elements:

An overview of condition and trends, which analyses current condition and historical development.
Scenarios, which will discuss future developments in the ecosystems’ condition.
Response options, which will discuss the effects of various policies and initiatives in the management of ecosystems.

The case study in this pilot project will fall principally under point 1 above. Since this case study is not in phase with the global process, it is not possible to utilise the methodological development in the global project at this time. Participation in the planning meetings for the global process has nonetheless ensured that some relevant elements from this process have been utilised in the study. This includes, among other things, the scoping process for identifying and prioritising relevant datasets.

The analyses undertaken in the case study will be based on an adapted version of MIRABEL. MIRABEL is based on thinking in the “Drivers-Pressure-State-Impact-Response” (DPSIR) model (NERC 1995) (**see box 2, Chap. 2.2**). Central to the MA process are the ecosystem services and the products and services the ecosystems supply to humanity.

MIRABEL is built up around three main elements:

- The classification of ecological regions
  Environmental pressures (and scenarios)
  The impact of pressures on ecosystems (or biodiversity)
- These elements are set up in matrix form where the significance of influences and effects in the various ecological regions can be evaluated, either by the presence of solid data or through expert assessments. A matrix of this type is provided for the Glomma river basin (**table 7.2**).

4.4 Datasets

For the pilot project's case study, it was necessary to limit oneself to easily accessible datasets consisting of examples of information about the most important goods and services in the river basin, and the factors which influence the types of natural environment. In order better to understand the cause/effect connections, it is desirable to assess development over time in relation to condition, influence, effect and response. There has been little opportunity to conduct such analyses within the case study's framework. This will be a central element in a full-scale analysis, however. References to the data sources which are used in this study are provided in connection with each figure or in the text.

Data about the condition of and developmental trends in the ecosystems which supply the goods which people depend upon are relatively incomplete. This is particularly the case for dataseries with good data collected in the same way over many decades. On a higher level, DN's work compiling maps of encroachment-free areas from 1900 up to today is valuable. There are also other dataseries which we have not had the opportunity to use in the pilot study; i.e. data about soil quality, forest condition, water quality etc. Biological monitoring data are as a rule connected with pollution problems, while more detailed data about developments in biological diversity (species richness, population data, biotope data) are still unavailable. The national monitoring programme for biological diversity will hopefully improve this situation.

4.5 Ecological regions

The Glomma river basin can be subdivided into six natural or ecological regions based on geographic, biological and use-related characteristics. These regions are:

- Coastal landscape,
- Agricultural landscape below the upper marine limit
- Agricultural landscape above the marine limit
- Valleys
- Forests
- Mountains **(table 7.2)**.

Such a rough classification is based largely on altitude, but in the higher altitude areas (which comprise mainly forest and mountain) the valleys will form a special region which is distinct in terms of both nature and use. We include the coastal zone as a region in itself, even though of necessity it constitutes only a small fraction of each river basin. The coastal zone has special values and is exposed to specific pressures. The purpose of the classification is to establish concrete geographical areas which may be easily recognised, and which can be treated at a relatively coarse-grained level of analysis. As is made apparent in **figure 7.1,** the different types of natural environment are in reality distributed within the landscape in a far more complex manner than is conveyed by **table 7.2**. This phenomenon is far more marked in the Norwegian countryside than it is in Sweden, Finland or Denmark. In Norway, every land area of a certain size will encompass a complex patchwork of many different types of natural environment.

In contrast to most European countries, Norway does not have a good nation-wide dataset dealing with land surface cover. We have digital soil type maps connected to the economic maps, but this is far from being nation-wide and is also partly out of date. We have land signatures on our topographic maps at scales of 1:50,000 and 1:250,000 (N50 and N250), but these barely cover a systematic monitoring requirement, both because there are relatively few land type classes and because there is no systematic updating so that the date for the data varies from map to map. A collaboration has been started between the Ministry of Environment, the Ministry of Agriculture, DN, the National Mapping Authority, NIJOS and the Norwegian Space Centre with the aim of developing a nation-wide system for land surface cover data which can be updated regularly.

At a larger scale there are nevertheless a number of maps showing different types of biogeographic regions which can be used in such an overview (Nordic Council of Ministers 1977, NIJOS 1993, Moen 1998). There are also maps of Norway's land forms (Klemsdal & Sjulsen 1992) which are relevant on a rough scale. **Figure 7.1** shows comparative data for the Glomma river basin based on height information and N250 surface cover data from the National Mapping Authority. We have only made calculations for the Østland counties, so that the areas in Trøndelag and Sweden are reproduced without data.

To conform with the simplest form for regionalisation, the area has been subdivided into 4 main regions: Mountain over 1000 m.a.s.l., mire landscape, forest and areas below the marine limit. Together these form a gradient running from north to south in the river basin. Mountain is only defined on the basis of height above sea level; mire landscape in forest is based on the mire layer in the N250 map base. The forest layer is taken directly from the N250 map base, but is not reproduced in areas over 1000 m.a.s.l or in the mire landscape.

Agricultural areas do not form an independent land class in the N250 map base, but can be seen as areas without data in the forest landscape. Urbanised areas are reproduced in pink, but form extremely small areas. In addition we have marked areas lying below the marine limit. This area includes deposits of marine clay which form our greatest cultivation resource. This signature is depicted by transparent shading in order to allow the distribution of forest and cultivated land to be seen.

In so far as we have surface cover data for change in the condition of the natural environment, human activity and industrial practice, these will be broken down into statistics which are relevant for the different land classes. This will be important, both for studying regional differences and for analysing what ecological significance such changes have.

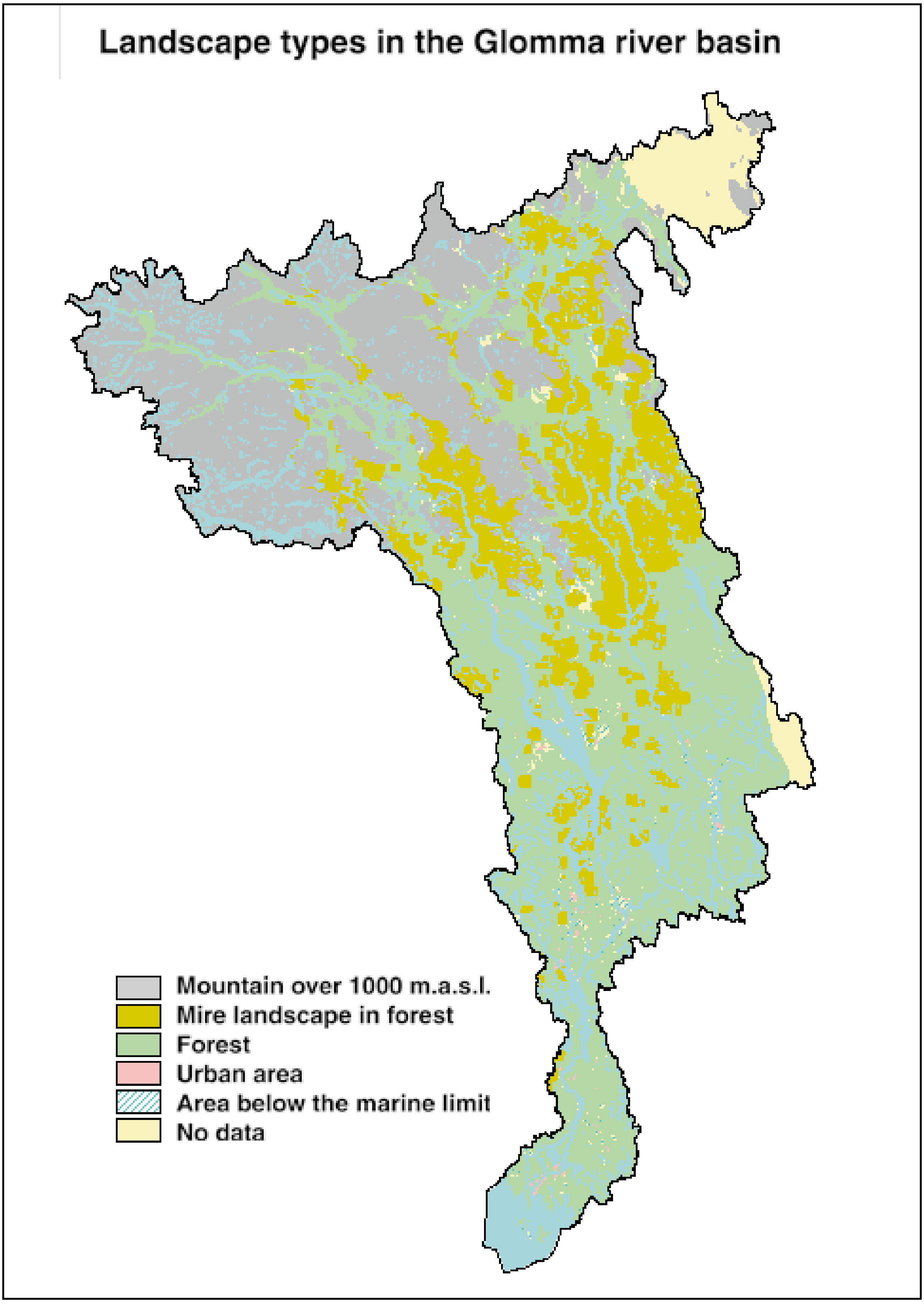


Fig. 7.1
Landscape types in the Glomma river basin. The distribution of landscape types is complex, so that a simple cartographic representation of the natural/geographic subdivision we have produced in table 7.2 is not possible on such a map.

Table 7.2
Natural-geographic subdivision of the Glomma river basin, with keyword-type specification of dominant types of natural environment, the most important goods and services, and a selection of important man-made pressures. Pressures such as, for example, pollution and climate change, are not included here. This presentation is based on a geographical subdivision of the river basin into six regions with particular biological, geographical and industrial (economic) characteristics. The value "biodiversity" includes all values connected with biological diversity as defined in the Convention for Biological Diversity, i.e. diversity from genes via species to ecosystems. The variation in ecosystems can in this connection be said to represent variation in the landscape.

Natural geographic subdivision	**Dominant type of natural environment**	**Most important products**	**Most important ecosystem services**	**Important pressures**
Coastal landscape	Urban area Wetlands/ estuaries Forest Cultivated land Beaches Rock outcrops Navigable coastal waters Watercourse environment	Harvested food Cultivated food Recreation Fibre Energy (windmills) Archaeological/ historical monuments	Land for infrastructure Biodiversity	Infrastructure/ urbanisation Traffic Harvesting Aquaculture (but not on the Glomma coast) Pollution
Agricultural landscape (under the marine boundary)	Cultivated land Forest Urban areas Wetlands Cultural landscape Watercourse environment	Cultivated food Harvested food Fibre Recreation	Land for urbanisation Biodiversity Cleansing capability Erosion protection Flood defence	Land levelling Cultivation Erosion/run-off Forestry Irrigation water Pollution Infrastructure/ urbanisation
Agricultural landscape (over the marine boundary)	Cultivated land Forest Wetlands Cultural landscape Watercourse environment	Cultivated food Harvested food Rough grazing Fibre Drinking water (surface-) Irrigation water Recreation	Biodiversity Cleansing capability Erosion protection Flood defence	Cultivation Abandonment of agriculture Erosion/run-off Pollution (local) Acid rain
Valleys (including the watercourse)	Agriculture Forest Wetlands Cultural landscape Watercourse environment	Cultivated food Fibre Drinking water (surface-) Irrigation water Electricity Recreation Gravel	Land for infrastructure and urbanisation Recreation Biodiversity Watercourse Cleansing capability Erosion-protection Flood defence	Cultivation Abandonment of agriculture Infrastructure Flood precautions Hydropower installations Acid rain Gravel extraction
Forest	Forest Agriculture Watercourse environment Wetlands	Fibre Drinking water (surface-) Irrigation water Game/ berries/ mushrooms / fish Rough grazing Recreation	Recreation CO_2-storage Climate/air Biodiversity Cleansing capability Flood defence	Changing land use Acid rain
Mountain	Mountains Wetlands Watercourse environment Glaciers	Rough grazing Recreation Game/ berries/ mushrooms/ fish	Biodiversity Water reservoirs	Traffic Acid rain Pasture Hydropower installations Power lines Holiday cottage building

4.6 Underlying reasons for change

The most important underlying reasons for changes (drivers) in the ecosystems' ability to supply values and services are connected with population and consumption level. Here we use data for population growth as an example of such an underlying reason for change. **Figure 7.2** shows the relative development in the populations of the four counties which cover most of the Glomma river basin – Østfold, Akershus, Hedmark, Oppland – since 1951. It is clear that the population of Akershus has increased most, while Hedmark and Oppland have experienced very little growth during this 50-year period. Østfold shows a greater increase than Hedmark and Oppland, but much less than Akershus. In a full-scale analysis it will be possible to analyse changes in real income and consumption patterns, as well as increases in transport and trade, as an expression of how the population increasingly obtains its incomes and the goods and services it uses from outside its own local area.

4.7 Pressures

Changes in population size and consumption pattern and level lead to changes in occurrence and condition in the different ecosystems or natural environment types. Among the most important pressures in Norway are infrastructure development, and changes in agriculture and forestry management. Pollution, particularly long-transported pollution, is also important in certain parts of the Glomma river basin (National Pollution Authority 2001). Local pollution sources have also had significance for the condition of parts of the watercourse, but various initiatives, such as cleansing of emissions, have mitigated this. Climate changes may also become an important factor in the future. Neither climate changes or pollution will be dealt with further in this report.

The construction of roads and other infrastructure brings with it change in land use away from agriculture, forestry etc., with the aim of satisfying the population's needs for transport, settlement or industrial production.

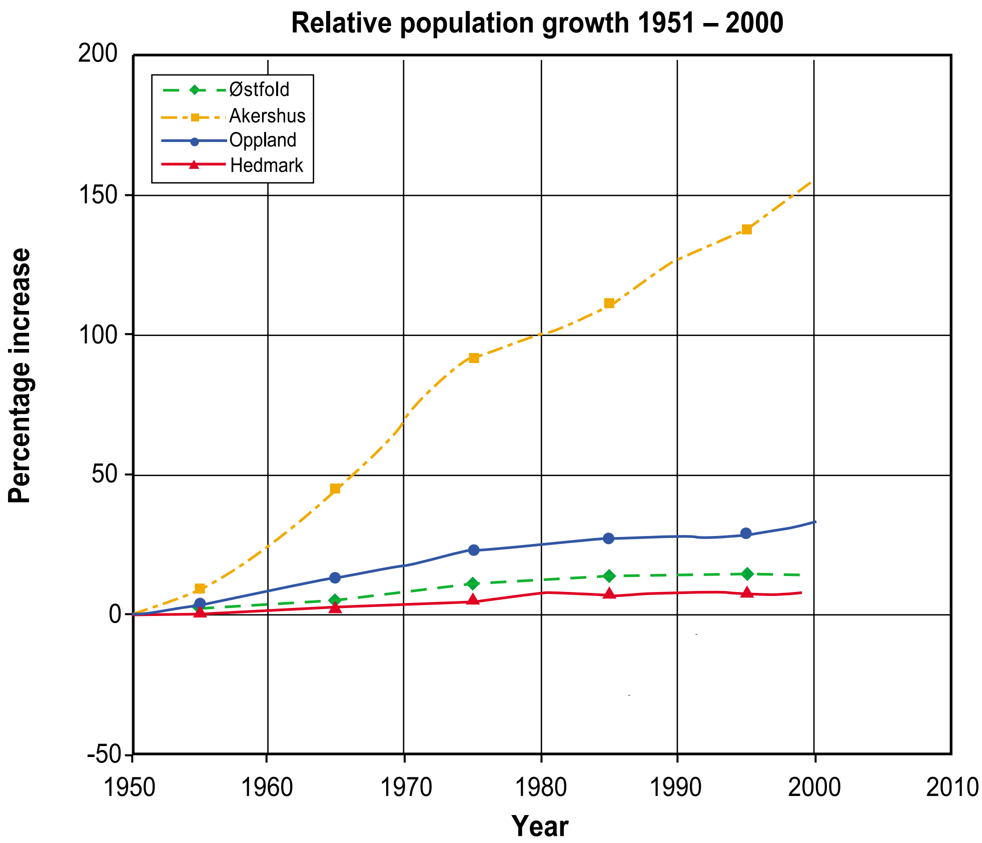


Figure 7.2
Relative population growth in the counties of Østfold, Akershus (not including Oslo), Hedmark and Oppland during the period 1951 to 2000. The population in 1951 is set as a common starting point, and the increase in the subsequent period is calculated as a percentage of the starting total for each individual county. The population totals in 1951 were: Østfold, 185492; Akershus, 183116; Hedmark, 173167; Oppland, 160496. Data from the Central Bureau of Statistics.

Changes in agriculture lead to land-use changes (e.g. from forest to cultivated land) and changes in the structure of the cultural landscape. Changes in forest management often lead to changes in forest species and age composition, and changes in the forest ecosystem's structure and function.

These keywords suggest that pressures are for the most part connected with society's use of ecosystems as means of satisfying diverse needs; we extract different products and services from the ecosystems. At the same time this leads to a reduction in the ecosystems' ability to supply other products and services. Nearly every use of nature entails a conflict or clash of interest with other forms of use. The management of natural resources is aimed at assessing exactly these forms of conflict or trade-off situations, in order, among other things, to reduce conflicts.
Below, we present the development of some of these pressures in the Glomma river basin, with the aim of illustrating some trade-off examples.

