A framework of values and criteria for interdisciplinary evaluations of nature and landscapes

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For an integrated approach of the human species
to nature and landscapes.

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Contents

1. **Introduction**

1.1 Nature conservation and society demands

Nature conservation in the modern sense is a spatial and time related planning process (cf. Plachter, 1991a; Jessel and Reck, 1999; Schekahn et al., 2004; overview of planning structures and legal constraints in Germany in Barsch et al., 2003). In contrast to ecology, which is value free in analysing objectively ecological interrelations ranging from particular species to whole ecosystems. Nature conservation is an applied science of the requirements of our societies, which needs subjectively determined tasks and performance figures (cf. Plachter, 1991a; Erz, 1994). People and the environment are closely connected and depending on each other. We need to make decisions with an impact on nature and landscapes[1] every day, especially in planning processes and for project evaluations.

However, nature conservation is a science at the beginning of its development and even more of its practical application. The society itself decides how it wants to develop the future of our nature and landscapes as a result of more or less democratic processes. For example, the decision to support certain species can be harmful to other species or species diversity, respectively. Clear decisions are required, which are not only determined by scientific facts, but which are results of debates of values in our societies.

1.2 Deficits of current evaluation methods

Several authors criticize that evaluations of nature and landscapes are still mainly based on natural sciences. Social sciences and humanities are underrepresented (Kruse-Graumann, 1997; Schramm, 1999; Erdmann, 2002a; Theobald, 2003), as well as, the different functions of nature and landscapes in our societies. Scientific evaluations of nature and landscapes are based on values and norms according to conventions, which cannot directly be verified by methods of natural sciences (Dierßen, 1993).

In practice, there is a high discrepancy between the importance of social and human sciences for the effectiveness of management processes of nature and landscapes on the one hand and research deficits on the other hand. There are scientific and argumentative deficits in weighing up different requirements of our societies. Furthermore, the focus of evaluations of nature and landscapes and their research on mainly ecological reasons causes deficits in the acceptance of evaluations for management decisions and their power of implementations (cf. Stoll, 1999; WBGU, 1999a; Hübner, 2002; Stoll-Kleemann, 2002, 2003; Schmidt et al., 2002). Therefore, there ought to be an interdisciplinary exchange

[1] The term “landscapes” is understood on a wider scale of landscape scenery, whereas “nature” contents of all elements of our biosphere on larger and smaller scales.

between natural sciences and humanities (Kals, 1996). Different scientific disciplines have investigated the relation of the human being to nature and landscapes to a certain extend, but there is no coherent method, which brings the results of the different values together for evaluations of nature and landscapes.

Currently, there are several different evaluation methods applied in Germany, which cause different results of the same subject (Runge et al., 1999). They have in common to apply several evaluation criteria and methods, but they do not clarify sufficiently and comprehensively the determining values. For example, § 1 of Germany's Federal Nature Conservation Act (Bundesministerium der Justiz, 2002) emphasizes the diversity, peculiarity, and beauty, as well as, the recreational value of nature and landscapes to the human being and on their own. Diversity describes a condition of the variety of elements of nature and landscape on different scales ranging from ecosystems, landscape structures to (sub-) species and genetic variety (cf. Groombridge, 1992; United Nations, 1992; BMU, ?).

Some people might appreciate a higher (species) diversity than others at a certain time and spatial location, depending on the particular (species) object or habitat type, for example, a wild flower meadow or uniform grassland, respectively. Peculiarity is a result of natural and culture-historical developments of nature and landscapes of a horizontal spatial and a vertical time component. However, not everything is automatically of value to the human being, which is peculiar. Some species are considered as vermin to be eradicated, because their ecological niche might be to live as a parasite. The assessment of beauty is highly subjective anyway, as much as, the recreational value depends on the specific demands of the particular user. Some people appreciate jogging in woodlands around a lake; others prefer a woodland free golf-course. It is not made clear, which are the background values and motivations that determine if the diversity or peculiarity is valued positively or negatively, respectively? Which reasons make elements of nature and landscapes beautiful for us, and why are nature and landscapes of higher recreational value to someone?

Therefore in practice, evaluation results are often not based on generally understandable targets, but on individual evaluation methods of the particular surveyor. In addition, these evaluation methods are often not sufficiently explained (Heidt and Plachter, 1996). There are often arbitrary selections of evaluation objects, a mixture of objective information and value judgements, as well as, a missing structural clearness (Knospe, 2001). Furthermore, the evaluation part itself is generally underrepresented in relation to data collection and analysis. However, these three parts need to be clearly separated (Heidt and Plachter, 1996; Poschmann et al., 1998; cf. Gerhards, 2002).

Moreover, the wide spectrum of different methodical proposals has not lead to more transparency and quality of results in practice. There is still a general need of specific minimum requirements and conventions of practical methods of evaluations of nature and landscapes (Dierßen and Reck, 1998b; Bernotat et al., 1999; Plachter et al., 2002; Appel-Kummer et al., 2003; Jessel, 2003). Generally accepted evaluation methods in nature conservation have not yet been put through. There are no methodical guidelines for the selection of evaluation criteria, value relations, and scales (Müssner et al., 2002). This can even lead to different evaluation results of the same subject (Figure 1.2; Dierßen, 1999).

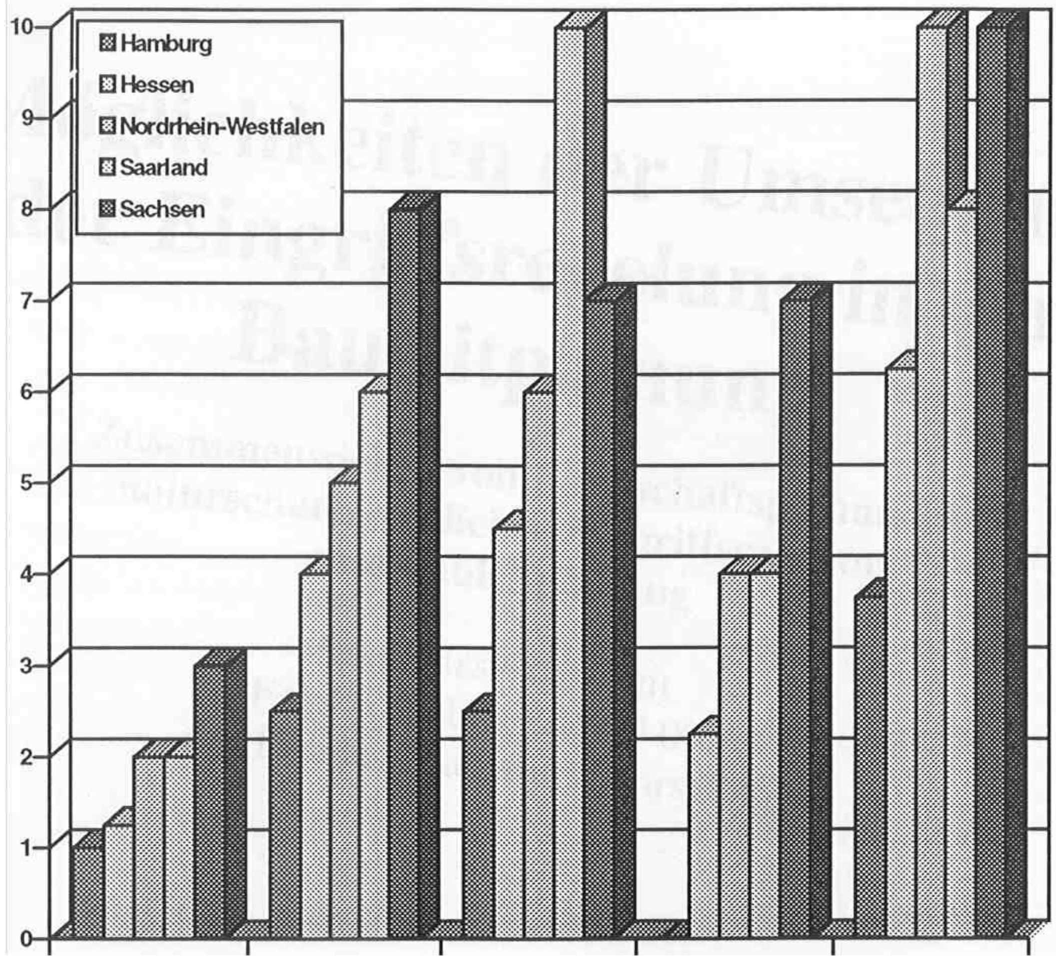

Figure 1.2. Divergent evaluation results on a standardized ten-parts scale of the same habitat types due to different habitat[2] type evaluation schemes in five Federal States of Germany (Runge et al., 1999)

[2] In the German language, the term "biotope" is instead used in this context, which defines a living space of a community of species ("biocoenosis"), whereas the term "habitat" refers to the living space of one species (cf. Breckling and Müller, 1998; Martin, 2002).

Currently there has no general evaluation method been developed, which integrates comprehensively and equally natural sciences, as well as, humanities to reflect all demands of the society and the value of nature and landscapes on their own. Moreover, there is no interdisciplinary evaluation method, which systematically and clearly allows applying the various commonly used criteria for evaluations of nature and landscapes to certain values, despite the different scientific disciplines of certain values have very well developed their own survey and analysis methods.

1.3 Public consciousness of environmental protection

On the other hand, public consciousness of environmental protection of nature and landscapes has significantly fallen in Germany after reunification in 1990 (Empacher et al., 2002; BMU, 2004) of a former leading country, while unemployment and the economic crisis have become most important features in public awareness (cf. Haaf, 1997). Nowadays, the most important problems of German inhabitants are first of all unemployment (55 %), then after a large distance the economic situation (20 %), and social aspects/justice (18 %) equally as environmental protection (18 %) according to a representative survey in 2004 (BMU, 2004; Figure 1.3).

Environmental consciousness 2004

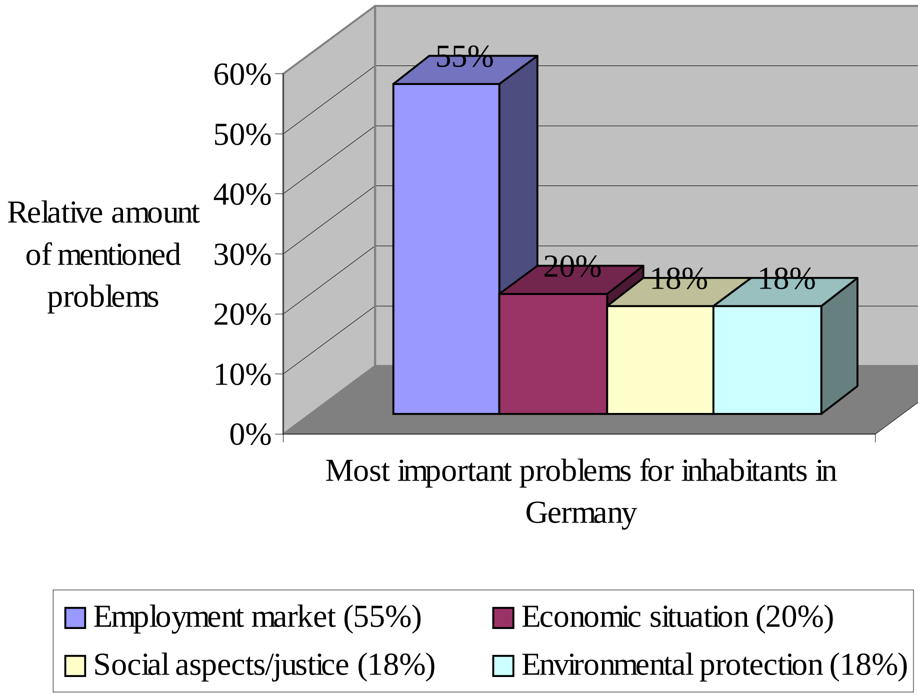

Figure 1.3. Most important problems for inhabitants in Germany according to a representative survey in 2004 of two possible answers at the maximum (BMU, 2004)

Nevertheless, the percentage of people in Germany, who think that the environment would be an issue beyond their control as an individual (36 %) is still much lower than those, who have the opinion that their actions can make a real difference to the environment (56 %), in comparison to an equal distribution at average (43 %) of all 15 European Union member states according to a survey of the European Commission in 2002 (EORG, 2002).

However, the majority of inhabitants in Germany (67 %) does not think that public authorities' efforts to protect the environment also brings more jobs or other social benefits in comparison to people in Germany (27 %), who expect this. Inhabitants in Germany thereby take up the last position of all 15 European member states, where at average the majority (56 %) as well does not expect these positive social benefits in comparison to the positive assumption (39 %) of all member states according to a survey by the European Commission in 2002 (Eos Gallup Europe, 2002).

These recent studies of the public attitude towards nature and landscapes underline the importance of an interdisciplinary evaluation framework to cover all demands of the society for practical planning processes and project decisions. Moreover, it reveals that the particular values of nature and landscapes to the public change by time in a certain area. Therefore, an interdisciplinary evaluation framework, which takes into account the different particular values of nature and landscapes is firstly scientifically necessary to be complete, but secondly it could help to overcome the mentioned grave implementation and acceptance problems (cf. Beirat für Naturschutz und Landschaftspflege, 1997; Stoll, 1999; Der Rat von Sachverständigen für Umweltfragen, 2002; Stoll-Kleemann, 2002).

However, it is not only important to set up a framework of comprehensive values and condensed criteria for evaluations of nature and landscapes, but also to substantially fill this evaluation framework with the determining relations and backgrounds of the different values of nature and landscapes to the human being and on their own. Moreover, it is necessary to arrange and to discuss common survey and analysis methods, as well as, concepts to provide the evaluation ground for the application of the particular criteria according to the leading different values.

1.4 Questions of the research

Therefore, it is firstly necessary to sort out for evaluations of current conditions and future changes of nature and landscapes, which fields of the society are directly or indirectly depending on the status and development of nature and landscapes. In other words, what are the decisive components of nature and landscapes for the society? Furthermore, values must be decided depending on individual and social requirements, as well as, our ethical consciousness towards nature and landscapes (Jax, 1999). Therefore, it needs also to be revealed, what are the human backgrounds, as well as, the interacting influences between nature and landscapes and the human being for each value[3]?

Secondly, it is important to gather a selection of appropriate evaluation methods of the different scientific disciplines that cover the values. It needs to be discussed to which extend these methods can serve to evaluate the components of nature and landscapes as part of an interdisciplinary evaluation framework? However, the research can neither examine these methods in detail nor it can cover all methods of different value disciplines, which would unrealistically demand to review completely all scientific disciplines of values.

Thirdly, the research needs to find out, which condensed number of the same criteria allows comparable results for democratic weighing up processes of evaluation results of the different scientific disciplines and their particular methods, i.e. what is the framework of condensed criteria that can be used to evaluate nature and landscapes according to the particular survey and analysis methods of each scientific discipline?

Thus, the research shall identify appropriate components of an interdisciplinary evaluation framework, which contents of a comprehensive

[3] This research uses the term values instead of potentials (e.g. Marks et al., 1992; Jessel and Tobias, 2002), because it intends to provide a framework for evaluations mainly of the current value of nature and landscapes based on elements, structures, and functions instead of potential uses (cf. Bastian, 1997), which are much more uncertain to be estimated.

amount of values of nature and landscapes that are applied by the same framework of condensed criteria for particular evaluation cases. The specific survey and analysis methods of the different scientific disciplines ought to serve for the data basis of planning processes and project decisions.

