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Spatial and Ecological Assessment of the TEN: Demonstration of Indicators and GIS Methods

Progress Report of the DGVII-DGXI-Eurostat-EEA Working Group of the SEA of the TEN
April 1998

European Environment Agency

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1. Introduction

The present report is written in view of the Commission's aim to develop appropriate methods for the strategic evaluation of the environmental impacts of the trans-European transport network (TEN). In order to study the possibilities of evaluating a particular type of environmental impact – namely spatial and ecological impacts – the Directorate-General for Transport (DGVII) and the Directorate-General for Environment, Nuclear Safety and Civil Protection (DGXI) in March 1997 initiated a co-operative effort with the European Environment Agency (EEA) and Eurostat.

The Commission's request led to the creation of a working group consisting of DGVII, DGXI, Eurostat and EEA representatives, and the present study was steered and developed by this working group. The EEA European Topic Centre on Land Cover carried out most of the technical work, including the GIS development. The EEA European Topic Centre on Nature Conservation provided data on nature conservation and gave methodological feedback.

The objectives of the present methodological study were:

I. to develop and evaluate a number of indicators and GIS assessment methods and to demonstrate their feasibility - taking account of the present data available - for an assessment of the overall trans-European transport network, and consequently provide a common discussion platform between and within Commission services, with external experts, policy makers and other stakeholders on this issue;
II. to identify issues for further research as a result of this broad and multi-disciplinary consultation.

In this context, the reader should bear in mind that all the results and figures that are presented in this methodological report serve only to illustrate the potential output of the various assessment methods. They are not the final results of the assessment.

2. Executive Summary

In accordance with the provisions of the European Union (EU) guidelines for the trans-European transport network (TEN), a European Commission working group has investigated the feasibility of carrying out a full spatial and ecological assessment of the TEN. The aim of the study was to develop and test a number of indicators, to consider the availability of data and to identify issues for further research, if necessary. The study and the resulting report are intended to promote further discussion between all stakeholders on the issue of strategic environmental assessment (SEA) in relation to TENs.

On the basis of EU environmental objectives, mainly specified in the 5th Environmental Action Plan, the working group identified a number of indicators that could be taken into account in a spatial and ecological assessment of the TEN. Five different environmental themes were highlighted: biodiversity and nature conservation, water resources, coastal zones, noise and land resources.

The working group considered only quantitative evaluation methods, using a Geographical Information System (GIS) as an analysis tool. The methodological approach was mainly based on land-suitability or sensitivity analysis. This type of analysis focuses on the environmental characteristics of the land and relies on expert judgement (based on scientific knowledge). The quantitative approach involves indicator categories selection, impact estimation and ratings or priorities assignment. Map overlay techniques are the most suitable for carrying out the analysis; therefore, GIS tools - given the scale of the analysis and the geographical differentiation of the impacts - have proven to be the most useful. With these types of methodologies, impacts are implied but not explicitly reported. Qualitative results may be integrated subsequently but an evaluation without any degree of quantification was not considered feasible, given the objectives of the study.

Six different TEN network development variants - considering only linear road, rail and water infrastructures - were used to demonstrate how the indicators could be used. For the current study, it was decided to define overall network variants that do not represent true policy options, but that are useful in raising awareness about the possible environmental impacts of the trans-European transport network. The variants are:

I. a “do-nothing” option: no further extensions to the existing network;
II. a “do-minimum” option: the existing network is extended by the execution of the fourteen specific projects agreed at the Essen European Council in 1994;
III. the existing network is further developed through the carrying out of all road projects;
IV. the existing network is further developed through the realisation of all rail projects;
V. the existing network is further developed through the implementation of all inland waterway projects;
VI. the existing network is completed by the development of all planned projects.

Two broad types of indicators were tested. The first type is based on identifying specific sites in the vicinity of planned infrastructure links. In principle this technique can be used to evaluate the potential impact on, for example, designated biodiversity or nature sites and water catchment areas.

The second category of indicators is based on the identification of different land cover types according to their degree of vulnerability to certain impacts. For example, certain habitat types may be more vulnerable from a biodiversity point of view than others. Alternatively, one could define non-fragmented areas that are more likely to have a high value for nature and biodiversity than zones that are already fragmented by existing (TEN) infrastructure. This type of indicator can also be used to combine different environmental aspects into an overall vulnerability / sensitivity index per zone.

It must be noted that the results of an assessment at EU-level must be interpreted with great care, especially when it concerns spatial and ecological impacts whose significance very much depends on local circumstances. The design and alignment of the infrastructure, the vulnerability of the species in the area concerned, the traffic volume and several other factors determine the extent of the ecological impacts. Moreover, mitigation measures at project level can reduce (sound barriers) or even eliminate (tunnelling) adverse impacts. Therefore, an EU-level network assessment should primarily be seen as a warning system for potential risks.

The feasibility study clearly underlined the practical difficulties that arise in an assessment of the overall network. The quality and availability of data at EU-level turned out to be rather poor. For example, digitalised maps of the TENs are only available on a very large scale (1:1.000.000), information concerning the possible alignment of new links is often lacking, the actual boundaries of designated areas are unknown or not available in GIS-format, and overlaps between different designation categories cannot be identified.

The insufficiency of information limits the performance of the assessment methods. Based on the currently available data, the measurability and analytical validity of the proposed indicators cannot be fully assured. Therefore, either additional data must be collected at EU-level or a different approach must be followed, namely a more detailed but still strategic, assessment per infrastructure scheme. An example of this method is the way in which strategic assessments are carried out for the German Bundesverkehrswegeplan. Furthermore, additional data collection would be particularly important for improving information on planned TEN infrastructure. Another priority action is the completion of the NATURA 2000 network, as this would provide a more consistent basis for assessment of impacts on habitats.

The models and parameters that were used in this study have been applied in a rather straightforward manner, and have been employed using expert judgement, which inevitably involves a certain degree of subjectivity. The key assumptions that have been made and their transferability to EU scale should be improved by a broad and multi-disciplinary consultation of experts. In particular the EU wide definition of sensitive zones, which inevitably relies to a certain extent on a subjective use of sensitivity values, should be further researched.

As a broad conclusion, the present methodological study can be considered successful as it realised most of its original objectives. It demonstrated the technical feasibility, but also the limitations, of a European-wide SEA of the TEN, and stressed the usefulness of multi-disciplinary data collection at an European scale.

As a result, the present exercise helped suggest further research and methodological improvements:

1. Refining the indicators and methods through a wide and multi-disciplinary consultation process;
2. Filling the major data gaps on the TEN and on the environment;
3. Carrying out a full spatial and ecological assessment of the TEN, including the integration into the GIS of the results of the traffic-related impacts and a comprehensive multi-criteria analysis of the predicted impacts;
4. Initiating longer term research on the above outlined issues, in order to gradually improve methods, data and tools for the ecological and spatial impact assessment of transport plans;
5. Performing “zoom analyses” or “sample surveys”, enabling a testing of the inter-relation between different planning/ geographical levels and corresponding assessment techniques.

3. Context

3.1. Background

In July 1996 the European Parliament and the Council adopted Community guidelines for the development of the multi-modal trans-European transport network (TEN)[1]. By 2010, it will gradually be established by integrating land, sea and air transport infrastructure networks throughout the Community. The transport infrastructure will comprise road, rail and inland waterways networks, seaports and inland waterway ports, and other interconnection points. The guidelines provide the framework for the development of the TEN and specify objectives, principles and outline maps. One of the main objectives of the TEN is "...to ensure the sustainable mobility of persons and goods within an area without internal frontiers under the best possible social and safety conditions..." (article 2 of the guidelines). The network should not only strengthen the economic and social cohesion of the Union, but should also help to achieve the Union's environmental objectives. Integration of environmental concerns into the design and development of the TEN is considered a key priority.

The Commission has long recognised that the development of a process of strategic environmental assessment (SEA) is a prerequisite in this regard. This view has been confirmed in the guidelines. Article 8 §2 of the TEN guidelines states that "the Commission will develop appropriate methods of analysis for strategically evaluating the environmental impact of the whole network [...] and will develop appropriate methods of corridor analysis covering all relevant transport modes without prejudice to the definition of the corridors themselves [...]". The article also stipulates that the result of the work will, as and when appropriate, be taken into account by the Commission in its report on the revision of the guidelines, which is to be published by July 1999.

It should be noted that the concept of strategic environmental assessment is not limited to transport policies or plans. In several Member States and in a number of countries outside Europe, SEAs are already commonly carried out for land use and development plans. Moreover, strategic environmental assessments may become mandatory for a wide range of plans and programmes if the Commission's proposal for a Directive on SEAs is adopted[2]. In April 1997, the Council of Ministers of the European Conference of Ministers of Transport formally endorsed the principles of SEA at its session in Berlin and called for SEA to be put into practice.

3.2. The Commission Work Programme on a SEA of the TEN

Following the adoption of the TEN guidelines, the Directorate-General for Transport (DGVII) and the Directorate-General for Environment, Nuclear Safety and Civil Protection (DGXI) of the European Commission started to co-operate closely . A state-of-the-art review showed that a wide range of SEA methods and techniques already exist and that SEA practice in the transport sector is growing. However, there is little experience in applications on a scale comparable to the trans-European transport network. Thus, a practical-oriented work programme was developed and adopted by both DGs. It included the following major tasks:

- carrying out a pilot SEA of the overall trans-European transport network, in co-operation with the EEA and in consultation with the Member States;
- supporting a number of pilot assessments of TEN corridors conducted by the Member States in co-operation and with co-financing of the Commission;
- developing a methodological handbook for SEA of infrastructure networks and corridors, featuring the findings of past state-of-the-art studies, case studies and the above mentioned pilot SEAs. Practical guidance is also given.

The present work forms part of the pilot SEA of the overall trans-European network, which - for pragmatic reasons - has been split in three main parts:

I the assessment of spatial and ecological impacts of the TEN. This part focuses on the mere physical impacts of the infrastructure. The idea is to evaluate land use, disturbance and fragmentation of

1) Decision N° 1692/96/EC on Community Guidelines for the development of the trans-European transport network, OJ L 228, Volume 39, 9 September 1996

2) Proposal for a Council Directive on the assessment of the effects of certain plans and programmes on the environment - COM(96)511 final

3) European Commission - DGXI, Spatial and ecological assessment of the trans-European transport network: scope, methods, data and research needs, Workshop proceedings, Brussels, 24 - 25 April 1997.

nature areas, etc. by using geographical information system tools;

II the assessment of traffic-generated impacts such as emissions of greenhouse gases, acidifying gases and pollutants, energy consumption, safety and - if possible - noise. This task, which requires the use of predictive traffic and environmental models, will be carried out by an international research team in the context of the Commission's 4th Frame work Programme on Transport RTD;

III the aggregation of the results of the previous two steps and the comparative evaluation of the predicted impacts in the light of the Community's environmental objectives and targets.

The present methodological study was conducted as a preparatory phase for the first part of the pilot assessment, i.e. the spatial and ecological assessment of the TEN. It builds on the findings of a technical workshop on this issue organised by the Commission in April 1997[3]. The workshop was attended by representatives of the European Commission (DGXI, DGVII, and Eurostat), the EEA and its Topic Centres on Land Cover and Nature Conservation, a number of international NGOs, as well as consultants and scientists.

The work, steered and developed by a DGVII-DGXI-EEA-Eurostat working group, consisted of the following tasks:

- the development of an integrated database and Geographical Information System (GIS) on the TEN, including thematic data maps on infrastructure, land cover, demography, geography, environment and nature;
- the selection and review of indicators for assessing the spatial and ecological impacts of the TEN, taking into account the current data availability and limitations;
- the development and testing of a number of GIS assessment techniques;
- the compilation of the results in a GIS demonstration package to allow an interactive demonstration of indicators and methods;
- a broad consultation on the findings and a consensus-building process regarding full assessment methodology.

4. Methodology

4.1. Purpose and Scope of a SEA of the TEN

The SEA is a systematic process of evaluating the environmental impacts of a strategic action and its alternatives. The main aim of a SEA is to ensure that environmental considerations are addressed at the earliest appropriate stage of decision-making and on a level equal to that of economic and social considerations.

In developing methods for the SEA of the TEN, it is important to keep in mind the general aim of such an evaluation and the information that it is expected to generate. The main objective of developing a SEA system for the TEN is to raise awareness about the environmental consequences of developing the TEN, to improve planning and to assist investment decisions. The SEA of the TEN should therefore provide the following information:

- an overall evaluation of the extent to which the current TEN outline plan will help to achieve the Community (and other) objectives and targets for environmental protection. This evaluation should distinguish the effects per transport mode, the potential modal shift and the effect of induced traffic;
- a broadbrush impression of the geographic distribution of positive and negative impacts of the TEN. In particular, the assessment should allow the identification of potential conflict areas. The SEA will not address alignment options per link or corridor, but can for example be useful in determining the size of the corridor that should subsequently be assessed in more detail by the Member States at a more local planning level (e.g. corridor level).

The SEA should produce information that is of greatest relevance to the particular decision-making level it addresses and on a level of detail that is appropriate. Thus, the assessment of the TEN will differ in scope and detail with the assessment of the TEN corridors: an assessment at TEN-level will inevitably be more broad and will focus on impacts of “Community-importance” (e.g. greenhouse effect, acidification, loss of biodiversity). Corridor assessments will enable more detailed evaluations and will have to take into account specific and more detailed national and regional characteristics and objectives.

4.2. Environmental Objectives and Targets

Strategic assessment is generally considered as an objective-led process. The purpose of a SEA is to assess to what extent the strategic action and its alternatives contribute to the realisation of certain environmental objectives and targets. A framework of environmental objectives and targets is essential for the identification of proper indicators and for the evaluation of impact predictions.

The broad (environmental and other) objectives of the TEN are set out in Article 2 of the TEN guidelines. For a SEA at the TEN level, the targets of the 5th Environmental Action Programme (5EAP)[4] and its recent review[5] provide a minimum framework. The White Paper on the Common Transport Policy (CTP) also identified a number of priority environmental objectives. As regards nature conservation, the designated areas covered by the Directives 79/409/EEC (Birds Directive) and 92/43/EEC (Habitats) and other (inter)nationally designated conservation areas should be incorporated. The present study focuses on Community-level targets. At a later stage, an investigation should be conducted as to whether and how national or regional strategic options and objectives can be included within the framework of the SEA of the TEN.

4.3. Impact Indicators Selection

An indicator is a variable that enables an evaluation of the impact intensity for a particular environmental stake or objective. Environmental indicators can be measured in physical units (e.g. emissions), on an ordinal scale (e.g. landscape quality) or can simply be described in a qualitative manner (e.g. biotopes).

One of the main aims of the working group was to identify possible indicators of spatial and ecological impacts of the TEN. In the context of this study, ecological and spatial

4) European Commission, DG XI (1992): Towards Sustainability: A European Community Programme of Policy and Action in Relation to the Environment and Sustainable Development (The Fifth Action Programme). Brussels.

5) European Environment Agency (1995): Environment in the European Union 1995. Report for the Review of the Fifth Environmental Action Programme. Copenhagen.

impacts are broadly defined to include the following impact categories:

- Ecological impacts of infrastructure, i.e. impacts that are directly related to ecosystems, habitats and species and the degree of biodiversity. Examples are habitat loss, habitat fragmentation and disturbance or loss of species. Indicators are mostly related to habitats.
- Functional impacts, e.g. on agriculture and forestry: large-scale infrastructure development can create barriers, dividing functional land units such as parcels of farmland. They can consume part of the agricultural area and may make further exploitation impossible substitution effect).
- Impacts for which indicators with a spatial dimension can be used. An example of this is noise, which can be evaluated among other ways by estimating the number of people living in the vicinity of the infrastructure or by defining noise sensitive zones ("tranquil" zones) on the basis of a number of spatial / ecological criteria.

The scope and choice of impacts and indicators should match the appropriate policy level (in this case the EU level). For the SEA of the TEN simple indicators have to be used, which are applicable to the whole of the Union. For more local-level assessments (e.g. corridor assessments), other, more detailed indicators can be used, which also

Relevant selected spatial and ecological issues for a strategic environment assessment of the TEN Figure 4.1

Theme	Environmental objectives	Environmental targets	Potential indicator
Biodiversity and nature conservation	safeguard of biodiversity (5th EAP, CTP, Birds Directive, Habitats Directive, Ramsar Convention, Biodiversity Convention, etc.)	conservation of designated areas and the wider environment	vicinity of sites to the infrastructure density of sites within buffers around the infrastructure consumption of natural habitats
Water resources	sustainable use of water resources maintenance and improvement of groundwater quality maintenance of the ecological quality of surface fresh water eduction of discharges into marine water (5th EAP, CTP)	reduction of pollution, protection of watersheds, prevention of environmental damage from shipping activities	number of crossings of waterways number of water and groundwater protection zones touched
Coastal zones	sustainable development of coastal zones and their resources (5th EAP)	improve the balance of land use and conservation and the use of natural resources performe integrated planning and management improve co-ordination between relevant EC policies and between EC, national and regional policies	number of coastal zones touched size of coastal zone stretches taken by links
Noise	avoid exposure to dangerous noise levels for health and quality of life (5th EAP)	reduction of noise exposure (especially night-time exposure)	area under influence along the links number of tranquil zones touched
Land resources	sustainable maintenance of economic activities improve land-use planning	avoid disrupting functional units	land take (agricultural land, forestry)

Figure 4.1: Relevant selected spatial and ecological issues for a strategic environmental assessment of the TEN

account for more specific characteristics of the immediate environment. In short, the initial selection of spatial and ecological indicators has been made based on the following criteria:

- relevance in regard to Community environmental objectives and targets;
- applicability on EU scale (+ Switzerland).