4.7.1 Infrastructure

Road density
One of the pressures closely connected with population density is road density. **Figure 7.3** shows the road network in the Glomma river basin, reproduced with a "road zone" of 200 m on either side of the road. The map also shows the relative density of forest roads and private roads. In the overview we have distinguished the mountain areas over 1000 m.a.s.l. from the other areas which are mainly different types of forest landscape (see **figure 7.1**).

With access to more detailed information about land surface cover one would be able to analyse the surface cover of the areas (agriculture, forest etc.) and follow the development of surface cover and ecological function over time. The N250 map base is not refined enough to make this meaningful, so we have not conducted practical experiments in this direction. The "road base" contains fields which specify the building dates for roads, but these have not usually been filled out for older roads. Use of the database for analyses of chronological development therefore require a substantial amount of extra work and this has not been done here.

For forest areas that are located more than 1 km from a public road, we have measured the frequency of forest roads and private roads as an index of human activity and industrial activity, in this case mainly forest management. This can also be done in the mountain areas even though it is not shown in this figure. Viewed together with maps of encroachment-free areas (see **figs. 7.4 and 7.5**), this supplements the regional picture of human activity and ecological function in a gradient from urban areas to wilderness. Since the "road base" is continually up-dated, this will also form a good surface-cover indicator which can be broken down in order to view development in selected types of landscape and natural environment at all desired scales. It is worth noting that in the forest areas in the lower-lying parts of the river basin, there are very small areas which are not influenced by any form of road. The situation is somewhat different in the mountain areas.

Encroachment-free areas
The work of mapping encroachment-free areas has its starting point in road construction and other permanent or substantial technical encroachments. **Figure 7.4** shows the status for encroachment-free areas in the Glomma river basin in 1998. This confirms the picture conveyed in **figure 7.3** based on road density. The areas with relatively untouched nature are concentrated in the northerly and higher altitude parts of the basin. Some small areas in the lower-lying forest tracts which were situated relatively far from technical encroachment in 1988 have been reclassified during the ten-year period up to 1998, so that today there is no area south of the axis Trysil – Elverum – Hamar – Gjøvik which is more than 1 km from a technical encroachment.

Figure 7.5 shows the development from 1900 via 1940 to 1998 for areas situated more than 5 km from a technical encroachment. The figure reveals that already by 1940 there were only very small areas with wilderness character in the southern part of the river basin.

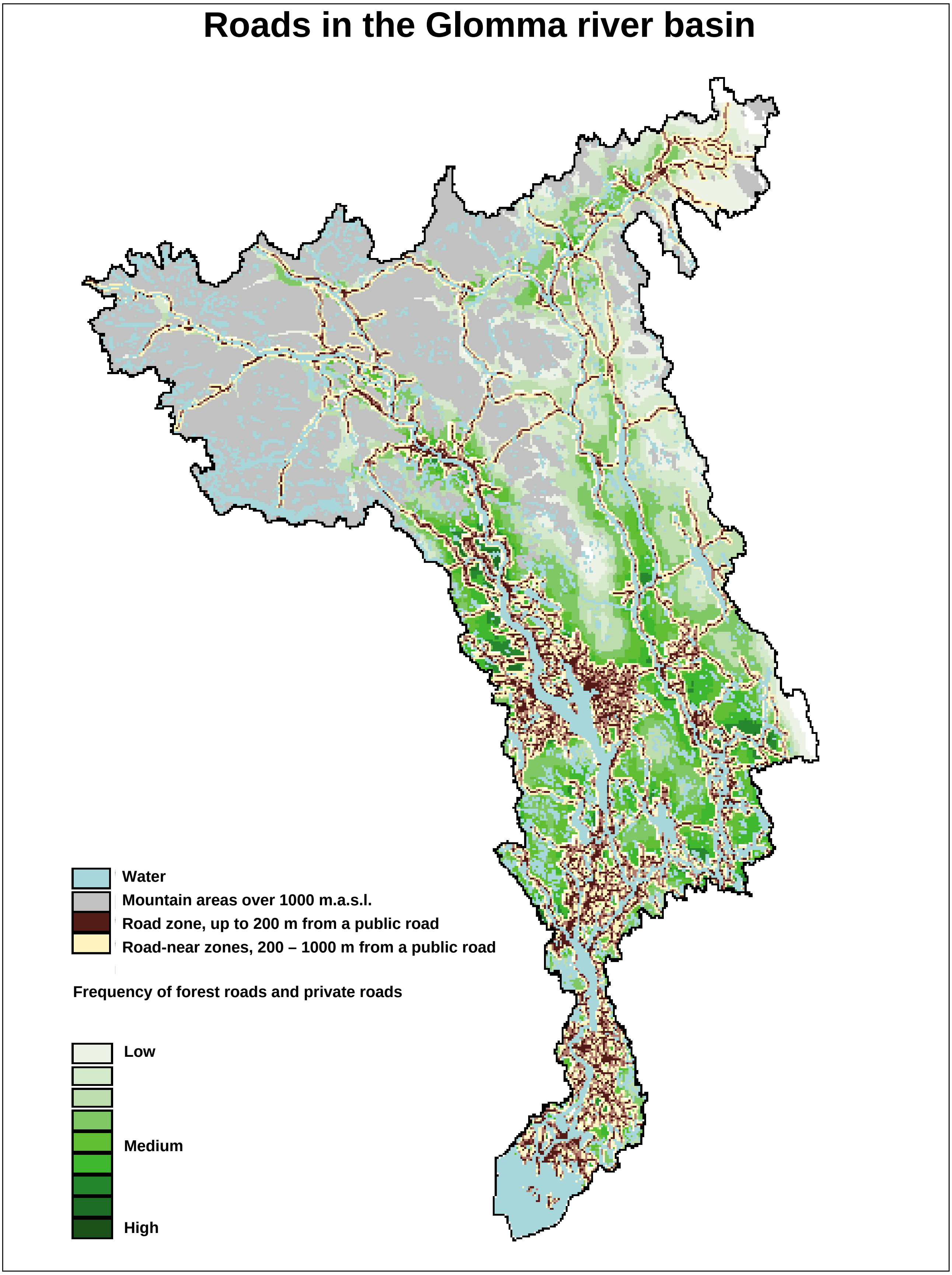


Fig. 7.3
Roads in the Glomma river basin. The public roads are shown as 400 m-wide zones in brownish red, together with road-near zones (200-1000 m distance) coloured pink. The density of forest-vehicle tracks and private roads is reproduced in a relative colour scale (not including the mountain region). The calculations are undertaken using GIS raster techniques. All public roads are transferred to a 50x50 metre raster with 400 m breadth ("road zone). Outside this zone (up to 1000 m from the road) we have laid a "road-near zone". In the figure, these two zones will appear as the main road network, but at more detailed scales they will comprise areas representing two classes of distance from public roads. Data from "the road base" (The Directorate for Roads).

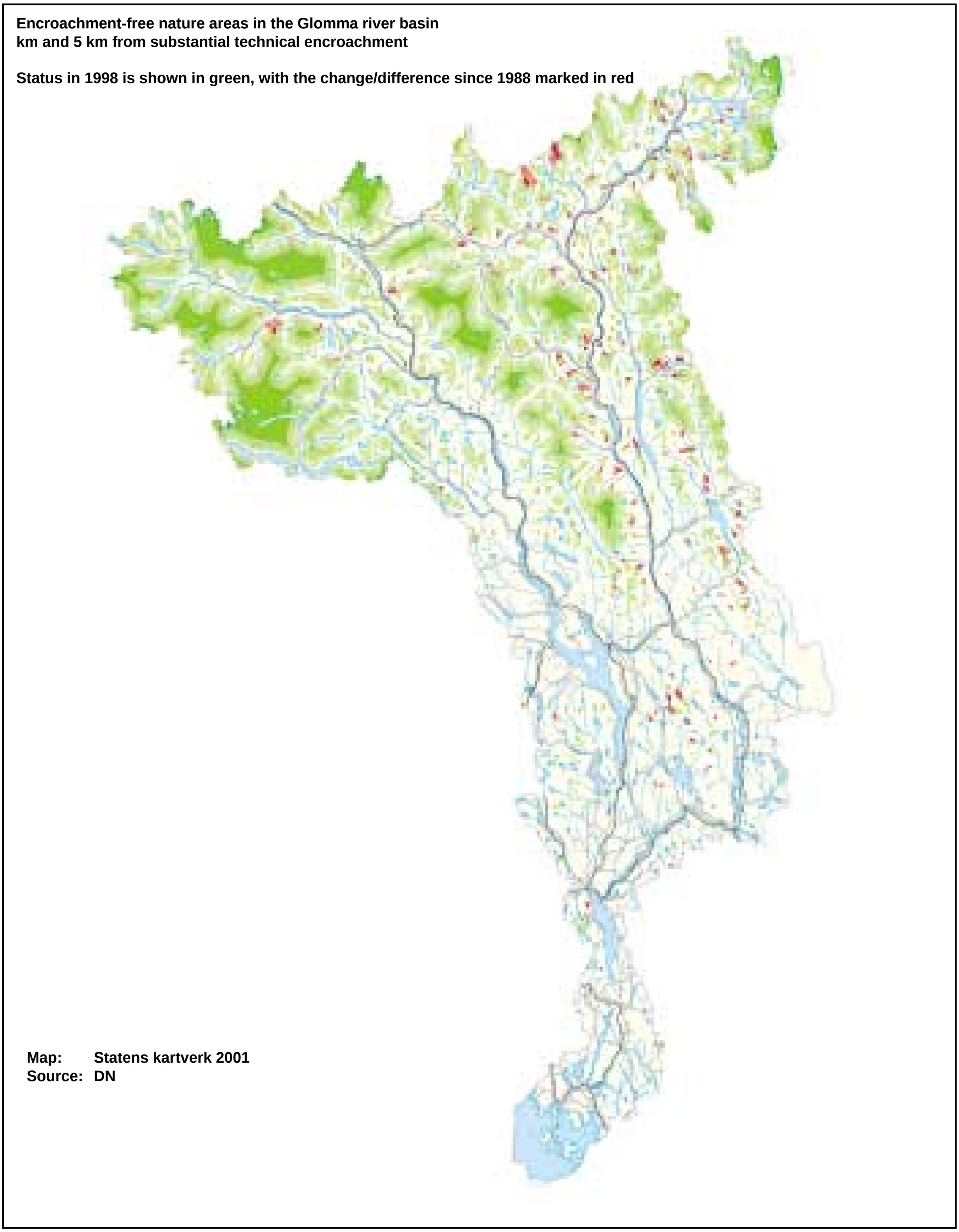


Fig. 7.4
Areas situated more than 1, 3 km and 5 km from the nearest technical encroachment in the Glomma river basin. Data from DN.

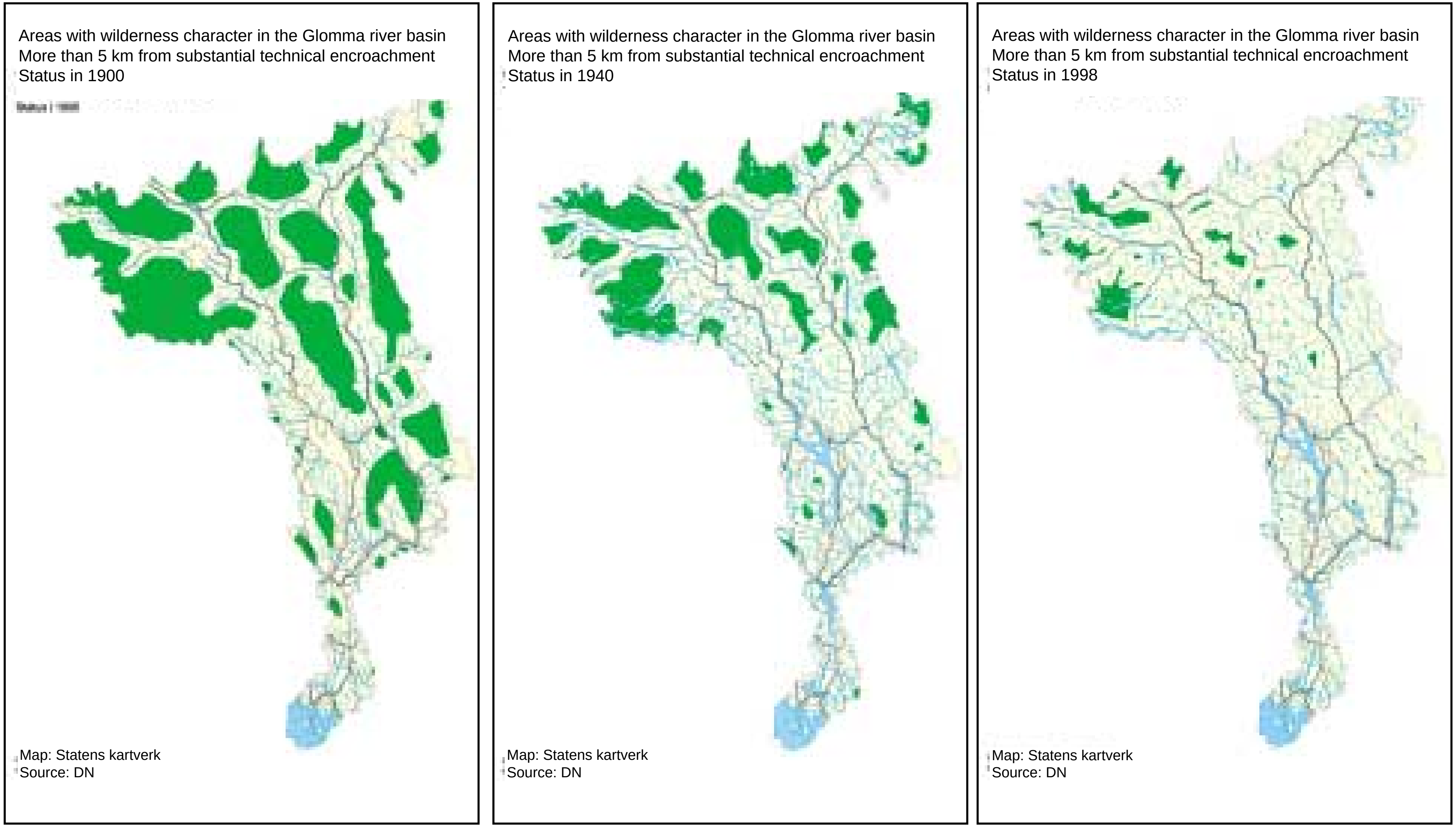


Fig. 7.5
The development of areas with wilderness character in the Glomma river basin from 1900, through 1940 and up to 1998. An area with wilderness character is defined as an area situated at least 5 km from a road or any other technical installation. Data from DN.

Infrastructure and biological diversity – examples from the mountains

Road density and the area of encroachment-free land are readily interpreted as indicators of the incidence of natural or relatively untouched ecosystems ("wilderness"), and of the occurrence and condition of wild plants and animal species. However, there is little concrete knowledge about how a road influences nature in the areas alongside it. An important question which needs to be addressed is: what is the actual situation for biodiversity in the zones 0-1, 1-3 and 3-5 km from the road? (cf. **fig. 7.4**). A number of results are available from the mountain ecosystem, where research has been conducted into the wild reindeer's relationship to roads, holiday cottage concentrations and other tourist amenities in the mountains. We will present these results in some breadth. It is important, however, to remember that what is relevant for one mammal species such as wild reindeer is not necessarily relevant for other mammals, other plants or other animals.

Historical development in the mountains

About one third of the area of the river basin of the Glomma-Lågen comprises mountain over 1000 m.a.s.l. (**fig. 7.1**). This area is characterised by variable amounts of snow, varying from very little in the central parts of Rondane, to large amounts in the south near Lillehammer. The area includes, among other things, the last remnants of Europe's stock of genuinely wild reindeer (as opposed to tame reindeer which have become wild), and has a range of threatened animal and bird species, including wolverine, wolf, arctic fox and gyrfalcon. There are a number of national parks and conservation areas in the region. The areas can be described as some of the few remaining relatively untouched mountain ecosystems in Europe, but this situation is fast undergoing change. Nonetheless, the mountain ecosystems are still important suppliers of products and services. These benefit the local communities (alpine communities), but a more important impulse behind the mountain region's development is that many of the products and services are in demand from society in general i.e. the markets in the low-lying and urban areas.

The mountain areas have been exploited throughout thousands of years for hunting, fishing, berry-picking, haymaking (on mires) and comprehensive pasturing of horses, cattle and sheep. Many alpine dairy farms are now falling into neglect as alpine dairy farming is abandoned. Alpine dairy farming nonetheless continues in some areas, while haymaking on mires has been abandoned completely. Today, grazing consists almost exclusively of sheep grazing. While, for example, willow (*Salix* sp.) suffers greatly as a result of grazing, species such as juniper (*Juniperus* sp.) are fast increasing. There is still some commercial fishing in the mountain region, although recreational fishing dominates.

The mountain areas have traditionally been very important recreation areas, a function which is on the increase. There is a comprehensive network of marked footpaths for walkers/skiers, and a broad range of fishing and hunting on offer. The wild reindeer stock is regulated exclusively through hunting, and 1500-2000 wild reindeer are shot annually in the Glomma-Lågen river basin and associated wild reindeer areas (Nord-Ottadalen, Nord-Rondane, Sør-Rondane, Knutsø, Snøhetta Øst and Snøhetta-Vest). The most noteworthy development within the sphere of recreation concerns alpine amenities and holiday cottage building. Some 500-1000 new cottages are built *annually* in the region, while more than 10,000 are planned. Most are built in the alpine forest belt . These are frequently large cottages (>150-200m^2), with connected sanitation facilities, roads and other infrastructure. Many of the areas given over to cottages contain concentrations of many thousands of cottages, together with shops and other services.