However, fourthly it is also important to verify, if the developed interdisciplinary evaluation framework can be sufficiently applied to a certain theoretical and practical evaluation example of nature and landscapes to prove, *inter alia*, its flexible, transparent, and universal applicability?

Fifthly, it needs to be confirmed by an empirical study to which extend the proposed values and criteria of the comprehensive framework are already applied in practice for evaluations of nature and landscapes in Germany, i.e. if there is a practical demand of the proposed interdisciplinary evaluation framework?

1.5 Methods and structure of the research

The research is mainly based on an intense critical literature review to which extend the current knowledge, concepts, and methods of the different scientific disciplines can contribute to an interdisciplinary evaluation framework of nature and landscapes. However, this selection of different approaches, backgrounds, and methods is on purpose incomplete, because it would extend the possibility to gather and to discuss the contents of an interdisciplinary evaluation framework in one research by one author. Furthermore, it shall leave space and time to apply the interdisciplinary evaluation framework to a theoretical and a practical evaluation example. Moreover, the research shall also serve to prove, if the mentioned grave deficits of evaluation methods in Germany are justified by an empirical study of Environmental Impact Assessments (EIA) of the 1990s.

Therefore, the following research shall discuss the contents and backgrounds, as well as, selected common methods and concepts of the different values of nature and landscapes, and hand over key criteria for interdisciplinary evaluations in planning processes and for practical project decisions. After the brief introduction in the first chapter on page 12, you will find a summary of the different values of nature and landscapes and examples of their research methods in the second chapter on page 19.

The third chapter Criteria for evaluations of nature and landscapes continues with a condensed selection of criteria that are proposed by different authors on page 105, after a short introduction of the general conditions of evaluations. In addition, mainly species and population ecological survey and analysis methods,

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[5] In the German language, the term “biotope” is instead used in this context, which defines a living space of a community of species (“biocoenosis”), whereas the term “habitat” refers to the living space of one species (cf. Breckling and Müller, 1998; Martin, 2002).

as well as, concepts within an ecosystem context are arranged to the particular criteria and discussed of their weaknesses and strengths.

The fourth chapter Evaluation example of neobiota (non-native species) on page 225 defines neobiota and reveals the relevance and impacts of their appearance in Central Europe to apply the framework of evaluation criteria according to the different values to the human species and on their own to a theoretical and a practical evaluation example of Neobiota in general and the London Plane-tree (*Platanus x hybrida*) in particular.

In the fifth chapter Empirical study of Environmental Impact Assessments (EIA) on page 282, there is a sample of 51 Environmental Impact Studies (EIS) in Germany of the 1990s examined to which extend these EIS already consider the mentioned criteria and values, their relations to each other, as well as, a selection of the general methodical and specific ecological components, which were discussed in the third chapter Criteria for evaluations of nature and landscapes on page 105.

As a result of the severe deficits of current evaluation approaches and those revealed by the empirical study of Environmental Impact Studies (EIS), there are some general methodical comments necessary in the sixth chapter Discussion of general methodical concerns on page 299 to serve also to apply the proposed interdisciplinary evaluation framework.

Then the research leads to general conclusions in the seventh chapter on page 313 for interdisciplinary evaluations of nature and landscapes and an outlook into future research in the eighth chapter on page 321.

2. **Different values of nature and landscapes**

This chapter intends to summarize the contents and backgrounds, as well as, to discuss selected common methods for each value of nature and landscapes. It shall also point out interactions between the different values, which are decisive for the human perception of elements of nature and landscapes itself in a feedback process.

2.1 Economic values

2.1.1 Economic backgrounds

The economic force in a believe of unlimited growth and prosperity (cf.; Müller, 1999) is one main reason that has reduced natural resources and ecosystems (cf. Wackernagel and Rees, 1997) to endangered, deteriorated and fragmented habitats on earth (cf. World Resources Institute, 2000; Millennium Ecosystem Assessment, 2005a, 2005b; Millennium Ecosystem Assessment Board, 2005). Short time money counts more than long time benefits for the public. The complexity of direct and indirect economic benefits makes it so difficult to estimate and to argue for preserving our natural heritage.

There are just limited market mechanisms, which secure an efficient supply of goods of nature and landscapes. Therefore, from the economic point of view, interventions of the state are necessary at a point, when market mechanisms do not provide sufficient solutions for public goods any more (cf. Bräuer, 2002). Purely profit orientated benefit analyses have often-negative results for the environment and people. The private outcome is regularly worth the deterioration of nature, irrespectively if there would be higher economic benefits for other users in the long- or even short-term. Private companies barely care about public resources, if there are no controlling rules of the public by elected governments. Their economic system is entirely focused on themselves.

However, some economists are questioning traditional concepts of economic growth and underlining the importance of pursuing economic objectives that take into account the full value of the capital of natural resources (e.g. Wackernagel and Rees, 1997) according to chapter 4 of the adopted Agenda 21 during the United Nations Conference on Environment and Development in Rio de Janeiro in 1992 (Quarry, 1992; BMU, 1997). In any case, it is important to apply common direct and indirect economic methods to estimate the economic value of nature and landscapes for practical planning processes and project evaluations.

2.1.2 Methodical aspects

Nevertheless, when it comes to evaluations of certain private or public goods of nature and landscapes, it is decisive to apply economic methods for determining the economic value. Cost-Benefit-Analysis allow calculating direct (primary, internal) costs and benefits for directly involved people and goods. Whereas it is more difficult to estimate indirect (secondary, external, spill over) costs and benefits, and it is almost impossible to calculate intangible (tertiary, meta-economic) costs and benefits of not identifiable groups of persons and goods (cf. Lerch, 1999; Bräuer, 2002).

Therefore, it is necessary to estimate certain prices of costs and benefits for people and goods, as well as, to calculate time delays for discounting. There are Benefit-Value-Analysis, which allow calculating relations between certain goals and different alternative realizations. However, their components depend highly on subjectively determined values of the researcher in selecting, weighing up, and analysing these goals. In addition, future orientated time components are not included in Benefit-Value-Analysis of current values (cf. Macoun, 2000; Waldmüller, 2000; Bräuer, 2002).

Basically, it is possible to distinguish between direct and indirect use values on the one hand, current use values and existence values, as well as, bequest values, and optional values on the other hand (Figure 2.1-1).

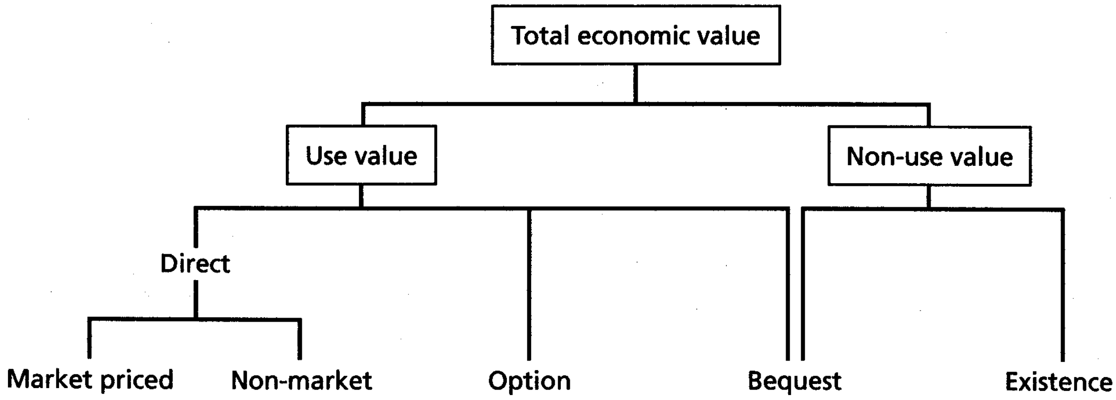

Figure 2.1-1. Economic human values (Bateman, 1999, modified) reproduced by kind permission of Blackwell Publishing, Oxford, UK

All economic values can be calculated together as a total sum, not forgetting that not all values of nature and landscapes can be calculated in money. Use values refer to the current direct use of nature and landscapes, for example, for harvesting and recreation of local residents, visitors, and commercial users, or indirect use, for instance, for environmental benefits, whereas, existence values consider the willing price of people to preserve nature and landscapes without directly or indirectly benefiting of it. As a projection into the future, bequest values consider the economic value of maintaining nature and landscapes for future generations. Optional values of nature and landscapes take into account the optional use of nature and landscapes by current and future generations (cf. Pearce and Moran, 1994; Lerch, 1999; OECD, 1999, 2002; WBGU, 1999a, 1999b; Waldmüller, 2000; Bräuer, 2001, 2002; Wolfrum et al., 2001; Baumgärtner, 2002; Marggraf, 2003; Gaston and Spicer, 2004; Mulongoy and Chape, 2004).

There are several methods to evaluate particular economic values of nature and landscapes on wider and lower scales in detail, which are described below. They range from global estimations to local economic values of green spaces (cf. Hampicke, 1991, 2000; Pearce and Moran, 1994; Groombridge and Jenkins, 1996; Mühlenberg and Slowik, 1997; Schweppe-Kraft, 1997; Endres and Holm-Müller, 1998; Geisendorf et al., 1998; Rommel, 1998; Bateman, 1999; Schneider, 1999; WBGU, 1999b; Elsasser, 2000; van Kooten and Bulte, 2000; Wagner, 2000; Waldmüller, 2000; Goede et al., 2001; Rollins, 2001; Bräuer, 2002; Elsasser and Küpker, 2002; Hellmann, 2002; Luther et al., 2002; OECD, 2002; Kokott et al., 2003; Nunes et al., 2003; Brahms, 2004; Küpker, 2004), including economic indicators (e.g. Endres et al., 1996).

The Safe Minimum Standard focuses just on preserving a minimum of biodiversity and natural resources, whereas the Primary and Secondary Values Concept distinguishes between the costs of preserving natural functions of ecosystems on the one hand and use benefits of harvesting the environment on the other hand. For example, if woodlands are supposed to be cut down for timber use, the market price of formerly gathered nuts, fruits, and flowers could be used to calculate in comparison, how much it would be economically worth to preserve these woodlands.

Similarly, the Substitution Costs Approach (Replacement Cost Technique) estimates the artificial costs to substitute functions of nature and landscapes. For example, substitutional costs can arise to build and to manage sewage treatment facilities compared with preserving natural filters, such as reed banks or unconcreted green spaces. However, the Substitution Costs Approach does not allow including the cost-price relations of available goods of nature and landscapes during different stages of demands and supplies, apart from those goods that cannot be calculated in money.

Moreover, the Production Approach calculates benefits of environmental functions, for example, to reduce wind speed and thereby erosion by planting hedges, which increases production performances of agricultural goods. In addition, the Restoration Approach is widely used for Environmental Impact Assessments (EIA) to calculate costs to restore similar habitats, which would be destroyed by the evaluated project. Preservation costs to manage and to protect certain areas are included in the calculation.

In particular, there are several studies to evaluate recreational values of woodlands, the willingness to pay for hunting and fishing, and to preserve certain wild species, particular habitats, traditional agricultural landscapes, natural areas, and other components of nature and landscapes (overview in Geisendorf et al., 1998). Moreover, green spaces can significantly increase rents and prices of real estates. There are research examples of Berlin (Ribbert, 1999; Luther et al., 2002) and Munich (Blümmel, 1999) in Germany, as well as, Bristol (Smith, 1999) and London (GLA, 2003a, 2003b) in the UK. Other research proves that green spaces in cities are an important economic location factor of enterprises (Kowarik, 1998b, Luther et al., 2002).

Therefore, a selection of the common direct and indirect methods for calculations of economic values of nature and landscapes (Table 2.1-1) will be discussed in the next sections to reveal certain practical methodical advantages and problems of their application.

Table 2.1-1. Selection of common direct and indirect methods to estimate total economic values (cf. Pearce and Moran, 1994; Groombridge and Jenkins, 1996; Endres and Holm-Müller, 1998; Geisendorf et al., 1998; Rommel, 1998; WBGU, 1999b; Frör, 2003; GLA, 2003a, 2003b; Kokott et al., 2003)

Total economic values	
Indirect methods	Direct methods
• Travel Cost Method	• Contingent Valuation Method
• Hedonic Price Method	

2.1.3 The Contingent Valuation Method

The Contingent Valuation Method (CVM) is the most important direct way to calculate economic values of certain parts of nature and landscapes. It is based on asking people, how much they would pay, for instance, to use certain places, or alternatively, how much would they demand for compensation for not being able to use these places any more. The method includes a description of expected quantitative and qualitative changes, potential users, the way to pay and ways of implementation. Therefore, the Contingent Valuation Method has the advantage to provide additional non-use economic values by directly asking for optional and existence figures in contrast to the indirect methods below.

Furthermore, the Conjoint Analysis (CJA) allows to decide between different alternatives (choice modelling), or to rank these alternatives (contingent ranking), or to relate each alternative to a certain value (contingent rating). In addition, there is the benefit transfers' approach to reduce survey costs of the willingness to pay from one site, which has been already investigated, to estimate the economic value of another similar site without a new particular study.

However, we need to consider that in general the willingness to sell certain goods is lower than the willingness to pay for the same objects, depending on personal income and available substitutes. In addition, economic losses are weighted higher than gains. There are also strategic inaccuracies, which are caused by biased answers to influence results in either ways. Moreover, it is also possible that answers fluctuate, because of the unfamiliarity with the method and due to too abstract personal use values. On the one hand, the particular good of nature and landscapes needs to be accurately described. On the other hand, the asked person must not be overloaded with information. In addition, it happens that asked persons filter the information by perceiving this kind of information more that supports their own opinion. Moreover, it can be assumed that new information is more weighted than already known aspects. The way that the information is presented is another important factor, which can cause biased answers.

Therefore, there are additional questions necessary to find out, if the asked persons have understood the market system und if they accept it as being real. Moreover, there are questions important concerning the individual relationship to the particular good of nature and landscapes, for example, concerning the degree of information, personal interests, experience, and spatial distances (cf. Bräuer, 2002). The theory of reasoned actions describes behavioural intentions, for example, the willingness to pay, as functions of individual consciousness and social norms (cf. chapter 2.4 Social values on page 50). Finally, there is a need to find out socio-economic characteristics of the asked people. For example, the willingness to pay depends also on the personal income. Therefore, it can be appropriate to ask additionally for the willingness to offer personal working hours to contribute to the project (Matz, 2004).

Another crucial point is the methodical way to ask, either in person, or by telephone interviews, or by using written questionnaires. Personal interviews can significantly reduce the number of people, who do not respond. They allow feed back questions, which however can be biased depending on the interviewer's presentation of the subjects. We can distinguish between focused interviews, ethnographic interviews, half-standardized interviews, problem centralized interviews, and expert interviews (Stoll, 1999). Strategic answers can be widely reduced by combining them with referendums and making it clear that the resulting figures will be crucial for everybody in case the majority has voted for it. Another way to reduce biased answers is by pre-tests. For instance, the US have set certain research standards by a panel of the National Oceanic and Atmospheric Administration (Hanley et al., 1997).

Furthermore, the sample areas of the surveyed people have additional influences on results, as well as, the chosen way to pay, for example, by taxes or entrance fees, respectively. The question of money itself is important, if answer opportunities are open, or if they differ at certain payment levels, or alternatively, if payment figures increase until an individually chosen maximum of willingness to pay. For example, the dichotomous choice response method starts with a certain figure, which causes already a certain starting point bias effect. If it is rejected, half of it is proposed. In case it is accepted, the double will be asked.