As a second step, the working group assessed the feasibility of the impact indicators in terms of the availability of suitable data and evaluated the uncertainties involved.

Figure 4.1 summarises the impacts and potential indicators that were identified by the working group. The figure also indicates the policies that relate to various impacts and indicators. It distinguishes five different themes or issues: biodiversity and nature conservation, water resources, coastal zones, noise and land resources. The environmental objectives and targets concerning these issues primarily follow what is laid out in the 5th Environmental Action Plan, the White Paper on the Common Transport Policy, the Birds Directive, the Habitats Directive as well as a number of other international agreements. In general, the aim is to protect and conserve the areas concerned and in the case of noise, to reduce the number of people exposed to certain noise levels.

According to its modal scope this study focuses on terrestrial, linear TEN infrastructure, i.e. motorways, conventional and high speed rail links and inland waterways.

Airports, maritime ports and terminals are not included, mainly because the TEN guidelines do not identify specific planned projects for nodal points (with the exception of priority project 10, Malpensa Airport). Naturally, an assessment requires proposed plans or actions. For airports the guidelines do contain outline maps, but the maps only subdivide the main European airports into four categories (international connecting points, EU connecting point, regional and accessibility point, and airport as part of an airport system) without indicating any planned projects. As to maritime ports and inland terminals, the guidelines provide a general reference, but provide no outline maps nor an indication of planned projects. The Commission has meanwhile prepared a proposal for the integration of ports, inland ports and terminals in the trans-European network, in a similar way to that of airports.

In general, an impact assessment consists of three different steps:

impact prediction; making an objective estimate of the type and magnitude of the actions likely to have future impacts;

impact evaluation; the subjective appraisal of the significance of the predicted impacts, taking into account the sensitivity or importance of the receiving environment, and by comparing (e.g. using multi-criteria analysis) the impact levels with environmental objectives and targets;

analysis of the uncertainties that underlie the impact prediction and evaluation. One manner of dealing with uncertainties in a SEA is by basing the analysis on a relative comparison of alternatives, rather than on absolute impact predictions. It is of course important that the uncertainties at strategic level are not so large as to make subsequent assessments at more local levels of decision-making significantly different (and perhaps contradictory).

The working group focused on the first and third steps of impact assessment. The current report is an attempt to demonstrate how impacts could be predicted using the indicators suggested by the working group. The report does not include an evaluation of the impacts, since the predicted impacts should at this stage be seen as methodological tests. An evaluation of the impacts would be premature. However, the working group has considered the degree of uncertainty linked to the different indicators, taking into account the quality of the currently available data.

In this demonstration phase, a range of assessment techniques was tested, including:

- A proximity analysis of the planned TEN infrastructures to the (legally and scientifically) designated sites. This provides a very rudimentary indication of the potential risk that planned TEN links may constitute in terms of disturbance or damage to habitats.Calculations of single indicators for the whole network, such as total land take (per habitat type).
- A vulnerability mapping analysis, i.e. a confrontation of the TEN alternatives with sensitive zones. The zonesare defined on the basis of a combination of various indicators and are evaluated using indices of significance.

All assessment methods described in the present report were designed for consistency with geographical information system (GIS) techniques. A GIS is a computer-based system used for entering, storing, manipulating, visualising and analysing geographical and tabular data together. It is clear that computer hardware and software play a central role in a GIS; but data, models, expertise and documentation - orgware - are equally, if not more, important.

GIS tools are particularly useful for environmental assessments, because they can combine different databases and make overlays of different maps. The ability to present data and indicators in the form of maps greatly facilitates the understanding and interpretation of the evaluation. It should be noted that the maps included in the present document are only very small-scale representations of the actual output of the system and do not do justice to the degree of detail that is in fact present in the databases.

In order to test the different indicators mentioned above, several GIS techniques were applied:

- conversion algorithms were used to bring the data into the appropriate formats. Raster formats proved more suitable for overlay processes, vector formats were used for neighbourhood functions;
- spatial analysis operations were carried out including masking, proximity analysis, overlay, and data set re-combination;
- generation functions enabled the creation of specific support data such as sampling grids and perimeters.

Each individual indicator should be considered a result of a series of data transformation and manipulation steps using several of the above activities.

5. Data and Information Sources

A first important task in the demonstration work consisted of bringing together all necessary data in a single information system and checking their quality and appropriateness for use in the assessment. Guidance on the range of assessment methods to be tested was obtained through a review of various existing studies and SEA practices, which can be found on a regional, national and, to a lesser extent, international level.

5.1. Major Data Sources and Limitations

5.1.1. Transport Infrastructure Data

The use of transport infrastructure in the SEA requires information on the location, the mode, the type and the state of the European Networks. Eurostat-GISCO provided a number of spatially-referenced data sets covering the necessary information. These databases were reorganised to enhance their suitability for analysis.

It is important to note that the infrastructure data have important limitations. The outline plans that are included in the TEN guidelines only give very rough indications about the (future) location of the new infrastructure links. For some links, such information was completely lacking and their location has been entered in the Geographical Information System on the basis of a “best guess”. In addition, there is very limited information at European level currently on the status of the planned infrastructure links. In the case of roads, conventional rail and inland waterways, the guidelines do not distinguish upgrades of existing infrastructure from completely new links. Of course, this distinction is an elementary requirement for a proper assessment of the ecological impact of a planned road or rail connection.

Also, comprehensive and digitalised information concerning, for example, the number of motorway lanes or rail tracks is lacking.

The European Commission has initiated a number of activities to enhance the existing database on the TEN projects. These activities involve co-operation with the Member States and different international organisations (e.g. WERD and CCFE). Through this data collection exercise, the Commission’s GIS will gradually contain more information about the quality of the TEN links. However, it is not expected that more detailed information concerning the location of new links will be obtained.

It should also be noted that the scale of the available maps for the whole trans-European transport network is much larger than the scale of the maps used in any SEA applications used thus far. In fact, a recent study on a SEA concluded that “any GIS mapping at larger than 1:200.000 scale would be inadequate for SEA purposes”[6].

The working group that prepared the present document fully acknowledges the limitations of the available infrastructure data and therefore stresses that the output should not be seen as actual predictions of the possible environmental impacts of the planned TEN links. The aim of the current study was primarily to investigate how indicators and GIS could best be used and to test whether meaningful results can be pro-

6) Steer Davies Gleave, “State of the art on strategic environmental assessment for transport infrastructure”, prepared for the Directorate-General for Transport of the European Commission, Final report July 1996, p. 113.

Figure 5.1 **Available digitalised data concerning European TEN infrastructure**

Theme	Content	Source	Year
trans-European rail Network	as published in the Official Journal	Eurostat	1996
trans-European road Network	as published in the Official Journal	Eurostat	1996
trans-European water Network	as published in the Official Journal	Eurostat	1996
European Roads	1/1.000.000 road network	Eurostat	updated 1996
European Railways	1/1.000.000 rail network	Eurostat	updated 1997
Specific TEN projects	13 projects as published by the CEC	EEA	1997

duced, taking into account the quality of the available data.

5.1.2. Environmental Data

The term "environmental data" refers to a large variety of spatially referenced data sets. It is the combination of the different data that enables the creation of a model of the European terrain. From the basic material, derived data sets are produced for assessment purposes.

The figure below describes the core raw data used for the present study. All databases have a nominal scale of 1 / 1.000.000, unless specified otherwise.

As *Figure 5.2* illustrates, some of the databases are rather heterogeneous as far as age is concerned (land cover and population density in particular). The stability column provides an indication of the need to update the data sets. "Stable" indicates that the database concerned does not require frequent updating (e.g. topography, coastal zones and water pattern) whereas "dynamic" databases need regular updating over time (administrative units and nature inventories).

The available environmental spatially referenced data on the EU level also suffer certain limitations, either in scale, coverage or content. Certain impacts (e.g. impacts on soil quality and groundwater) had to be excluded from the assessment because of a lack of data. The EEA and its Topic Centres are making continuous efforts to solve the problems encountered in the environmental data sets.

The main problems are the following:

- coastal zones have only been defined in a linear way; there is no EU definition that enables the identification of the real or total area that should be considered;
- the database on population density (to be used for noise impact assessment) is heterogeneous in the sense that data come from different years; Eurostat-GISCO is working on an improved database;
- the land cover data is a compilation of various (national) databases. The EU database is not yet fully harmonised, but the European Topic Centre on Land Cover is working on this issue;
- the databases on designated sites and nature inventories only contain information on the size and the centre co-ordinates of the sites; information on the actual site boundaries is not (yet) available. DGXI has started initiatives to obtain information on site boundaries;
- the database on water patterns is hetero geneous and coverage is incomplete. The European Topic Centre on Inland Waters is currently involved in updating the database.

Available (digitalised) data for environmental assessment on European scale Figure 5.2

theme	content	source	year	stability
Coastal zone	derived from administrative regions	Eurostat	1996	stable
Topography	1 km resolution digital elevation model	Eurostat	1994	stable
Administrative units	mask defining the European Territory	Eurostat	1996	dynamic
Population	population density by smallest administrative units	Eurostat SFSO(CH)	1981/93	average
Land cover	1/100.000 CORINE land cover classes of the EU	ETC/LC	1986/97	average
Ecological regions	1/3.000.000 digitised map of the European ecological regions	ETC/NC	1997	stable
Designated sites	sites designated under international conventions	ETC/NC	1993 version	average
Nature inventories	sites complying to scientific criteria of importance to nature conservation	ETC/NC, Birdlife Int.	1989/95	dynamic
Water pattern	surface water pattern	CEC DGXI, ETC/IW	1985	stable

6. TEN Alternatives

6.1. Selection of Alternatives

The comparison of alternatives forms the core of each SEA. In the case of the TEN, the choice of alternatives must focus on modal choices and on varying degrees of network extensions.

In line with the concept of “tiering” and for practical reasons, it seemed appropriate that an assessment of an European network does not consider alternatives for each individual link, but rather illustrates the (potential) environmental impact of different overall network settings (or scenarios). The selection of the alternatives to consider is an issue in itself that requires further development and also a wide consultation process. It demonstrates that the European network assessment should primarily be seen as a tool to raise awareness about the possible environmental consequences of the TEN, which may compare different general orientations for the TEN.

For this pilot assessment, six alternative network developments have been selected. They must be considered only as examples of possible options. The six network alternatives are:

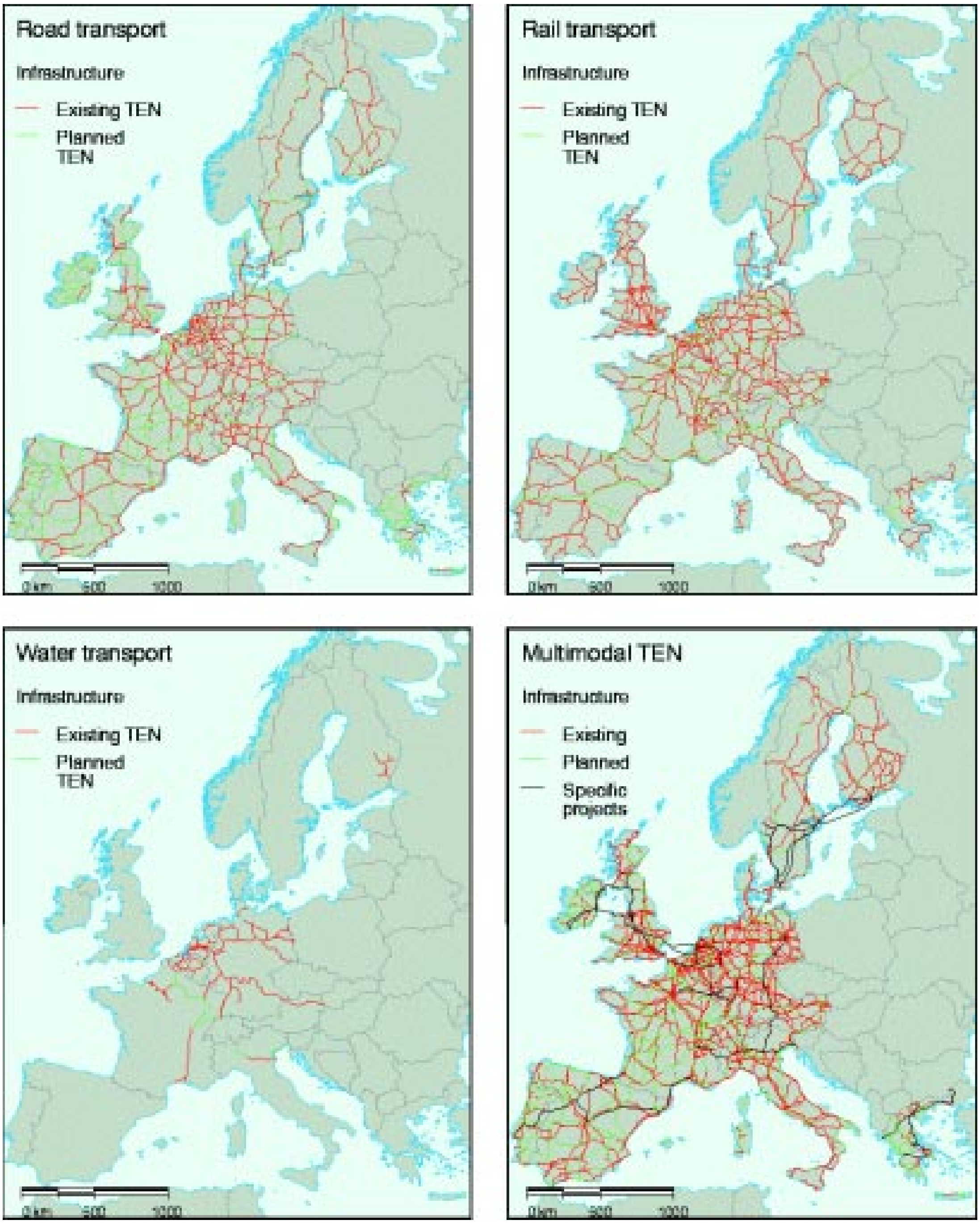
1. the existing TEN network (existing primary and secondary road, rail and water infrastructure is not included)
2. the existing TEN network plus the fourteen priority projects that were agreed at the 1994 Essen European Council (except project N° 10, the Malpensa Airport)
3. the existing TEN network plus all planned rail projects
4. the existing TEN network plus all planned inland waterway projects
5. the existing TEN network plus all planned road projects
6. the complete multi-modal TEN

The first alternative represents the “do-nothing” option (or present situation) that can be considered as a reference situation against which other alternatives can be evaluated. Variant 2 could be considered a “do-minimum” alternative. The other variants represent differing degrees of implementation of the TEN plans. Variants 3 to 6 are based on the outline maps 2 to 4 in Annex 1 of the TEN guidelines; planned projects are those projects indicated as “planned” in the outline maps. The projects of specific interest are those projects that were adopted by the European Council at

Figure 6.1 **Decision No 1692/96/EC Annex III priority projects**

Project	Mode	Member States	Location
1	High speed rail	DE, AU, IT	Berlin-Nürenberg, Brenner axis
2	HSR	UK, FR, BE, NL, DE	Paris-Brussels-Köln-Amsterdam-London
3	HSR	FR, ES	Madrid-Montpellier, Madrid-Dax
4	HSR	FR, LU, DE	Paris-Karlsruhe, Mannheim, Luxembourg
5	Rail	NL, DE	Betuwe Line
6	Combined	FR, IT	France-Italy
7	Road	GR	Greek Motorways
8	Road	PT, ES	Motorway Lisboa-Valladolid
9	Rail	IR	L link Cork-Dublin-Belfast-Larne-Stranraer
11	Rail/road	DK, SE	Øresund link (Denmark-Sweden)
12	Rail/road	SE, FI	Nordic Triangle
13	Road	IRL, UK, NL, BE	Ireland/UK/Benelux road link
14	Rail	UK	West Coast main line

The three transport modes included in this study and a multi-modal overview including the 14 specific projects Figure 6.2



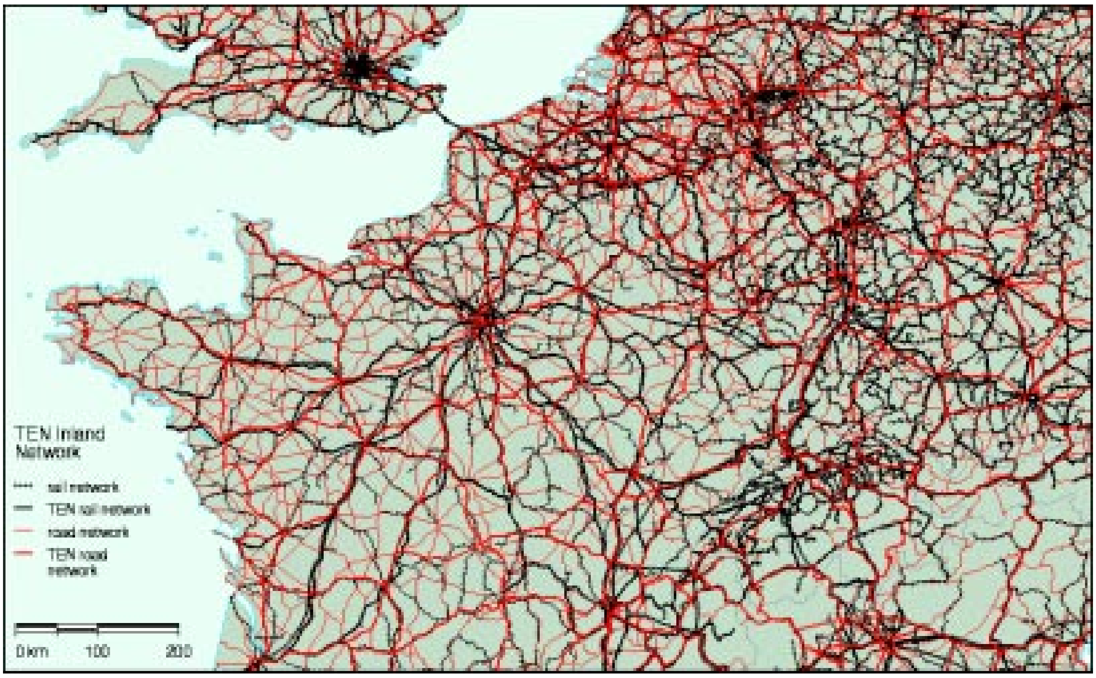
Essen on 9 and 10 December 1994 and are contained in Annex III of the TEN guidelines. Project n° 10, the Malpensa Airport, is not considered in this report, as this study's scope is limited to linear infrastructure plans.