Alpine recreation consists of everything from individual use in the form of walking, hunting, berry-picking and fishing, to massive commercial development. Collectively, this forms one of the fastest growing industries in these communities. The economic interests represent billions of Norwegian kroner (NOK) and contribute significantly to local economy and employment.

In the course of the last 50 years, the construction of roads and hydropower installations have also changed the mountain areas. Most of the larger rivers and lakes have now been regulated or dammed, and bridges, roads and power lines have been constructed. These activities have had great economic significance for local communities and for the region as a whole. Military activity has also influenced the mountain areas. Shooting ranges can be specially mentioned, the most important being the Hjerkinn/Snøhetta range in the north. The ranges attract activities connected with military exercises, the construction of shooting facilities and other forms of infrastructure of more local character.

The mountain areas supply water for power stations, drinking-water and irrigation installations, and the annual snowfall and snowmelt are closely monitored, also with an eye to the risk of flooding. Hydropower regulation and reservoirs can reduce the effects of spring floods, while the risk of autumn flooding has increased.

Infrastructure and wild reindeer

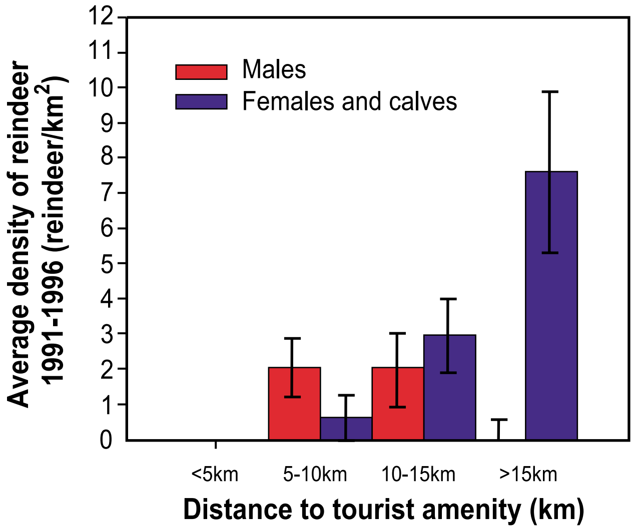
The development of infrastructure in the form of holiday cottages, roads, power lines, dams, power stations and railways has led to major consequences for the wild reindeer stock in the alpine areas of the Glomma river basin.

Encroachments during the 20th century led to the fragmentation of the wild reindeer population (both the original population and the formerly tame animals which turned wild), so that today we have in all 6 disconnected populations. There is a large winter grazing area in Rondane, but the comparative lack of summer grazing and much disturbance has led to low slaughter weights indicating poor food availability. In the Snøhetta area there is much summer grazing, but little winter grazing, and there is a persistent problem with over-grazing. The outcome of this is that the reindeer numbers for the region as a whole have had to be kept extremely low. The restrictions imposed on the reindeers' movements also make them very vulnerable to climatic change.

The most important winter grazing areas lie on the margins of the alpine areas - precisely those areas most exposed to construction development. A series of investigations has shown that the reindeer, and especially females with calves, avoid grazing on otherwise vitally important pasture near concentrations of holiday cottages. There is typically a 50-90% reduction in grazing within a distance of 2-5 km from tourist facilities (**fig. 7.6**). Together with fragmentation, this major development has led to a significant reduction in the area's ability to sustain reindeer.

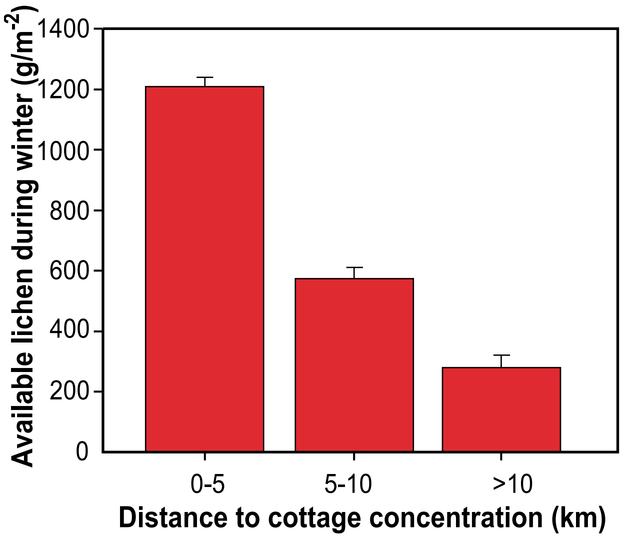
Indirectly, the construction of infrastructure probably has a positive effect on some of the medium-sized predators, such as crows and red foxes, for example. This is the result of an increase in refuse and litter (alongside roads) and an increase in marginal zones (ecotones) which favour these groups. This has negative consequences for other birds and possibly also for a highly threatened animal species such as the arctic fox.

Infrastructure construction is also believed to cause greater conflict between sheep farmers and predators. Predator species such as wolverine, for example, prefer to keep away from roads and built-up areas, and are therefore pushed into increasingly smaller areas. This leads to particularly high predator losses in these areas (**fig. 7.9**).



The effect of roads and cottages on lichen degradation. The reindeer first graze down the areas which lie furthest from technical encroachments, while the extensive, rich pastures on the margins of the mountain areas are largely untouched due to disturbances. The figure shows lichen quantities for comparable heights and snow conditions.

Fig. 7.8

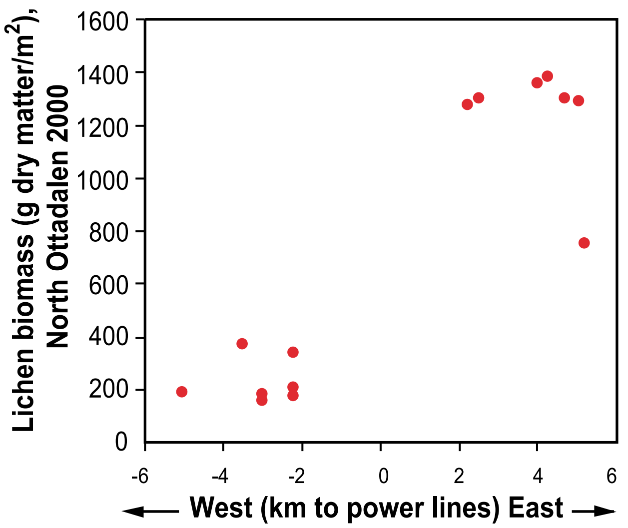


Large parallel power lines form barriers which reindeer seldom cross. As a result, large areas of unused winter grazing (lichen) arise. The differences in grazing resources can be great within small areas on the available side (the west side in this case) and non-available side (the east side) of the barrier. In addition to the effect of dams on grazing areas, the infrastructure associated with hydropower development contributes to the major reduction in the reindeers' grazing area. The observations are from Slådalen in the North Ottadalen wild reindeer area, 2000.

Fig. 7.6

The effect of roads and cottage concentrations on wild reindeer in North Rondane. The reindeer often avoid very good winter grazing land in areas near roads and cottages and confine themselves to increasingly smaller areas 5-15 km from cottage concentrations and roads.

Fig. 7.7



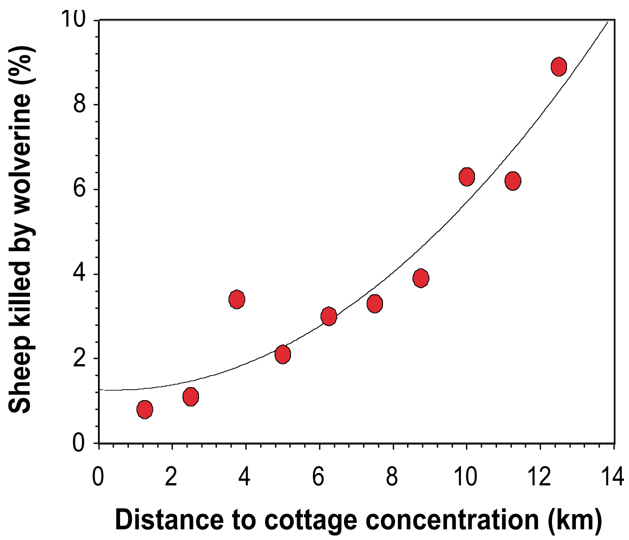


Fig. 7.9
Provisional calculations of the risk to sheep from predators in relation to distance to cottage concentrations and roads in a mountain area in Lesja. (The calculations are based on actually registered sheep cadavers thought to have been killed by wolverines corrected for the distribution of sheep in the landscape. Data from the County Governor's Office, Oppland). Even though the wolverine will often follow its prey, it avoids areas containing much traffic and people, such as cottage concentrations. The results provisionally suggest that wolverines concentrate much of their hunting activity on sheep in less disturbed areas, leading to particularly high losses for some farmers, which in turn leads to increased levels of political conflict. The predator problem cannot therefore be solved simply by controlling the number of predators, but will also be influenced to a large degree by access to encroachment-free areas.

4.7.2 Technical installations on the watercourse

A number of user groups have interests in the Glomma watercourse. Some of these interests lead to technical encroachments which influence the entire watercourse or parts of it. The encroachments that are carried out can have a basis in important social interests, such as the production of electric power or the securing of infrastructure or settlements against flooding, or they can be based in private industrial interests, e.g. gravel extraction. Alternatively, they can be founded on the needs of specialised user interests requiring specific forms of preparation. In this connection, we concentrate on encroachments or initiatives which have a major social value in that they provide a significant profit in the form of products and services which are in demand by society. Such initiatives have been relatively extensive in the Glomma river basin during the last 100 years. Their cost takes the form of changes in the condition of the natural environment and the values connected with this, as well as a reduction in opportunities for the exploitation of other forms of resources or services.

NVE's encroachment register (a part of the Watercourse Register) is used to make an overview of the development of measures implemented on the Glomma watercourse in the form of structures associated with erosion- and flood-protection. In addition, data from the Glommen and Laagens User's Association (GLB) is used to produce an overview of developments in hydropower development (reservoirs and power stations) and energy production on the Glomma watercourse.

According to the DPSIR model, measures taken to secure against flooding and erosion, and structures associated with power generation form important pressures. The electricity which is generated, and the measures taken to secure land areas and infrastructure against flooding and erosion constitute important products and services.

Flood and erosion

Flood defence is a physical initiative for reducing the risk of damage through the submergence of settlement, communications, cultivated land etc. This measure is implemented by the building of flood embankments along the riverbanks, or by lowering or correcting the course of the river so that it has a greater area and consequently an increased capacity.

Erosion protection is a physical initiative taken to reduce the risk of damage to settlement, communications, cultivated land etc. by protecting riverbanks and/or river bottoms against excavation by water. Stone is the dominant material in such structures, but there are also examples of the use of other materials, such as gravel, timber, vegetation, concrete and fibre cloth.

Development through time
Securing against flood and erosion have long traditions in the Glomma watercourse. Already during the 19th century, when the construction of the road network, and later the railways, really took off, a great need arose to secure the new lines of communication against erosion and flooding. Similarly, the development of agriculture led to an increase in the use of land near the watercourse for agricultural production, with an accompanying need to secure these areas against flooding. The agricultural area in the Glomma river basin has increased significantly, especially since 1930. (The development of fully cultivated land from 1969 to 1999 is shown in **figure 7.20**).

Figure 7.10 shows the development of erosion protection measures in the Glomma watercourse since 1890. Today, a total of c. 400 km of river in the Glomma watercourse (the main river course and tributaries) has been modified in this way.

Figure 7.11 shows the corresponding development for flood-defence measures. There is currently a total of c. 240 km of river which has been modified to secure against flooding. There has been a strong increase in both types of measure after 1980. The 1990's are also distinguished by the fact that the increase in the construction of flood defences has been greater than the increase in anti-erosion structures, with the result that the respective lengths of river which underwent both types of adaptation roughly corresponded in the 1990's. The major flood in the Glomma/Lågen in 1995 increased the speed of construction of flood defences and measures taken to reduce problems connected with erosion.

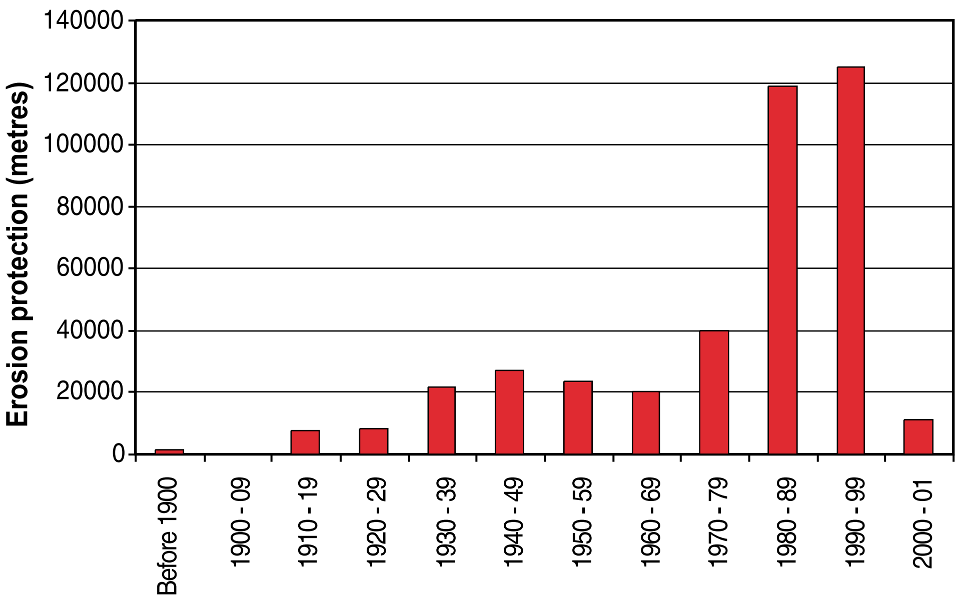


Fig. 7.10
Erosion protection measures in the Glomma watercourse 1890-2001, represented as the number of metres of river stretches influenced by measures taken per decade. The total erosion-secured stretch of river is c. 400 km. Data from NVE, Watercourse register.

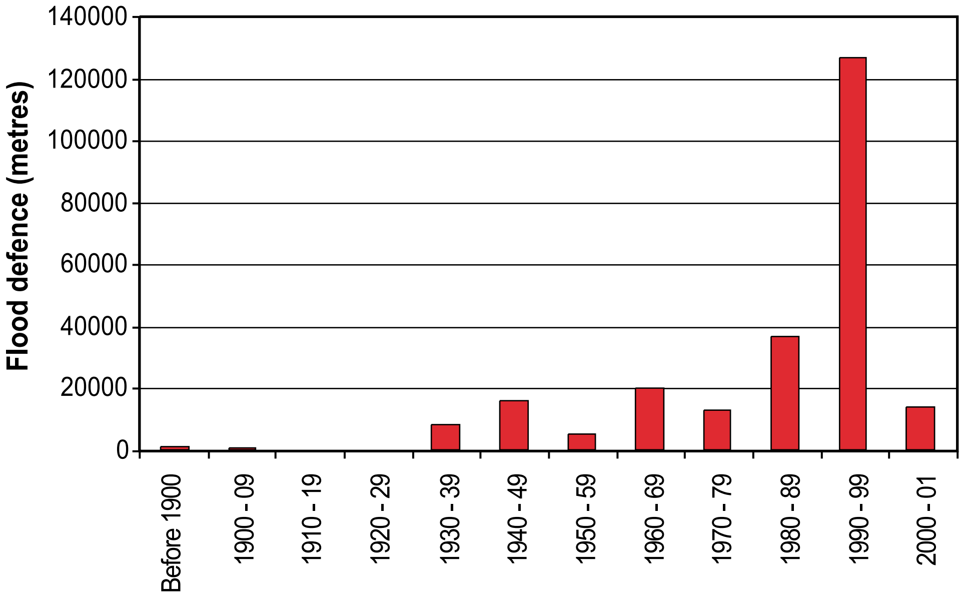


Fig. 7.11
Flood-defence measures along the Glomma watercourse 1890-2001, represented as number of metres of river stretches affected by measures taken per decade. The total stretch of river secured against flooding is c. 240 km. Data from NVE, Watercourse register.

Ecosystem effects
When the water level in rivers or lakes rises and floods areas which are normally dry land, a natural decrease and delay of the flood's peak occurs. This effect will be particularly great where the watercourse has many lakes or relatively large flood plains i.e. low-lying land alongside the river. Flood defence structures will have a negative influence on the watercourse's ability to regulate itself, in that the amount of water which is stored will be reduced. The result is that the flood peak will arrive more quickly and reach a higher maximum level. Flood defence measures located upstream will increase the flood peak's height and intensity downstream. Since flood defence structures influence the course of the flood itself, this will produce negative ecological effects downstream from where they have been established, through increased erosion in the river course, for example.

Along a stretch of river where measures have been taken, contact between the river and the flood plains will be closed. Areas which are to be protected against flooding often comprise cultivated land or concentrated settlement, so that the purpose of flood defence is primarily to impede or reduce economic loss arising from floods. Areas with natural vegetation and animal life are also affected, and natural habitats which are adapted to annual flooding will develop more terrestrial plant and animal communities over time.

The ecological effects of erosion protection measures will primarily be connected with the fact that they contribute to reducing the production or addition of erosion material in the watercourse. This is positive in relation to the sedimentation of spawning or nursery grounds for salmon fish and for zoobenthos species which are dependent on a stable and heterogeneous bottom substratum. The negative effect will principally be connected with the fact that dynamic processes associated with the formation of new river courses will either stop or diminish, and contact between the river and neighbouring marginal zones and flood-plain biotopes will be poorer. This leads to the loss of diverse wetland biotopes and flood-plain areas with their own special plant and animal life. Such biotopes are rare today and usually need protection.