In addition, there is the part whole bias effect (embedding effect). Individual payment willingness is generally higher, if people are asked for isolated parts of nature and landscapes in comparison to a total sum, for example, if people are asked for payments for keystone species (cf. section 3.2.4.3 Keystone species on page 171) instead of whole ecosystems. Furthermore, the warm glow effect considers that the willingness to contribute depends on comparisons with the importance of other problems on earth at the same time.

The mentioned effects cause some significant problems, which make it impossible to just add environmental costs of different approaches and databases to calculate overall ecological costs (e.g. Wicke, 1991; Radermacher, 1998). However, there are some examples of willingness to pay for nature and landscapes in Germany on wider and smaller scales (Table 2.1-2; Bräuer, 2002).

Table 2.1-2. Examples of willingness to pay for nature and landscapes in Germany (Degenhardt et al., 1998, modified)

Parts of nature and landscapes	Willingness to pay
Habitat and species protection of West-Berlin	• 64.84 € per person per year, i.e. about 97 million € per year in total
Habitat and species protection in Germany	• about 10 € per household per year, i.e. 1.5-4 billion € per year
Prevention of species extinction in Germany	• 8.24 € per household per month, i.e. 2.64 billion € per year
Establishment of 15 % nature reserves of nature and landscapes in the Federal state Schleswig-Holstein	• 8-13 € per person per month
Preservation of the traditional rural cultural landscapes of Austria	• 0.6 € per visitor and day of holidays, i.e. approximately 50 million € per summer season
Management of wastelands of the Federal State Baden-Württemberg	• 30 € for 1/3 of all areas, 33 € for 2/3 of all areas, and 34 € for the total areas
Nature conservation and landscape management of the region Emsland at the Werra-Meißner district	• 7 € per household per month (landscape development fee) and 1.3 € per person per day (holiday taxes)
Landscape management at Lahn-Dill-Bergland	• 8.76 € per household per month
Environmental sensitive harvesting of agricultural landscapes at the Allgäu and at Kraichgau	• 28.69 € and 39.64 € per household per year for the preservation and improvements of landscape scenery, respectively, and 51.03 € per household per year for species protection
Landscape management at the Lüneburger Heide	• 13.18 € per month per person (mean value), 9.09 € per month per inhabitant (mean value), 16.27 € per month per tourist (mean

	value), and 5 € per month per tourist and inhabitant (median)
Preservation of ecologically important areas through sheep grazing at Solnhofen and Göhren/Rügen	• 1.2 € and 0.46 € per tourist per night at Solnhofen and at Göhren/Rügen, respectively

Nevertheless, some of the mentioned biased influences can be limited to acceptable levels by detailed neutral descriptions of subjects and by pointing out practical consequences of the answers.

2.1.4 The Travel Cost Method

The Travel Cost Method is an important indirect economic method to evaluate expectations of people to visit and to use parts of nature and landscapes. Principally, there are two ways to apply the Travel Cost Method. Firstly, it is possible to count visits per person, and secondly, the average number of visits can be calculated from regions of certain spatial distances.

However, the latter zone approach deals with the problem of artificial boundaries of selected districts. They do not exist as statistically desired concentric circles, which can cause inaccuracies in results. Theoretically, each region should be considered, which has at least one visitor of the area. Otherwise the consumer value can be underestimated. Moreover, as longer there is the distance to the evaluated place, as more likely it becomes that there is another alternative green space of attraction, which influences the result. However, the Random Utility Theory is based on discrete data models, which integrate these substitutional opportunities. In addition, few long distance travellers can increase significantly the average travel costs. However, using the median instead of the mean for calculations can reduce this latter distortion of results.

Moreover, there is also the question, if the evaluated place was the main and only destination of the trip and how the other places of interest can be included in the calculation. One solution is to calculate visitors in figures ranging from 1.0 to 0.0 of full time and part time visitors, respectively. Another approach is to separate all exclusive visitors from the others, to ask for their minimum willingness to pay, and to use those average results to calculate the total value of the group. However, potential travellers are completely underestimated, who cannot effort the trip.

In addition, it is also necessary to consider long distance travel costs to holiday residences, which appear just once, in relation to daily costs to reach certain places. Furthermore, there is even a greater difficulty in calculating travel costs for those people, who have changed their residence permanently to live closer to their evaluated places of interest. However, specific questions can be used to find them out. Moreover, visitors who use their own car have to pay more than just fuel costs. Therefore, it is necessary to include certain figures of costs for purchasing, repairing, durability, and insurance in calculations of travel costs by using cars.

Additionally, there is also the possibility to calculate individual time costs. In this case, the time span must be calculated for each journey. However, individual assessments of time durations depend apart from spatial distances, also on qualities of transport systems, and the individual positive or negative perception of the passed environments, i.e. time costs are also subjectively determined by travel qualities. Moreover, visitors who live closer to recreational places might spend longer times at places of interest than those who have to travel a long time to reach it.

Apart from the use quality of certain places for calculations by the Travel Cost Method, there are additional factors, which are likely to influence visitors, for example, personal income, age, children, domestic animals, educational level, and membership in environmental organizations (Stoll, 1999; cf. overview socio-demographic variables in Kals, 1996).

2.1.5 The Hedonic Price Method

The Hedonic Price Method is another indirect estimation method, which takes into account that higher qualities of the environment increase economic values of private goods on the market, such as real estates. Prices of real estates depend on different variables including age of the building, number and size of rooms, infrastructure of the neighbourhood, and environmental quality.

However, the Hedonic Price Method assumes an ideal free market system of free information and free mobility of residents. Therefore, this method can hardly be applied to state regulated markets of real estates, such as in Germany. In addition, it assumes that the characterizing variables are equally distributed in each area. For example, green housing estates in the suburbs have often the disadvantage that other attractive cultural and entertaining location qualities are located in more polluted and highly concreted central areas of the city, for instance, museums, cinemas, theatres, and bars.

Furthermore, personal consumer variables influence also market demands, which is a comparable methodical difficulty to the Travel Cost Method on page 26. Moreover, local differences of certain compared environmental qualities must be the decisive reason of different housing prices, and it must be possible to clearly separate their values. For example, the number of trees in streets can vary essentially between two areas, but the dominating environmental factor of air quality might be similar in both locations due to equal traffic volumes. In addition, there are other ways to reduce environmental impacts than by paying more to change the location of the residence. For example, it might cost less to install noise reducing double glass windows, than searching on the real estates' market for another more silent place. Moreover, these preventing efforts can be combined with other additional benefits, which make it difficult to separate them from general housing market prices, for instance, to reduce heating costs. In addition, obligatory costs are not included, for instance, costs of public laws that demand filters in heating systems to limit emissions.

2.1.6 Conclusive summary

Nature and landscapes as a public good are not sufficiently considered in economic evaluations of our societies. One reason is that private companies are entirely orientated towards their own profits, irrespectively if there are different or long-term benefits of nature and landscapes to the public, which would be more valuable than their deterioration for short time profits. Therefore, in our economically dominated societies, it has become essential to find methodical ways to estimate the economic value of the public good nature and landscapes on a wider comprehensive scale, apart from their immaterial values.

The total economic value considers current direct and indirect use values, as well as, existence values for those people, who do not profit of the particular good of nature and landscapes. Optional economic values include the optional current and future use of nature and landscapes. Furthermore, there is also the bequest value calculated of the total economic value, which refers to the economic value of maintaining nature and landscapes for future generations. However, the total economic value does not cover immaterial values of nature and landscapes.

In particular, there are indirect economic methods, which are based on the costs to travel to certain parts of nature and landscapes (Travel Cost Method), or the price of real estates due to the conditions of the surrounding nature and landscapes (Hedonic Price Method), respectively. However, these two indirect methods depend on different theoretical assumptions, for example, the Travel Cost Method assumes that the visited area is the only destination and that there would be no alternative interesting green area accessible. The Hedonic Price Method supposes theoretically that there would be a free mobility to change the residence as a private good, as well as, an equal information access. In addition, other important features would have no significant influence on the decision to buy a real estate at a certain area, such as the cultural infrastructure. Therefore, practical examples of the Hedonic Price Method are rather limited.

The most important direct method to estimate the economic value of goods of nature and landscapes is to ask directly the people concerned, which amount of money they would accept to pay for certain parts of nature and landscapes, or how much they would demand for compensations of losses of them (Contingent Valuation Method). The asked way to pay is important to reduce biased answers of social acceptance, for example, either paying directly or indirectly through taxes. Therefore, the design and implementation of questionnaires and interviews is decisive to get trustworthy results. Furthermore, the further developed Conjoint Analysis allows gathering public opinions on the economic value of parts of nature and landscapes by ranking different alternative measures.

Therefore, either direct or indirect methods should be chosen to calculate economic values of nature and landscapes, depending on the particular case. Direct methods allow calculating additionally non-use values in contrast to indirect methods, which thereby generally underestimate total economic values. Hopefully, these economic methods can help to support measures for preserving and enhancing our nature and landscapes due to better estimating their complexity of direct and indirect economic benefits.

However, the diverse methodical difficulties to gather a certain figure in money for the economic value of certain goods of nature and landscapes have become obvious in this chapter. The main function of money is to be convertible for satisfying different individual and group demands of the society. Therefore, there is an economic need to concentrate all values of nature and landscapes on a total sum. A total sum however, does not reflect the various reasons and circumstances of economic values of nature and landscapes. Furthermore, the non-use values can be undervalued.

Economic methods have already enlarged their pure field of direct or indirect use values to non-material values by directly asking people for their willingness to contribute financially or to make preferences of certain goods of nature and landscapes. However, exactly this is the difficulty that limits economic methods to estimate non-use values. Nature and landscapes and their contents are not entirely tradable goods, especially if there are practically neither ideal free market systems nor it is possible to sufficiently separate the other influencing variables of a market price to gather a total economic value of certain parts of nature and landscapes.

Nevertheless, it is decisive to estimate an economic value of certain goods of nature and landscapes in a mainly economically determined society for practical decisions with impacts on nature and landscapes, especially for planning processes and project evaluations. However, there are other leading motivations to value nature and landscapes, which cannot be estimated by economic methods. Furthermore, these motives originate in other disciplines than economics. People seem to offer more than money to preserve and to enhance nature and landscapes due to a certain attitude, i.e. consciousness to nature and landscapes. This personal consciousness can be distinguished from the economic value of nature and landscapes as an ethical value. Ethical values are of major importance for the willingness of people to contribute to the development of nature and landscapes also financially. Therefore, different ethical approaches shall be discussed in the next chapter, as well as, their practical implications.

2.2 Ethical values

All logical reports and empirical research have not been able to change the constant destruction of our environment. Short time economic benefits of a few people weigh generally more than long-term orientated politics for the future. However, humanity is based on feelings, as well as, responsibility for nature and landscapes. Logic arguments come after our feelings in most decision-making processes. Our societies are based on ethical principles of how to treat our human and non-human parts of nature and landscapes, which are passed on during thousands of years of cultural development. Therefore, ethical considerations might be the key attempt to influence individual and political decisions on a more sustainable long-term orientated scale.

Basically, there are two antagonistic ethical[6] approaches (cf. Erdmann and Grunow-Erdmann, 1993; Hampicke, 1993, 1995; Billmann-Mahecha et al., 1998; Gorke, 2000; Jax, 2002; Nagel and Eisel, 2003). On the one hand, there is the anthropocentric approach, which considers nature and landscapes just for the benefit of the human species. For example, the 1992's Rio Declaration on Environment and Development puts human beings as its first principle at the centre of concern for sustainable development (Quarrie, 1992). The pathocentric approach goes even a step further by including also suffering organisms into its ethical concept.

On the other hand, there is the competing biocentric approach, which takes into account that nature and landscapes have a value on their own. Since 2002, § 1 of Germany's Federal Conservation Act grants nature and landscapes an own value and a value as a basis of life for humans also of future generations (Bundesministerium der Justiz, 2002).

Last not least, the physiocentric (holistic) approach is the widest ethical view by integrating also the non-living parts of nature and landscapes. Intrinsic values of nature and landscapes exist irrespectively, if they are of specific benefit to the human species, which are defined as inherent values (cf. Hampicke, 1993, 1995, 1998; Potthast, 1999; Schneider, 1999; Doppler, 2000).

2.2.1 Anthropocentric approach

Nature and landscapes are valued just for the benefit of human beings. Firstly, there are direct material benefits of nature and landscapes as a resource. Secondly, the human species benefits indirectly of the productivity of ecosystems, for instance, by using clean air, water, and productive soils. Thirdly, nature and landscapes have a subjective immaterial value for the human species, when people have developed personal relations to certain subjects either living or non-living. For example, a certain woodland area can have such a personal human value, when it was a place where grandfather used to distribute eggs and other sweeties for his grandchild at Easter every year.

[6] Ethics is the science of moral willing and acting of the human being in different life situations (Müller et al., 1982), or the science of morals in human conduct (Allen, 1990).

2.2.2 Pathocentric approach

Those animals are also moral subjects, which can suffer pain similar to the human species. The logical scientific explanation is that vertebrates have similar nerve systems to the human species. Therefore, they are considered to be able to suffer similar feelings of pain, despite it is assumed that they are not able to have the ability to imagine painful thoughts as the human consciousness. Modern animal rights groups are based on this attitude to protect mainly vertebrates against human caused pain. However, it is the feeling of sympathy and respect for our closest animals, which is also the first step to humanity.

2.2.3 Biocentric approach

All living organisms have a moral status. There is a respect for live, which takes into account that each organism makes an effort to survive. This biocentric consciousness shall be considered for each decision with an effect on nature and landscapes (cf. Neuenschwader, 1974; Schweitzer, 1991).

2.2.4 Physiocentric/holistic approach

The physiocentric or holistic approach covers all living and non-living elements of our biosphere. It is the most integrating consideration of nature and landscapes as a whole. Physically, it does not hurt someone, if we diminish dead material. However, there has been a development on time and spatial levels, which has brought non-living objects and constellations into current situations and relations. If we respect the human interest in life, as well as, the efforts of each organism to survive, it is just a further consequential ethical step to recognize the destiny of life also for dead elements of it.

2.2.5 Indigenous people

Indigenous people are frequently seen as guardians and stewards of nature and landscapes (Posey, 1999; WBGU, 1999a). Harmony and equilibrium among components of the cosmos are central concepts in most cosmologies. However, local communities are more likely to employ sustainable practices of nature and landscapes, when they enjoy territorial security and local autonomy (Posey, 1999) than big societies in a global market. Sacred sites act as conservation areas for natural resources and thereby ecosystems by restricting access and behaviour, for example, sacred groves and holy places (Posey, 1999; cf. Kaule, 2000; Lee et al., 2003; Ono, 2005).

2.2.6 Conditions for practical applications of moral guidelines

The different revealed ethical approaches to nature and landscapes allow a certain theoretical moral attitude towards nature and landscapes for decisions with an impact on them, i.e. either individually or as a group for practical planning processes and project evaluations. However, moral guidelines are only as efficiently practiced as they consider behavioural and psychological aspects (cf. chapters 2.4 Social values on page 50 and 2.3 Psychological values on page 12, respectively). Moral intervention strategies to change practical behaviour are more effective than stirring up fears on general levels, for example, of the global destruction of nature and landscapes (cf. Kals, 1996; section 2.4.5 Sociological methods on page 63). However, if we want to influence our behaviour by ethical considerations, it is necessary to integrate human basic needs and behavioural mechanisms in our approaches. Reflections upon human behaviour cannot substitute ethical considerations, but they can essentially support their practical applications and understandings. There is often a discrepancy between verbal statements of people and their practical behaviour towards nature and landscapes.