Hence, the alternatives should not be interpreted as true policy options. They reflect (hypothetical) extreme situations, but make possible the identification of the range of possible outcomes concerning the environmental impact of the TEN and allow an evaluation of the modal liability for environmental impacts.

As mentioned before, plans for non-linear infrastructure (maritime ports and airports) have not been taken into account.

The working group acknowledges that by defining the variants in the above mentioned way, the "added value" for decision-making is limited, though important in raising awareness about the environmental implications and modal liability of the TEN development.

Figure 6.3 **Example of the multi-modal TEN network compared to the national and regional network**



It would be preferable to define alternatives that represent true strategic options and possibly different investment levels. One could for example think of a development variant that focuses on key corridors, a development variant that primarily aims at strengthening cohesion, a variant that requires limited investment and a variant that requires high investment levels. However, definition of such variants requires selection or prioritisation of individual links and therefore requires careful preparation and extensive consultation and discussion with all parties involved, in particular the Member States. The working group considered the definition of such TEN strategy options outside the scope of its primarily methodological work, but recommends this as an important issue for further research.

Figure 6.2 consists of four maps showing the existing and planned infrastructure that is considered in the current study.

Figure 6.4 **Estimated length of the trans-European transport network compared to the overall European infrastrukture (kilometres)**

mode	existing TEN (1996)	planned TEN (2010)*		existing overall European infrastructure**
		upgrade	*new*	
road	49,598	n.a.	+26,875	49,024***
conventional rail	48,477	n.a.	+1,372	155,836
high speed rail	4,901	+14,408	+10,088	2,406
inland waterways	12,239	n.a	+1,412	30,191

* *All planned roads, conventional rail links and waterways are assumed to be new*
** *Source: European Commission, “EU transport in figures - statistical pocketbook”, 2nd issue 1997 (figures refer to 1995)*
*** *Motorways only*

6.2. The TEN in Perspective

In order to facilitate the understanding of the scope of the trans-European transport network, *Figure 6.3* sketches the density of the TEN compared to the national and regional road and rail networks.

Figure 6.4 shows a different way of putting the trans-European network into perspective. It provides graphical estimates of the length of the planned links. The estimates were performed at a cartographic scale of 1/1.000.000 and provided the following cumulative lengths of the network alternatives. The calculations are based on the assumptions mentioned earlier, i.e. all planned roads, conventional rail and inland waterways are considered to be new infrastructure. A comparison of these measured values is made with the reference values made by DGVII.

7. Nature and Biodiversity

7.1. Main Objectives Concerning Nature and Biodiversity

The importance of safeguarding nature and biodiversity is undisputed. It is also one of the key priorities of the EU's 5th Environmental Action Plan.

The construction and use of roads, railways and canals produces several negative effects on nature and biodiversity. The infrastructure in itself may cause a loss of nature sites or lead to partitioning and isolating ecosystems and species populations. Secondly, the traffic that is using the infrastructure can disturb nature through noise, vibrations and accidents.

Different conventions and agreements have been established to protect nature sites and biodiversity, ranging from international legislation to regional programmes. At international level, the United Nations Convention on Biological Diversity (CBD) plays an important role. The signatories to the Convention (including all EU Member States) have committed themselves to the conservation of biological diversity and the sustainable use of its components.[7] In 1998, the European Commission adopted a Community Biodiversity Strategy in view of the fulfilment of the European Community's obligations under the CBD.

At European level, the 5th Environmental Action Plan obviously constitutes a central element, together with the Directive on the conservation of natural habitats and of wild fauna and flora (commonly referred to as the Habitats Directive) and the Directive on the conservation of wild birds (Birds Directive)[8]. The EU policy aims to create an ecological network of protected areas across the Union, the so-called Natura 2000 network. The network will consist of areas designated under the Habitats and Birds Directive.

When it comes to assessing a potential conflict the TEN might create in respect to nature conservation interests and biodiversity maintenance, the question arises whether only impacts on formally designated sites should be examined or whether nature and biodiversity should be interpreted in a broader sense. The latter would include other sites, like habitats and species, as well as buffer-zones and corridors. This leads to two different types of analyses.

The first analysis focuses on the vicinity of the existing and planned TEN infrastructures to the (legally and scientifically) designated sites of nature conservation interest. If a link is located in or near a designated site, it is assumed to constitute a potential risk to the site concerned.

The second evaluation method specifically considers the partitioning effect of the TEN infrastructure. The partitioning, or fragmentation effect constitutes an important element of the adverse environmental impacts that infrastructure may have. The evaluation uses information concerning designated areas, but also uses other information.

7.2. Vicinity to Sites of Nature Conservation Interest

A first way of estimating the impact of the TEN infrastructure on nature and biodiversity is through identifying the vicinity of planned and existing TEN links to designated nature sites. If a link runs through or is located near a designated site, it may be assumed that there is a potential risk of adverse impacts to the site concerned.

This type of analysis has been suggested and tested before by the Royal Society for the Protection of Birds (RSPB) in its report "The impact of trans-European networks on nature conservation: a pilot project" (1995).

It should be noted that the strategic network assessment can only identify potential risks; the actual impacts naturally depend on the exact location of the link (and site), the type of construction and the mitigation measures that are taken. However at the strategic level, it is neither possible nor appropriate to take account of detailed information per link (in accordance with the principle of "tiering", this should be left to corridor or project assessment). The aim of the network assessment is simply to present an overall picture of the possible environmental impact of the TEN. Of course, by presenting potential risks

7) The CBD defines "biological diversity" as the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.

8) Council Directives 92/43/EC and 79/409/EC.

rather than actual impacts, the assessment paints a "worst-case scenario": not all potential risks will become real impacts.

7.2.1. Methodological Approach

Using a methodological approach, the first question to be answered is what sites are taken into account. Several thousand sites are defined throughout Europe. The majority, however, can only be mapped on a local scale. Digitalised information on the European scale is currently only available for sites designated on a formal international or European basis.

Several limitations of the data must be noted. Firstly, the existing site lists contain only extremely limited information. For example, the actual site boundaries are in general not known. Instead, the databases provide centre co-ordinates and an indication of the surface of the site. Secondly, certain databases do not cover all countries and / or contain data of varying age (this is particularly true for the CORINE Biotopes). Thirdly, areas may be double counted, as the same site may be designated under various conventions. A typical example is the Camargue area in the south of France. The problem of double counting may be solved in the future once more detailed site descriptions become available under Natura 2000.

The nationally designated sites have not been considered in this study either, due to the current lack of consistency and heterogeneity of the data (definitions of the sites depend on national legislation that vary

Site description according to its legal statute Figure 7.1

Sites	Description
	Designated sites protected under community legislation
Bird Directive (SPA)	Directive 79/409/EEC provides a general system of protection for all species of wild birds. Its purpose is to regulate the hunting, capturing, killing and sale of such species. Its main objective is the conservation and restoration of natural habitats. Data is not complete for all countries (only a sample of sites has been tested).
	Designations under international conventions
European Diploma	Network of the CoE to promote better management of important natural sites, scientific research and awareness raising.
Barcelona Convention	(16 Feb. 1976). The Convention for the Protection of the Mediterranean Sea constitutes the main legal instrument for the protection of the Mediterranean environment. It is a framework convention that has been progressively developed through the adoption of further instruments and protocols.
Biosphere Reserve	The UNESCO "Man and the Biosphere" programme aims to encourage interdisciplinary research, training and demonstration activities with a view to improve the understanding and management of the resources of the various ecosystems. A BR aims to reconcile the conservation of biodiversity with its sustainable use by involving local communities.
Biogenetic Reserve	A network of the CoE to include sites with special emphasis on endemic species and biodiversity.
World Heritage	The UNESCO World Cultural and Natural Heritage Convention preserves outstanding ecosystems and landscapes.
Ramsar Convention	(2 Feb. 1971) The Convention on Wetlands of International importance, with emphasis on waterfowl habitat, aims to combine long-term national policies with co-ordinated international action.
	Scientific inventories
CORINE Biotopes	A scientific inventory of sites important for nature conservation, regardless of the designation given. Sites were selected according to the presence of species, habitats or landscapes. The data varies considerably in age.
Important Bird Area (IBA)	Birdlife International used its global network of national organisations to create a database to monitor the conservation of bird species and habitats, identify and secure conservation of the most important sites, and build a greater understanding of the relationships required for sustainable development.

enormously). The EEA European Topic Centre for Nature Conservation is compiling a list of all national sites (without however harmonising the definition of the sites) in the common database on designated areas.

As already indicated, the information concerning the location of new TEN links, as well as the boundaries of the designated sites, is rather imprecise. The databases on the TEN provide only rough indications of the locations of new links (sometimes "best guesses") and the nature sites can often only be represented symbolically by a circle with a radius that is proportional to the site surface.

In order to take account of these uncertainties, a buffer-zone around the infrastructure centre lines can be used. Of course, the width of the buffer-zones is a significant determining factor for the outcome of the study. On the one hand, the buffer-zone should be wide enough to reflect all potential impacts in a reasonable way. On the other hand, the buffer-zone should be narrow enough to avoid unnecessary overestimation of the possible risks. Ideally the buffer-zone should be a fair reflection of the "average uncertainty" concerning the location of the nature site and the planned infrastructure link. Simultaneously, it should take account of the fact that the impact of the infrastructure - through for example noise and vibrations - stretches further than the actual borders of the infrastructure itself. An additional complication arises from the fact that many sites have an oblong shape, thus are not compact. The working group acknowledges that by making random sample surveys, an indication of the "average uncertainty" of the geographical information might be obtained. Such sample surveys have not been carried out, but could be a subject for further research.

An indication for choosing the width of the buffer-zones can be obtained from other studies. The RSPB used for example corridors of 2 and 10 kilometre wide[9]. The French Ministry of Transport generally applies 10 kilometre buffer-zones in the assessments that are carried out on corridor level[10]. Consequently it was decided for the current analysis, a 10 kilometre buffer-zone should apply.

7.2.2. The Results

There are different ways in which the results can be presented. A first option is to identify per TEN development variant, the number of sites that is potentially at risk. *Figure 7.2* shows the proportion of potentially threatened sites for the six network alternatives, according to its statute. It suggests that the development of the planned road network will increase the number of potentially

Figure 7.2 **Designated sites potentially affected by the development of the trans-European transport network. Status in mid 1997 (overlaps between sites not taken into account)**

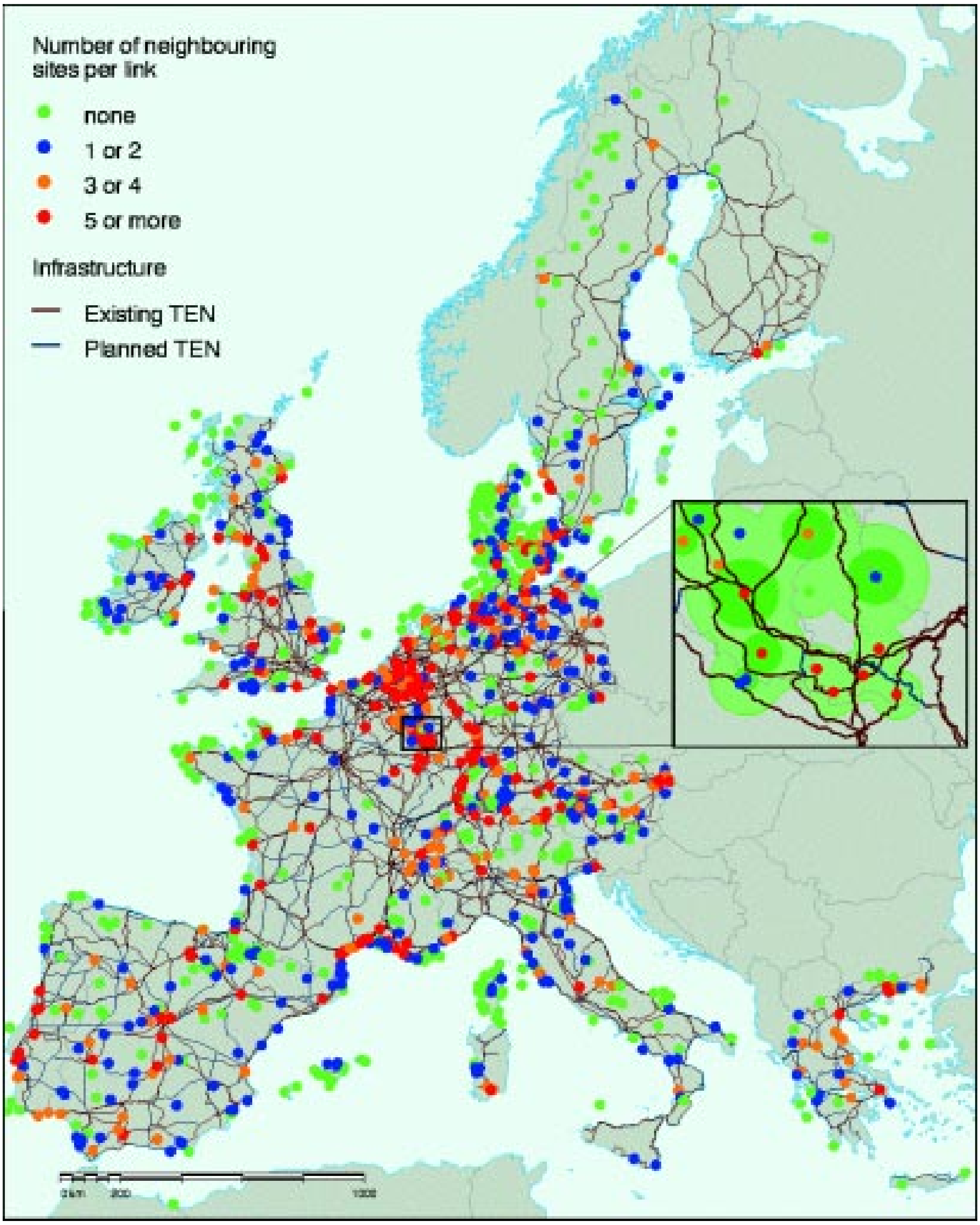
	variant (% of sites within 10 km)						
site type and inventories	**1**	**2**	**3**	**4**	**5**	**6**	**number of sites**
S.P.A.	53	53	55	53	60	61	743 (EU12)
Barcelona C. site	43	44	44	44	47	49	94
Eurodiploma site	44	53	47	44	56	59	34
Biosphere Reserve	66	68	66	68	72	75	47
Biogenetic Reserve	52	53	54	52	57	59	253
World Heritage	20	20	20	20	20	20	5
Ramsar C. site	71	72	72	71	79	80	246
CORINE Biotopes inventory	49	50	51	49	56	58	7740 (EU12)
Important bird area	51	52	53	51	58	59	1644

Variants: *1) existing TEN network*
2) existing TEN network + 13 specific projects
3) existing TEN network + all planned rail projects
4) existing TEN network + all planned inland waterway projects
5) existing TEN network + all planned road projects
) complete multi-modal TEN

9) RSPB, idem.

10) See Ministère de l'Equipement, des Transport et du Tourisme - Direction des Routes, "Flux est-ouest au sud du bassin parisien, dossier pour un débat", Décembre 1994. It must be noted that the scope and nature of this study is slightly different from the network assessment at European level.

Indication of potential conflicts between complete TEN and nature sites. Nature sites classification according to neighbouring links | Figure 7.3



threatened sites by 14 percent. The development of the rail projects has a considerable smaller impact. This is barely surprising considering that the extension of the road network is assumed for this exercise to consist of around 27,000 kilometres of new infrastructure, whereas the rail network is only extended by around 11,000 kilometres.

The presented results should only be considered as hypothetical, considering the uncertainties both for the infrastructure data (distinction between new links and upgrading) and for the environmental data (double counting of sites).

Figure 7.3 gives a geographical representation of the sites that are potentially at risk. The map distinguishes four different risk categories. The sites indicated with a green dot are not within the 10 kilometre buffer-zone of any of the existing or new TEN infrastructure links. The sites represented by a blue dot are "threatened" by one or two links, the orange ones by 3 or 4 links and the red sites by 5 or more links.