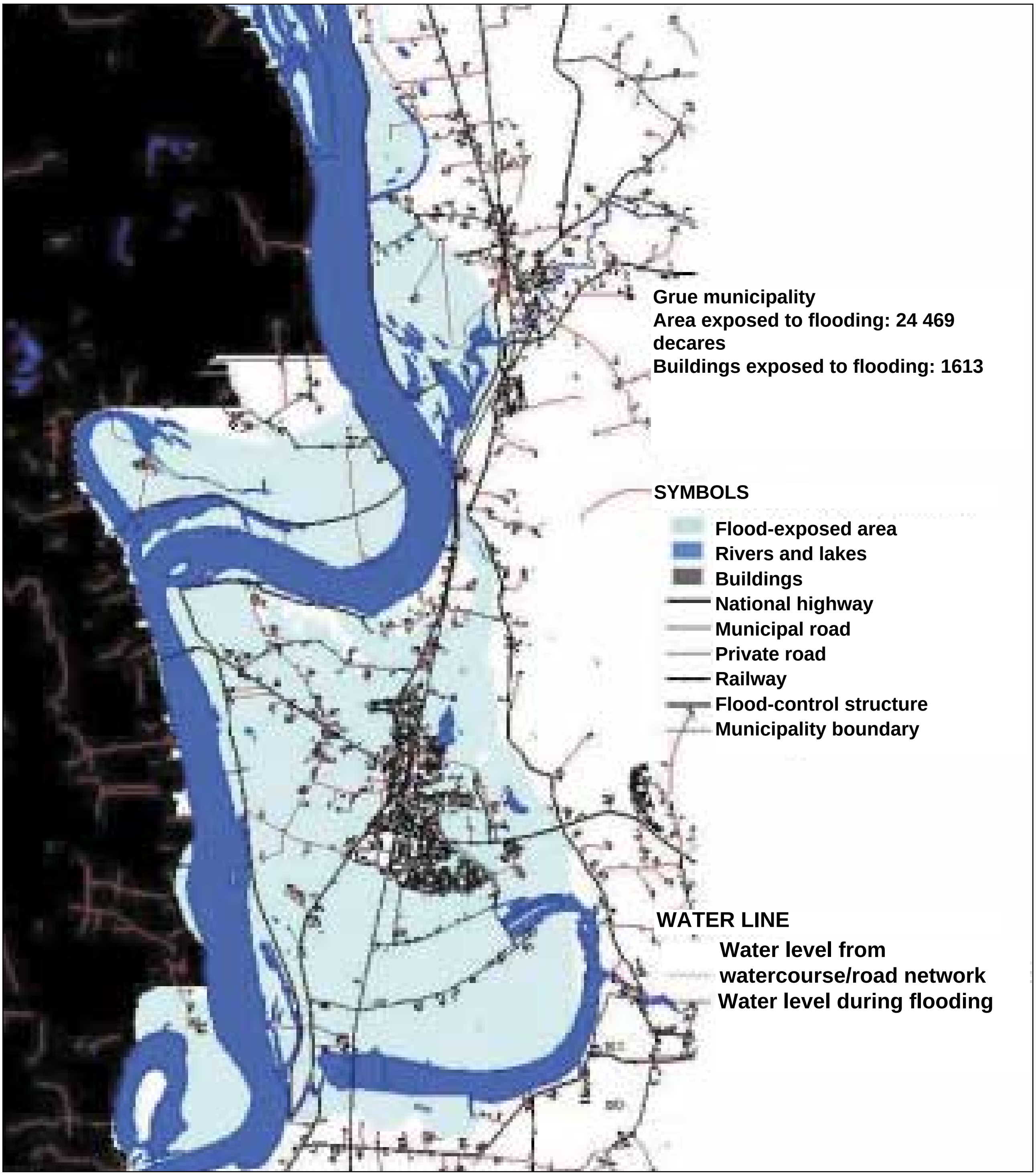


Fig. 7.12
An example of changes resulting from flood defence measures, Grue municipality, Hedmark. Most of the flood-prone area (light blue) of nearly 2,500 ha will be protected against flooding through planned and completed embankments. Data from NVE.

Hydropower

Extent and development

Hydropower development has been a dominant user-interest in the Glomma watercourse for more than 100 years. The production system for hydropower in the watercourse currently consists of more than 50 power stations and c. 40 hydropower reservoirs (**Figure 7.13**). Development has taken place in stages from the end of the 19th century up to today, and the generation of electricity has increased gradually with the establishment of new power stations and reservoirs and their integration into the system (**Fig. 7.14**). Today (2001) the total installed effect in the Glomma power stations is 2,165 MW and the total annual production of electric power lies at c. 10 TWh. The coordination and management of the regulating reservoirs on the Glomma are organised through the Glommen and Laagens Users' Association (GLB).

Ecological effects

The normal cycle of regulation in the reservoirs on the Glomma watercourse is that they are filled in summer and autumn and then gradually emptied during the course of winter at the time of greatest energy demand. This entails a change in the natural water flow regime downstream from the reservoirs, with a reduction in summer water flow and increased winter flow. In addition, the stretches of river below the falls which are exploited will have a diminished water-flow level equivalent to the amount of water which is channelled through tunnels and power stations. Such stretches of river as a rule have a stipulated minimum water-flow level set out in the concession terms. In older concessions this minimum flow can be small or not enforced at all.

Because the regulating reservoirs on the Glomma watercourse are mainly based on natural lakes, the total dammed area on the watercourse is relatively small, namely 46.6 km^2. The area affected is somewhat larger because the regulation zone also includes the lowering of the regulation reservoirs. Ecological effects in the reservoirs themselves are connected with the erosion and deterioration of the living conditions for plants and animals in the regulation zone and general decline in the production of harvested species. The trout populations in long, shallow reservoirs in the mountains are particularly badly affected. The negative effects are greatest where the trout occur together with fish such as char and whitefish.

Some examples of the effects on fish catches in hydropower reservoirs

Lake **Tesse** lies on a tributary watercourse to the Gudbrandsdalslågen and was first regulated in 1943. The regulation was expanded in 1963. The regulated height is currently set at 12.4 m.

Annual production of trout during a 14-year period from 1979 to 1992 was 850-3500 kg. This corresponds to 0.6 to 2.5 kg per hectare (Hesthagen 1997). Catch statistics for a 10-year period (the 1930's) prior to regulation indicates an annual catch that was three times greater than it was following regulation. The available food for trout was reduced in the Tesse following regulation, by, among other things, the disappearance of *Gammarus lacustris*, and a sharp decline in populations of snails and mussels. The effect on planktonic fauna has been small, but trout are note able to utilise this source of food to compensate for the loss of the littoral fauna.

In **Vinstern**, which is a reservoir with a regulated height of 4 metres, the trout catch has varied between 0.60 and 1.73 kg per hectare in the period 1973 to 1993. This is thought to be similar to the yield prior to regulation. Regulation here has had little effect on the crustacean *Lepidurus arcticus* which is the most important source of food for trout in many mountain lakes (Hesthagen & Gran 1997).

In hydropower reservoirs such as **Osensjøen** and **Aursunden** in the Glomma river basin, the fish communities prior to regulation were characterised by dense and slow-growing stocks of grayling, whitefish, etc. Following regulation, numbers have fallen but the individual growth rate has increased. The result is that the total fish production and potential catch have fallen, while fishing has become more attractive due to the increase in fish size (Quenild 1981, Linløkken &Quenild 1987, Linløkken 1990, 1992, 1993).

Downstream from the reservoirs, the ecological effects will depend on how great the changes in water flow are. On minimum-flow stretches, the water-covered area that is available for biological production will often be severely reduced. In addition, spawning and nursery areas for harvested species such as trout, for example, will deteriorate due to changes in the speed of the current and erosion. In the lower reaches of the Glomma, rapids are rare, and those that exist are often called “waterfalls”. The power stations on this part of the watercourse are for a large part built on rapids, so that riverine habitat elements which were previously naturally rare are even more so today.

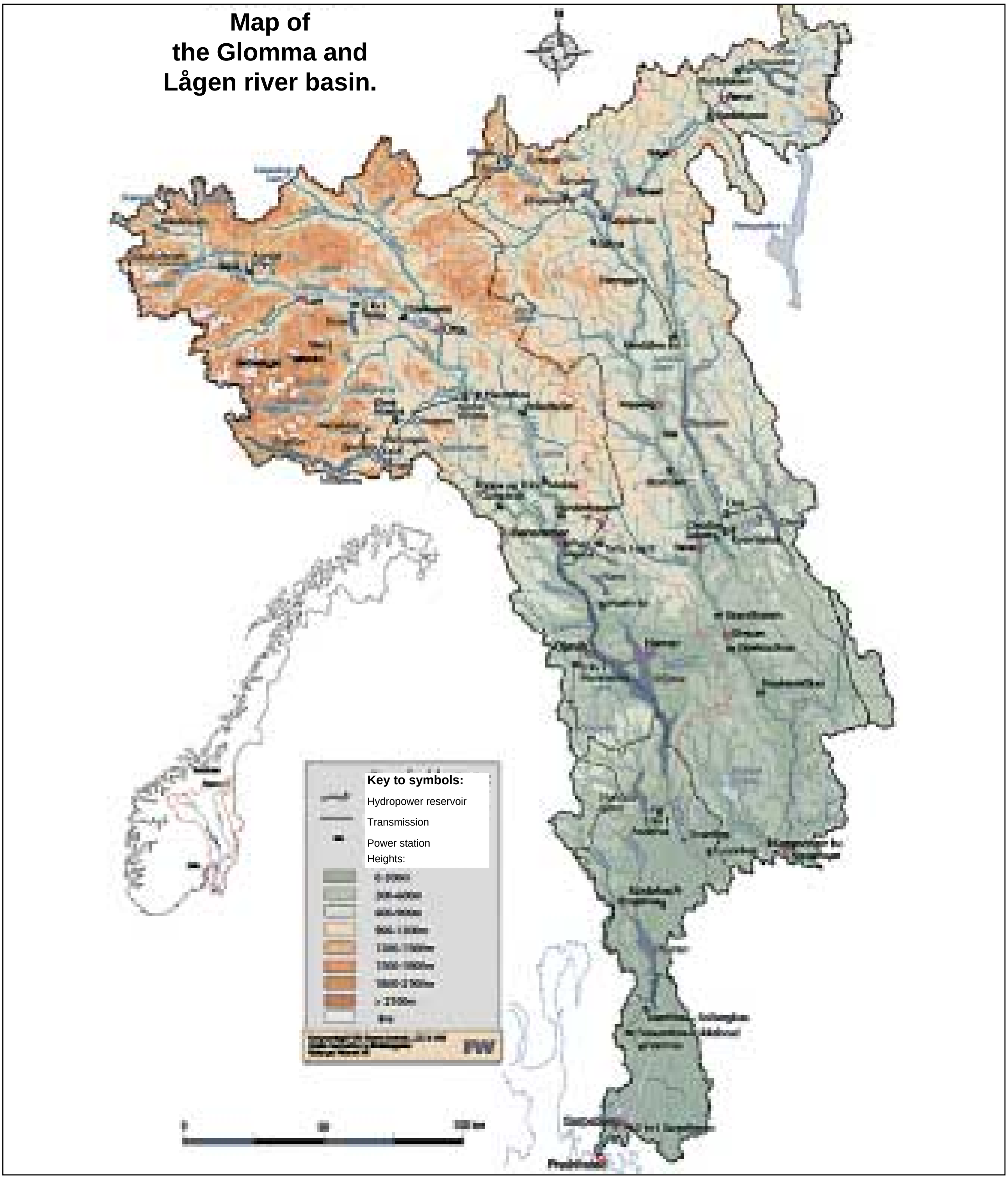


Fig. 7.13
Hydropower development on the Glomma watercourse. The installations and facilities today include more than 50 power stations and c. 40 reservoirs. Data from GLB and National Mapping Authority.

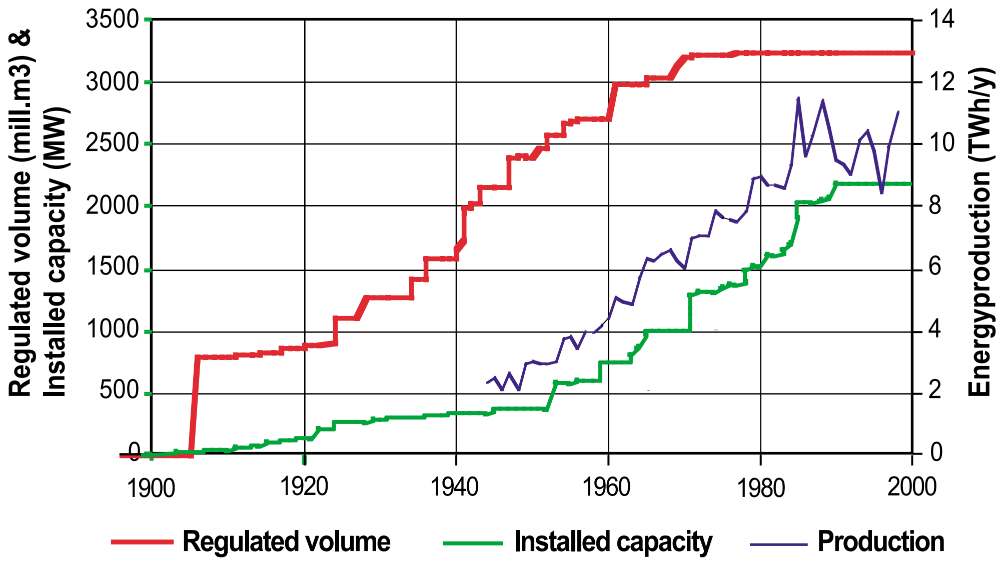


Fig. 7.14
Regulated volume (mill. m3), installed capacity (MW) and annual production (TWh) on the Glomma watercourse. Source: World Commission on Dams (2000).

In natural river systems many fish species undertake long spawning and feeding migrations. Dams and other hydropower-related installations on the watercourse form barriers for fish migrations. Prior to the regulations in the Glomma, species such as trout and grayling could migrate from Øyern in the south all the way up to the upper reaches of the river. The migration pattern prior to regulation is not known in detail, but it is clear that the Glomma did have strong migrating populations of both large trout and grayling. Following regulation, these migrations have been strongly affected by the barriers formed by the dams. A number of fish-ladders have been built as compensatory measures, but the number of fish which pass through the ladders is low and tagging experiments suggest that the original migratory patterns are to a great extent broken (**Table 7.3**). This is especially the case for grayling (Quenild & Linløkken 1989).

In the lower Glomma, there are a number of dams where no fish-ladders have been built. The falls on which these dams are built probably formed migration barriers for most fish species even before the dams were built. The only exception is the eel, for which the dams formed a barrier for migration up the Glomma. These dams consequently form a bottleneck impeding potential eel production on the Glomma watercourse.

Table 7.3
Overview of the fish-ladders on the Glomma watercourse, and an evaluation of their function. Source: Report from the Committee on Fish-ladders 1990.

		Function		
Part of river basin	**Number of fish-ladders**	**Good**	**Less good**	**Does not function**
Lågen	21	5	5	11
Glomma	10	3	7	-
Downstream of confluence	3	1	2	-
Total	**34**	**9 (26%)**	**14 (41%)**	**11 (32%)**

Pollution of the watercourse

The Glomma and Lågen have always functioned as recipients of waste from human activity. When supply of waste material becomes too great, several other services and products we desire from the watercourse are damaged. From the mid-1950's and throughout the 1960's and 70's the pollution load on the watercourse reached a critical level. We saw the clearest results in Lake Mjøsa and its tributaries, where surface run-off from farmland, leakage from manure storage and unprocessed household sewage caused serious problems. During the1970's, Lake Mjøsa experienced a major algal bloom, including poisonous cyanobacteria ("blue-green algae"), to the extent that the use of the lake water for drinking, bathing and fishing suffered. Tributary rivers and streams experienced so-called heterotrophic growth i.e. the normal ecosystem which, among other things, produces juveniles for the large brown trout stock in Lake Mjøsa, was destroyed. The principal reason for these changes was a much greater influx of phosphorus to both the lake and running waters than they were able to absorb without undergoing major changes in the ecosystem (Nashoug 1999). When the "Mjøsa Action" was launched in 1973 and expanded in 1977, it was an all-out effort made necessary by nearly one hundred years of neglect regarding sewage processing and agricultural and industrial cleansing measures.

During the second half of the 1970's a major drop in pollution levels was achieved by implementing comprehensive mitigation measures (http://www.fylkesmannen.hm.no/org/miljoe). Important elements were, for example, cleansing plants for sewage from villages and towns, a total renovation of the drainage system for sewage and surface water in towns, measures for processing sewage from dispersed settlements, renovation of manure storage facilities and fodder silos, as well as the reduction of surface run-off from cultivated land.

Developments in Lake Mjøsa during the 1960's and 70's demonstrate the fact that the limits of nature's own renovation service, whereby the watercourse absorbs and decomposes pollutants, were about to be exceeded. It is difficult to calculate the economic value of this service, but the costs of measures subsequently needed to clear up and cleanse provide a picture of the economic values represented by these ecosystem services. According to the Steering Committee for the monitoring of Lake Mjøsa, the total costs of the measures which were launched as a result of the Mjøsa Action from 1973 through to the 1990's reached NOK 5.3 billion (recalculated at 1998 prices) (Nashoug 1999). The steady maintenance of drainage systems, cleansing and anti-run-off measures would have been far cheaper, even though such an analysis is not available. It is quite clear that without these measures further eutrophication or over-fertilisation of the watercourse would have occurred. In Lake Mjøsa we would have probably experienced an irreversible development involving oxygen deficiency in deep waters and annual mass blooms of partly poisonous algae (see e.g. Kjellberg 1986).