Therefore, behavioural observations (cf. Hellbrück and Fischer, 1999) are necessary to validate questionnaires and interviews (Jessel and Tobias, 2002). Implementations of ethics need to take into account every day experience, personal capacities, possibilities, and limits. In conclusion, ethical consciousness is important for developing a different behaviour towards nature and landscapes, but it needs to integrate psychological and behavioural aspects to be implemented in practice (cf. Heiland, 1999). Perception, knowledge, the human being, its behaviour, and reality are woven together in a tangle of interactions (Rudolf, 1998; cf. section 2.4.1 Social aspects of our perceptions, evaluations, and behaviour on page 50 and section 2.3.2 Psychological perceptions on page 40).

There are different conditions for practical applications of moral guidelines to nature and landscapes (Table 2.2-1).

Table 2.2-1. Different conditions for practical applications of moral guidelines to nature and landscapes (Renn, 2001; modified)

Conditions for practical applications of moral guidelines to nature and landscapes
• perceived action opportunities • positive attitude • relevant acting knowledge • economic incentives • moral appreciation • unambiguous communication and information contents

- support by social networks
- sensible perception of positive consequences

For example, humans in general intend to preserve existing actions and decision opportunities. It can cause resistance, if they are restricted, for example, by limiting rules without behavioural alternatives. Behavioural changes towards nature and landscapes are often combined with changes of values, habits, and self-consciousness of people. In addition, personal evaluations of actions for nature and landscapes depend highly on subjectively determined social perceptions. Personal experience of life, needs, and views can cause irritations of communication processes for evaluations of nature and landscapes, as well as, emotional conflicts and disturbances on levels of personal relations (Stoll, 1999; Pretzell, 2003). Therefore, there are specific communication strategies necessary for target groups (cf. Stoll, 1999; Brendle, 2000, 2002; Hübner, 2000; Luz and Weiland, 2001; Kuckartz et al., 2002; Mangels-Voegt, 2002; Stoll-Kleemann, 2003; Wilhelm and Edmüller, 2003; Vogtmann, 2003; von Haaren, 2004h) and professional public relations (cf. WBGU, 1999a; Goppel, 2003; Reinbolz and Pretzell, 2003), as well as, responding systems of personal actions (Kals, 1996). People need to become emotionally and intellectually involved in a democratic participatory process (cf. Hoisl et al. 2000; sections 2.6.3 Personal contacts on page 88, 2.4.3 Social participation on page 59, and 2.4.5 Sociological methods on page 63, respectively).

In addition, stereotypes can develop of nature conservationists, which can cause significant evaluation problems. Selective perceptions might be the result, when just the information is noticed, analysed, and kept in mind, which fits into the stereotype. Moreover, opinion milieus and social networks of relevant groups can cause communication problems. If subcultural norms are negative in these groups, conformity pressure can lead even those group members to wholesale resistance, who would be originally positively orientated. Farmers are an example (Stoll, 1999).

It seems to be a general tendency of humans to think and to act in accordance with others. There are two dimensions of group influences to personal consciousness. Firstly, there is conformity as a normative influence, which expresses personal needs of getting sympathy and acceptance, as well as, preventing rejections. Secondly, there is trust as an informative influence, which causes that new information and new arguments of the group are easily accepted, because there is more trust into the judgement of the group than into its own (Stoll, 1999).

Ethical consciousness needs to activate motivating emotional processes and to change values and norms. Nature conservationists mostly argue scientifically and intellectually, which does not consider the majority of the public with an aesthetic and emotional access to nature and landscapes. This might be a central reason for the communication problems between nature conservationists and other people (Meier and Erdmann, 2003; cf. Kals, 1996; Goppel, 2003; Röchert, 2003; Theobald, 2003). Therefore, some authors consider aesthetic and emotional contacts as the basis for our ethical approach towards nature and landscapes (Billmann-Mahecha et al., 1998; Gebhard, 2001; cf. chapters 2.3 Psychological values on page 38 and 2.6 Educational values on page 85, respectively).

Furthermore, there are encouraging behavioural aspects necessary. Ethical consciousness needs to be specific and concrete for every day life applications. It must be related to individual capacities and requirements of every day life, including personal habits, interests, and needs. The corresponding relation of ethical considerations and behavioural aspects is important for our individual behaviour towards nature and landscapes and personal evaluation of practical planning processes and project decisions with an impact an them. Changes of personal ethical consciousness can influence our own behaviour, as well as, external structures and our social environment (cf. chapter 2.4 Social values on page 50).

On the other hand, structural reforms and support are necessary by our social environment to secure long time and comprehensive behavioural changes of us that are based on our ethical consciousness. Again, they need to take into account personal capacities and limits of each human being. In other words, it is a corresponding circle of intellectual, emotional, and behavioural conditions, which allows the human species to develop a different ethical approach to nature and landscapes in practice (cf. Heiland, 1999) that determines the subjective evaluation of nature and landscapes.

2.2.7 Conclusive summary

There are different ethical approaches to nature and landscapes ranging from the anthropocentric approach as a pure value to the human species via the pathocentric approach, which grants those animals an ethical value that can suffer pain similar to the human species, to the biocentric approach, which respects the effort of each organism to survive, and the most complete physiocentric (holistic) ethical approach, which considers also non-living elements of our biosphere.

From a systematic point of view, some authors criticize that nature and landscapes could not have a value on their own, because only the human being can develop consciousness and take over responsibility for actions with an influence on them, i.e. only the human species can value positively or negatively elements, structures, and functions of nature and landscapes (Riedl, 1991). Nature and landscapes could just have an indirect or direct ethical value as an evaluative interest for the human being in the short- and long-term, because the descriptive interest to survive would not imply an ethical value itself (von der Pforten, 1996). It would be the subjective mystic and aesthetic experience of each human being that has developed a value for elements of nature and landscapes, which could not be generalized as an ethical approach (Birnbacher, 1980). Subjective moralization would substitute a rational ethical approach to nature and landscape (Dierßen and Wöhler, 1997).

The pathocentric and biocentric ethical approach, respectively, would equalize the members of the “moral community”. In consequence, the physiocentric (holistic) ethical approach would not allow anything more than necessities for our survival (Ott, 2000). However, this would not lead to practical measures (Ott, 2000), which can be rationally discussed (Dierßen and Wöhler, 1997), but to any possible value for nature and landscapes (Birnbacher, 1996). Therefore, we should follow instead an enlightened anthropocentric ethical approach, which considers that nature and landscapes ought not to be overharvested, that nature and landscapes serve also for the human well-being, but provide much more than material benefits, and that nature and landscapes have an additional inherent value, which is ascribed by the human species (Seiler, 1999). There would be an aesthetic own value of nature and landscapes, but just according to the value to the particular observer. In addition, nature and landscapes would have an own home value, as well as, a grandeur for the human being (Krebs, 1997; cf. Nagel and Eisel, 2003).

However, the purely focused anthropocentric approach to nature and landscapes even in an enlightened form is based on a misunderstanding of the biocentric approach. The reverence for life proclaimed by Albert Schweitzer does not include an irrational abstract equality of all living organisms, irrespectively of our personal human needs to survive and to influence creatively nature and landscapes as an expression of our cultures. It is a principle ethical consciousness of a moral guideline, which shall be practically implemented in each of our decisions with an impact on nature and landscapes (cf. Neuenschwader, 1974; Schweitzer, 1991).

Therefore, the biocentric or even comprehensive physiocentric (holistic) approach do not put the human being or just what is needed or appreciated by him in the centre of the world for practical planning processes and project decisions with an impact on nature and landscapes, but they demand a permanent weighing up process between the necessities for human survival, as well as, human well-being and the own value of elements, structures, and functions of nature and landscapes. This ethical weighing up principle of a value of nature and landscapes to the human being and on their own is neither impracticable nor irrational. It is also based on a feeling of responsibility for nature and landscapes, which has psychological, culture-historical, educational, and social backgrounds. Due to the fact that nature and landscapes cannot express directly their vote for their intentions of existence and development, including non-living elements, the human being needs to respect and to consider also their value on their own.

Such a behaviour or such an ethical approach, respectively, is only anthropocentric to an extend, that the responsibility for the rest of nature and landscapes can only be discerned by the human species (Steubing et al., 1995).

Of course, the interpretation of the value of nature and landscapes on their own by the human being will be always subjective and incomplete, but it does not need to be abstract. Nevertheless, the human being will never be able to understand, to simulate or to create nature and landscapes completely in their complexity and unpredictable development (cf. chapter 3 Criteria for evaluations of nature and landscapes on page 105). At least, the human being can choose the ethical approach that integrates all elements of nature and landscapes, irrespectively of the value to the human being, as a guiding ethical principle for practical decisions. The physiocentric (holistic) ethical approach grants an ethical value to all elements of nature and landscapes, including the non-living, whereas the biocentric attitude to all living organisms, and the pathocentric just to those animals, which are able to suffer pain. The anthropocentric ethical approach is the least complete, because it leaves all elements and interactions of nature and landscapes out, which have no granted value to the human being.

Nevertheless, in practice there is no significant difference between the anthropocentric and the biocentric approach for the ethical value on ecosystem level. It is as essential for the survival of the human species as for the rest of fauna and flora that natural processes are in function depending on their particular ecological components (cf. Eser and Potthast, 1999). However, on species level and lower, the biocentric approach takes into account the whole diversity in contrast to the anthropocentric ethical approach, irrespectively if it needs to be justified to be of short- or long-term value to the human species (cf. Mühlenberg et al., 1991; Linsenmair, 2002; Jax, 2003). The loss of one species or one genotype, respectively, can have unexpected impacts, which are manifested very slowly or which can reveal detectable consequences just after changes of environmental conditions (Wolfrum et al., 2001).

Furthermore, a certain ethical consciousness does neither guarantee its practical implementation, nor it provides the results of the necessary human weighing up decisions for particular evaluations of nature and landscapes in practice, which are influenced by rational and emotional reasons. Implementations of moral guidelines need to take into account psychological, social, and educational aspects in a certain culture-historical environment, such as human basic needs and behavioural mechanisms, as well as, personal experience and knowledge, communication barriers, social norms and structures, and motivating elements. Nevertheless, moral intervention strategies to change practical behaviour are more effective than stirring up fears on general levels.

Charles Darwin has revealed the development of the human life-form as the most important factor in the evolution of the human species, apart from the evolvement of languages, intelligence, sympathy, and learning ability (Erdmann and Kastenholz, 1992). The human species is like every living organism part of nature and landscapes, but it has a special position due to its mental abilities to intervene and to change them like no other species (Hellbrück and Fischer, 1999). We are currently the dominant powerful species on earth, which has lead to the end of other species in an amount that natural evolutionary processes have caused in thousands or even millions of years. In Central Europe, there has been a dramatic decline of the diversity of landscapes and their dependant species during only the last 150 years (cf. Plachter, 1991).

The biological ability of the human species to develop an own consciousness does not necessarily lead to the conclusion that all other living or non-living parts of nature and landscapes would have only a value, if we ascribe it to them due to directly or indirectly benefiting of it in material, psychological, or emotional ways. Our evaluation of nature and landscapes is like every evaluation subjectively limited to our personal perception and analysis, but we can decide for us to consider an ethical consciousness, which includes also non-anthropocentric values of nature and landscapes. We have evolutionary become able to be aware of the severe reactions to our influences on nature and landscapes, and we are able to conclude practical decisions of planning processes and project evaluations with an impact on them out of it. It is our decision now, if we extend our responsibility for our environment as a whole, including the human species and the value of nature and landscapes on their own. The biocentric approach has overcome the selfish anthropocentric attitude by concentrating already on all living organisms. However, it has overlooked the non-living parts of nature and landscapes, including the human heritage, which have a value on their own. The physiocentric (holistic) ethical way is the most complete. It needs to be promoted by all media.

Moreover, if we just act for ourselves, there is a danger that we do not take care of us, nor for our neighbours, nor for future generations of the human species or even for nature and landscapes on their own. The current social development goes to more and more individualism in a sense of egoism (cf. section 2.4.4 Social life-styles and milieus on page 60). The individual human species becomes an exchangeable good itself. Feelings of love and friendship deteriorate to commodities. However, this moral attitude of life can only achieve fair trade at its best (cf. Fromm, 1983, 1998). We develop to unfeeling exchangeable objects, which have no relationships to their environment any more. Friends become as exchangeable as partners of no deeper relationships (Fromm, 1990). However, this is the contrary of what humanity is about. Happiness is the feeling and the consciousness of being connected with each other, of being integrated in the process of life.

The literary Peter Camenzind wanted to open people's minds and hearts to love nature and landscapes as a source of happiness and as streams of life at the beginning of the 19th century. He referred to those people, who might know more about foreign wars, fashion, gossips, literature, and art than about the simple beauty of springtime. He wanted people to listen to the heart's pounding of the earth and to participate of life as a whole. Camenzind intended to do not forget that we are not gods created by ourselves during small parts of our life's proceedings, but offspring and parts of the earth and the cosmos (cf. Hesse, 2002).

Many indigenous communities practice already an integrated life in harmony and equilibrium with nature and landscapes in contrast to our "civilized" societies. However, these often-spiritual relationships might only function on local levels and not in dimensions of industrialized societies in a global market. Nevertheless, the relationship of indigenous communities to nature and landscapes can function as a model for our own ethical consciousness and practical behaviour.

This chapter has revealed that there are different ethical approaches to nature and landscapes ranging from just granting an ethical value for the pure benefit of the human species to a value of living and non-living elements of nature and landscapes on their own, including their interactions. However, the practical impacts of moral principles and personal evaluations of elements, structures, and functions of nature and landscapes depend also on psychological, social and educational influences during a certain culture-historical period. Furthermore, these influences develop themselves and determine the personal ethical consciousness of people to nature and landscapes and of the society as whole during a socialization and education process. Consequently, some authors have already tried to integrate culture-historical and psychological values in an enlightened anthropocentric ethical approach, in particular an aesthetic (psychological) value and a (culture-historical and social) home value (cf. Krebs, 1997; Nagel and Eisel, 2003).

However, different values of nature and landscapes need to be clearly separated for a comprehensive evaluation framework to be able to weigh them up against each other for practical planning processes and project decisions. Therefore, the following chapters shall reveal the psychological, social, culture-historical, and educational values of nature and landscapes and their feedback influences on the subjective behaviour towards and evaluation of nature and landscapes itself. Moreover, common methods of these scientific disciplines shall be discussed to allow interdisciplinary evaluations of nature and landscapes.

2.3 Psychological values

2.3.1 Psychological benefits

Nature and landscapes have deeply psychological benefits for human life. The aesthetic quality of our nature and landscapes is of great value for our psychological and physiological health (cf. Gareis-Grahmann, 1993, 1997; Homburg and Matthies, 1998; Miller, 1998; Gebhard, 1998, 2000, 2001; Millennium Ecosystem Assessment, 2005a, 2005b; Table 2.3-1). In 1946, the World Health Organization (WHO) defined already health as a state of optimal physical, mental, and social well-being, not merely as the absence of disease and infirmity (Hellbrück and Fischer, 1999; Weckwerth, 2000; Lawrence, 2002).