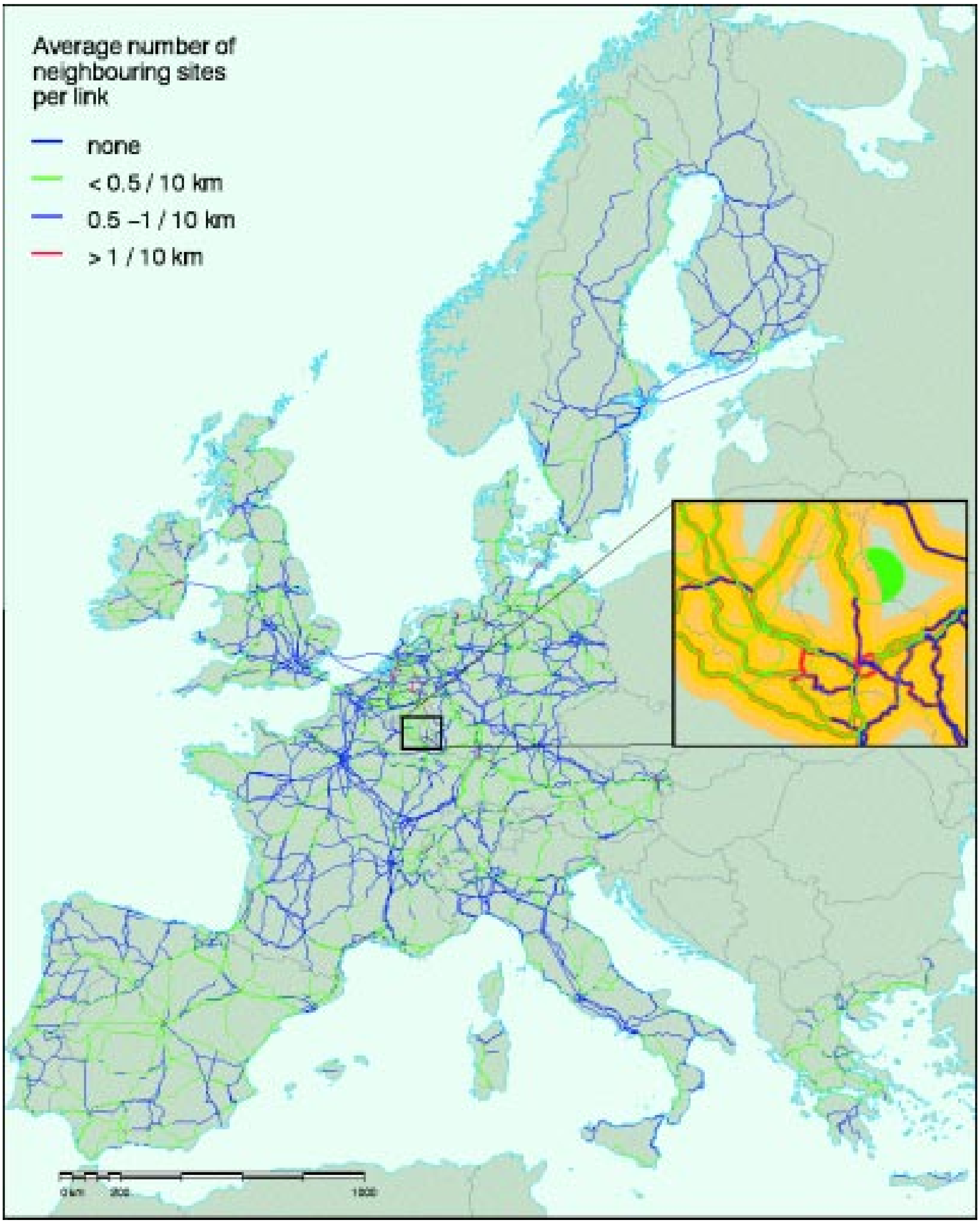
Instead of showing the results per site, the outcome can also be presented per link. *Figure 7.4* shows the average number of designated sites at risk for each link. The map is based on a density calculation per link because a longer link naturally has a higher chance of neighbouring sites than a shorter link.

Combining approaches allows the identification of problematic links and sites with a high probability to exposure. It could be considered that special caution is required when dealing with projects on these locations (red flag approach).

7.3. Partitioning of Land

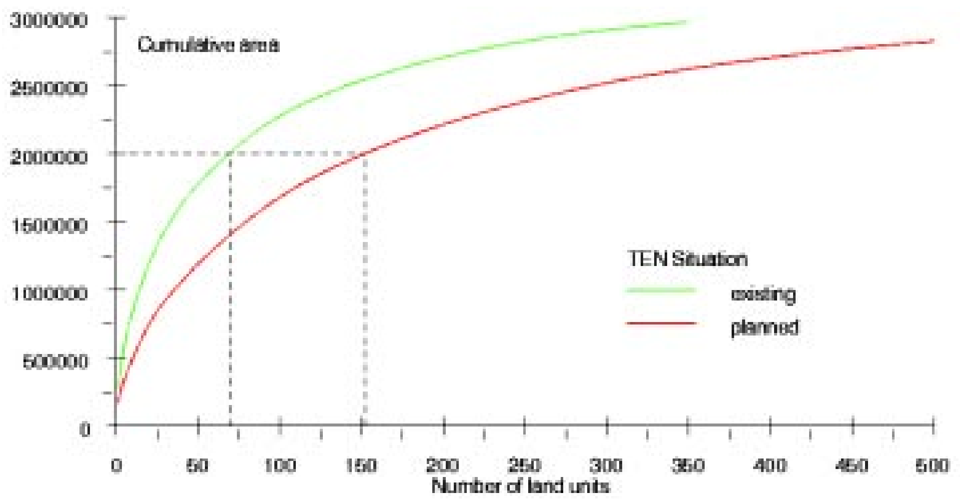
A particular effect that linear infrastructure has on nature - and landscape - is that it partitions land or, more specifically, fragments habitats.[11] Habitat fragmentation can be defined as the splitting of natural ecosystems into smaller and more isolated units

Figure 7.4 **Indication of potential conflicts between complete TEN and nature sites.**
TEN infrastructure classification according to neighbouring nature sites.



11) More detailed research on the problem of habitat fragmentation is planned in the framework of COST Action 341 (European Co-operation in the field of Scientific and Technical Research).

Number of land units and their cumulative surface - existing and TEN planned situation | Figure 7.5



thus endangering the survival of animal and plant species and communities. The decline in biodiversity witnessed after a land unit has been split into smaller fragments depends on the condition of the original unit, the size and distribution of the newly formed parts and the barrier effect of the infrastructure delineating the unit. Moreover, partitioning can constitute a form of visual intrusion to valuable landscapes.

7.3.1. Methodological Approach

For the above stated reasons, a good indicator for measuring the partitioning effect should take both size and ecological quality into account. The size of a unit can be determined graphically; yet to assess its ecological quality is more difficult. Two approaches to the quality problem have been explored, i.e. quality evaluation based on:

I. the proportion of the land unit area that is designated by international conventions
II. the proportion of the land unit area that is covered by forest or semi-natural habitats.

If a land unit scores above the European average on both observations, it is considered of high quality; if it fails on both accounts, it is considered of lower quality.

For the present exercise, only the TEN links were included. The other existing primary and secondary road and rail infrastructure was not taken into account. It follows that this is a simplistic assumption and that the derived results can only be considered as "dummy" results that merely serve to illustrate the methodology. The working group acknowledges that further testing is required to determine how and to what extent influences other than the TEN, can be dealt with properly.

Another simplifying assumption has been made-to ignore original land units (delineated by the existing TEN network) that were smaller than 1000 km². This was done purely for scale reasons. It does not imply that smaller land units of biological interest are considered to be unimportant. However, because of the rough scale of environmental data on EU level and the uncertainty of the location of TEN links, it is not possible, at this level, to evaluate effects on smaller land units. This is a task for national, regional or local level assessment.

A similar type of analysis has been tested by the French consultancy BCEOM for the assessment of national infrastructure plans ("Schémas Directeurs").[12] The French study considered all main railway lines, all roads and motorways with an average daily traffic of more than 4000 vehicles per day, all canals and all natural fragmentations (such as valleys). Even though large-scale maps were used for other parts of the assessment, BCEOM used relatively detailed maps for the evaluation of habitat fragmentation. The methodology proved very feasible in a test application at a regional level.

7.3.2. The Results

Again there are different ways in which the results can be presented. *Figure 7.5* shows a graph with the number of land units compared to their cumulative surface. The green line represents the existing situation; the red line indicates the situation after implementa-

12) BCEOM, "Etude stratégique d'impact sur l'environnement - essai méthodologique", Ministère de l'Environnement - Direction de la Nature et du Paysage - Sous-direction de l'Aménagement et du Paysage, Décembre 1994.

tion of the trans-European transport network. The red line runs clearly below the green line. This illustrates that the same cumulative area (for example 2,000,000 ha) is formed by more individual land units after the realisation of the TEN than before. The disadvantage of this presentation is that it does not take account of the quality of the fragmented land.

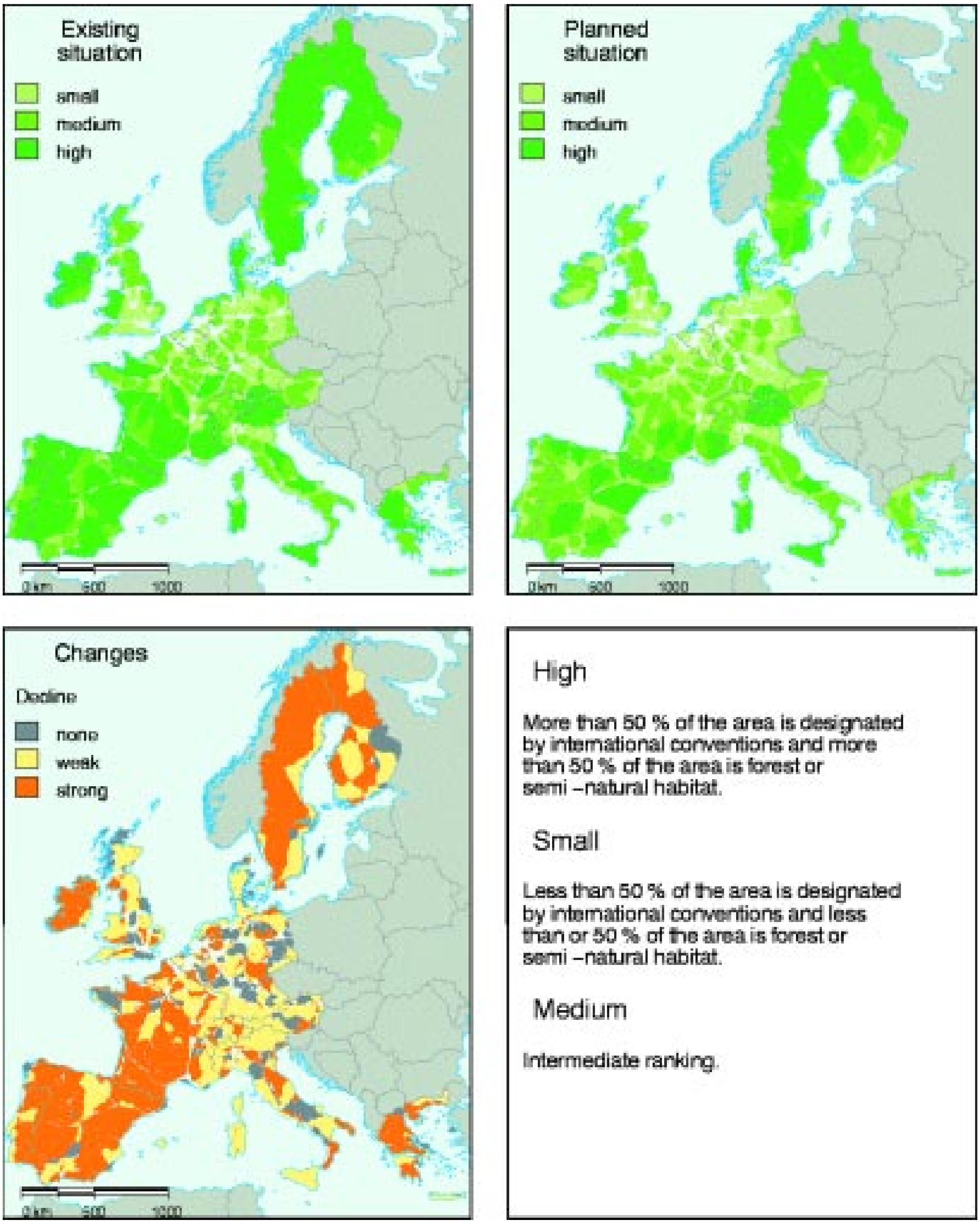
Figure 7.6 below illustrates the partitioning effect taking into account the characteristics of the land units. Map 7.6-A shows the existing situation and map 7.6-B shows the situation after the development of the TEN. Map 7.6-C illustrates the differences between map 7.6-A and 7.6-B. The green areas on map 7.6-C have not changed due to the execution of the TEN; whereas the brown areas have deteriorated from “high quality” land (with an above average proportion of designated land and an above average proportion of land covered by forest or semi-natural habitats) to “poor quality” land (a below average proportion of designated land and forest / natural habitats).

Figure 7.6	**Partitioning of Land effect on the complete TEN**

A. Quality of land units according to size and ecological criteria. Existing situation.

B. Quality of land units according to size and ecological criteria. Complete TEN planned situation.

C. Induced land quality changes by land partitioning effect of the complete TEN (Drop in indicator value set at 20%).



8. Water Resources

8.1. Main Objectives Concerning the Protection of Water Resources

Infrastructure building and use can affect water quality through pollution from exhaust emissions, de-icing salts, weed control along roads and railways, fuel spills, sewage from train discharges onto tracks, and pollutants associated with transport of hazardous materials. Transport infrastructure building can furthermore affect the hydrological functioning of ground and surface water, e.g. can disturb the groundwater table and affect the course and run-off of surface water.

Surface and groundwater quality are key elements in a healthy environment as it forms the very basis of life itself. National and international networks monitor water quality , and various kinds of protection measures are implemented throughout the Union accordingly.

The European Union Fifth Environmental Action Programme identified the most important problems and set priorities. With respect to groundwater and surface freshwater, it stressed the need to integrate resource conservation and sustainable use criteria into other policies including agriculture, industry and land-use planning. Concerning the qualitative aspects, and taking into account surface freshwater, it called for the safeguarding of existing high quality and the improvement of the ecological quality of water.

The proposal for an EU Action Programme for Integrated Groundwater Protection and Management (COM(96) 315 final), adopted by the Commission in August 1996, together with the proposal for a Water Framework Directive (COM(97) 49 final), issued in February 1997, aim to protect groundwater, inland surface waters, estuaries, coastal waters and groundwater, which form the framework for the water policy. The Water Framework Directive would require Member States to prepare a programme of measures to attain “good” surface water and groundwater status by the end of 2010.

There are some regional and international agreements that concur to the same broad objectives and targets. Regional agreements include the Rhine Action Plan, the Elbe Action Programmes, the Helsinki Convention - Baltic Sea Joint Comprehensive Environmental Action Programme - 1993 to 2012, the Oslo and Paris Commission [OSPAR] - North Sea Ministerial Conferences, the Hague Conference of 1990, the Mediterranean Action Plan, and the Arctic Monitoring and Assessment Programme. International agreements include the Convention on the Protection and Use of Transboundary Watercourses and International Lakes.

8.2. Crossing of Surface Waters

8.2.1. Methodological Approach

In principle, a similar type of indicator as for biodiversity and designated areas could be used to identify the surface water areas or water catchment areas at risk by determining the vicinity to new infrastructure links. Similar to the former chapter, the actual impact on water quality and hydrology are extremely difficult to predict as it would require accurate knowledge and data, for example, on the complex relation between the emissions of pollutants and their dispersion in the water. Again, the strategic assessment at European level can only aim to identify potential impact risks on the basis of a very simplified risk indicator.