4.8 Products and services from the ecosystems

A significant amount of food and fibre is harvested from both the “natural” and the human-dominated ecosystems in Norway. We present here some examples of developments over the last decades in the harvesting of different products of this type from the Glomma river basin, or the four counties which cover most of the basin (Østfold, Akershus, Hedmark, Oppland). A more detailed analysis lies outside the pilot study’s mandate and resources.

4.8.1 Hunt yields

The meat harvested by hunting forms an important product from areas lying outside cultivated land. The hunting of moose and reindeer provide the highest yields of meat from the Glomma river basin. The added value of hunting in terms of recreation is not dealt with here. The harvesting of food by hunting is associated with the mountains (reindeer hunting) and the forests (moose hunting), both above and below the marine limit.

The yields from reindeer hunting in Hedmark and Oppland have practically doubled during the period between 1969 and 1999 (**fig. 7.15**). Common to both counties, however, is the fact that the number of felled animals has dropped since 1989. This should probably be seen in the context of land availability for wild reindeer and the various encroachments that affect the wild reindeer’s living conditions. The numbers of felled moose have also stabilised during the last 10-20 years, with the exception of Oppland, where the number of felled animals has increased right up to 1999 (**fig. 7.16**). It is probable that the development in hunt yields largely reflects the development in the population sizes of both moose and reindeer.

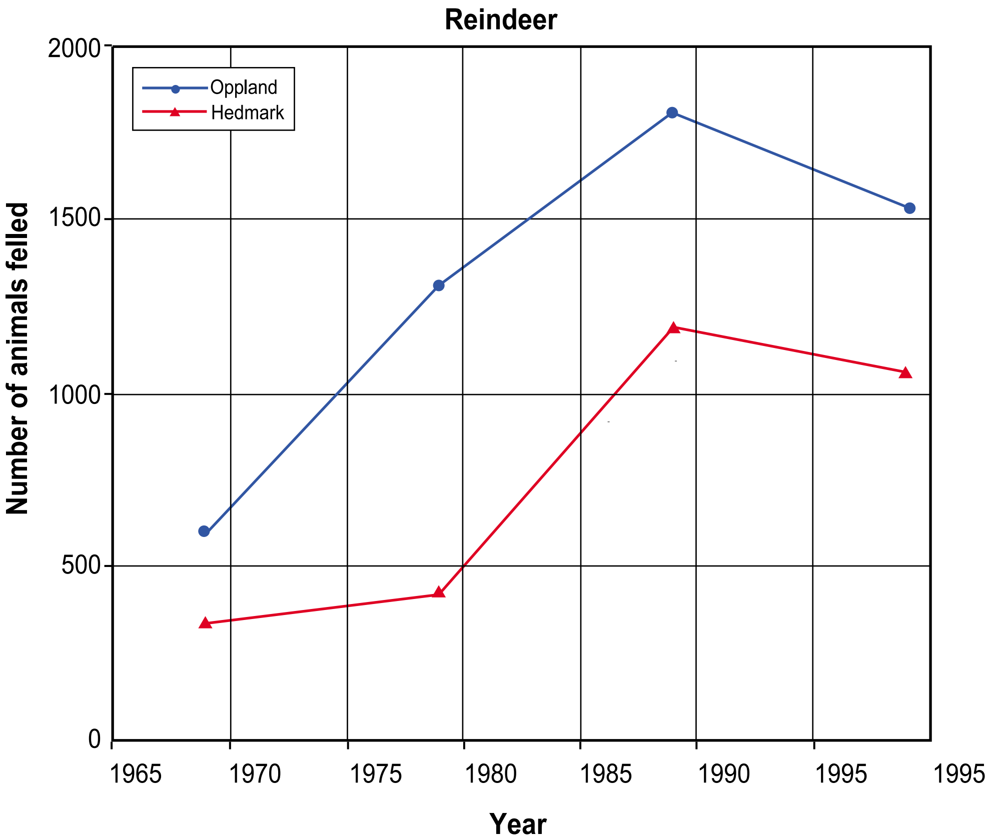


Fig. 7.15
Hunt yields in numbers of felled reindeer in 1969, 1979, 1989 and 1999 in Hedmark and Oppland. Data from SSB.

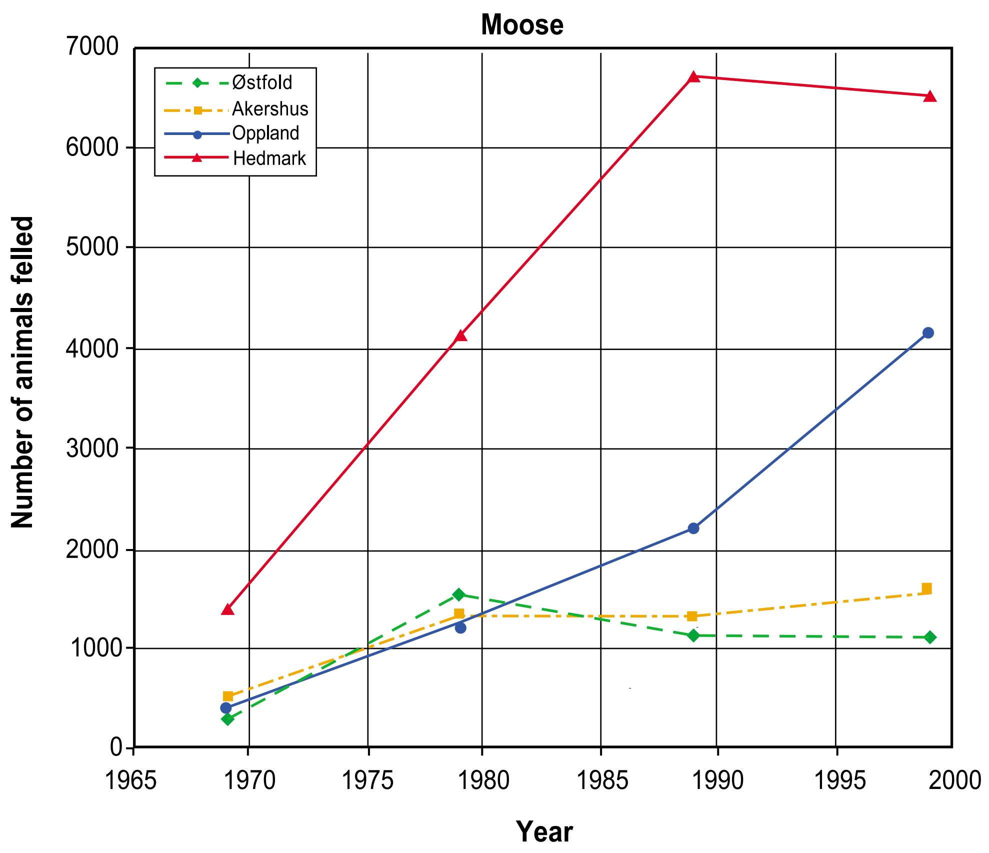


Fig. 7.16
Hunt yields in numbers of felled moose in 1969, 1979, 1989 and 1999 in Østfold, Akershus, Hedmark and Oppland. Data from SSB.

4.8.2 Harvesting the forests

Statistics for the harvesting of timber from forests in the four counties in question testify to a relatively stable situation from 1979 to 1999 (**fig. 7.17**). Timber extraction reflects many factors, including productive forest area, the condition of the forest (distribution of felling classes), and not least, market prices for timber and other economic incentives (subsidies etc.). The development of timber extraction therefore does not directly reflect the forest's capacity to supply timber. Data from the National Forest Audit provides better information about the forest's quality regarding potential timber production and also partly for biological diversity. Data for the condition of the forests in the four counties show that there has been a slight increase in productive forest land in Hedmark and Oppland from the 1950's to the 1980's (**fig. 7.18A**). There has been a steady increase in standing biomass of forest trees in all counties (**fig. 7.18B**). Annual biomass production has also increased significantly over the last 20 years. The growth in volume is reflected in the forests' age and size distributions, with an increase in the age and number of large trees (diameter at chest height >30 cm, **fig 7.18C**). However, as a result of clear-cutting forestry, the area of young forest (felling class I+II, age < 40 years) is significantly larger than in previous decades.

Modern methods of forest management connected with clear-cutting have resulted in a strong increase in the forest's potential to produce timber and other products from trees, including the storage of CO_2. Nationally, the increment of timber volume is more than double the rate of extraction. Climate change and a certain fertilising effect from long-distance transported pollution may have contributed towards this. The landscape structure caused by clear-cutting has at the same time provided good access to areas of young forest and deciduous forest, factors which have contributed to the strong increase in the production of large game over the past decades. Parallel with this, however, there has been a reduction in total area and number of areas with old continuity forest as a result of fragmentation and shorter circulation time for forest stands. This negatively impacts on many species connected with old-growth forests, including many red-listed species.

In addition, some modern forestry methods have produced negative effects on the forest ecosystems' ion balance, hydrology and diverse ecological processes. The undoubted success of modern forestry in terms of increased production of timber and large game should therefore to some degree be weighed against the negative effects it has for many forest species and some important ecological processes.

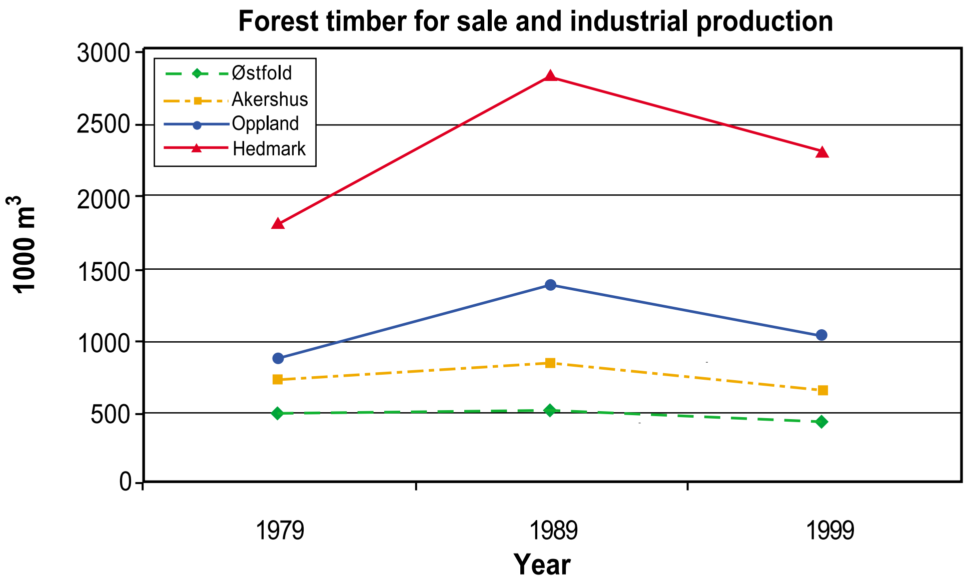


Fig. 7.17
Extraction of forest timber in Østfold, Akershus, Hedmark and Oppland in 1979, 1989 and 1999. Data from SSB.

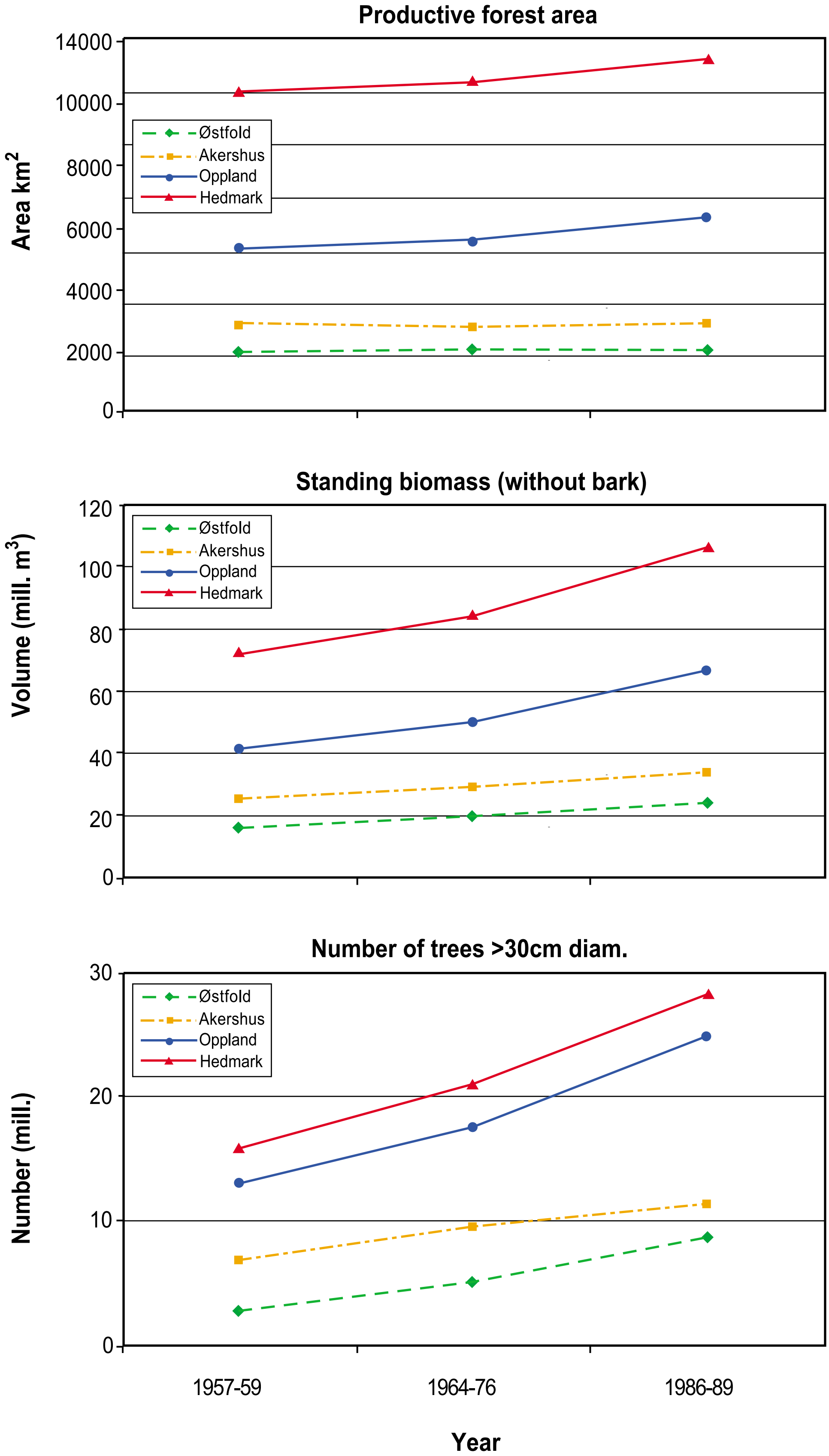


Fig.7.18
The development of productive forest area (A, top), standing biomass of timber (B, middle) and the number of trees with diameters greater than 30 cm at chest height (C, bottom), during the period 1957-59 to 1986-89. Data from NIJOS.

4.8.3 Agricultural land and production

There has been an increase in actively farmed agricultural land in the four counties which dominate the Glomma river basin during the period 1969 to 1989; Hedmark and Oppland show the greatest increase, while there has been stagnation in Østfold and Akershus during the past ten years. For fully cultivated land, the increase over the last ten years has been lower, with stagnation in Oppland and Hedmark and weak decline in Østfold and Akershus (**fig. 7.19**). The use of agricultural land varies much between these counties, as is shown for the classes “field and garden/orchard” (i.e. intensively cultivated) and “meadow” (more extensively cultivated) in **figure 7.20**. While 87% of the cultivated land in Østfold during 2000 comprised fields and gardens, the equivalent in Oppland was just 31%. Following a marked increase in land cultivated for cereals and oil plants in the typical cereal-growing counties (Østfold, Akershus, Hedmark) up to c. 1990, there has been a slight decline during the last ten years. In contrast, fully cultivated meadowland and other meadowland have increased quite significantly over the last ten years (mostly in Oppland), following a sharp decline, especially for other forms of meadow in previous years. This is also reflected in the numbers of cattle, which show a slight decline over the last ten years (**fig. 7.21**). New regulations for animal husbandry which state that cattle must spend a fixed number of weeks outside on pasture during the summer have also contributed to this development. In Hedmark, and especially in Oppland, there has been a clear increase in the number of sheep over recent decades (**fig. 7.22**).

We can obtain a more detailed overview of the different types of agricultural production and animal husbandry by examining the figures for the individual municipalities; figures which, for example, can be analysed in relation to variation in natural conditions. One example comprises the figures for sheep farming (**fig. 7.23**) for each municipality in the Glomma river basin between 1969 and 1999. The greatest numbers of sheep are found in the municipalities along the upper reaches of the Lågen and the northernmost municipalities in the Glomma valley. This probably reflects the amount of forest and mountain areas available for grazing, and indicates the same trend as other datasets relating to agriculture in the river basin (e.g. **fig. 7.20**).