Table 2.3-1. Clinical psychological benefits of nature and landscapes (Gebhard, 2001, modified)

Clinical psychological benefits of nature and landscapes
• relief of different painful and frightening feeling conditions • support of self-realization • deepening of reality feelings • support of esteem and positive attitudes towards fellow human beings

Nature and landscapes are the source for our recreation and inspiration. There is a deep resonance of our psychological wellness to their conditions. Landscape views determine our every day life. Green spaces are reservoirs to relax and to be emotionally and intellectually stimulated. Nature and landscapes are the contact to our outdoor environment. They influence our emotions, thinking, and behaviour. However, recreational values of nature and landscapes are crucially combined with access, distance and infrastructure of recreational opportunities (cf. Zisenis, 1993; Schemel, 1998; Hoisl et al., 2000; konsalt, 2000; Coles and Caserio, 2001; Ott, 2004). It is important to experience nature and landscapes directly by being in it.

Nature and landscapes stimulate all senses of our viewing, hearing, smelling, tasting, and feeling (Gareis-Grahmann, 1993, 1997). They have emotional and cognitive aspects (Haubl, 1998; cf. Gebhard, 2001). At short distances, all senses are relevant, especially smelling and tasting. Middle distances are more determined by hearing and viewing, and long distances mainly by viewing (Gareis-Grahmann, 1997). Furthermore, psychological interpretations of influences of nature and landscapes have to take into account the subjective perception of each person depending on personal development, environmental consciousness, as well as, the individual social and historical background (cf. chapters 2.2 Ethical values on page 29, 2.5 Culture-historical values on page 73, and 2.4 Social values on page 50, respectively). Our personal experience during our life, our education and our visits of other nature and landscapes in our country or abroad has an influence on which of their elements, structures, and functions we expect or desire (cf. chapter 2.6 Educational values on page 85). Our knowledge of environmental processes, our cultural habits, and our social context of our time epoch let us assess conditions of nature and landscapes differently (cf. Demuth, 2000; Gebhard, 2000).

There is a psychological longing for connections with nature and landscapes, for unity and luck, whereas the more frightening aspects of nature and landscapes are not on main focus of this romantic attitude. However, the development of sciences and technology has allowed developing independence, but also an estrangement of the human species from nature and landscapes (cf. Gebhard, 2001; chapter 2.5 Culture-historical values on page 73). Industrialized human uses of nature and landscapes in agriculture, forestry, fishing, tourism, traffic, and settlements have caused uniformity and losses of opportunities of psychological perceptions (cf. Demuth, 2000).

Furthermore, individual awareness of changes in nature and landscapes depends also on psychological reasons. Slight deteriorations of nature and landscapes are generally badly recognized by humans. Changes of ecosystems become obviously visible above certain levels of deterioration, for example, lakes polluted by nutrients at certain levels. Despite species and structural changes might have been already detectable for experts during longer times. Human thinking is generally concentrated on short periods, slowly changing times, manageable areas, and small social groups. The structure of environmental problems does not fit to this thinking attitude, for example, their complexity. Furthermore, psychological reasons can also lead to ignore or to deny changes of nature and landscapes, if people are afraid of their consequences or if this response is much easier than to change our individual behaviour. Information on deteriorations of nature and landscapes can cause fear. There is a contra-productive danger, if alternative opportunities are not pointed out at the same time (cf. Schahn, 1993).

2.3.2 Psychological perceptions

Unconsciously, we adapt to what is widely accepted by our societies, and we have incorporated culture-historical guidelines during our education and socialization (cf. chapters 2.2 Ethical values on page 29, 2.4 Social values on page 50, and 2.6 Educational values on page 85, respectively). In addition, we need to take into account that human relations to nature and landscapes are widely unconsciousness (cf. Gebhard, 2000). Perceptions of nature and landscapes depend on the evaluation approaches of our societies, current individual consciousness and expectations of perceiving persons. Furthermore, they depend also on individual knowledge and experience, and cultural opinions during a certain period of time (Becker, 1998). What we perceive depends also on what we know. What we ascertain depends also on what we expect, and what we find depends also on what we are looking for (Rudolf, 1998).

Fromm has analysed in detail, why most people tend to adapt to current trends to be integrated in the society (cf. Fromm, 1983). Furthermore, our personal perceptions are also influenced by how nature and landscapes are discovered. There are close and mutual relations. Absorbed meanings of nature and landscapes are translated into actions. Thereby objects get subjective meanings and mutual influences develop (Jessel and Tobias, 2002).

Theoretically, there are three levels of psychological perceptions of nature and landscapes: firstly, there is the pure sensory perception of form and composition of nature and landscapes without human interpretations and associations. Secondly, there is the cognitive level of interpretations of the meaning of elements of nature and landscapes, for example, their meaning for culture-historical landscapes during 1850. Personal experience and knowledge are decisive for cognitive analysis of nature and landscapes, as they are for different perceptions of art. Thirdly, there is the symbolic level of elements of nature and landscapes that has also a social component for individual and collective identifications (Table 2.3-2; Becker, 1998; Seiler, 1999; Hoisl et al., 2000; Gebhard, 2001; Luther et al., 2002). Nature and Landscapes are perceived in as socialized form, i.e. in an adapted and culturally coded way. Therefore, nature and landscapes become always experienced reality in human contexts (Meier and Erdmann, 2003).

Table 2.3-2. Levels of psychological perceptions of nature and landscapes (cf. Becker, 1998; Seiler, 1999; Hoisl et al., 2000; Gebhard, 2001; Luther et al., 2002)

Levels of psychological perceptions		
Sensory level	Cognitive level	Symbolic level
• pure sensory perception of form and composition	• personal experience and knowledge	• social components for individual and collective identifications

However, in practice all three levels are combined in simultaneous perceptions of nature and landscapes by our senses, which are analysed and combined with personal experience, knowledge, and desires in our mind. In addition, our perceptions of nature and landscapes are limited by the amount of sensory impressions, which we can perceive during a certain period of time, the limited resolution ability, and the restricted spatial perception ability of the human species (cf. Demuth, 2000). Nevertheless, this theoretical approach can help to analyse different psychological, culture-historical, and social components of perceptions of nature and landscapes.

2.3.3 Aesthetic analysis

An aesthetically pleasant environment is the condition for positive reactions and well-being as a basis for identifications of the human species with nature and landscapes (Demuth, 2000). The psychological value of nature and landscapes contents of the experience of continuity on the one hand, which provides security, and development on the other hand, which provides inspiration (cf. Gebhard, 1998, 2000). Man has the basic desire of familiarity, as well as, the principle behaviour of curiosity (Gebhard, 2000).

Moreover, the process of perception of nature and landscapes depends also on our personal motivation, mood, memories, familiarity, education level, age, and specific knowledge about their elements (Gareis-Grahmann, 1997; Augenstein, 2002). The observer brings in all of his subjective state in the perception of nature and landscapes, including existential hopes, wishes, and dreams. Therefore, it is a highly emotional experience (Nohl, 1991). There is an intensive dynamic exchange between the human perception and nature and landscapes (Riccabona, 1991). Our expectations of nature and landscapes as an expression of beauty can be distinguished between satisfaction of an emotional part of our seeking for security, home, and local connection, and a mental part of orientation, information, variety, and usability (Gareis-Grahmann, 1993; cf. Schemel, 1998; Seiler, 1999; Table 2.3-3).

Table 2.3-3. Psychological functions of nature and landscapes (Demuth, 2000, modified)

Psychological functions of nature and landscapes	
• security and home	• originality and purity
• beauty	• variety and news
• connection and harmony	• orientation
• freedom and independence	• leisure
• history and tradition	• self-realization

Of course, the impression of beauty is highly subjective. However, in general the variety of elements of nature and landscapes, their structure and dispersal are decisive components for positive individual feelings. Regularity, simplicity, unity, and symmetry are important components for positive perceptions of nature and landscapes by certain people (Gareis-Grahmann, 1993, 1997), whereas others prefer complexity and variety for feeling comfortable or for being inspired. The aesthetic value of nature and landscapes does not necessarily increase with the diversity of them, because elements of nature and landscapes can be assessed as being beautiful even when they are of low diversity (Augenstein, 2002).

Nevertheless, there is a demand of arrangeable contrasts and variety. Some proportions are appreciated as pleasant, balanced, and harmonic, for example, the golden section (Demuth and Fünkner, 1997; Rudolf, 1998). A balance between stimulating and orientating perceptions of nature and landscapes seems to be assessed as most positive by people, i.e. variety and order, but also surprises and constancy (cf. Hellbrück and Fischer, 1999; Hoisl et al., 2000; Augenstein, 2002). Perceived parts of nature and landscapes are configured together as a unity. They are assessed in a different quality than their separated particular elements.

Nevertheless, 80-90 % of our perceptions of nature and landscapes are optic. There are general tendencies of visual perceptions and configurations of them (cf. Albertz, 2000; Demuth, 2000; Augenstein, 2002; Table 2.3-4).

Table 2.3-4. General tendencies of visual perceptions by human beings (Demuth, 2000, modified)

General tendencies of visual perceptions by human beings	
Simplicity	• complex perceptions are reduced to simple forms
Configuration	• perceptions are arranged together to clear and stable configurations by using close, similar, and encircled objects
Memory	• often experienced structures and forms are easier recognized
Balance	• structures are preferred of high variety of forms combined with a simple composition
Contrast	• elements of nature and landscapes are easier noticed, which are distinguished from the background by size, colour, form, brightness, and movement
Distance	• human perceptions change by distance to objects resulting in different resolutions of the same objects

Therefore, some authors criticize the increasing uniformity and monotony of our natural and constructed environment. There would be a loss of forms, colours, diversity, ecological and biological variety, as well as, of characteristic elements of nature and landscapes in Central Europe since the beginning of the 20th century (cf. Demuth and Fünkner, 1997; Gareis-Grahmann, 1997; Seiler, 1999; Demuth, 2000; Jessel et al., 2003).

Different consciousness of how nature and landscapes should be in order is often also the origin for conflicts between landscape architects and nature conservationists. Landscape architects wish mainly to preserve a specific status of nature and landscapes of a certain period, when different colours, smells, and structures of mainly plants shall provide a planned aesthetic human value. French, Japanese, and Chinese garden architecture are examples for this type of intensively managed nature and landscapes that need permanent planting, cutting, fertilizing, etc. Whereas nature conservationists have a different understanding of nature and landscapes in order that it can freely develop its variety, peculiarity, and beauty as a functioning ecological system. A field of spontaneous vegetation can be seen as wasteland covered by wild plants or as a refuge of the diversity and structure of naturally grown plants. Either side has its legitimacy depending on the particular case.

Furthermore, the psychological value of nature and landscapes has also symbolic and mystic aspects (cf. Güsewell and Falter, 1997; Gebhard, 2001; Klingenstein et al., 2003a; Theobald, 2003). The loss of the aesthetic value is a loss for the human being of relations to nature and landscapes (cf. Falter, 1992; Gebhard, 2001). For example, an old tree can symbolize the steadiness against the transience of time and life. Woodlands of old trees at dawn might cause a fairy tale atmosphere. Literature and art would be rather poor without the romantic and inspiring influences of nature and landscapes. The German romantic period is based in literature and painting on the perception of wide landscapes and detailed descriptions of natural elements (cf. Theobald, 2003; Figure 2.3-1). In addition, what would French impressionism be without nature and landscapes?

Figure 2.3-1. Landscape painting “Arcaded landscape during sunset light” by Johann Nepomuk Schödlberger in 1812 (Schödlberger, 1812) reproduced by kind permission of Neue Galerie Graz, Graz, Austria

In conclusion, aesthetic analysis of nature and landscapes must take into account the current status of nature and landscapes and its natural and cultural elements. It is necessary to assess them in relation to the mentioned psychological needs of the society. The current status of nature and landscapes is as much important for its assessment as the emotional perception and logical interpretation by its users. Nature and landscapes have an objective and a subjective level (cf. Nohl, 1991; Gareis-Grahmann, 1997). Therefore, crucial elements for the subjective perception of nature and landscapes are personal motivations, social and historical backgrounds and specific knowledge (Gareis-Grahmann, 1997; WBGU, 1999b; cf. chapters 2.2 Ethical values on page 29, 2.5 Culture-historical values on page 73, 2.4 Social values on page 50, and 2.6 Educational values on page 85, respectively). Expectations depend on social trends of current societies of how they wish nature and landscapes to be (Gareis-Grahmann, 1997). These expectations are variable on horizontal spatial and vertical time levels.

2.3.4 Methodical applications

There are several methods to assess psychological values of nature and landscapes (cf. Gareis-Grahmann, 1993, 1997; Krause and Klöppel, 1996; Gassner and Winkelbrandt, 1997; Demuth and Fünkner, 1997; Homburg and Matthies, 1998; Köppel et al., 1998; Bastian and Schreiber, 1999; Demuth, 2000; Augenstein, 2002; overview in Wöbse, 2002, 2004). However, the assessment criteria “aesthetic stability” of nature and landscapes (Gareis-Grahmann, 1993, 1997) seems to be a rather unpractical construction, because there is no certain level of disturbance, when nature and landscapes lose their aesthetic value.

Indirect methods of assessments of psychological values of nature and landscapes are often based on simulations, and open or closed questionnaires of the people concerned (Demuth, 2000). Nature and landscapes can be simulated by maps or perspective drawings, photos or photographic montages, models, computer and video simulations (cf. Figure 2.3-2; McCabe and Jinman, 1999; Jessel et al., 2003; Wöbse, 2004).

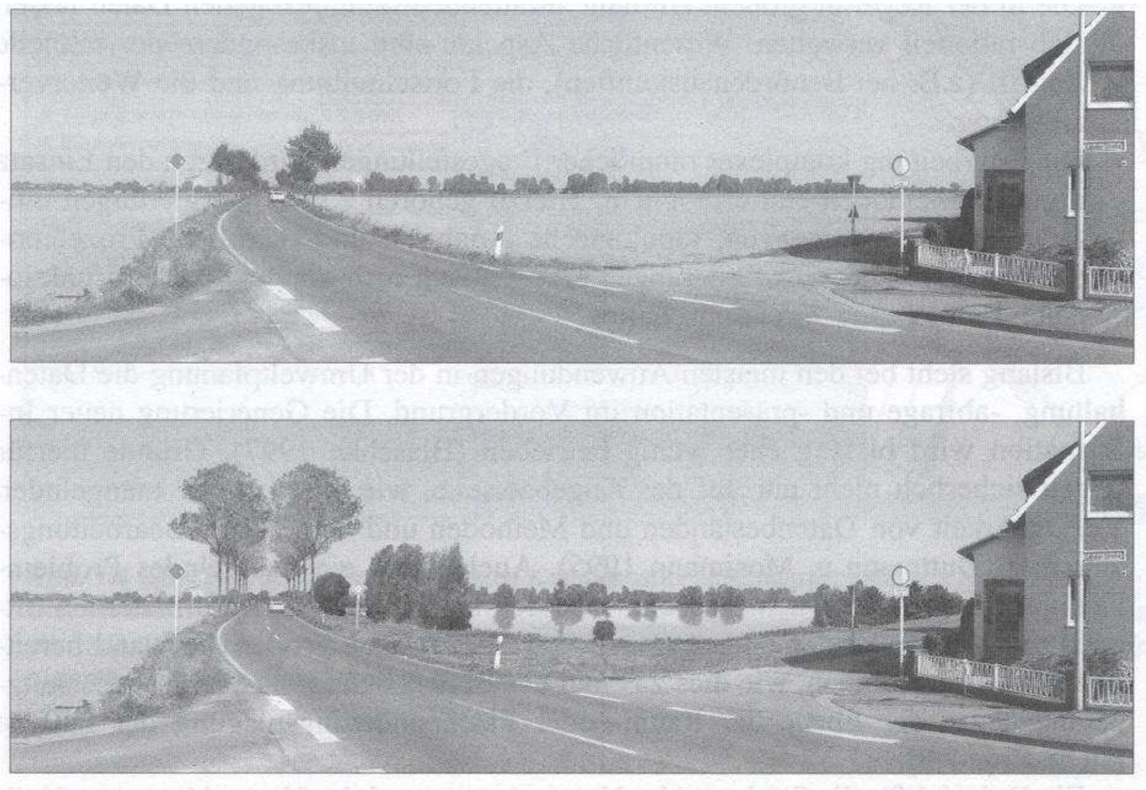

Figure 2.3-2. Computer based photo simulation of changes of nature and landscapes due to a gravel pit (Franke et al., 1999)

The practicability of these simulations depends on their content of abstraction, vivacity, and usability for planning purposes and for public relations. Black and white photos look darker than those in colour. Three-dimensional models allow considering spatial perspectives, but they are still passive. Whereas moving images provide an impression of being actively in simulations. Videos can be less abstract and more real than computer simulations, depending on the quality on either side. However, all these methods are vulnerable to be manipulated, influencing the result. Furthermore, they are just visual, i.e. they cannot substitute experience of all kind of human senses mentioned above (cf. Krause and Klöppel, 1996; Köppel et al., 1998).