It did not appear feasible to consider water catchment areas simply because EU-wide spatially referenced information on the

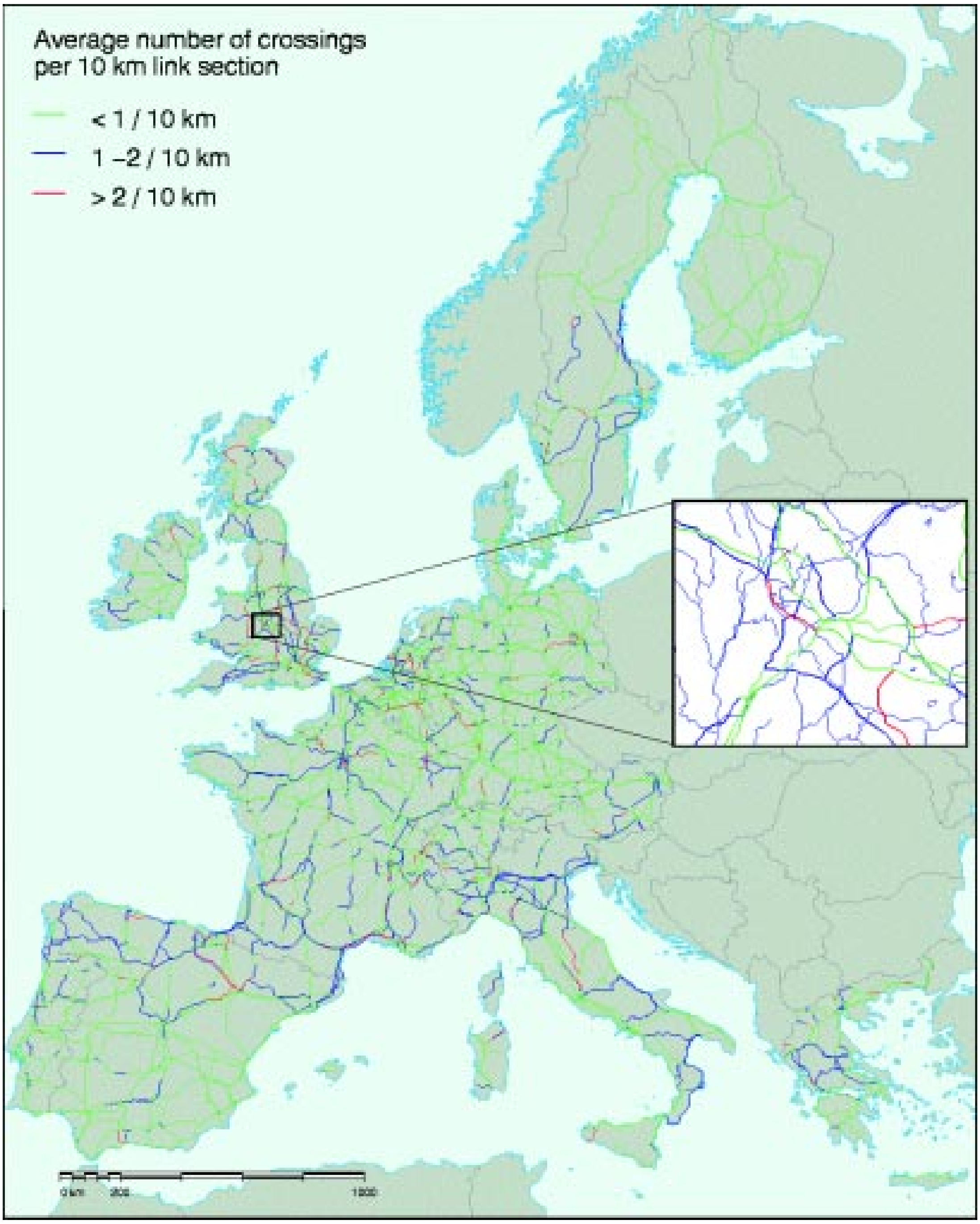
Water crossings of the existing trans-European transport network Figure 8.1

observed crossings	road	rail
number of crossings of the existing TEN network	3373	6050
density of crossings of the existing TEN network	6.8/100km	8.9/100km

Figure 8.2 **Comparison of the number of water crossings under different TEN variants**

Alternative	road	rail
existing TEN network	100	100
existing TEN network + 14 projects of specific interest	108	106
existing TEN network + all planned rail projects	100	116
existing TEN network + all planned road projects	166	100
complete multi-modal TEN (rail and road links only)	166	116

Figure 8.3 **Complete Multimodal TEN classification according to potential conflicts with surface water**



quality of surface water and groundwater resources is lacking. Therefore, only a very simplistic, morphological indicator was tested. It is based on the crossing of surface water. In other words, the density of crossings, measuring the potential proximity between links and surface waters, was considered as an indicator for environmental risk to surface waters.

For self-evident reasons, the TEN inland waterways were not included in this exercise.

8.2.2. The Results

Figure 8.1 summarises the number of water crossings and the density of crossings (per 100 kilometre of infrastructure) on the existing situation. It suggests that on average the rail network crosses more water patterns than the road network.

Figure 8.2 presents the increase in the number of crossings compared to the existing network. The figures are given as indices (existing network = 100). The table suggests an extremely large increase of water crossings due to the construction of new roads. However, similar to all results on the previous chapter, the outcomes should not be seen as estimates of the actual impact, but rather as “dummies” to illustrate the output of a methodology.

Results can also be presented per link. “Critical” links can be identified by measuring the density of surface water crossings they induce. *Figure 8.3* includes a map drawn for the complete TEN variant and provides an illustration of this type of presentation.

9. Noise

9.1. Main Objectives Concerning Noise

Noise pollution is one of the most tangible and direct effects related to the use of transport infrastructure. The importance of this issue on urban areas was pointed out in the 5EAP - where it was shown that more than 16% of the Community population suffers because of noise levels over Leq 65 dB(A) during the night, mainly resulting from road and air traffic. Noise pollution has also recently been highlighted in the Commission's green paper on a future noise policy[13].

Noise is an impact that can be effectively mitigated at project level (e.g. through the use of tunnels, cuttings, noise screens). Still, it is also important to consider the impact at earlier planning stages, in particular at the level of route determination.

Noise emissions not only depend on traffic characteristics (e.g. traffic intensity, speeds) and vehicle technology but also on the infrastructure design and materials. Furthermore, the degree of nuisance that noise emissions cause is very much determined by local elements, as noise propagation depends largely on the typology of the local environment (i.e. topography, existing obstacles and screens such as buildings or vegetation) and meteorological conditions. This means that although noise levels can be effectively measured and modelled at a local scale, it is much less straightforward to model noise impact quantitatively at European scale.

Nevertheless, two approaches have been tested. The first approach considered the population within buffer-zones around the existing and new infrastructure. The second approach consisted of the identification of so-called "tranquil zones" that could be at risk due to the TEN infrastructure development. In fact, the two approaches illustrate typical issues when assessing noise. On the one hand, the aim is to avoid noise exposure for people in their dwellings, offices and work places, and on the other hand, the aim is to maintain "tranquil areas" both for reasons of nature conservation and recreation.

9.2. People in the Vicinity of Infrastructure

9.2.1. Methodological Approach

The increase in the number of people susceptible to noise disturbance could be used as an indicator. Ideally, the indicator for noise impact should take into account the traffic intensity for the infrastructure concerned and identify critical noise contours (e.g. 65 dBA). However, this would require traffic forecasts and modelling, which is outside the scope of this report.

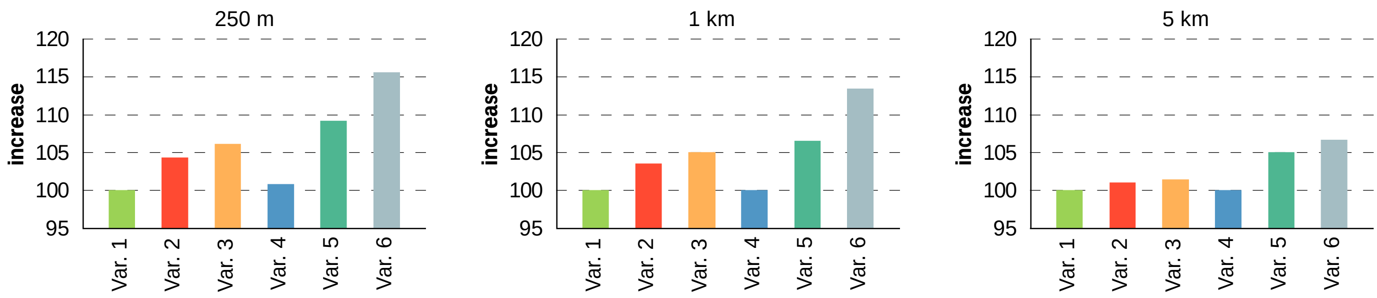
In order to measure the increase in the number of people susceptible to noise disturbance, a database describing the detailed position of dwellings, offices and other working places (e.g. special ones such as schools and hospitals) for the entire European Union would be necessary. Such a database is, however, not available. The most

Figure 9.1 **Population susceptible to noise exposure due to TEN infrastructure**

Alternative	Influence zones 250 m	1 km	5 km
Existing TEN network	100	100	100
Existing TEN network + 14 projects of specific interest	104	103	101
Existing TEN network + all planned rail projects	107	105	102
Existing TEN network + all planned water projects	101	100	100
Existing TEN network + all planned road projects	109	107	105
Complete multi-modal TEN	116	113	107

13) European Commission (1996), Future Noise Policy, European Commission Green Paper, COM(96)540 final

Population exposed to noise impacts per TEN variant Figure 9.2



detailed information is on population and is available at local administrative level (NUTs level 5, e.g. communes). By assuming that this population is evenly distributed over the territory of the considered administrative level, one obtains a fairly accurate population density map at European scale.

An additional problem in assessing noise impact is that its harmful effects are rather local. Risks will generally only occur within a 250 metre buffer-zone around the infrastructure. Inhabitants living at greater distances would only perceive disturbance from the constant background noise from, for example, a motorway. On the other hand, the uncertainty around the exact location of future TEN links is quite large. Partly to take account of this uncertainty, the use of a 10 kilometre wide buffer-zone was suggested in Chapter 7 (analysis of nature sites). Taking account of the different kind of impacts of each subject, namely its spatial behaviour using a similar buffer-zone for estimating possible noise impacts, would lead to a disproportionate overestimation of the effect. Therefore, a 1 kilometre and a 5 kilometre buffer exercise was performed.

9.2.2. The Results

Figure 9.1 presents the proportional increase of the population in the vicinity of the TEN infrastructure. The table sketches outcomes for the different TEN variants using a 250 metre, a 1 kilometre and a 5 kilometre buffer-zone. The results are presented in the form of index figures (existing network = 100).

As in the case of all other indicators, one can argue that for a proper evaluation of the results, the effects of the different TEN variants should not be compared to the existing trans-European network, but to the effect of the general existing infrastructure.

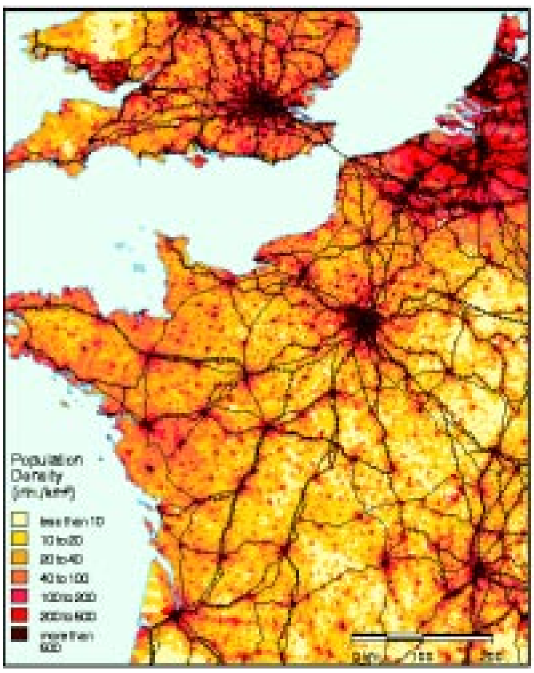
The results can also be presented in diagrams (*Figure 9.2*) or on maps. *Figure 9.3* shows an overlap of the population density and the multi-modal network.

9.3. Crossing of Tranquil Zones

9.3.1. Methodological Approach

The French consultancy BCEOM suggested in its 1997 report for the Ministry of Environment to identify "tranquil zones." This is to a certain extent comparable to the definition of non-fragmented areas in Chapter 7. Tranquil zones have been defined as (semi-) natural areas - forests, semi-natural land and wetlands - that are at least 7.5 kilometres remote from existing TEN infrastructure[14].

Population density map and multi-modal TEN network Figure 9.3



14) Ministère de l'environnement (1997), Evaluation environnementale des schémas d'infrastructures de transport - Essai méthodologique The French report argues that, on average, noise generated by transport infrastructure can be detected as far as 7.5 kilometres from the source track.

Figure 9.4 **Intersection with tranquil zones per TEN variant**

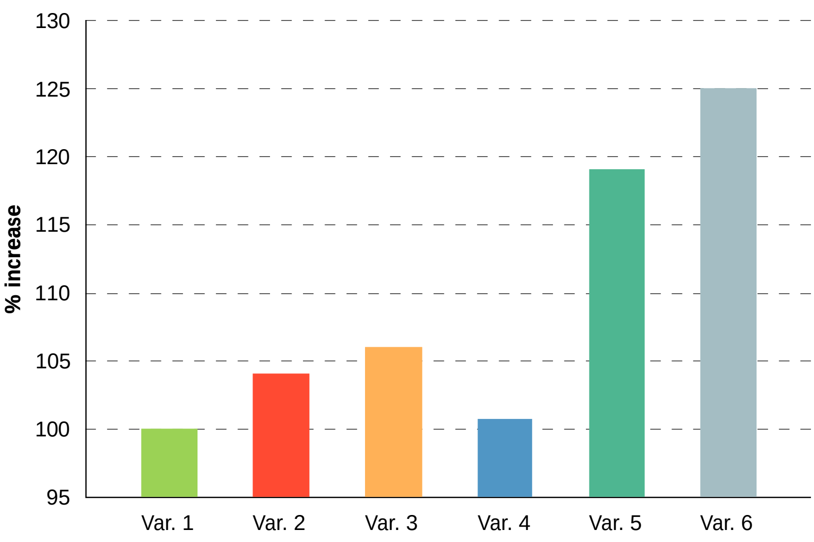
Alternative	Intersection with tranquil zones (km²)	%
Existing TEN network	411 413	100
Existing TEN network + 14 projects of specific interest	427 208	104
Existing TEN network + all planned rail projects	435 615	106
Existing TEN network + all planned water projects	413 277	101
Existing TEN network + all planned road projects	490 902	119
Complete multi-modal TEN	512 556	125

This excludes areas where noise producing human activities are intrinsically present (urbanised areas, areas with predominant industrial and agricultural activities).

Although noise generated by transport infrastructure can be detected as far as 7.5 km from the source track, at this distance its level will not be high enough to have actual health effects, even if it can still render a certain disturbance. “Silence” is a quality that becomes more and more difficult to find in our society. On the one hand, the possibility for people to temporarily escape urban pressures and to relax in remote tranquil areas contributes to the general quality of life. Tranquillity may also be an essential prerequisite for nature conservation.

A possible indicator for disturbance of tranquil zones is the intersection between those zones and new TEN infrastructure (including a 7.5 km influence zone). This can be estimated within a geographical information system by overlaying the networks with the tranquil areas. The surface of the tranquil area that falls within the 7.5 kilometre buffer-zone around the infrastructure is calculated relatively easily. In fact, by calculating overlapping surfaces, this approach goes a step further than a simple vicinity analysis that was used in Chapter 7. This can be justified for two reasons: firstly, the actual boundaries of the tranquil zones are known, whereas the designated areas were represented only by a circle around the centre co-ordinates. Secondly, the number and size of the tranquil zones (under the current definition) is so much larger that it seems less appropriate to speak of individual tranquil zone, but rather consider it as a specific land cover type.

Figure 9.5 **Intersection with tranquil zones according to TEN variants**



9.3.2 The Results

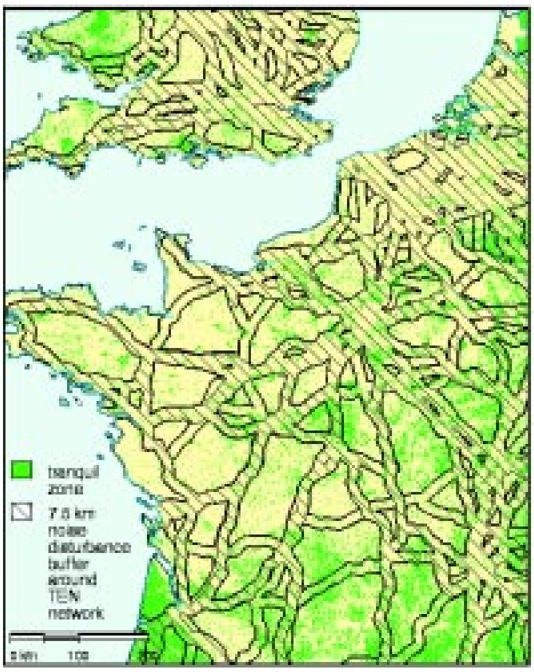
The results can be presented in a table such as the one in *Figure 9.4*, and by *Figure 9.5*, which summarise the overall increase in the intersection between tranquil zones and TEN infrastructure per variant, compared to the intersection with the existing network. The effects of developing the rail projects appear to be less than those of the development of the planned road network, which triggers both a partitioning and a deterioration process. Both options seem to have a cumulative effect on the amount of tranquil zones threatened.

Again, this indicator does not account for the loss of smaller tranquil areas, as the data available for an EU level assessment do not include such smaller-scale effects. These should be addressed at regional or corridor level.

A critique, which also applies to this indicator, is the fact that other infrastructures, not included in the TEN, were not considered. Possible improvement in the use of this indicator could be achieved by also including non-TEN infrastructure in the definition criteria for tranquil areas. In this respect, an investigation should be made as to which infrastructure level should be taken into account (i.e. should all roads included in the GISCO secondary road network be included, or only roads of a certain importance).

The results can also be shown on a map as the one displayed on *Figure 9.6,* useful merely as an illustration of the indicator analysed.

Noise disturbance zones around the Complete Multimodal TEN network | Figure 9.6



10. Land Resources

10.1. Main Objectives Concerning Land Resources

In Europe, land resources are relatively scarce, and reaching a sustainable balance between competing land uses is a key issue for all development policies. Land use planning and land resources are not dealt with specifically as strategic themes in the 5th Environmental Action Programme. However, their importance is fully referenced as a requisite for some strategic issues such as biodiversity and nature conservation, management of water resources and coastal zones, as well as for the sustainable development of several selected target sectors, such as transport, agriculture and tourism.