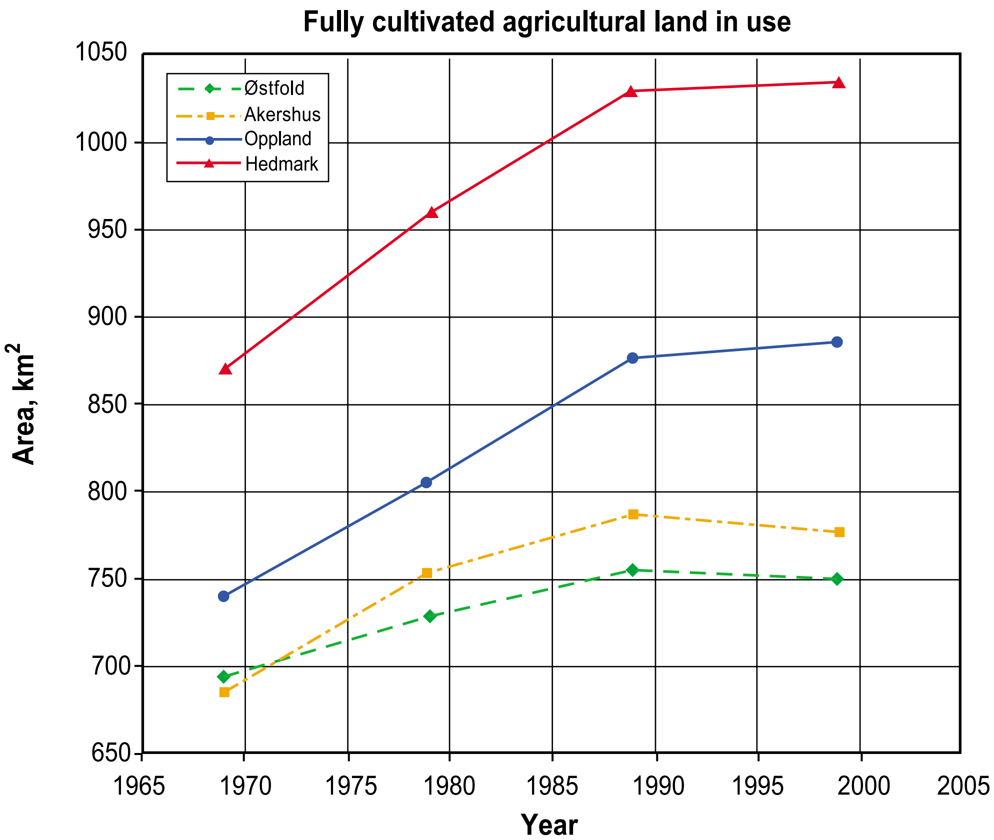


Fig. 7.19
Fully cultivated agricultural land in Østfold, Akershus, Hedmark and Oppland in 1969, 1979, 1989 and 1999. Data from SSB.

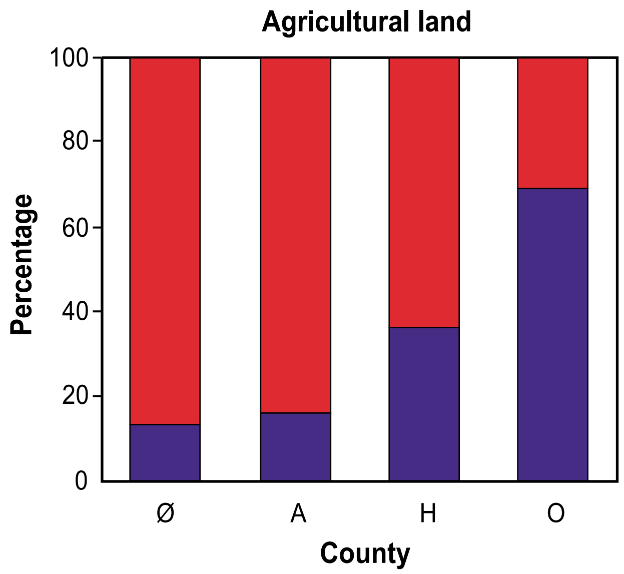


Fig. 7.20
Distribution of fully cultivated agricultural land in Østfold (Ø), Akershus (A), Hedmark (H) and Oppland (O) in 2000, divided between fields and gardens/orchards, where cereal crops, potatoes or vegetables are grown (red, uppermost) and meadowland, where grass for fodder or pasturing is grown (blue, lowest). Data form SSB.

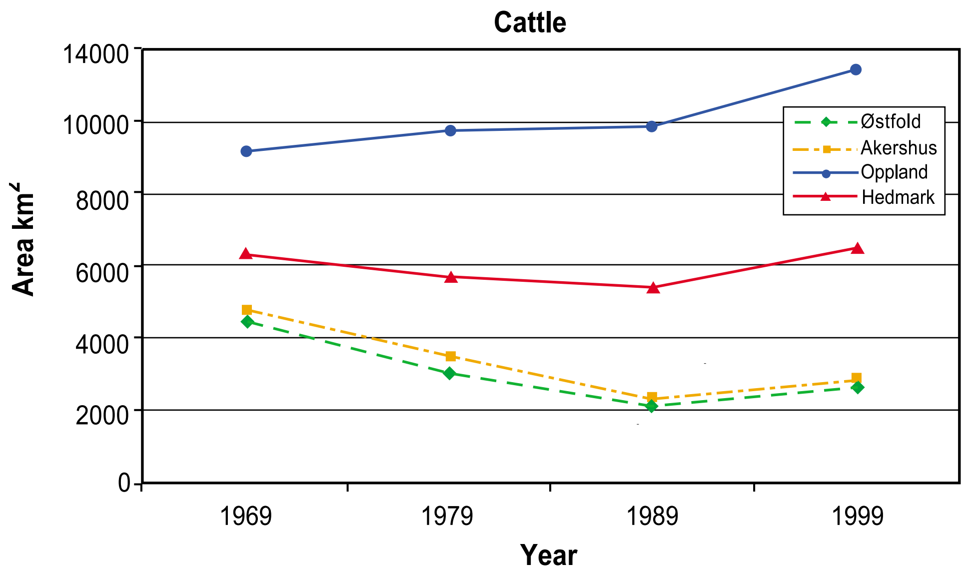


Fig. 7.21
Number of cattle in Østfold, Akershus, Hedmark and Oppland in 1969, 1979, 1989 and 1999. Data from SSB.

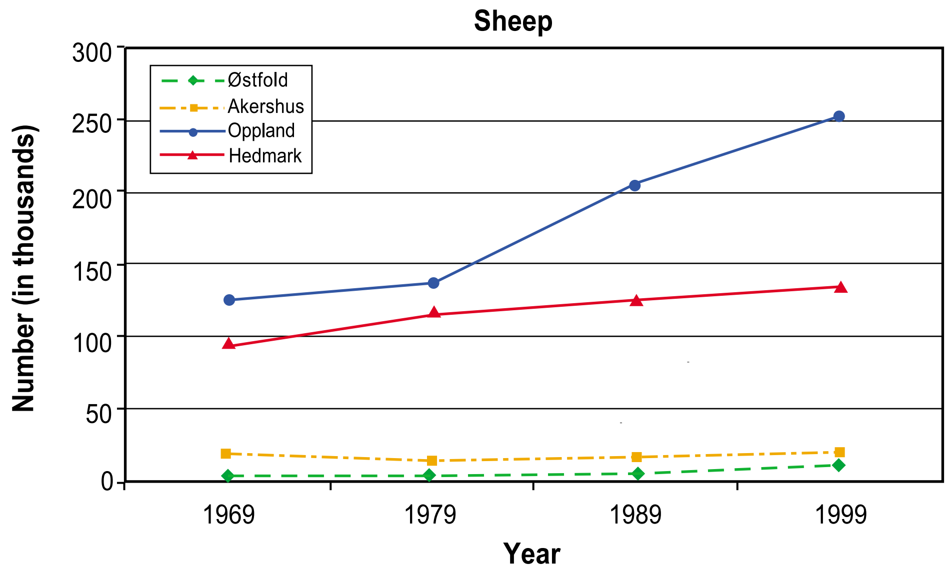


Fig. 7.22
Number of sheep in Østfold, Akershus, Hedmark and Oppland in 1969, 1979, 1989 and 1999. Data from SSB.

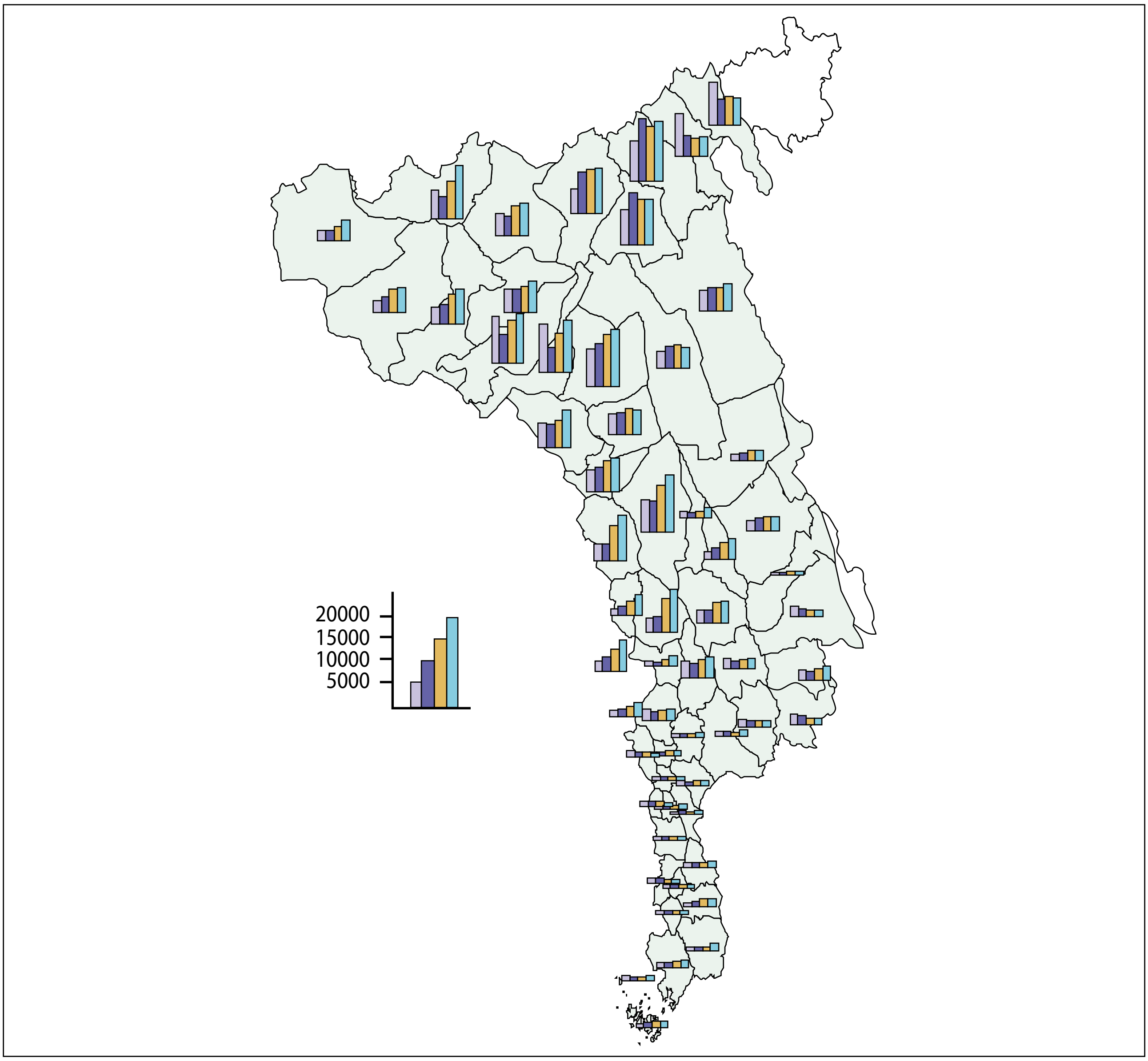


Fig. 7.23
Development in the numbers of sheep in each of the Glomma river basin municipalities from 1969, through 1979 and 1989 to 1999. Data from SSB.

4.8.4 The character of the landscape

A monitoring programme for agricultural land was established in 1998 (known as 3Q) as part of the authorities' system for monitoring condition in agriculture, and controlling results. Data from this programme has been analysed in detail in the course of a project financed by the Norwegian Research Council. This included a comparative analysis of air photos from the 1960's and 1998 showing selected 3Q-surface areas, with the aim of studying changes in the agricultural landscape. In two examples from the Glomma river basin (**figs. 7.24, 7.25**) we can see in detail how changes in agricultural policy and other social conditions have an impact on the landscape. In both instances, simplification of the landscape structure has occurred: through the amalgamation of field strips into larger units; by a development towards less variation in land types (e.g. greater emphasis on respectively forest and arable cultivation); and through the removal of many marginal zones and relict biotopes. Such simplification of the agricultural landscape and loss of relict biotopes has been shown to have a negative effect on species richness and peoples' appreciation of the landscape, among other things (as revealed by the research project connected with the 3Q programme). Measures such as the burial of streams in culverts, the removal of marginal zones

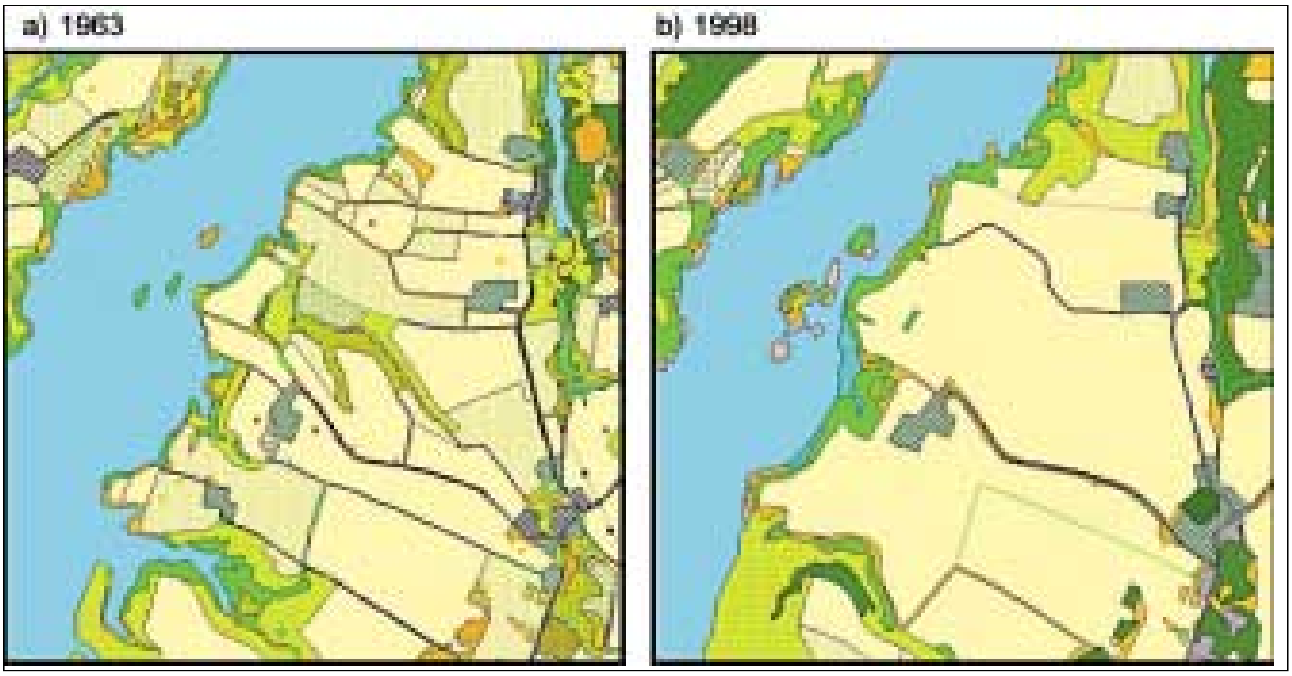


Fig. 7.24
Surface area 2171 from the 3Q project (Varteig, Sarpsborg municipality) illustrates the simplification of the agricultural landscape through the removal of field boundaries. Arable fields (light yellow) appear now as large entities and many small biotopes have disappeared, either ploughed up or replaced by forest (light green represents deciduous woodland, dark green coniferous forest). The hix-value has fallen from 0.61 to 0.43. The numbers of relict forest patches (from 17 to 4) and ponds (6 have disappeared) have fallen significantly. (Hix is an index which describes variation in area/object-classes in 3Q surface areas).