For the assessment of whole landscapes, it is necessary to map all biotic and abiotic elements with an influence on landscape scenery. Landscapes structures are assessed on macro-, meso- and micro-levels. They can be analysed depending on spatial, linear, and punctual elements, considering relief, fauna, flora and vegetation[7], atmospheric features (i.e. climate, light, colours, etc.), periodical conditions, land use, and development (Krause and Klöppel, 1996; Köppel et al., 1998).

[7] Flora is considered as the sum of plant species of specific areas (Sedlag and Weinert, 1987; Wittig, 1991, 1998, 2002) and of specific habitat types (Wittig, 1991, 1998, 2002). Whereas, vegetation refers to the sum of plant communities of specific areas (Sedlag and Weinert, 1987; Wittig, 2002) and of specific habitat types (Wittig, 2002).

Changing the current status of nature and landscape status can be positive or negative for the aesthetic value. There is no general rule. New elements of nature and landscapes can be integrative, for example, farms in agricultural areas. They can point out nature and landscapes without disturbing them, such as castles in mountainous regions. Or they can contrast more or less to the environment, for example, industrial buildings in open landscapes. Methodical steps are historical analysis in comparison to the current situation and future changes (cf. Gareis-Grahmann, 1997). Photos of nature and landscapes can be stored to provide comparable data (cf. Paar and Voß, 2001).

Different economic methods have already been discussed to estimate the material economic value of nature and landscapes for recreation (cf. chapter 2.1 Economic values on page 19). Again, recreational values can differ significantly from pure aesthetic values of nature and landscapes, because they include the user aspect. For example, reed banks can be of high aesthetic value due to landscape scenery, but they might be of low recreational value due to access problems.

Moreover, there are methods to assess psychological values of nature and landscapes by directly observing numbers of visitors and their behaviour, but they do not sufficiently allow finding out their motivations and personal assessments. Therefore, additional questionnaires are necessary (cf. Demuth, 2000). Questionnaires can be oral or written and more or less standardized. Written questionnaires normally require less time and numbers of persons than interviews. In addition, personal influences of interviewers can be reduced as possible error sources. However, there is a significant disadvantage to oral questionnaires that answers cannot be controlled. For example, other persons can influence answers of written questionnaires of the asked person (Jessel and Tobias, 2002).

In addition, relatively low structured interviews by not using questionnaires allow more flexible adapting questions to the asked person. However, they require a very well trained interviewer. Whereas strongly structured interviews are based on questionnaires, which determine the specific development of interviews and thereby limit the freedom of interviewers and asked persons., Partly structured interviews lie between those two methodical interview approaches. They are based on prepared and pre-formulated questions while their order is open, but they generally follow an interview guideline (Jessel and Tobias, 2002).

Standardized answers are categorized, whereas non-standardized responds will be categorized in the analysis part. For example, a method of standardized questionnaires is the semantic differential, which is based on adjectives of contrary meanings, such as “beautiful” and “ugly”. The interviewed person marks his opinion along point scales between these extremes. At first, the dimensions of the experience must be determined for constructing a semantic differential that can be assumed to be of importance for the observation. Each dimensional content should be characterized by some adjective pairs to equalize meaning differences of different interviewed groups of persons (Jessel and Tobias, 2002). Moreover, different adjectives can also be arranged in a row to be selected, or answers can be arranged on a scale of different categories. In addition, there are also preference measurement methods, for example, comparisons of two different photos for selection. In contrast to these direct methods of semantic differentials, adjective check-lists, scale questions, and preference measurements, indirect methods use simulations for open or closed answers and thereby initiate memories and imaginations (Demuth, 2000).

However, answers can be biased for social acceptance. Questions that concern individual behaviour towards nature and landscapes are often influenced by an assumed good will demand of the society (social desirability response). One way to reduce the possibility of biased answers is to distribute questionnaires without the presence of interviewers, who mark the answers. There is no influence of an interviewer, but also no control and assistance to answer. Therefore, answers can be honest and thought over. Furthermore, they can be more concentrated and motivated, because time and place of answering can be chosen individually (Wormer, 1998).

Nevertheless, spontaneous answers are not detectable, for example, when people might read the whole questionnaire first and answer differently within the whole context. The number of responses might be reduced in comparison to interviews. Questionnaires have to be easy understandable, because there is no assisting interviewer available. Another way is to carry out open interviews without standardized answers. There are just key questions to answer and more detailed ones, if the interview might go this direction. This has the advantage to be able to explore new contexts. However, it is difficult to compare different open interviews due to the lack of standardization (Wormer, 1998). Moreover, also behavioural observations can be more or less structured and open, respectively. They are important to confirm questionnaires and interviews, when observers can participate (Jessel and Tobias, 2002).

2.3.5 Conclusive summary

Nature and landscapes have an essential value for our psychological and physical health. They are the source for our recreation and inspiration. Nature and landscapes are perceived by all senses of our viewing, hearing, smelling, tasting, and feeling. However, the perception of each person is highly subjective depending on personal development, environmental consciousness, as well as, the individual social and historical background. We can distinguish between sensory, cognitive, and symbolic levels of psychological perceptions of nature and landscapes.

The aesthetic value of nature and landscapes is based on an expectation of continuity, security, home, and local connection on the one hand, and a mental part of orientation, information, variety, curiosity, and usability on the other hand. Thus, regularity, simplicity, unity, and symmetry are important components for the subjective personal perception of beauty of nature and landscapes, but also complexity and variety for feeling comfortable or for being inspired. Moreover, there are symbolic and mystic aspects of nature and landscapes that influence our personal psychological and physical condition. 80-90 % of our perceptions of nature and landscapes are optic.

The psychological value of nature and landscapes can be assessed by direct and indirect methods. Indirect methods allow simulating different conditions of nature and landscapes by different media, but also gathering perceptions of the people concerned by questionnaires and interviews. For the assessment of whole landscapes, it is necessary to map all biotic and abiotic elements with an influence on landscape scenery. Moreover, the psychological value of nature and landscapes can be directly estimated by observing numbers of visitors and their behaviour, which however does not sufficiently allow finding out their motivations and personal assessments. Therefore, additional questionnaires or interviews are needed. Open questions and interviews have the advantage to be able to explore new contexts, but they lack of standardization for comparisons.

Some authors criticize the loss of forms, colours, diversity, ecological and biological variety, as well as, of characteristic elements of nature and landscapes in Central Europe since the beginning of the 20th century. Different consciousness of how nature and landscapes should be in order often contributes to conflicts of psychological assessments of nature and landscapes in decisions about practical measures. Therefore, it is decisive to apply methods to determine the subjective perceptions of nature and landscapes by people for creative measures to preserve and to enhance their psychological values in the 21st century.

The psychological aesthetic and health perception and evaluation of nature and landscapes are based on a cognitive interpretation process, which depends on social values of a certain culture-historical period of time, as well as, educational knowledge and experience. Therefore, when we assess the psychological value of elements, structures, and functions of nature and landscapes for practical planning processes and project decisions by common survey and analysis methods, we need also to find out the social circumstances and values, which have lead to the subjective aesthetic perception and evaluation by people. It is no surprise that psychological and social survey and analysis methods are quite similar due to the close relations of both disciplines. Therefore, the next chapter shall discuss the circumstances, which form a social value of nature and landscapes, as well as, common social intervention and participation methods of the public.

2.4 Social values

2.4.1 Social aspects of our perceptions, evaluations, and behaviour

Our relation to nature and landscapes is determined by our personal perceptions, motives, values, and behaviour (cf. chapters 2.2 Ethical values on page 29 and 2.3 Psychological values on page 38, respectively). Therefore, natural sciences and engineering studies are not sufficient to explain our concrete behaviour towards nature and landscapes, as well as, our individual and collective evaluation of their elements, structures, and functions. The humanities widen this horizon (cf. Kruse-Graumann, 1997; Erdmann, 2002a; Hübler, 2002), while they explain the relationship of our human societies to nature and landscapes and ourselves. Our personal and group behaviour towards nature and landscapes, respectively, determines also our individual and collective evaluation of elements, structures, and functions of nature and landscapes for practical planning processes and project decisions with an impact on them.

Our behaviour towards nature and landscapes is firstly motivated by satisfying personal needs (Kruse-Graumann, 1997; cf. Hellbrück and Fischer, 1999; Renn, 2001; Table 2.4-1), which can be detected by social indicators (cf. Empacher and Wehling, 2002).

Table 2.4-1. Elements of Maslow’s pyramid of personal needs (Macoun, 2000, modified)

Categories of personal needs	Examples
Physiological needs	• physical survival, for example, nutrition, clothes, shelter, etc.
Security requirements	• order, protection, predictability of physical dangers (such as natural catastrophes), reliability especially of the social environment, freedom of anxiety
Belonging and love needs	• affection, territorial and group membership, interpersonal relations, company
Needs of high regards	• self-respect, independence, acknowledgement, prestige
Self-realization requirements	• to develop themselves according to personal abilities and inclinations

These personal motives are influenced by social values, which are expressed in norms of the relevant group. Personal behaviour becomes only stable, if external norms by the society are incorporated in own consciousness and willingness (cf. Kals, 1996; Kruse-Graumann, 1997; Lantermann, 2002). Socio-economic and socio-cultural conditions of our societies have decisive influences on the form of nature and landscapes (Becker, 1998; cf. chapter 2.5 Culture-historical values on page 73).

Experience and preferences of the environment are socially determined and they depend also individually on personal developments. We can distinguish between directly experienced nature and landscapes, and media transported information about nature and landscapes (cf. Centre d'Estudis d'Informació Ambiental, 1998). It depends on socially incorporated cultural values, which condition of nature and landscapes is preferred in certain different cultures (cf. Haubl, 1998; Meier and Erdmann, 2003). Mass media play an important role in creating new demands, especially moving images on TV. VIPs are paid in advertisements to transport these consumer goods and life-styles into the public (cf. Faber and Manstetten, 2003). Mass media can also have an important influence on our social attitude to nature and landscapes (cf. Centre d'Estudis d'Informació Ambiental, 1998; Brendle, 2000; Schuster, 2003a).

Individuals incorporate public values and norms during their socialization. They adapt these values in their personal behaviour by more or less reflecting about them. Thus, there is an interactive exchange and development of values by individuals and the society as a group (cf. Erdmann and Grunow-Erdmann, 1993; Heiland, 1999, 2002). Functions of values, norms, and attitudes are leading and canalising behaviour. They are simplifying the complexity of the environment, providing security, achieving and stabilizing the belonging to social groups, justifying and verifying own and others behaviour (cf. Heiland, 1999, 2002). In addition, there is a significant resistance to overcome established behavioural habits (cf. Matthies and Homburg, 2001) that are contingent on the openness of social (life-style) groups to behavioural changes. Our practical behaviour towards nature and landscapes depends on the following conditions (Figure 2.4-1; cf. Erdmann and Wehner, 1996; Kruse-Graumann, 1996, 2000; WBGU, 1999a, 1999b; Renn, 2001; Schuster, 2003a).

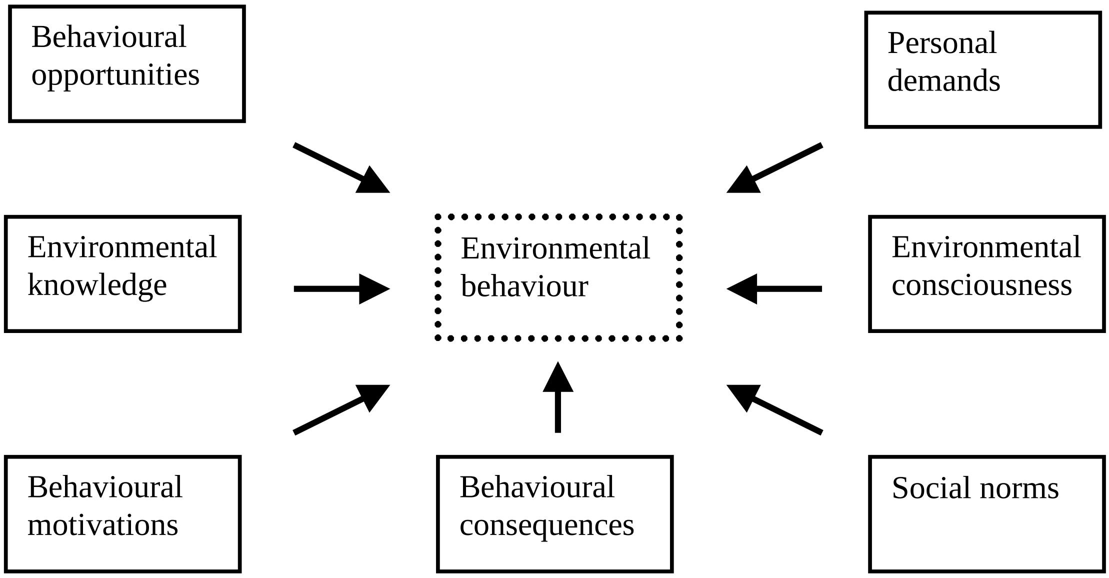

Figure 2.4-1. Scheme of conditions for our environmental behaviour (cf. Homburg and Matthies, 1998; Hellbrück and Fischer, 1999; Krömker, 2002)

It takes years to change behaviour by values, but it only takes a couple of weeks to change values by behaviour (Heiland, 1999). Moreover, individual spatial distances are important for individual consciousness and behaviour (Stoll, 1999). Furthermore, communication aspects are also decisive for personal evaluations of nature and landscapes and resulting behaviour (cf. Centre d’Estudis d’Informació Ambiental, 1998; Stoll, 1998, 1999; Brendle, 2000, 2002; Hübner, 2000; Luz and Weiland, 2001; Meier and Erdmann, 2003; Wilhelm and Edmüller, 2003). There are different social components of individual and group behaviour towards nature and landscapes and evaluations of them (Table 2.4-2).