Thus, identifying land take according to the various major habitat types of land cover can constitute an indicator for a wide variety of impacts. For example, the calculation of land take in semi-natural areas can be considered an indicator for a potential decrease of biodiversity. Similarly, land take in urban areas may indicate the risk of impacts on humans, while the taking of agricultural or forestry land may indicate how the TEN may affect certain economic activities.

10.2. Land Take

The broadest way of assessing the spatial and ecological impact of the TEN would be to simply look at the land take of existing and new infrastructure. It was not considered appropriate to merely examine designated nature sites, populated areas, tranquil zones, water catchment areas, and so on separately. Instead, it was thought important to consider any land take as potentially indicating adverse environmental impacts. For example, land take in semi-natural areas may lead to a decrease of biodiversity. Land take in urban areas could represent the risk of impacts on humans (safety and noise) and the use of agricultural or forestry land could be considered harmful for nature in general, for landscape (visual intrusion) or even for certain economic activities.

Naturally, looking at land take tout court is an ultimate simplification and a “worst-case” estimate, but given the flaws in the methods and data (in particular) available for more sophisticated analyses, this crude indicator has its merits. One could go one step further and, as a minimum, take account of the land cover types, but the report will show that this method has the same limitations.

10.2.1. Methodological Approach

Roads, rail and waterways consume land directly or indirectly. Direct land take refers to the land needed for the actual infrastructure and is a function of the number of traffic lanes or tracks, the number of safety lanes, embankments, dug-outs, etc. Indirect land take is caused by land reallocation due

Figure 10.1 **Estimated surface requirements per infrastructure type**

***Source**: EUROPEAN COMMISSION (1993), The European HSR Network: Environmental Impact Assessment*

Traffic mode	Total cross section (m)		Surface (ha/km)
Rail	Conventional	25	2.5
	HSR upgrade	32	3.2
	HSR new	35	3.5
Road	2x1 lanes	60	6
	2x2 lanes	90	9
	2x3 lanes	100	10
	2x4 lanes	120	12

Land take by TEN variant Figure 10.2

Alternative	Land take Area (km²)	Score
Existing TEN network	8,598	100
Existing TEN network + 14 specific projects	9,408	109
Existing TEN network + all planned rail projects	8,964	104
Existing TEN network + all planned inland waterway projects	8,767	102
Existing TEN network + all planned road projects	11,285	131
Complete TEN	12,632	137

to the infrastructure construction, such as parking places, rail stations, etc.

In the present study, only direct land take has been considered. The proposed indicator is direct land take (derived from the lengths of the infrastructure development) differentiated by major land cover types that underlie the existing and planned links. Of course, the fact that the location of the routes is still not precisely defined introduces a factor of uncertainty into the estimates.

The surface required by transport infrastructure is directly related to its construction characteristics. Because these are increasingly set to international standards, the variations between different countries and data sources are marginal. *Figure 10.1* illustrates the surface requirements of different infrastructures. The figures are based on a study carried out for DGVII of the European Commission in 1993.

To get an indication of the land use efficiency of each mode, the direct land take must furthermore be put into the perspective of the related traffic capacity that the infrastructure offers. For example, taking into account the capacities of a motorway (1500 person car units per hour per traffic lane) and of a HSR (15 trains per hour per direction), the capacity of a HSR line equals that of a motorway with 2x4 lanes, but requires much less land resources.[15]

Data on the number of traffic lanes for TEN roads and the number of rail tracks per TEN-link are as yet not available. For the purpose of the present demonstration work, the amount of land take by linear infrastructure is estimated to take on average 3.2 ha / km for rail lines, 12 ha / km for inland waterways and 10 ha / km for motorways. This corresponds to widths of 32 up to 120 meters. By combining these factors with the estimated length of the existing and new network, total land take can be obtained. Results are summed up in *Figure 10.2*, which presents total land take for the existing network and the 5 network variants. The comparison of the figures is facilitated by using index scores (the existing network is 100). The smaller width of rail infrastructure explains the "favourable" score of the planned rail network.

It goes without saying that land take in itself is not necessarily directly environmentally harmful. The potential impact depends on the type of land that is affected. A refinement of this indicator can be achieved taking into account land cover types. Land cover types were obtained from the European CORINE land cover inventory supplemented by national land cover inventories.

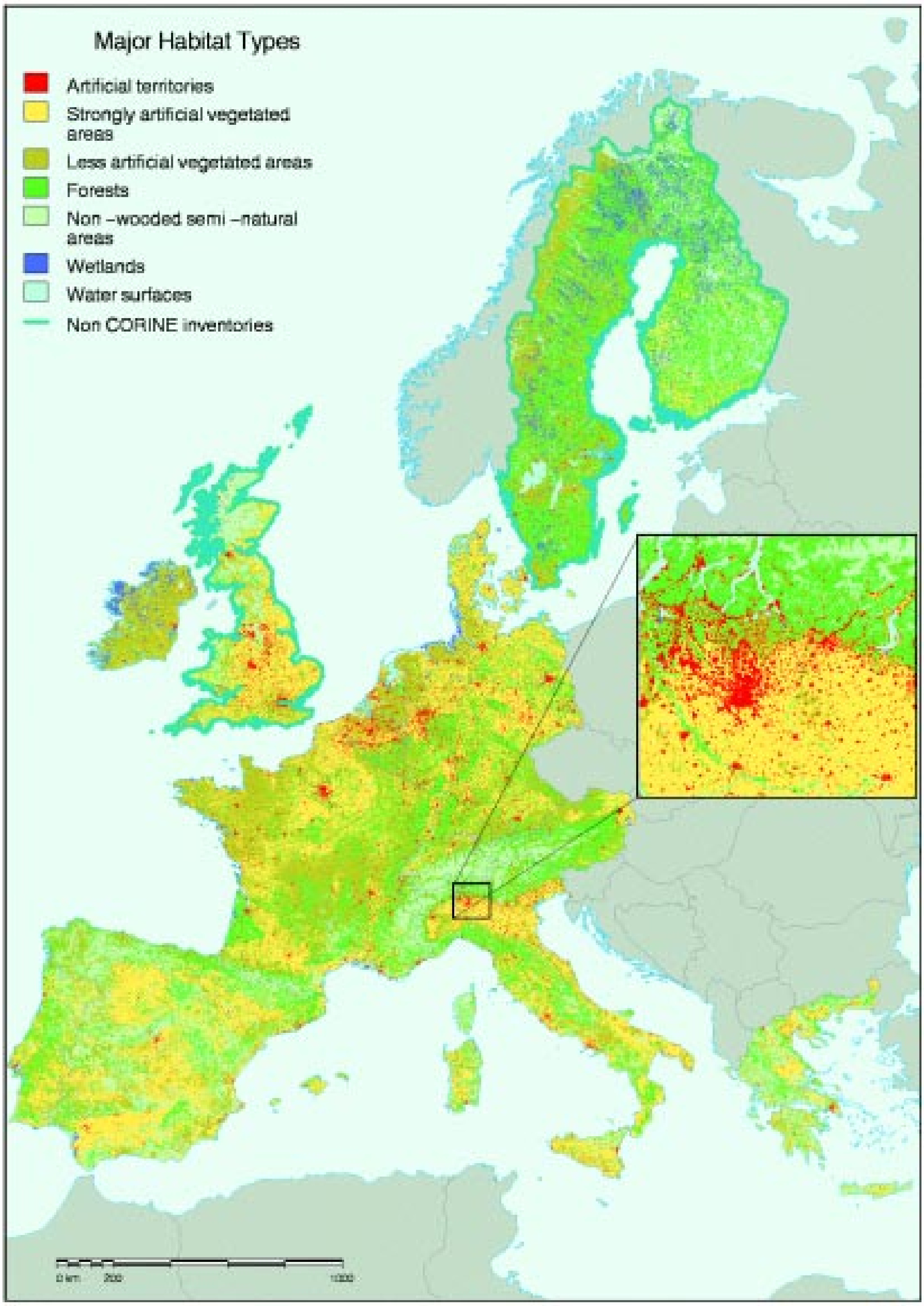
The land type or habitat information that was used for this study is available at a resolution of 250 metres, which seems compatible with the infrastructure widths mentioned.

The CORINE database that was used for this analysis distinguishes seven major land cover or "habitat" types (in order of increasing environmental sensitivity):

- *vegetated, strongly artificial land* (which includes artificial non-agricultural vegetated areas, arable land, permanent crops and annual crops associated with permanent crops);
- *vegetated, less artificial land* (which includes pasture, complex cultivation patterns, agriculture with natural vegetation and agro-forestry areas);
- *semi-natural land* (which includes shrub and / or herbaceous vegetation and open space with little or no vegetation);

15) European Commission (1993), The European HST Network: Environmental Impact Assessment

Figure 10.3 **Distribution of the major land cover types in Europe**



- *artificial land* (which includes urban areas, industrial areas and mines);
- *forests*;
- *water bodies* (which includes inland waters, coastal lagoons and estuaries);
- *wetlands* (which includes inland and coastal wetlands).

If the different major habitat types are considered, it is clear that vegetated land will suffer the most. However, data also shows the impact of the planned road network on forests and semi-natural habitats.

10.3. Sensitive Zones Mapping

A second option for refining an indicator based on land use would be by defining sensitive zones on the basis of more criteria than land cover type only. Various countries commonly use “sensitive zone mapping” as a tool in strategic environmental assessment. However, given the scale of the TEN and the data limitations at EU scale, only a very simplified version of these national or regional approaches can be applied.

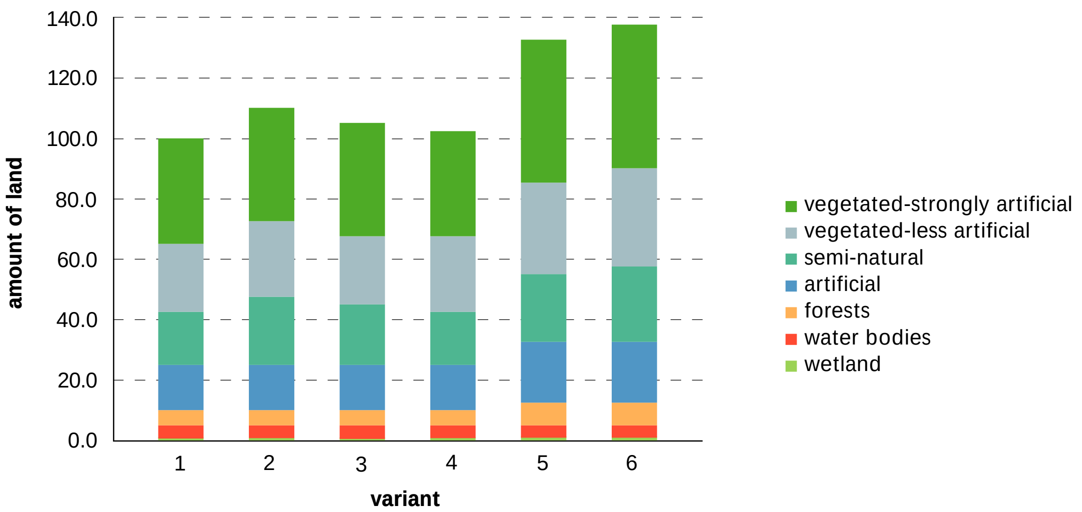
Sensitive zone mapping derives from the so-called land-suitability analysis, an approach commonly used in the USA since the early 1970s. Its main characteristics are that: i) it focuses principally on natural characteristics of the land, that is, it can be spatially referenced and reported; ii) expert judgements (based on scientific knowledge) play a central role in the method; and iii) impacts are implied but not explicitly reported. Based on a quantitative approach, this method uses categories or impact group selection, ratings or assignment of priorities and can also yield a large index calculation. Map overlay techniques are the most suitable to perform this methodology, which was a precursor for early GIS developments.

10.3.1. Methodological Approach

The present identification of sensitive zones is based on a methodological approach which, generally combines the use of GIS and the use of indices, and which integrates existing environmental and non-environmental information into general potential impact maps. The aim is to give an indication of the sensitivity of an environmental system (e.g. local community, ecosystems) according to the potential impacts of a certain activity (such as transport). The method consists of the following basic steps:

- The selection and mapping of areas that are considered sensitive for specific related impacts, in this case sensitive to transport infrastructure. This is done on the basis of an analysis of the geographic, demographic and environmental characteristics of the area and by aggregating a limited number of spatial / ecological indicators. This is carried out from the perspective of different “impact groups”;
- An appraisal of the expected sensitivity of the area using simple qualitative indices such as “not sensitive”, “moderately sensitive” or “highly sensitive”.

Land take by land cover type for TEN variants Figure 10.4



Variants :
1) existing TEN network;
2) existing TEN network + 14 projects of specific interest;
3) existing TEN network + all planned rail projects;
4) existing TEN network + all planned inland waterway projects;
5) existing TEN network + all planned road projects;
6) complete multi-modal TEN. The sum of the contributions for variant 1 adds up to 100.

Figure 10.5 **Sensitivity thresholds attributed to baseline data sets**

** class 1: lowland; class 2: hilly land; class 3 : mountainous.*
*** class 1: within 1 km from the coast; class 2: between 1 and 5 km from the coast; class 3: between 5 and 10 km from the coast.*

Sensitivity group	Baseline data	Low sensitivity	Moderate sensitivity	High sensitivity
I	water patterns	<10 km /cell	10-20 km/cell	>20km/cell
	semi-natural	<25% SN area	25 -75% SN area	>75% SN area
	mountainous*	class 1 dominant	class 2 dominant	class 3 dominant
II	coastal zone**	class 1 present	class 2 present	class 3 present
	designated area	<2% DG area	2-10% DG area	>10% DG area
III	population	<50 inh/km2	50 - 250 inh/km2	>250 inh/km2
			5 - 20 % BU area	
	built up area	<5 % BU area		>20% BU area

An overlay of the infrastructure outline plans with the sensitivity maps enables the identification of areas where conflicts can arise. The objective of infrastructure planning should be to avoid, where possible, crossing through highly sensitive zones, or, when this is unavoidable, to ensure that proper mitigation measures are taken.

The mapping of sensitive areas is done according to “impact groups” or “sensitivity groups” using existing environmental, physical and social baseline data.

For the present report, three different sensitivity groups were distinguished:

- *Group I*
  Sensitivity based on the general environmental physical nature of the area: water patterns, occurrence of semi-natural land, and mainly mountainous characteristics (possible environmental impacts include habitat fragmentation, loss of biodiversity, and visual intrusion of landscapes);
- *Group II*
  Sensitivity based on environmental legal status (biodiversity, habitat fragmentation, coastal zones);
- *Group III*
  Sensitivity based on territorial demographic characteristics, such as population density or share of built up area (possible environmental impacts are noise and accidents).