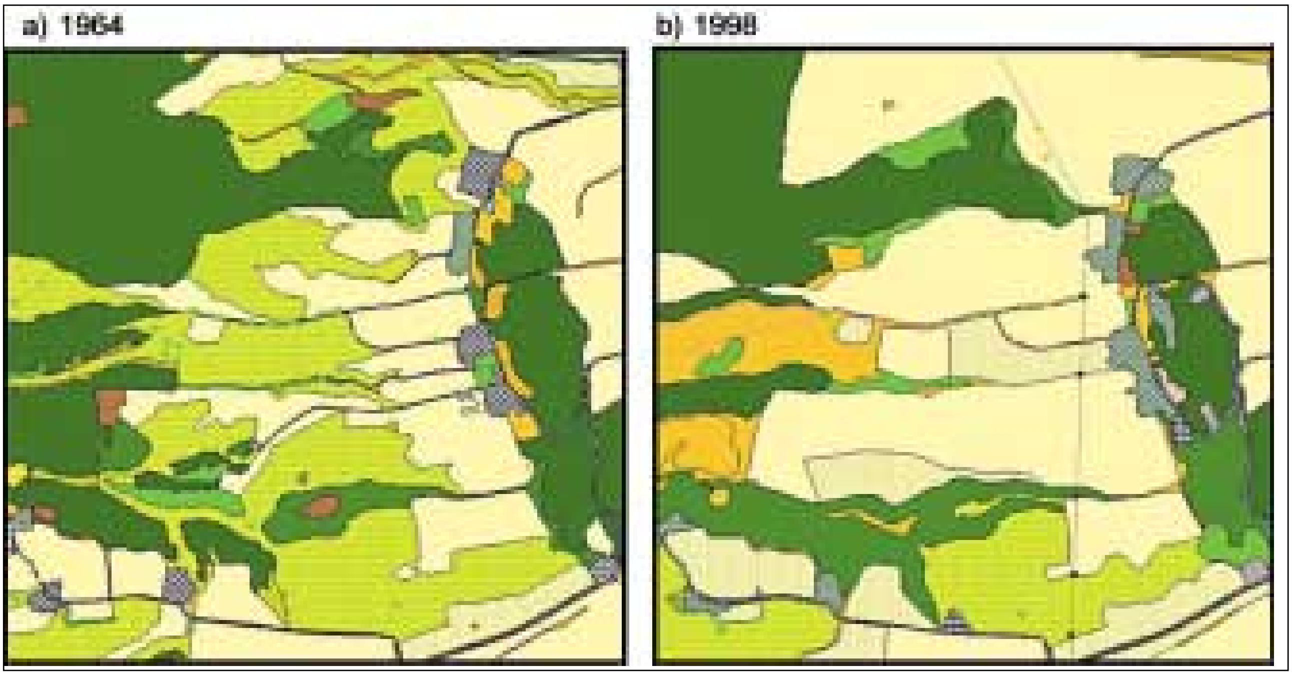


Fig. 7.25
Surface area 2095 from the 3Q project (Eidsberg) shows the effect of channelling activity. Pastureland (strong yellowish green colour) has either been converted to more intensively cultivated types of land, such as arable fields and cultivated meadowland (light yellow), or has been abandoned to become wild meadowland (orange) or forest (green). The number of ponds has fallen (from 3 to 1) and the number of tree-covered points has sunk from 29 to 9. The hix-value for this surface has not changed (0.61 compared to 0.62).

and the ploughing of large, uninterrupted fields affect the landscape's hydrology and can lead to increased erosion and pollution.

An activity which changes the character of the landscape is ground-levelling. Large areas under the marine boundary, particularly in Østlandet and Trøndelag, contain deposits of marine clay. These represent a large proportion of the areas best suited for cultivation. , particularly for cereal crops. The marine clays are easily eroded, however, and land rise following the last ice age has created a fragmented landscape characterised by ravines and landslides. The traditional farming practises in the ravine landscape have been animal grazing on the ravine slopes, with cultivated fields on flatter areas between them.

Mechanisation has been a dominant factor connected with changes in farming practices. The ravine areas with their small, interconnected fields are not well suited to mechanised agriculture. In the period from the end of the 1960's up to 1990, extensive support was given to the levelling of ground in connection with farming. The Department of Agriculture (1989) has reported that a total area of almost 28,000 hectares was levelled as a result of this support. In fact, the measures cover a larger area, as additional levelling has taken place in areas outside the fully cultivated land and without state support.

An air-photo analysis which covered Østfold (Erikstad 1992) shows that about 40,000 hectares of a total area of over 75,000 hectares of farmland have been subjected to levelling or similar measures, such as the burial of streams. Three chosen areas – near the southern end of Øyeren, near Rakkestad and near Skjeberg - were studied more closely using air photos taken before levelling started (1964, 1956 and 1965) and after most levelling had ceased (1978). The changes during this period measured as a percentage of remaining ravine lengths are respectively 33%, 20% and 42%. Today it is impossible to find ravine areas in Østfold untouched by such activity.

Ground-levelling has changed the agricultural landscape to the extent that topographic diversity has been reduced. The area of farmland has increased. Soil erosion has increased, particularly during the first phase of levelling. Soil quality has diminished and biological diversity is probably also strongly reduced, primarily because of the reduction of land containing semi-natural habitats in the ravines. On the other hand, mechanisation has increased farming efficiency. Maintenance costs connected with artificial drainage and erosion prevention measures have also increased. It is worth noting that, should the maintenance of levelled areas cease, the terrain will in time revert to a ravine landscape through the effects of erosion.

Landscape changes affect biodiversity. We have little documentation regarding how the changes occur, because there are few older datasets which describe the earlier situation in sufficient detail. However, **figure 7.26** illustrates an interesting dataset, gathered in connection with a scientific agricultural project conducted from 1958-60. The figure shows a map of the former Nes municipality (now amalgamated with Ringsaker) in the county of Hedmark. The area is one of Østlandet's best farming areas, with an extremely long farming tradition. This, together with its lime-rich geology, makes it an area with an extremely species-rich flora. For the study, the area was divided into 132 sub-areas defined by different types of nature lines (road-, forest- and field-perimeters). The sub-areas had an average area of c. 0.8 km^2. In the course of three fieldwork seasons, the vascular plant flora in all sub-areas was analysed. A total of 630 species was observed, of which 16 are listed as threatened on the national red list. The number of species found in each sub-area are shown in the figure. A provisional analysis shows that there is a close connection between the number of species and variation in the landscape: the more varied the landscape (with regard to the evening-out of farmland, number of types of landscape elements, topography), the greater the number of species. The provisional analysis is based on a terrain model and digital land use maps .

The dataset forms part of a research project funded by the Research Council (Quantitative analysis of changes in vascular plant flora in the cultural landscape between 1960 and 2000), and will be reanalysed in 2001 and 2002. Changes in the flora will be compared with changes in the landscape, which in this area can primarily be associated with changes in farming practices and forest management. The changes in the landscape will be assessed using air photos of different age, and also digital land use maps (DMK) form a useful tool. Experience from fieldwork so far indicates that the conversion from combined farming (dairy farming and arable crops) to exclusive cereal cultivation has led to a reduction in meadowland and an increase in the size of cultivation units. In addition, forests are far more cultivated than they were 40 years ago; in particular, many ditches have been dug in humid forest types. Furthermore, a wide range of newly introduced plants has been registered, especially escapees from gardens and weeds associated with road verges.

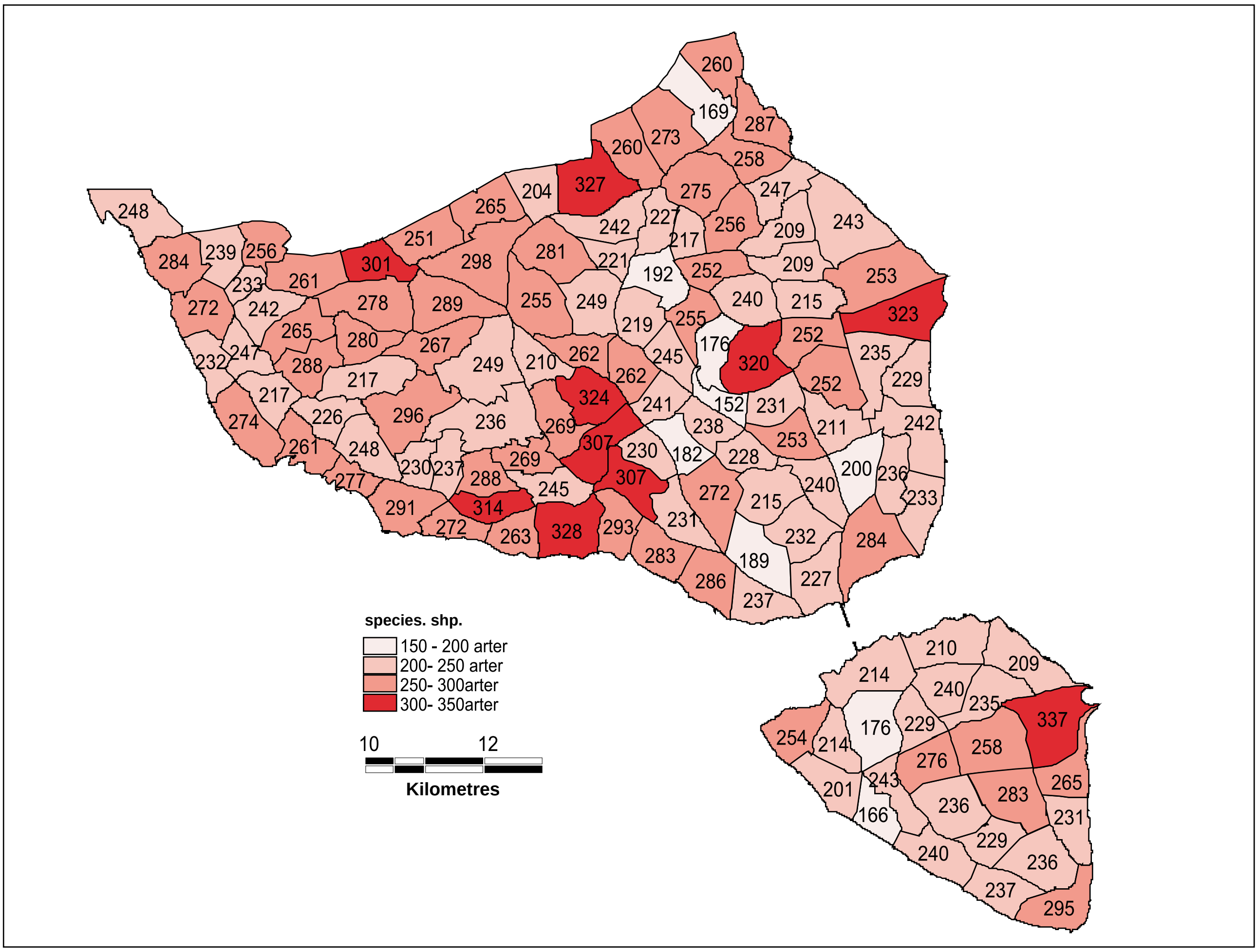


Fig. 7.26
The number of plant species in different sub-areas in the former municipality of Nes (now part of Ringsaker municipality, Hedmark), 1958-60.

4.8.5 Accessibility within the cultural landscape

The most important farming areas in the Glomma river basin are also the areas with the highest population density. An important part of the population's outdoor life takes place in the local area. The public's right of access to nature areas in the vicinity, as stipulated in the Law regarding Outdoor Life, is affected by the landscape structure which results from local farming activities. This can consequently be seen as a classic example of a conflict between different interests, each of which depends on the extraction of goods and services from the ecosystems, in this instance food production and recreation. Bakkestuen et al. (2001) have analysed accessibility at 112 points in the landscape in a part of Rakkestad in 1953 and 1992 (**fig. 7.27**). (Rakkestad lies in the Halden river basin, but is used here to illustrate developments in intensive farming areas). During this period, farming has undergone major changes, which have also contributed to changes in the landscape. For example, in Rakkestad municipality the farming counts for 1949 and 1989 (the counts which lie closest in time to the years of the analysed air photos) show almost a quadrupling of land area under cereal and oil-plant cultivation (**table 7.4**).

Table 7.4
Changes in types of farmland in Rakkestad municipality from 1949 to 1989. Data from SSB.

Land type	1949	1989	change (%)
total agricultural land (km^2)	103.4	111	+7
cereals and oil-plants (km^2)	27.1	93,8	+246
fully cultivated fields and pasture (km^2)	64.8	11.6	-82
other fields and pasture (km^2)	18.4	1.2	-93
number of cattle	9518	4011	-58

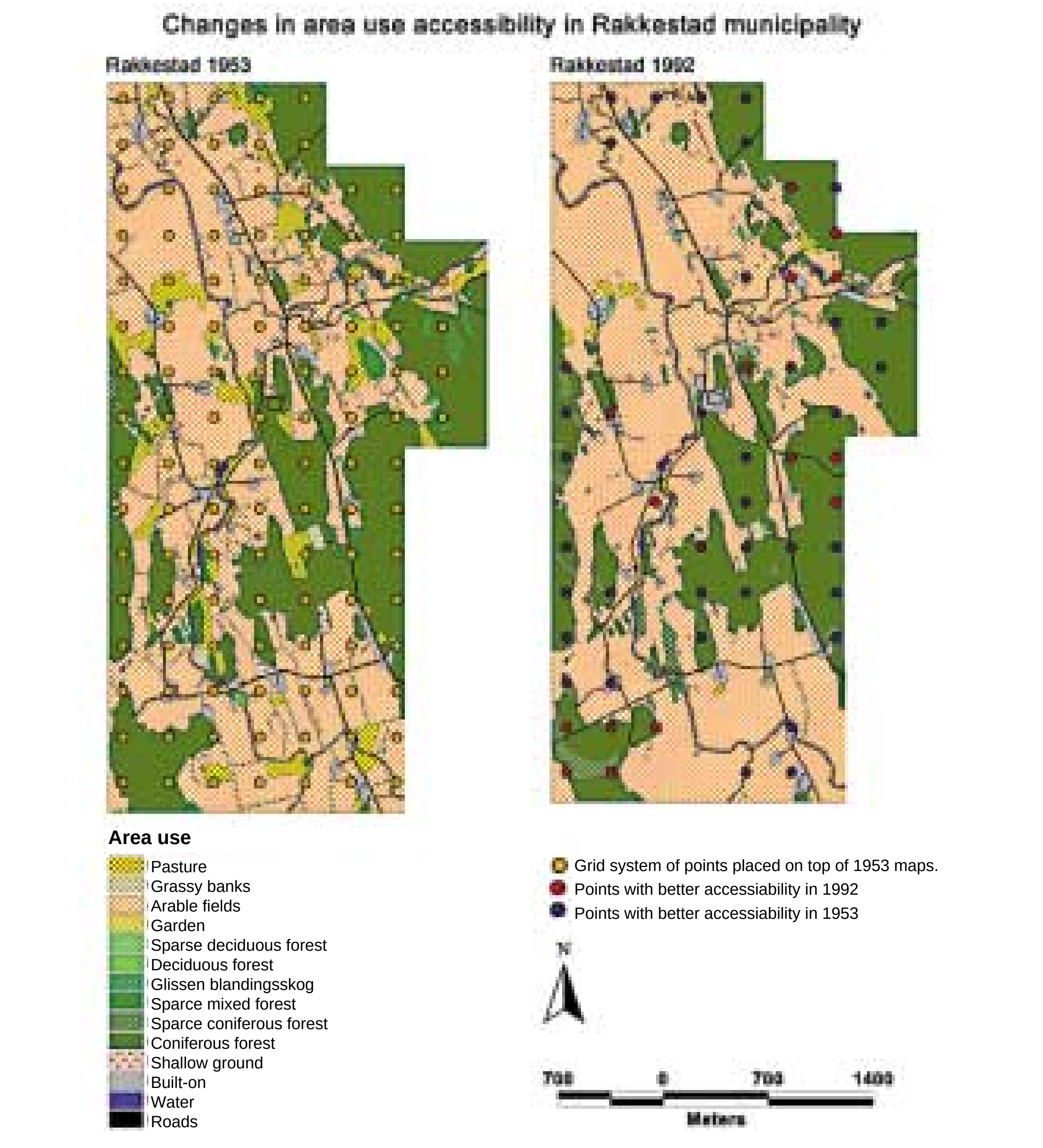


Fig. 7.27
Changes in area use and accessibility in part of Rakkestad municipality from 1953 to 1992. Rakkestad lies in the Halden river basin, but is illustrative of developments in relatively intensive agricultural areas. After Bakkestuen et al. (2001).

During this period the area of intensively farmed land has increased by c. 15%. Of the analysed points in the landscape, 54.5% were completely accessible in 1953, while 45% were inaccessible, either because they lay in cultivated land or on islands of uncultivated land which could not be reached without crossing cultivated land. In 1992 46.4% of the points were fully accessible, while 53.6% were inaccessible. Many of the points which were classified as accessible in 1992 had become less accessible than they were in 1953. In this case, it is apparent that increased intensity in agriculture means that the landscape becomes less suitable for outdoor pursuits and recreation.

4.8.6 Access to the coastal zone

The beach and coastal zones are important areas for recreation and outdoor life. This type of natural environment therefore provides a service which is valued by the general public, and initiatives which reduce public access to the beach and coastal zones have a negative effect. At the same time such initiatives exploit other values or services associated with this environment.

Land for infrastructure, urbanisation or other building development has formed an important "product" of the beach and coastal zones over recent years. Building developments have affected biological diversity and accessibility to these areas for most people. It is therefore of interest to assess how accessibility has changed up to the present day, as well as monitor future developments.