Table 2.4-2. Overview of social components of individual and group behaviour towards nature and landscapes and evaluations of them (cf. Heiland, 2002)

Social components of evaluations of nature and landscapes
• genetically, culturally, or individually determined norms or habits of perceptions, thinking, and behaviour • limited time, financial, physical, emotional, and intellectual personal capacities • material and immaterial needs and interests (secure income, pleasure, freedom of anxiety, keeping the sense of self-esteem, social recognition, etc.) • personal expectations of benefits • personal life context, including every day requirements depending on profession, social status, family, and acquaintances • personal consciousness, values, and moral expectations that are expressed in environmental consciousness, but also in competing views and evaluations

However, internal motivation has its limits, when there are no possibilities or opportunities for different behaviour (cf. chapter 2.2 Ethical values on page 29), i.e. when personal competence or skills are missing or there are no alternatives possible. A good social network provides social competition and social control, but also the chance for developing co-operative relations and behaviour in solidarity (Kruse-Graumann, 1997).

Getting people into political involvement can support different behaviour towards nature and landscapes by providing acting opportunities, by integrating them into participation processes, and by participating in social support systems and networks (Matthies and Homburg, 2001; cf. Kals, 1996; WBGU, 1999), which results also in a different evaluation of elements, structures, and functions of nature and landscapes for practical planning processes and planning evaluations. Moreover, participation processes in nature conservation contribute to prevent conflicts and to provide peaceful conditions (Brendle and Müller-Kraenner, 2003; Carius, 2003; Debonnet, 2003; Halle, 2003; Ludi, 2003; Schroeder-Wildberg, 2003). Furthermore, it also necessary to develop controlling and participating processes of people in power, such as politicians, who often count own interests more than contents, and as frequently lack of social competence and other personal skills, which are necessary for a different behaviour towards humans, as well as, to nature and landscapes (cf. chapter 2.6 Educational values on page 85).

In addition, sensible experience is decisive for permanent different behavioural orientations, as well as, to know the consequences of own actions. If there is no sensible experience, there is no connection with feelings. Without connections with feelings, there are no effective behavioural changes (cf. Lantermann, 2002; chapter 2.3 Psychological values on page 38).

However, guilty feelings can lead to resistances and excuses, which might reduce personal pressure, but are not contributing to solve conflicts of fixed negative behavioural habits to nature and landscapes (Table 2.4-3; Stoll, 1999; cf. Hellbrück and Fischer, 1999) that undervalue the different values of nature and landscapes in a democratic participatory process.

Table 2.4-3. Different averting argumentations that prevent to change fixed negative behavioural habits to nature and landscapes (Stoll, 1999, modified)

Averting argumentations to change personal behaviour towards nature and landscapes
• to refuse taking over the responsibility
• to try to postpone the controversy
• to pretend to do not have known the facts
• to deflect to other circumstances
• to play down the consequences
• to defend the necessity according to other factual or material constraints
• to relate to the unimportance of the own behaviour in comparison to the mass
• to relate to other fields of positive personal behaviour
• to disqualify the right of the demanding person, because of its own behaviour
• to ignore consequences for the future
• to claim to be not able to change or to be too lazy

Furthermore, most people consider themselves to be in the victim's role. There would be no other way than to damage nature and landscapes, for example, because of the need to use cars to get faster to work. In certain cases, there is no need to care less about nature and landscapes, but it is even socially accepted, because everybody does it. There are only a few people, who act more carefully to nature and landscapes as a principle. These are people, who consider their individual efforts positive on their own; despite they might have certain sacrifices. They are especially important as initiators, despite their contribution might not have a crucial effect on nature and landscapes for the time being, until it becomes a trend or life-style element for a significant part of the society (cf. Schahn, 1993; Kals, 1996; WBGU, 1999a). Furthermore, a direct personal benefit cannot be expected in the short- or long-term, apart form the indirect moral satisfaction of the motive to safeguard nature and landscapes (Kals, 1996).

Again, the ability of individuals to change their behaviour is influenced by different psychological factors, for example, cognitions, emotions, needs, interests, consciousness, and norms. In addition, there are social influences, for instance, education, role expectations, social control, as well as, specific conditions of the situation, for instance, problem structures, behavioural opportunities, time and spatial distances to occurrences. Therefore, nature conservation strategies and interdisciplinary evaluations of nature and landscapes for certain planning processes and project decisions must be orientated as much as possible depending on habits, demands, and interests of target groups and their consciousness. Otherwise, requests of different behaviour cannot be fulfilled (Heiland, 1999; cf. WBGU, 1999a; chapters 2.2 Ethical values on page 29, 2.3 Psychological values on page 38, and 2.6 Educational values on page 85, respectively).

On political levels, it is very difficult to implement long-term orientated targets of different behaviour towards nature and landscapes. The political issue and view will win the support of the politician, which is combined with the highest support of interest groups and voters during next elections (cf. WBGU, 1999b). However, pressure by the public is relatively low for politicians for other expressed demands. Thus, fast results of complex issues can hardly be achieved, for example, to alter global climate changes and their influences on nature and landscapes (Waldmüller, 2000; Meyer, 2001). Politicians have to fear not to be re-elected, if they introduce consumption related taxes of goods of nature and landscapes.

Therefore, there are often only placebo like measures for nature and landscapes to calm down the public. Especially on international level, there are often only indistinct intentions declarations, but rarely concrete and binding agreements. Furthermore, despite there are some international binding agreements of the conventions, *inter alia*, on global climate, biodiversity, and desertification, as well as, Agenda 21, practical implementation on national levels in our societies has been rather limited (Meyer, 2001).

Unfortunately, technical innovations have not sufficiently been combined with changes of social behaviour towards nature and landscapes, especially in industrialized countries and during the unguided process of globalization. Environmental innovations have supported an economic and technical structural change, but not a social implementation of different behaviour towards nature and landscapes. The necessary social changes to alter the reasons for this retarded development have even been partly hampered by the believe in technical innovations to be able to control impacts on nature and landscapes by our societies, for example, in technical environmental protection (cf. Meyer, 2001). Advertisements delude us into believing that we would live in an ideal world that would be permanently further developed due to better techniques and that would allow us unconcerned wasting (Noller, 2001). During the search for scientific truth, the human species gathered a knowledge, which he could use to dominate nature and landscapes. However, the human species has lost contact to himself and to life as a whole, because of the one-sided emphasis on technique and material consumption. Thereby, the human species has lost the ability to deeply emotional experience, happiness, and sadness (Fromm, 1980).

Furthermore, the dynamic of socio-economic developments towards the exploitation of its own ecological existence has become a major risk in our modern civilizations, especially due to economic and social competition mechanisms that do not sufficiently take into account the value of public goods (cf. Vogt et al., 1998; section 2.1.1 Economic background on page 19). For example, it is better for our global climate and the depending different values of nature and landscapes to change social consumer behaviour towards the extended use of public transport, provided that it has been politically developed as an efficient alternative, than technical developments of cars, which use less fuel. However, using cars is still socially highly accepted worldwide also to distinguish us in this way from other groups as an expression of social status. Apart from supporting advertisements of this attitude, the car industry and their dependant workers itself are used as social arguments, instead of more investments in public transport.

2.4.2 Social functions of nature and landscapes

Nature and landscapes are meeting points for people to get in touch, i.e. crucial conditions for life quality and humanity. They can serve as the key field of developing social contacts and to overcome anonymity. Neighbouring nature and landscapes are especially important for social contacts of those, who can only move within certain distances. Therefore, the social neighbourhood is of decisive importance for children and elder people, but also for more mobile social groups, which spend parts of their daily life in these neighbourhoods (cf. Wehrli-Schindler, 1995).

Furthermore, nature and landscapes can have especially important social values for all social groups, which need special recognition, because these people are out of responsible actions within their society, for example, unemployed people, patients, children and teenagers, as well as, pensioners (Rudolf, 1998). Moreover, nature and landscapes have also an important social security aspect, because they reduce aggressions while connecting and integrating people into the society and the surrounding neighbourhood (cf. Wehrli-Schindler, 1995). Nature/much greenery are on fourth position equally important as a good neighbourhood for the life quality of residences after firstly shopping opportunities, silent residence location, and a good residence environment in general according to a representative survey of German inhabitants in 2004 (BMU, 2004).

However, inner city areas often lack of sufficient parks as social meeting points (Figures 2.4-2 and 2.4-3).

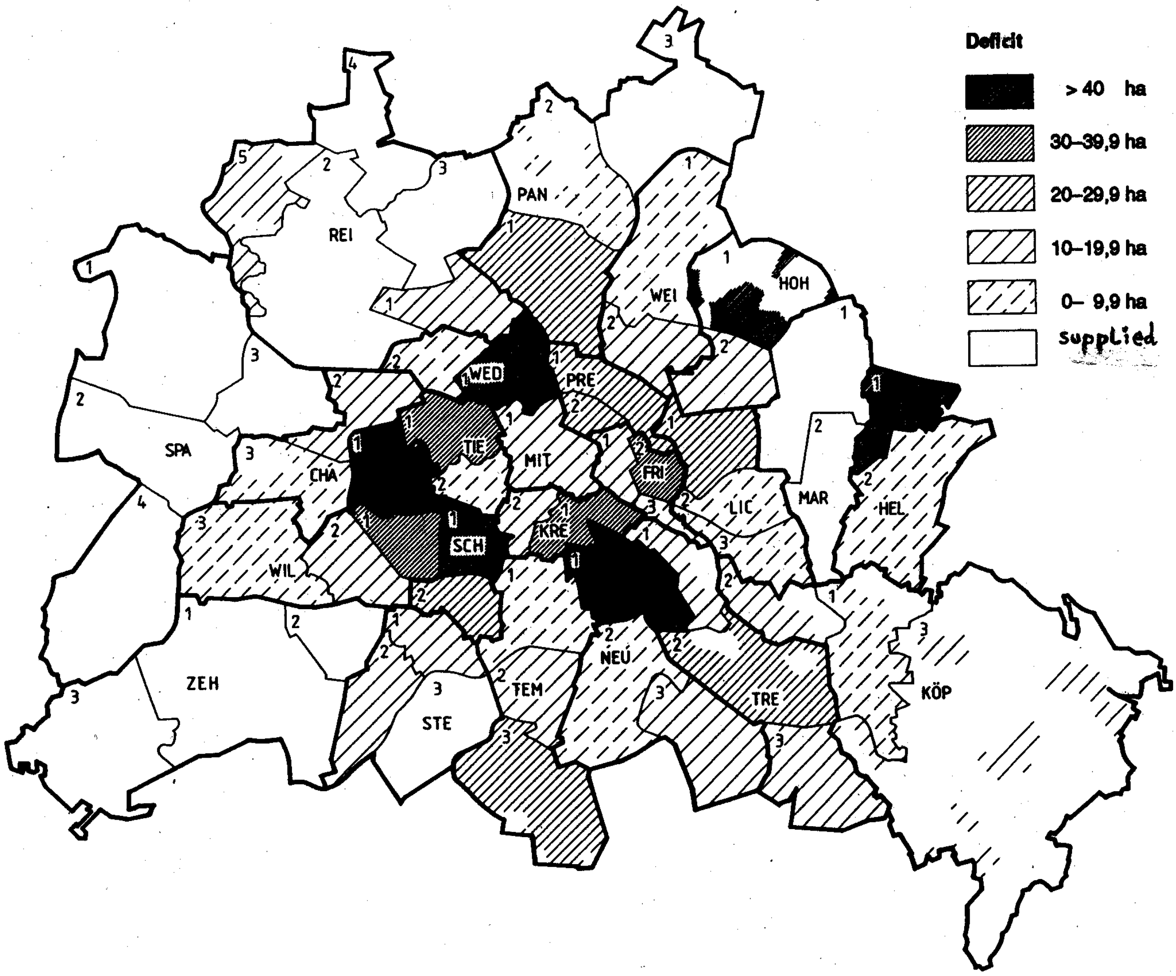

Figure 2.4-2. Availability and deficits, respectively, of parks close to particular houses at the central parts of districts of Berlin in Germany according to a subjectively determined demand of 6 m^2 per inhabitant by Berlin's regional parliament (parks of more than 10 ha close to whole housing estates are proportionally included) (SenStadtUm, 1994)

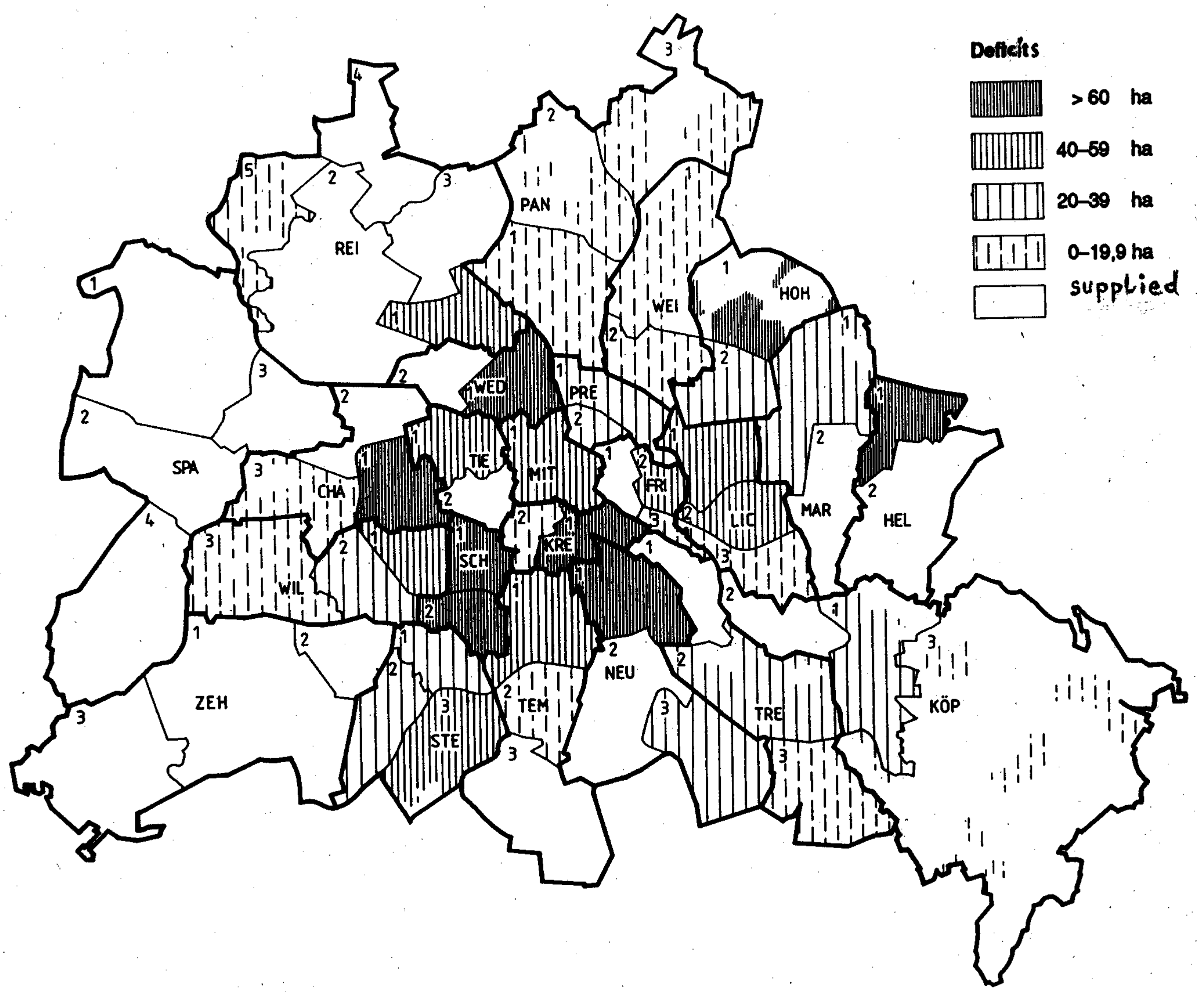

Figure 2.4-3. Availability and deficits, respectively, of parks close to whole housing estates at the central parts of districts of Berlin in Germany according to a subjectively determined demand of 7 m² per inhabitant by Berlin's regional parliament (parks of more than 50 ha are included, but not again the parks close to particular houses) (SenStadtUm, 1994)

In addition, children and teenager have to deal with public spaces, which are mostly planned and designed for the demands of adults, either for working, consuming or relaxing. In industrialized countries, there is a growing difficulty to find own living spaces, which children and teenager can discover, experience, self-design, and creatively use. Furthermore, nature and landscapes are designed in a way that children and teenager cannot freely develop their own feelings and thoughts any more. They have to adopt a social identification and to grow into a consumer world. TV and other media promote relevant products and their social values worldwide as a consequence of unguided globalization, which meanwhile creates social uniformity, dependences, and inequalities. There is an especially high social pressure on teenager to buy trendy consumer products for being still integrated in the society of their age. Elder people and children become banned from public spaces, when nature and landscapes just socially function as working or marketing places (cf. Wormer, 1998). This refers, *inter alia*, to shopping malls, which have become also fashionable in urban developments in Germany since the 1990s (cf. Müller-Hagedorn et al., 2003).