The present overall assessment scheme uses water patterns, semi-natural land, and mountainous areas (derived from DEM

Figure 10.6 **Assignment rules for determining sensitivity per group**

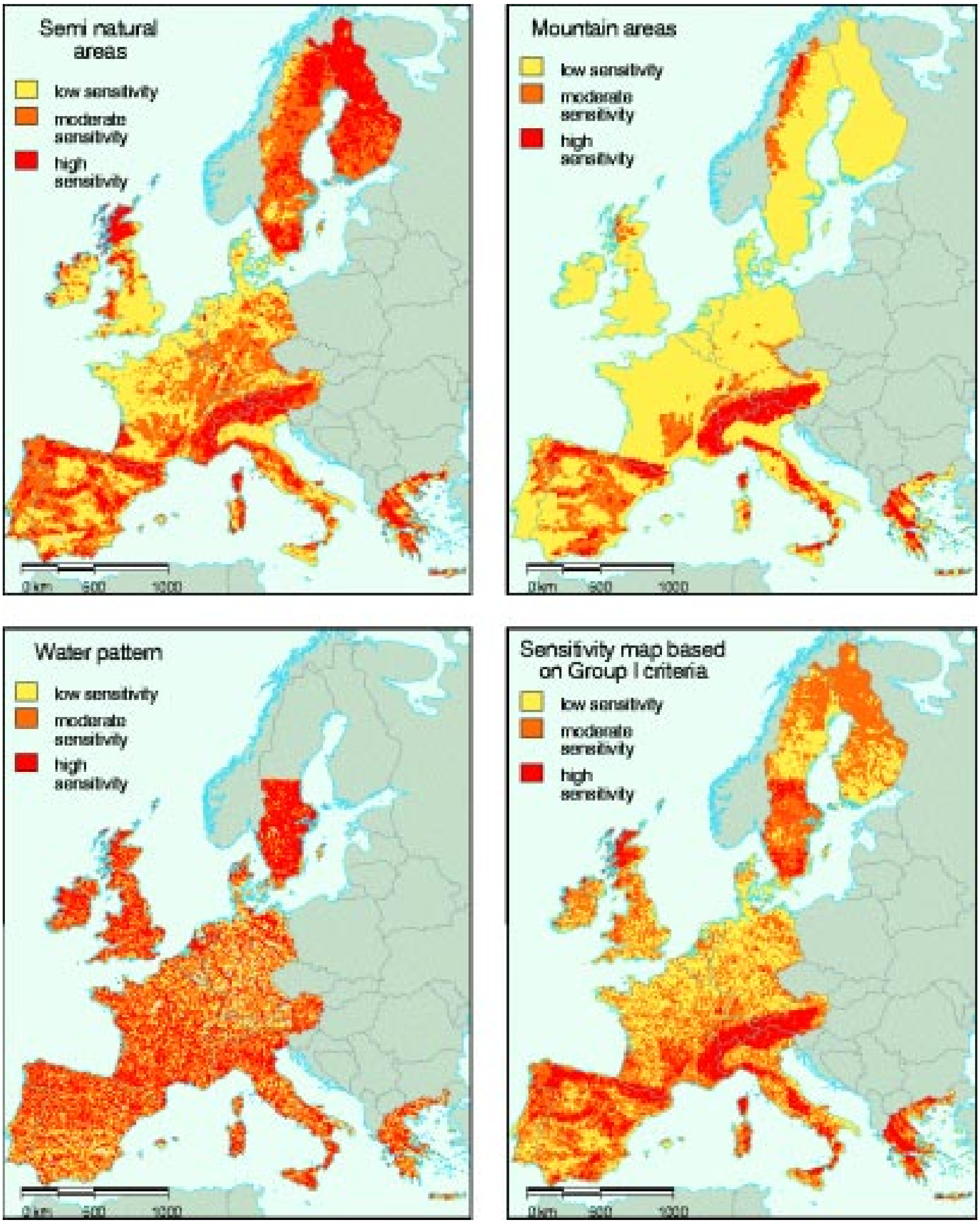
Combination of two risk data set (group II and III)

Original celle score	*Resulting sensitivity*
high + high	high
high + moderate	high
moderate + moderate	moderate
high + low	moderate
moderate + low	low
low + low	low

Combination of three risk data set (group I)

Original celle score	*Resulting sensitivity*
high + high + high	high
high + high + moderate	high
high + moderate + moderate	high
high + moderate + low	moderate
high + low + low	moderate
moderate + moderate + moderate	moderate
moderate + moderate + low	moderate
moderate + low + low	low
low + low + low	low

Sensitivity map based on Group I criteria (physical-environmental criteria) | Figure 10.7



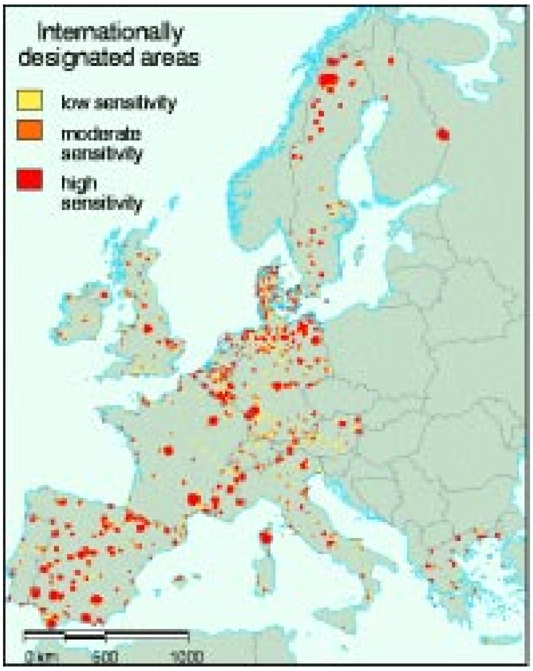
***Note**: surface water data for Finland and northern Sweden is missing*

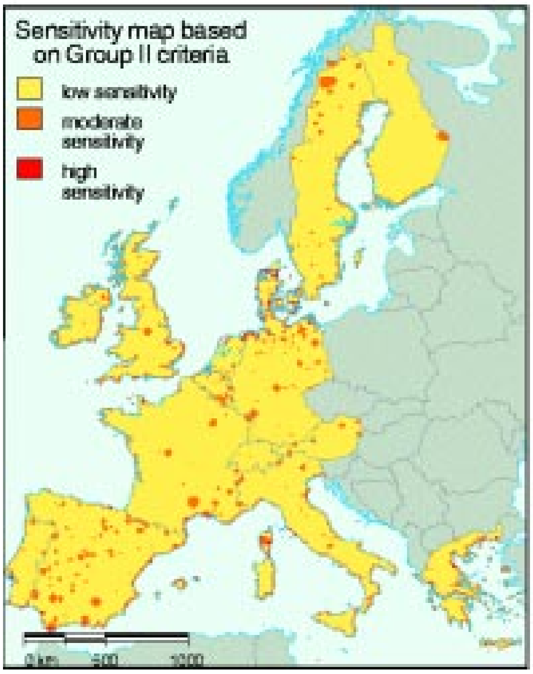
altitude and slope data-base) as GROUP I base-line data; coastal zone boundaries and designated areas as GROUP II base-line data; and population and built-up area as GROUP III base-line data. GROUP II impact group includes coastal zones, as they constitute an irreplaceable environmental heritage with unique ecological, cultural and economic resources subject to increasing pressures. As an example, approximately a third of the Union's wetlands are located on the coast, as well as more than 30% of the SPAs.

Using expert judgement, simple scores for sensitivity indices are attributed to the areas. A three-class criteria or sensitivity threshold was attributed to the 7 baseline data sets. As a result of this operation, each baseline data set will provide a sensitivity distribution map containing three impact classes. The thresholds are applied to square territorial units or cells measuring 10 km by 10 km. Data analysis was conducted on a raster format.

To combine the above indices into an impact group, assignment rules were used. Sensitiv-

Figure 10.8 **Sensitivity map based on Group II criteria (environmental legal status criteria)**

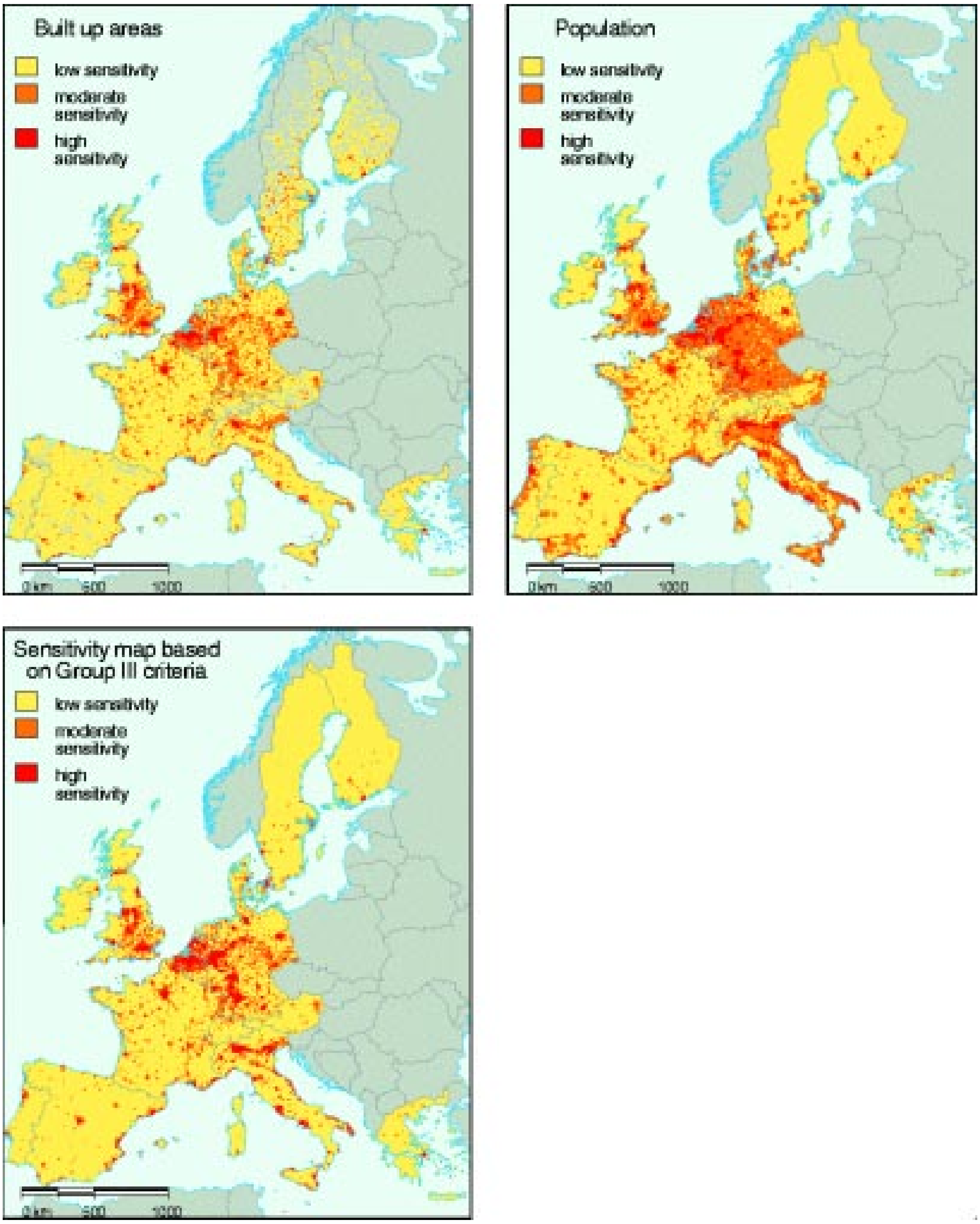




ity maps were then built, based on these data sets, and according to defined assignment rules. Semi-natural areas, mountainous areas and the density of surface water patterns were combined and overlaid to estimate the environmental / physical sensitivity of the area. Secondly, legally defined nature sites and coastal zones combined to form an environmental / legal sensitivity map. Lastly, built up areas derived from the major land cover types database and population density, gave rise to a territorial sensitivity map.

Figure 10.5 illustrates the criteria or sensitivity thresholds for the 7 baseline data sets. As a result of this operation, each baseline data set will provide a sensitivity distribution map containing three impact classes (low sensitivity, moderate sensitivity and high sensitivity). The thresholds are applied to square territorial units or cells ("grids") measuring 10 by 10 kilometres. The thresholds can only be considered, in this exercise, as rules of thumb. They are commonly, methodologically based on expert judgement, which is

Sensitivity map based on Group III criteria (demographic criteria) Figure 10.9



generally derived from the application of some expert judgement assessment rule, which was in fact not the case.

The next step was to combine the above indices to identify a general measure of sensitivity per group based on agreed assignment rules. (*Figure 10.6*)

Overlaying the multi-modal TEN network with the three sensitivity maps enables the identification of high risk cells ("red flags") according to each impact group - that are crossed by infrastructure links.

10.3.2. The Results

Applying the described methodology, sensitivity maps were processed for each impact or sensitivity group. These maps are presented in *Figures 10.7*, *10.8* and *10.9*.

Network assessment was then performed by identifying those links that cross the sensitive areas, using spatial overlay techniques. Each

Figure 10.10 **Overlay of the complete multimodal TEN network with sensitivity maps. Identification of high sensitivity cells crossed by infrastructure links.**

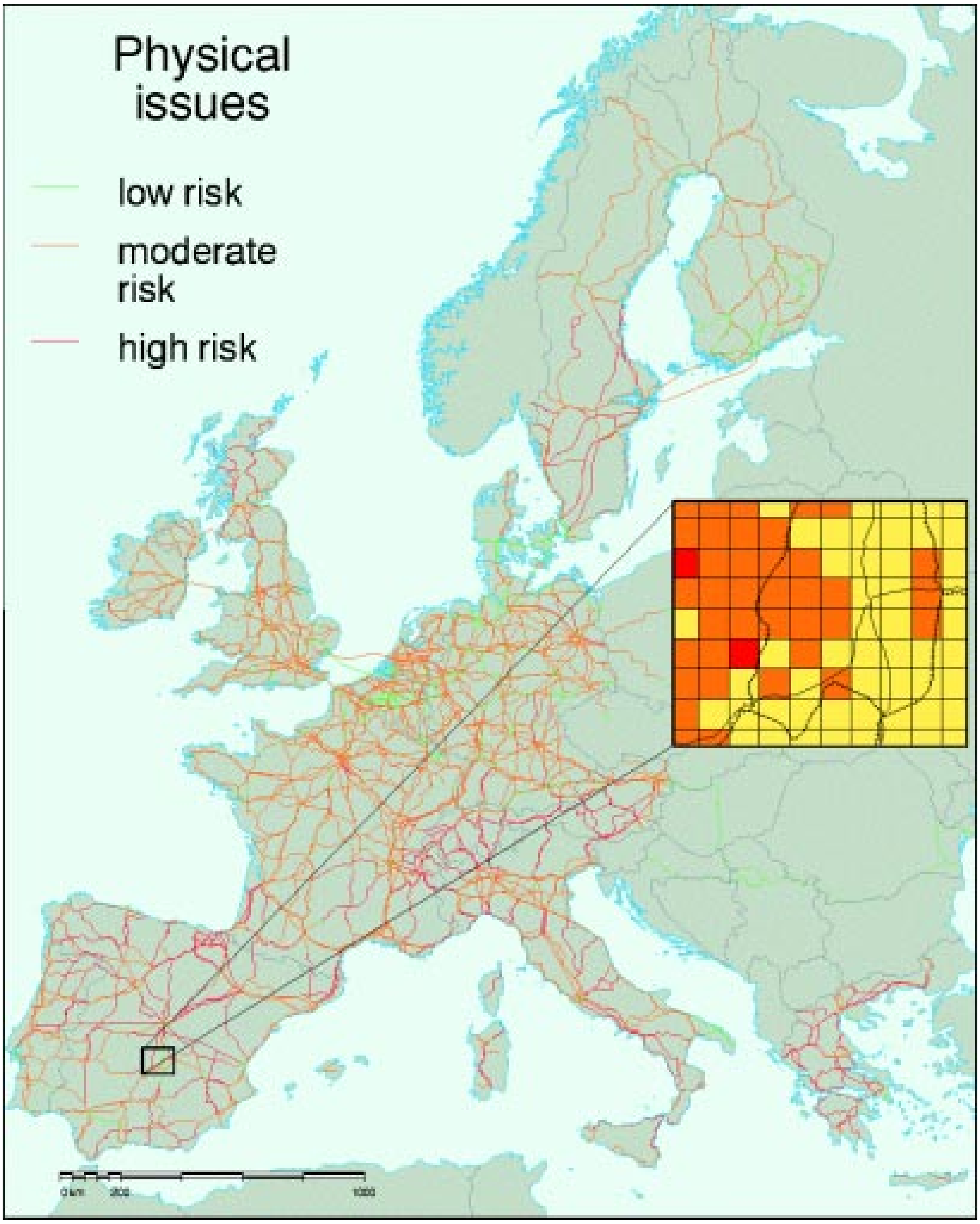
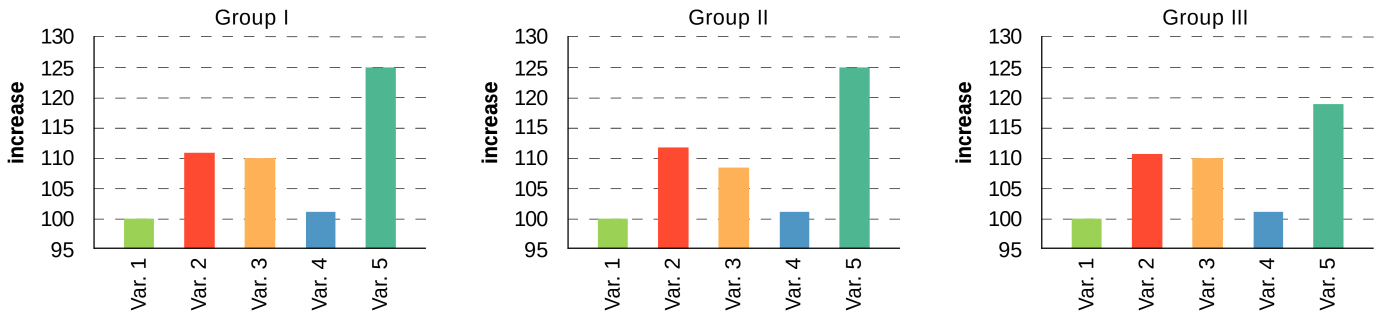


Figure 10.11 **Sensitivity index per impact group and TEN variant**

	Impact		
Alternative	**Group I**	**Group II**	**Group III**
Existing TEN network	100	100	100
Existing TEN network + 14 specific projects	111	112	111
Existing TEN network + all planned rail projects	110	108	108
Existing TEN network + all planned inland waterway projects	101	101	101
Existing TEN network + all planned road projects	125	125	118

Sensitivity index graphs per impact group and TEN variant | Figure 10.12



link is subsequently classified according to the highest sensitivity category it crosses (*Figure 10.10*), thus forming an average sensitivity index for each variant (*Figure 10.11* and *Figure 10.12*).

Figures 10.11 and *10.12* show that the specific projects are primarily located in built up and populated areas and that they, compared to overall planned road and rail networks, have less impact on the more "natural" areas.

An investigation of *Figures 10.7* to *10.9* demonstrates the following:

1. As it is not always feasible to avoid both areas of nature conservation interest and areas of dense population (as these are to a certain extent complementary), choices must be made with respect to the prioritisation of sensitive zones. However, the present method does not attempt this "weighting", as such decisions should be taken on a broader policy level (e.g. in the context of existing national or regional policies and circumstances), and in consultation between decision-makers and stakeholders. The only aim of the present method is to clearly bring forward the potential risks vis-à-vis all three sensitivity categories.
2. The incomplete water pattern baseline data set illustrates the importance of high quality source material. Data gaps and data heterogeneity complicate the risk assessment process and are clearly distinguished in the final results.
3. In this exercise, all baseline data were considered equivalent. If some kind of weighting were applied to accentuate or attenuate some vulnerability factors, fine-tuning could be within reach. However, irresponsible or biased use of the weight factors could easily undermine the goal of this procedure, which is to obtain an objective and general vulnerability assessment of the territory.