Fredrikstad municipality collaborates with Østfold County Council on the mapping and planning of the coastal zone's use. A project to develop an accessibility map with relevance for outdoor pursuits has been initiated, based on mapping and analysis of man-made barriers to access to beaches and the coastal zone. The data basis covers publicly approved building activity and other types of activity (including illegal building extensions and extensions which do not require official permission). The aim is to develop a land monitoring programme for the coastal zone. At the time of writing, a registration of initiatives which limit the public's access to a 420 km stretch of the coastal zone in Østfold has been conducted. In the municipalities of Sarpsborg, Fredrikstad and Hvaler which cover the mouth of the Glomma and areas in its vicinity, initiatives impeding access have been registered at a rate of respectively 10, 18 and 14 per kilometre. The distribution of types of encroachment for Østfold in total is shown in **figure 7.28**. The extent to which the encroach-

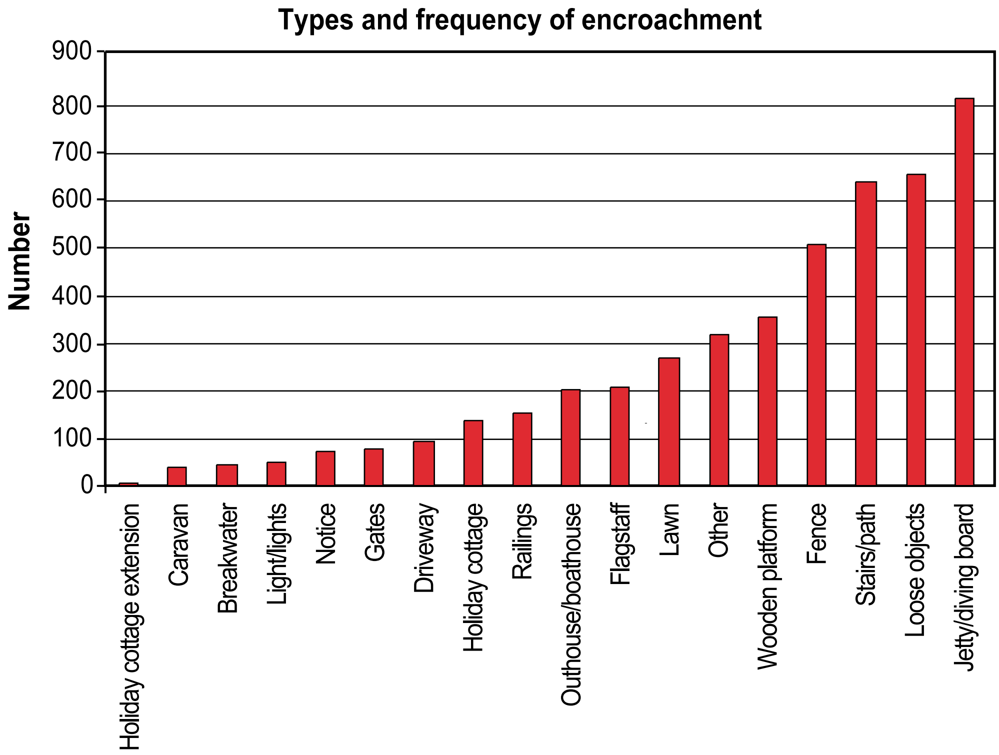


Fig. 7.28
Types and frequency of encroachment on the beach and coastal zones in Østfold, based on a survey along a 420 km stretch of coastline, which corresponds to 70% of the county total. Data from Per Vallner, FM in Østfold.

ments are considered to be obstacles is presented in **Figure 7.29**.

Building development and infrastructure are generally a benefit for holiday cottage owners and lead to economic activity which can benefit the local community. However, they also lead to reduced accessibility in the area, something which is regarded negatively (see **fig. 7.29**). It is apparent that it is the expansion of private space around approved buildings which constitutes more of a problem than the building of the cottages and houses themselves (**fig. 7.28**). It is therefore important to continue the work of gathering this information in the database. Cottage building and subsequent changes in area use and infrastructure affect values relating to outdoor life and recreation in the coastal zone. Physical obstacles (such as fences) have a direct influence by impeding accessibility. However, other forms of encroachment (e.g. jetties, wooden platforms and tended areas) are regarded as obstacles and lead to poorer access to the outdoor areas in the coastal zone. There is provisionally no data available that allows time analysis.

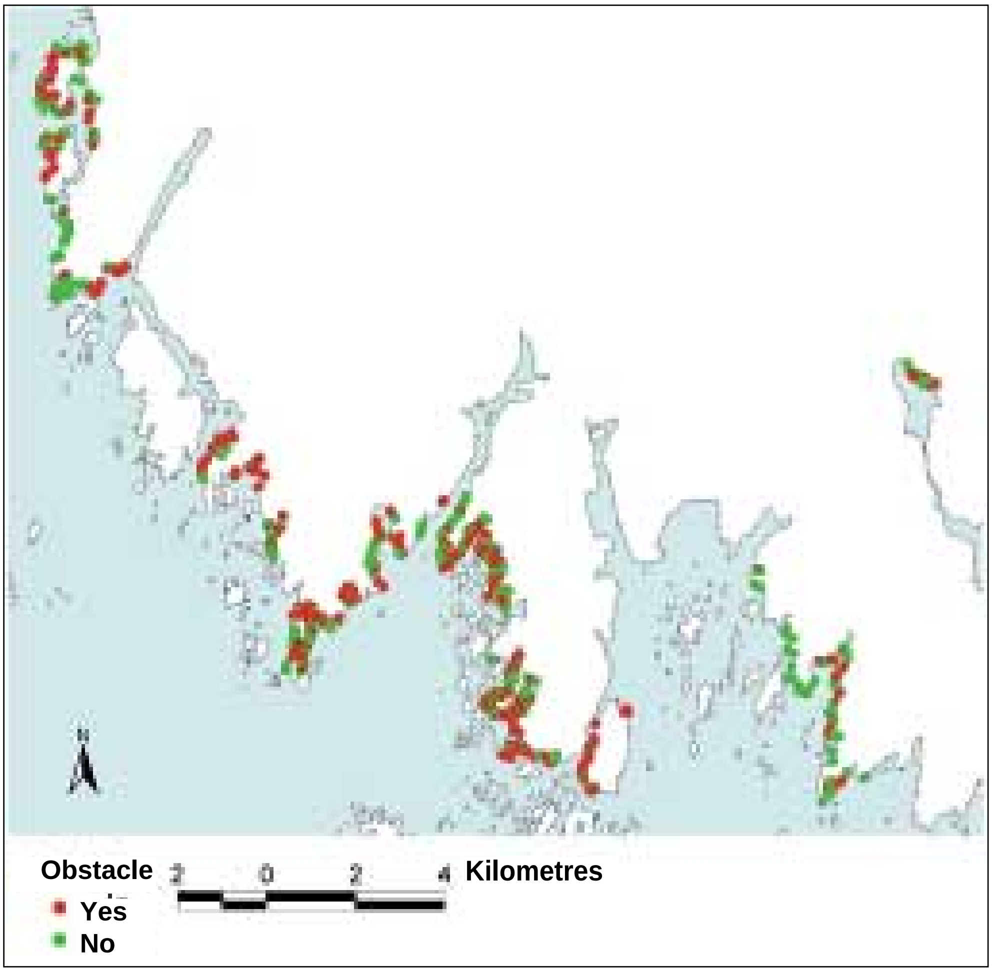


Fig. 7.29
An evaluation of encroachments in Fredrikstad municipality in accordance with criteria for and against their forming obstacles. Red points show encroachments which are judged to impede access to the beach and coastal zone, green points are those judged not to impede access.

4.9 Summarising discussion

The Glomma river basin illustrates many of the contradictory interests, conflicts and necessary compromises which are faced by those who manage natural resources. In this pilot study we have been able to document developments in some of the elements over the past 30 – 100 years.

The underlying reasons for the observed changes are found in factors such as population development, the population's pattern of consumption and the governing economic framework conditions in society. It is a characteristic of the last one hundred years that local conditions in rural communities and municipalities appear to play a diminishing role, while national, and frequently international conditions have become increasingly important for development, also at a local level.

In the Glomma river basin, we see that the population in areas near the city of Oslo has increased significantly over the past 50 years, while less central areas have maintained a reasonably stable population. At the same time, for example, the energy demands of the population in central areas are covered by hydropower development in the periphery. The road network is developed in order to cater to the needs of transport between towns. The population in the periphery also benefits from energy production and the transport network, but the economic driving force behind this lies to a large degree in urban needs and financing.

For simplicity's sake, we can classify the land areas as "natural" and "culturally influenced" areas. Natural areas include, for example, forest and mountain, while culturally influenced areas include cultivated land and settled areas. In the real world it is difficult to distinguish between cultural landscape and natural landscape, and many areas comprise a complex intermixture of both. Against this background, we can nevertheless state that one of the most important influential factors, or pressures, which changes the natural landscape and the living conditions for vegetation and fauna in natural ecosystems is the development of infrastructure in the form of roads, power stations, power lines and the like. Infrastructure development leads to the fragmentation of the natural landscape, as is clearly shown by maps of "encroachment-free" areas (i.e. areas more than 5 km from an encroachment) dating from 1900 to the present day. We know that wild reindeer are adversely affected by this development in mountain areas. It can be assumed that many other wild species, both in mountain and forest areas are also affected, but precise information about this is not available. For example, we do not know how flora and fauna are affected by proximity to the nearest road. Generally speaking, we can state that every road will create an edge zone which will favour particular species, such as foxes and crows, but negative effects will probably depend on whether the road is a heavily used national highway or an occasionally used forest road.

An important effect of road building is linked with the activity accompanying the road, i.e. activity associated with built-up areas, forest management etc. Such activity is mostly concentrated near the road, and leads to the expansion of the narrow zone affected by the road itself into a broader band of natural environment that is strongly influenced by humans. In the Glomma river basin, the areas south of a line through Trysil-Elverum-Hamar-Gjøvik are today devoid of encroachment-free areas, and in the areas to the north of this line, the encroachment-free areas correspond largely with existing or planned conservation areas.

Another important effect of roads lies in their forming the means by which exotic plant and animal species can enter an area. Road verges partly create good environments for pioneer species which have difficulty colonising natural systems, and increased traffic leads partly to the introduction of new species to an area.

In forest areas, the areas of old-growth forest have diminished as a result of the fact that road building has opened up larger areas to logging. This represents a threat to elements in the biological diversity which are dependent upon old-growth, or so-called continuity forest. At the same time, changes in forestry methods have led to a greater volume of timber in forest-covered areas and a completely different structure in the forest stands in comparison to the situation fifty years ago. We also see that the extraction of timber is influenced by other factors from year to year, such as timber prices.

Another important product from forest areas is the yield of meat derived from the hunting of large game, particularly moose. The yield has increased strongly since 1970, particularly in the northern parts of the river basin, i.e. Hedmark and Oppland. The increase in hunting yield for moose is closely related to the size of the moose population. The growth in the moose population is thought to have two causes. Firstly, the culling regime has led to greater production in the stock. Secondly, changes in forest management methods have created better fodder conditions for moose. The hunting of large game is an example of an activity which gives both a concrete product in the form of food, and a service in the form of recreation and experience value. Both aspects have great economic value. A large moose population is regarded as a benefit in many ways. At the same time, the moose affect the forests through grazing and browsing. This may cause economic loss through the reduction of fir and spruce regrowth ("browsing damage"), and partly affects the species composition of the forest by the fact that some species, such as aspen, can be so heavily browsed that they have almost no regrowth.

Roads and settlement are almost by definition dominant factors in the cultural landscape, which is otherwise characterised by a patchwork of various types of cultivated land, marginal zones, remnant forest or other more natural ecosystems. The structure of this landscape has nevertheless changed much over the last fifty years. The intensification of agriculture, which is driven forward by economic and political conditions at national and international levels has led to e.g. greater amalgamation of fields and fewer field boundaries and groves in the best farming areas. This affects the landscape's suitability for recreation and outdoor pursuits, since opportunities for gaining access on foot have been reduced. During recent decades, initiatives taken to reduce soil erosion and to preserve the cultural landscape have given positive effects. There has been an increase in the areas of riparian vegetation and other landscape elements which promote biological diversity and outdoor activities.

Public right of access to uncultivated nature areas is stipulated by law. The conversion of forest areas to cultivated land alters their potential for use in connection with outdoor activities. This can create local conflicts, especially when cultivation impedes access for anglers along watercourses etc. Along the coast, opposing interests between the building of cottages or infrastructure on the one hand, and the public's right of movement on land and sea on the other, lead to continual conflict. This is also a problem along the coast near the mouth of the Glomma. The conflicts in such cases are extremely complex. They revolve partly around two different forms of recreation; namely cottage life and freedom of movement in uncultivated areas. The municipalities must seek to cater for the population's need for both types of recreation. At the same time, cottage development is synonymous with economic activity, jobs and income from taxation. Landowners have obvious economic interests in the sale of building plots. In most coastal areas, the trend is towards reduced access for the general public and an increase in the amount of land reserved exclusively for private use. The effects of this trend on flora and fauna are little known.

The watercourse, that is to say the river with its tributaries and lakes, supplies a range of products and services. In some cases, the supply of these goods and services do not involve conflict, but in most cases their production means that other uses suffer. We are again faced with trade-offs between positive and negative sides of different uses.

Traditional food products, such as fish, can be harvested without noticeable effect on other areas of use. The most important economic products and services, which today comprise electricity and water for households and irrigation, on the other hand constitute important pressures on the watercourse's natural ecosystems. Hydropower development has a number of well-known effects on the watercourse as ecosystem, something which, among other things, means that landowners affected by a particular hydropower development are compensated for lost potential.

The extraction of water for agricultural purposes leads to a reduction in water flow, and can cause problems for watercourse environments in minor tributaries and streamlets in particular. The ability of the watercourse to supply this service to agriculture is primarily dependent on water quantity, while water quality is of lesser importance. This means that the watercourse can simultaneously be a recipient of waste water (supplying the service "decomposing pollutants") and a supplier of irrigation water. However, the extraction of drinking water from a watercourse is largely dependent on water quality. This means that the services "cleansing of waste water" and " supply of drinking water " are difficult to combine.

Some aspects of a watercourse's natural dynamic are regarded by society as being negative and costly, such as erosion and flooding. The technical measures for reducing the effects of erosion and flooding are complex, and have both positive and negative effects on different values and services. Anti-erosion measures in the watercourse which take the form of stone settings, for example,, as a rule have negative effects on the natural environment - and therefore the biological diversity - of a particular stretch of river. On the other hand, anti-erosion measures on land, such as the re-establishment of riparian vegetation, have positive effects on biological diversity, both in the river and on land.

Flood-defence structures are costly, and are built to protect settlements, farmland or infrastructure. At the same time, the land alongside the river which is naturally prone to flooding usually contains habitat types such as oxbow lakes, marshland and flood-plain vegetation, which are rare and should be protected. We are consequently faced with a trade-off between the protection of material values in the cultural landscape and the protection of valuable elements of the biological diversity.

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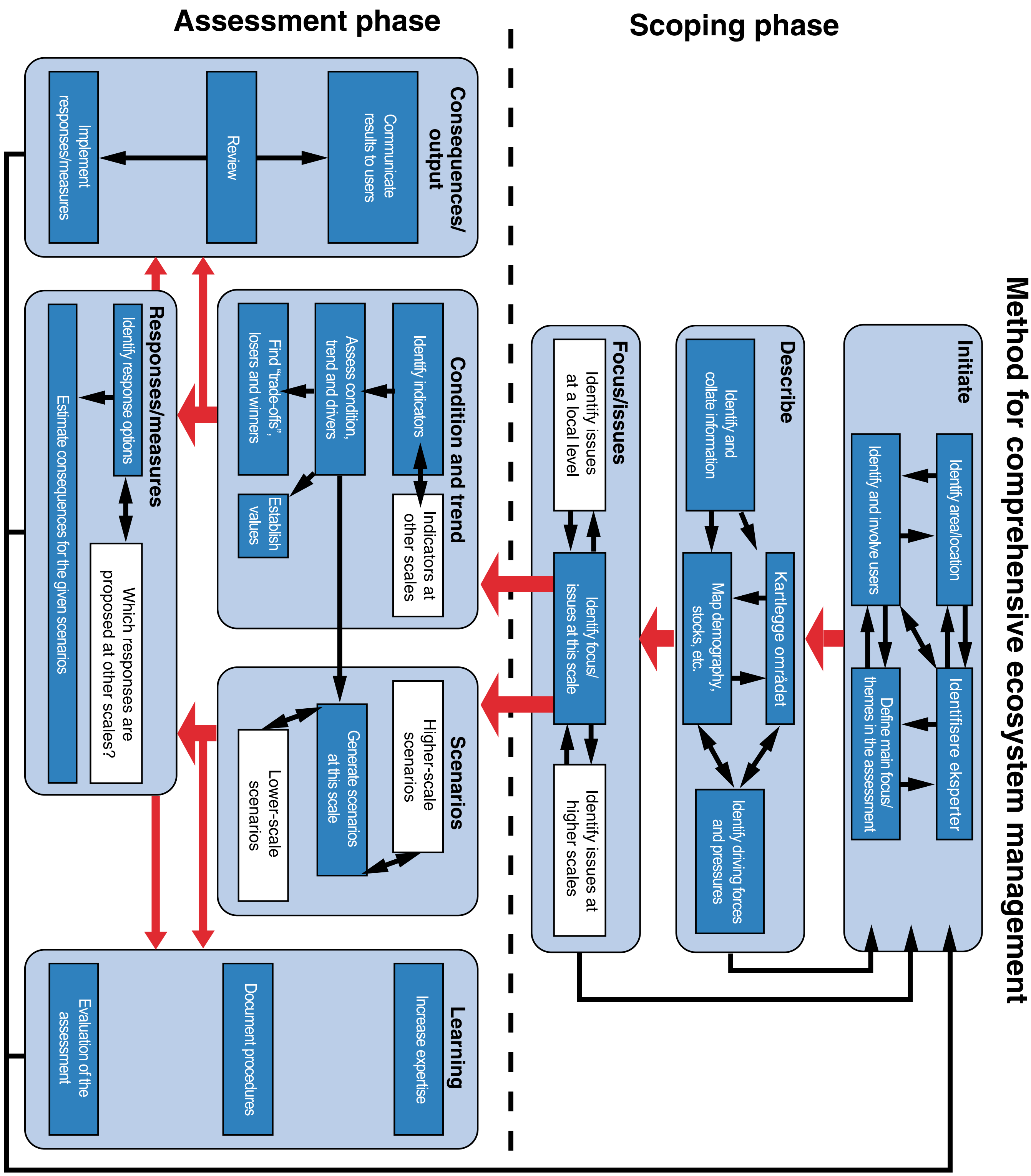
Appendix 1: Methodology for carrying out a full-scale study

Schematic methodology for the carrying out of global, or sub-global, studies. The start-up phase may be relatively long in order to prepare the analyses themselves.

The following is a slightly modified version of the original diagram developed for the global Millennium Ecosystem Assessment.



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