Finally, the present method could be significantly improved once estimates become available on the predicted magnitude of traffic impacts on the links (i.e. traffic volume, emissions of pollutants and noise). This new information could take into account the expected environmental pressures, which can differ amongst modes and amongst links.

11. Evaluation and Conclusions

11.1. Indicator Overview

As stated before, one of the main aims of the working group was to identify possible indicators for explaining spatial and ecological impacts of the TEN, considering both Community-level environmental objectives and targets, as well as data availability. The scope of the ecological and spatial impacts suggested the following impact categories:

- Ecological impacts of infrastructure, i.e. impacts that are directly related to ecosystems, habitats and species, as well as the degree of biodiversity;
- Functional impacts like those derived from barriers, as a division of functional land units and the reduction of the viability of land units;
- Impacts with a spatial dimension like noise, which can be evaluated by estimating for instance the number of people living in the vicinity of the infrastructure or by defining noise sensitive zones.

The chosen indicators are based on the level of planning (in this case the EU level), as well as data availability, as selected indicators have to be used Europe-wide. For more local-level assessments (like corridor or project assessments), other, more detailed (and data constrained) indicators can be used, which account for more specific characteristics of the immediate environment. In short, the initial selection of spatial and ecological indicators was based on the following criteria:

- relevance in regard to the Community environmental objectives and targets;
- applicability on EU scale;
- feasibility in terms of the available data.

A group of seven indicators was chosen, namely:

- vicinity to sites of nature conservation interest;
- partitioning of land;
- water crossings;
- population in surrounding of infrastructure;
- crossing of tranquil zones;
- land take by land cover type;
- sensitive zones analysis

The use of these indicators showed that they are quite different in concept, scope, comprehensiveness, usefulness for decision-making and communication to a broader public, as well as in the degree of uncertainty that is linked to them, taking into account the quality of the currently available data.

The Working Group felt that some assessment procedure should be applied to the chosen and tested set of indicators, keeping in mind further development of the exercise, namely additional research and consultation, as well as impact evaluation on a strategic level of TEN alternatives.

In 1993, the OECD defined the following issues as criteria for indicator selection: policy relevance and utility for users, analytical soundness, and measurability (OECD, 1993, OECD - Core Set of Indicators for Environmental Performance Reviews - A synthesis report by the group on the state of the environment, Environment Monographs No. 83, Paris).

As stated in the report, these criteria, which will not all be met in practice, describe an “ideal indicator” . Nevertheless, according to these criteria, the assessment of indicators can highlight their characteristics, and show their usefulness for certain specific objectives. The same report specified the issues within these criteria that should apply to each indicator. Concerning *Policy Relevance and Utility for Users*, each indicator should:

- provide a *representative picture* of environmental conditions, pressures on the environment or society’s responses;
- be simple, *easy to interpret* and able to show *trends over time*;
- be *responsive to changes* in the environment and to related human activities;
- provide a basis for *international comparisons*;
- be either *national in scope* or applicable to regional environmental issues of national significance;
- have a *threshold or reference value* against which to compare, so that users are able to assess the significance of the values associated with it.

Summary of indicator characteristics Figure 11.1

	Policy relevance and utility for users	Analytical soundness	Measurability
Vicinity to sites of nature conservation interest	Relates to defined environmental objectives and targets Identifies potential risks as problematic links and sites ("red-flag" approach) Easy to understand	Buffer-zones around network should depend on habitat/species type, for which information is lacking Allows (and requires) "sample surveys" at regional/local level	Site boundaries lacking Databases do not cover all countries Overlap of designated areas Definition of sites depend on national legislation Characteristics and location of new links missing
Partitioning of land	Relates to defined environmental objectives and targets Easy to understand Difficult to interpret	Based on several assumptions, difficult to agree upon (quality evaluation, thresholds) Most applicable at regional level (relatively detailed maps required)	Ignores land units less than 1000km2 Infrastructure other than TEN not considered Characteristics and location of new links missing
Crossing of surface waters (density)	Relates to defined environmental objectives and targets Easy to understand and interpret Too simplistic Allows for "red-flag" approach	Not only water proximity may lead to environmental impacts	Characteristics and location of new links, information on catchment areas and vulnerability of surface and groundwater is missing
People in vicinity of infrastructure	Not directly related to defined environmental objectives and targets Easy to understand Little added value, as it is an "implied" indicator	Gives only an indication of the potential population affected, but doesn't apply to impact magnitude	Characteristics and location of new links, traffic forecasts and noise modelling missing. Dwellings, working places, special infrastructure (hospitals, schools) not available
Crossing of tranquil zones	Not directly related to defined environmental objectives and targets Easy to understand and interpret More useful for issues other than noise (e.g. biodiversity)		Characteristics and location of new links missing
Land take (by land cover type)	Not directly related to defined environmental objectives and targets Easy to understand Little added value		Characteristics and location of new links missing
Sensitive zones mapping	Not directly related to defined environmental objectives and targets Easy to understand and to interpret Based on an extremely simplified model Useful as a general indicator	Data weighting not introduced Suited to raise awareness at strategic level Requires wide expert consultation	Characteristics and location of new links missing

Concerning *Analytical soundness*, each indicator should :

- be theoretically *well founded* in technical and scientific terms;
- be based on international standards and *international consensus* about its validity;
- lend itself to being linked to economic models, forecasting and *information systems*.

Concerning *Measurability*, each indicator should:

- be readily available or made available at a *reasonable cost/benefit ratio*;
- be adequately *documented and of known quality*;
- *be updated* at regular intervals in accordance with reliable procedures.

Figure 11.1 summarises the weaknesses and strengths of the indicators identified in the present study and *Figure 11.2* presents an evaluation of the indicators according to the OECD criteria. The assessment was conducted combining the results of an "experts panel", where each expert was asked to do the ranking according to presented scores. The evaluation was conducted in conjunction with the presented criteria, indicator concept, required environmental data and information display. Lack of data on infrastructure was also taken into account, as it seems more important for some indicators (population affected by noise) than for others (e.g. crossing of surface waters).

Some conclusions can be derived from assessing the indicators. In terms of their policy relevance and utility for users, they are all considered as good or very good, except the crossing of surface waters and land take by land cover type, which is mainly due to the "plain" characteristics of these direct indicators.

Concerning analytical soundness, it generally scores under the pointed relevance or utility, which means that further research on their theoretical validity as well as technical and scientific consensus building must be conducted. Although this is a broad conclusion over the general scope of the indicators, considering its importance for the SEA of the TEN, it points to further consultation between Commission services, Member States, the EEA and the scientific community on the most feasible and appropriate methods and indicators.

Some problems should be raised concerning the measurability criteria, which relates to data availability, quality and updating. Direct indicators such as the crossing of surface waters and land take, as well as the vicinity to sites of nature conservation were considered as the most reliable, considering the data driven issues. The importance of accurate and up-to-date data on land cover must be stressed, as it serves as baseline data for most of the indicators used.

Considering *biodiversity* indicators, vicinity to sites of nature conservation interest seems more meaningful and appropriate to be carried out at the corridor level. A necessary indicator refinement would be the improvement of the designated sites database and a qualitative analysis establishing the relation

Figure 11.2 **Assessment of used indicators according to OECD criteria**

++ very good
+ good
+/- fair
- poor
-- very poor

	Policy relevance and utility for users	Analytical soundness	Measurability
Vicinity to sites of nature conservation interest	+	+/-	+
Partitioning of land	+	+	-
Crossing of surface waters	+/-	+/-	+
Population in surrounding of infrastructure	+	+/-	+/-
Crossing of tranquil zones	++	+/-	+/-
Land take (by land-cover type)	+/-	+	+
Sensitive zones mapping	++	-	-

between sites / habitats / species and respective impact vulnerability, performed by specific “zoom analysis”. This work would be best linked, at a first stage, to the corridor analysis already under way, and through consultation with the Member States. Special attention must be given to potential risk sites identified by this exercise (“red-flag” analysis), but also to other specific situations which, because of an inconsistency in definition, or information available (the case of nationally designated sites) have not been considered.

Concerning the partitioning of land indicators, in spite of being easy to understand as a concept, it is difficult to interpret. This is partly because it is based on many assumptions, which are difficult to agree upon, particularly at a European level. It is best used at a regional level (where smaller units could be considered in the analysis), and it should be refined to consider infrastructure other than existing TEN. The impact evaluation also requires information on the characteristics and location of new links.

The *Water resources* indicator is simplistic and easy to understand, but its usefulness is quite limited. That is partly because environmental impacts are not just a result of proximity between water surfaces and infrastructures . An analysis based on water catchment areas, relating hydrology and quality of surface and groundwater, lacked accurate data at an European level. Again, at a strategic level, this indicator can be useful for scoping more in-depth analyses at a regional or corridor assessment.

The indicators used for *noise* assessment are an example of the need for more detailed infrastructure data, as their relation to noise is indirect and inferred. They do not consider noise levels and their spatial distribution (critical noise contours), which can only be calculated based on traffic estimates and physical infrastructure characteristics (pavements). They are both relatively easy to understand, but their added value for noise impact evaluation is very small. The first one is more a “social-indicator” as it considers the potential number of affected people (by noise but also by other effects such as “barrier effect”). As a “social indicator,” it is important to note that detailed information on location of special equipment and infrastructure (hospitals, schools, and residential areas) is missing. The second one seems, also, to be more useful for issues other than noise, e.g. for biodiversity and social impacts.

Land resources indicators, like land take, is straightforward, easy to understand, and useful as a general indicator for raising awareness at the strategic level. Sensitive zone mapping seems to be very useful for decision-makers at policy and strategic level. The specific characteristics of the method, based on data combination through map overlay, make the quality of data a significant issue. Again, the method could be significantly improved once estimates become available on the predicted magnitude of traffic impacts on the links (i.e. traffic volume, emissions of pollutants and noise). This would allow better accounting for the expected environmental pressures, which can differ amongst modes and amongst links.

11.2. Conclusions

The importance of improving certain databases has been clearly raised in the previous chapters. In fact data shortage and inconsistencies, as well as all the assumptions used to overcome them, limit the usefulness of the chosen indicators. Their measurability and their soundness, in particular, cannot be assured.

One of the main problems encountered in the study is the poor information on the planned TEN-infrastructure. Special attention should be paid to collecting additional data on the distinction between upgrade and new constructions for the planned TEN links and to the improvement of information on the location of the planned new infrastructure. Also estimates on the predicted magnitude of traffic impacts on the links (i.e. traffic volume, emissions of pollutants and noise) would enable a better understanding of the expected environmental pressures, which can differ amongst modes and amongst links.

Another priority action is the completion of the information on the NATURA 2000 network, as this would provide a more consistent basis for the assessment of impacts on habitats. Furthermore, this underlines the importance of developing a SEA system for the TEN in an ‘iterative’ manner, since this would allow the refining of the assessment techniques and scope as more accurate data become available.

The models and parameters that were used in this study have been applied in a rather straightforward manner, and using expert judgement which inevitably involves a certain degree of subjectivity. Parameters and threshold values (such as the criteria and indices used for identifying sensitive zones) have been entered in a pragmatic way, based on literatureexamples gathered from various national, regional or local environmental assessments. The key assumptions that have been made and their transferability to EU scale have to be improved by broad and multi-disciplinary consultation of experts. In particular the EU-wide definition of sensitive zones, which inevitably relies to a certain extent on a subjective attribution of sensitivity values, should be further researched.

In this study, it was also assumed that the impact a transport infrastructure exerts when crossing a sensitive environment is similar for all types of infrastructure (e.g. motorways, rail or inland waterways). This may not necessarily be the case. Also, it was not possible to differentiate between various types of motorways (e.g. number of lanes). In the future, attributing weights to various types of infrastructure could increase the value of the assessment. This could be done on the basis of, for instance, infrastructure characteristics (such as the number of lanes or tracks per link). Another solution would be to integrate the results of the prediction of traffic-related impacts in the GIS (i.e. traffic volume, emissions of pollutants and noise for each link). This would enable a better comprehension of the various degrees of environmental pressures, and thus allow a better weighting of the impacts according to mode and to links.

In order to ensure the compatibility of the outputs of both parts of the assessment, the RTD project that the Commission is currently launching on the assessment of global impacts should therefore be closely coordinated with the current work on spatial and ecological assessment.

The study also made clear that an assessment at EU level is naturally limited in scope and level of detail, due to data limitations. The methods that were tested allow the identification of potential conflicts with certain environmental concerns ("red-flag" approach), but do not permit a prediction of the magnitude of the actual impacts (in terms of losses in species or damage to human health, for example). This would require extremely detailed data on species and ecosystems and a qualitative investigation into the relationship between habitat types, species and their vulnerability to impacts of infrastructure and traffic. At this scale, it is not feasible to evaluate the impacts on small valuable areas. It is therefore essential that the SEA of the TEN be complemented by more local-level assessments, i.e. assessments of national / regional networks and of corridors, and, possibly, pilot project environmental impact assessments (EIA). Using such a "tiered" assessment process, the SEA of the TEN should be considered as a first broadbrush screening instrument for identifying those corridors or series of corridors that should be addressed as a priority.

During the April 1997 workshop on the Spatial and Ecological Assessment of the TEN, some issues were identified, which have not yet been addressed in the present study, as they require in-depth research, including:

- development of indicators and methods for the spatial assessment of secondary development around TEN-nodes;
- identification of ecological corridors and the use of such corridors in infrastructure network and corridor assessments.

Finally, in order for the SEA to become an integrated decision-aiding tool within the overall revision of the guidelines, it should be conducted in parallel with the evaluation of the socio-economic impacts of the TEN and of its impact on cohesion and accessibility. The studies that are carried out on all those aspects should be carefully coordinated, and should be based on the same underlying assumptions and data sets.

The present methodological study can be considered successful as it realised most of its original objectives:

- it provided a comprehensive compilation of a Union-wide spatially referenced database, holding information on the state of the TEN, as well as of a selection of environmental and other data, which is relevant for spatial and ecological impact assessment;
- the project initiated the development, testing and application of a series of impact assessment methodologies such as proximity analysis, impact prediction models and sensitivity mapping. These preliminary results will form a practical basis for refinements and further methodological developments;
- the provisional results are stored in a

new database that can be made available to all parties concerned in order to launch the discussions and raise awareness on the environmental impact of the TEN implementation;
- the importance of this SEA of the TEN exercise in the screening for corridor assessment must also be highlighted.

The study furthermore demonstrated the technical feasibility, but also the limitations, of a Europe-wide SEA of the TEN, and reaffirms the usefulness of the multidisciplinary data collection at European scale.

The present exercise also pointed to issues needing further research and methodological improvements:

1. Optimisation of the indicators and methods through a wide and multidisciplinary consultation of experts, stakeholders and Member States. In this respect, the following actions can be envisaged:
   • organisation of a technical workshop (involving the EEA, the Commission services, external experts and NGOs), which should allow consensus building on the methods and indicators.
   • presentation of the methods to the Member States in the next meeting of the Ad Hoc Group on the Environmental Evaluation of the TEN.
2. Filling of the major data gaps on the TEN and on the environment.
3. The carrying out of the full spatial and ecological assessment of the TEN, including the integration into the GIS of the results of the traffic-related impacts (emissions, noise, safety) and a comprehensive multi-criteria analysis of the predicted impacts. For this, sufficient resources (in terms of budget and staff) have to be made available.
4. Initiation of longer term research on the above issues, in order to gradually improve methods, data and tools for the ecological and spatial impact assessment of transport plans.
5. Perform some “zoom analyses” or “sample surveys”, enabling the testing of the interrelation between different planning / geographical levels and corre spondent assessment techniques (relation between strategic assessment and corridor and project assessment). For this purpose a follow-up and feedback of the 5 corridor assessments currently being carried out at national level with support from the Commission, should be performed.
6. The selection of the alternatives, should be a subject for further research, due to its strategic nature and assessment implications.

List of Acronyms

CBD - United Nations Convention on Biological Diversity
CCFE - Commission des Chemins de Fer Européens
CoE - Council of Europe
CORINE - Coordination of Information on the Environment
DEM - Digital Elevation Model
DGVII - European Comission Directorate-General for Transport
DGIX - European Comission Directorate-General for Environment, Nuclear Safety and Civil Protection
5EAP - 5th Environmental Action Programme
EEA - European Environment Agency
ETC/LC - EEA European Topic Centre on Land Cover
ETC/NC - EEA European Topic Centre on Nature Conservation
GIS. - Geographical Information System
GISCO - EUROSTAT Directorate on Social and Regional Statistics and Geographical Information Systems
HSR - High Speed Rail
NATURA 2000 Network - Process related to the Habitats and Birds Directives, on the conservation of european natural resources for the year 2000 and beyond
NGO - Non Governmental Organization
NUTS - Nomenclature of Territorial Units for Statistics
OECD - Organisation for Economic Co-operation and Development
RSPB - The Royal Society for the Protection of Birds
SEA - Strategic Environmental Assessment
SPA - Special Protected Areas under directive 79/409/EEC
TEN - Trans-European Transport Network
WERD - Western European Road Directorates