Moreover, there is a growing social separation of districts in cities of lower living qualities concerning green spaces and building standards to districts of higher income. The gap increases by economic power and social standards of industrialized to developing countries. Nature and landscapes are a public good that increasingly cannot be shared by everybody, but by those who can effort it. Metropolitan regions reveal more and more a separation of places, where people work, in case they have an employment, and where they commute to for sleeping. This means that also nature and landscapes have different developed social communities within working and living areas. In general, the importance of nature and landscapes in cities is justified by calculations, which show that 60 % of world's population will live in cities by 2025, whereas these were just 3 % in 1800 (Wormer, 1998). In Germany, 86.7 % of the population lives already in cities (Jedicke, 2002).

Nevertheless, if neighbours are encouraged to take over responsibility of their living grounds, public care about surrounding areas increases as much as they have contributed to it by their own hands and creativity. Human feelings of security and home are essentially combined with the needs of orientation features, variety, use, identification features, and creativity within nature and landscapes (Rudolf, 1998; sections 2.3.3 Aesthetic analysis on page 41 and 2.6.3 Personal contacts on page 88, respectively). Participating in decisions is a key part in democracies of pluralistic states, which incorporate different opinions and skills. It is a guarantee of innovative developments and stability of social and economic systems. Therefore, social functions of nature and landscapes have a key value of healthy developing societies.

2.4.3 Social participation

Participative processes and reductions of hierarchical decision structures generally increase the acceptance of practical planning processes and project decisions of nature and landscapes (cf. Table 2.4-4; Oppermann et al., 1997; Petts, 1999; Vieth, 1999; Sutherland, 2000; Bergweiler, 2000; Bischoff et al., 2001; Fürst, 2002; Hübner, 2002; Schmidt et al., 2002; Stoll-Kleemann, 2002, 2003; SRU, 2002; Hofstetter, 2003; Schuster, 2003a; Mönnecke, 2004).

Table 2.4-4. Benefits of social participation processes (Petts, 1999)

Benefits of social participation processes
• to reduce costs and decision delays • to prevent unforeseen situations arising from inaccurate information • to identify concerns before they escalate, i.e. an early warning device • to encourage different stakeholders to express their views

- to bring local knowledge and a fresh perspective to the assessment process
- to identify opportunities for project modification and impact mitigation
- to ensure that alternatives are considered
- to make decision makers and proponents accountable

Moreover, participating at processes encourages people also to contribute immaterial resources. Especially those people need to contribute information, who are affected by changes of nature and landscapes (Stoll, 1999; cf. Bischoff et al., 2001; Jessel and Tobias, 2002; Schmidt et al., 2002; Hofstetter, 2003) as also encouraged in chapter 10 of the adopted Agenda 21 during United Nations' Conference on Environment and Development in Rio de Janeiro in 1992 (Quarry, 1992; BMU, 1997; cf. Maurer et al., 2003). Regional and local institutions of self-organized people can function as bottom up initiatives (cf. Johnston, 1990; Petermann, 2002) as also mentioned in chapter 28 of Agenda 21 (Quarry, 1992; BMU, 1997) to develop a local Agenda 21 (cf. Böhme et al., 2002). Moreover, democratic decentralization can contribute to safeguard the different values of nature and landscapes to the human being and on their own on local and regional levels (cf. Wyckoff-Baird et al., 2000; Ribot, 2002, 2004).

2.4.4 Social life-styles and milieus

There is a social development of growing individualization in industrialized societies, which has lead to a different relationship to nature and landscapes and evaluation of their components for the benefit of the human species and on their own (cf. chapter 2.5 Culture-historical values on page 73; Meier-Ploeger, 2003; Schuster, 2003a, 2003b). Economic globalization and information technologies require high flexibility of employees, which destabilizes social connections (Brand et al., 2002), as well as, connections to nature and landscapes. Individual experience of life has become more and more just an entertaining short event. There are no longer silence, contemplation, and sensual reflection important for experience of the diversity and beauty of life. It counts more the current sensational event without thinking and feeling within the historical and personal background. If there are no further and further increasing stimulations, such as extreme sport activities, life seems to become boring. Intensive moments in life do not longer need time to be prepared, to be experienced, and to be thought over. Experience is more and more defined as a direct situational reaction of external stimulations (cf. Gebhardt, 1998). Mass media themselves have reacted to this sensational life-style by producing more emotional, shorter and more entertaining contributions, instead of longer, more substantial, and more silent reports (Haaf, 1997). Negative events in media are more weighted by observers than positive (Hellbrück and Fischer, 1999).

Almost everything becomes available as a consumer good on the market, including feelings and experience. The use value of goods is reduced, while a lot of other symbolic values replace it (Brand et al., 2002). Unguided globalization supports this development (cf. Schwaab, 2001). However, this consumer society approach does not necessarily lead to more life quality (cf. Fromm, 1980; Gorbatschow, 2003). Social recognition in our industrialized societies is mainly focused on status and property, but much less on social and human values. Individualization in the negative sense causes loneliness, which cannot be substituted by consuming goods of symbolic values. It is a circle of unsatisfied social illness of consuming resources of nature and landscapes to get recognition for a moment. Consuming can be used as a drug to cover internal emptiness, but only for a short time-period (cf. Fromm, 1986).

Furthermore, the consumer orientated life-style ("I am someone (of the advertisement?), when I am consuming!") influences significantly also our attitude towards experience in nature and landscapes. It is a historical socialization process, which lets the human distance grow to nature and landscapes, especially in cities. Nature and landscapes can be consumed artificially in shopping centres or on TV, but rarely experienced in reality. They are just decoration for our stressful life, but not a content any more. Meanwhile, nature and landscapes become unnecessarily overharvested and destroyed (cf. WBGU, 1999a; Pullin, 2002), because their different values to the human being and on their own are underestimated due to the growing personal and group life-style distance.

Therefore, United Nations Conference on Environment and Development urged a change in consumption patterns in chapter 4 of the adopted Agenda 21 in Rio de Janeiro in 1992 (Quarry, 1992; BMU, 1997). The European Commission considers in its Sixth Research Framework Programme 2002-2006 that technological changes with a view to sustainable development will only be possible if behaviour and life-style change. This is certainly the case in the rich countries, where patterns of consumption are the main cause of global environmental imbalances. However, it is also true for those developing countries facing huge demands and needing to develop growth models, which avoid the past mistakes of advanced societies – otherwise, they themselves will be the first to suffer the consequences of a deteriorating environment (European Commission, 2002a).

The individual and group life-style are decisive for the social evaluation of nature and landscapes. They determine the social values. Three different styles of experience in life can be identified. Firstly, there is the high cultural form, secondly the trivial form, and thirdly the suspense form (Schulze, 1998; Table 2.4-5).

Table 2.4-5. Different styles to experience life (Schulze, 1998, modified)

Styles to experience life		
High cultural form	Trivial form	Suspense form
• concentrated listening, silent watching, and deep contemplation	• simple, superficial, and repeating experience of life	• intense stimulations

Concentrated listening, silent watching, and deep contemplation are typical behaviour of the high cultural form of perceptive experience. The taste for it cannot be achieved spontaneously and intuitively, but it needs personal education and experience for years, as well as, talent. There are reflections about deeper feelings and intellectual contexts on wider scales of each experience in life. Intellectuals and artists are typical examples of this life-style (Schulze, 1998).

In contrast, the trivial form prefers simple, superficial, and repeating experience of life, for example, easy listening and modern folk music. Trivial experience does not intend to find out more complex contexts behind certain stimulations. Simple feelings are satisfied without intellectually reflecting about it. There is a demand for well-known environments without questions and conflicts. The intellectual scale is rather limited; feelings are unreflected. Tolerance is very restricted towards other opinions and feelings (Schulze, 1998). The German "Spießer" is an expression of this life-style.

Thirdly, the suspense style of experience in life is characterized by intense stimulations. High sound volume, high speed, and fashionable developments are characteristic for an always-searching life-style for new experience and new events. As the trivial life-style, the suspense life-style has neither an emotional nor an intellectual reflection or criticism of stimulations, but it needs to be open and tolerant enough towards new consumer products. Experience of life is just repeatedly consumed in form of different worldwide-promoted products. In extreme forms, this life-style is completely artificial and disconnected from natural, cultural, and traditional relations (cf. Schulze, 1998). The young techno music movement is an example for it.

Moreover, different milieus can be identified depending on social situations (educational and economic situations), certain targets in life, and specific life-styles (cf. Reusswig, 2002; Lantermann et al., 2003). Different life-style analyses have been carried out (cf. Möller, 2000; Empacher et al., 2002; Niesbach, 2002; Schuster and Lantermann, 2002; Lantermann et al., 2003; Schuster, 2003a, 2003b). Moreover, dissimilar consciousness and behaviour towards nature and landscapes can also develop in certain groups, for example, of different professions (WBGU, 1999b; Meier and Erdmann, 2003).

Therefore, evaluations of social values of nature and landscapes need to take into account certain life-styles and milieus of target groups for practical planning processes and project decisions with an impact on them. However, analysis of different life-styles and milieus need to consider clusters of different variables during certain time periods, for example, age and education at a particular location. The style of the whole life cannot be indicated by one type (Hartmann, 1999).

2.4.5 Sociological methods

There are different intervention techniques to influence individual behaviour towards nature and landscapes and evaluations of their elements, structures, and functions. Classic intervention techniques are focused on external behavioural conditions, i.e. improvements of opportunities of different behaviour, whereas internal intervention techniques intend to communicate behavioural knowledge and backgrounds. They can be combined with social norms and structures, such as self-commitments, social models, and blockleader groups. In general, rewards are more effective than penalties. The latter can even result in reactive actions towards the undesired direction. For changing practical behaviour towards nature and landscapes, there is an early socialization process necessary at schools, kindergartens, and at home (cf. chapter 2.6 Educational values on page 85), as well as, wide orientated information campaigns together with specific sympathy carriers for target groups. Participative social market techniques concentrate their efforts on disseminators in target groups and social networks (snowball effect), for example, school classes, neighbourhood communities, and associations (cf. Brendle, 1999; Matthies and Homburg, 2001). The foot-in-the-door technique starts with relatively easy behavioural changes to nature and landscapes, which can be combined in a second step with self-commitments to develop long-term behavioural changes. According to the theory of cognitive dissonance, personal consciousness adapts to the changed behaviour towards achieving cognitive consonance (Hellbrück and Fischer, 1999) and thereby a different evaluation of the various values of the elements, structures, and functions of nature and landscapes to the human being and on their own as an interactive process. Behavioural changes should be seen as a multi-staged process, which ought to be developed step by step during long-term support. Whenever possible, the individual freedom to decide about a certain behaviour should be retained (Kals, 1996). Otherwise, it can cause resistance and long-term behavioural changes and evaluation attitudes to nature and landscapes can be barely achieved.

Furthermore, intact communication structures are decisive for the acceptance of actions for nature and landscapes (cf. Bischoff et al., 2001; Stoll, 1999; Brendle, 1999, 2000, 2002; Hübner, 2000; Luz and Weiland, 2001; Meier and

Erdmann, 2003). It is helpful to make controversial views transparent, as well as, to develop responding systems of personal actions (Kals, 1996).

When participating methods are applied, for example round tables, the acceptance will increase, because individual liberties are respected and decisions between alternatives are allowed. In practice, there are different standardized participatory methods for fast actively orientated surveys of local knowledge, demands, and potentials, as well as, for conflict solving strategies, and particular problems (Stoll, 1999).

However, participation of the public is far more than an instrument to increase just acceptance, it is essential to make the right decisions (Stoll, 1998). Participation methods can contribute to social organizations, initiate private actions and learning processes. However, there is a combination of different participation methods necessary for interdisciplinary evaluations of nature and landscapes for practical planning processes and project evaluations, because each method cannot fulfil all demands in content and procedure. For example, some methods allow letting participate a lot of people, such as public inquiries, but due to the amount of persons only in a superficial way to discuss the subjects. Other methods enable more detailed discussions of contents and interests based on smaller participating groups, such as working groups, round tables, and planning cells (Bischoff et al., 2001). There are also common agreed value tree analysis to structure complex values and measures for decision processes (WBGU, 1999b).

Moreover, a qualified management is necessary for participative evaluation processes of plans and projects with an impact on nature and landscapes (cf. Sutherland, 2000; Breitschuh and Feige, 2003). People need to be convinced of actions, neither manipulated nor forced, to insure long-term lasting implementations of evaluation results of elements, structures, and functions of nature and landscapes. There are certain appropriate convincing communication methods (cf. Wilhelm and Edmüller, 2003), as well as, information, hearing, and co-operation methods (Luz and Weiland, 2001; cf. chapter 2.3 Psychological values on page 38). In addition, there is a professional social marketing necessary, which is based on target groups (Lantermann et al., 2003; Röchert, 2003; Schuster, 2003b; Sieber et al., 2003). Mediation, moderation, and co-operation methods can be very helpful to overcome social and other barriers, including individual and group resistances. Personal decisions of the content become more rationally than emotionally orientated (cf. Hellbrück and Fischer, 1999; Stoll, 1999; Oppermann, 2000; Waldmüller, 2000; Bischoff et al., 2001; Neuert, 2001; Troja, 2001; Böcher and Krott, 2002; Jessel and Tobias, 2002; Kals, 2002; Schmidt et al., 2002; SRU, 2002; Schuster, 2003a). These methods can also help to win acting persons and disseminators, who are involved in social networks (Kals, 1996; Hübner, 2002; Schmidt et al., 2002). In addition, there are different creativity methods to find common solutions (cf. von Haaren, 2004g).

Nevertheless, there are certain conditions of participatory methods for interdisciplinary evaluations of nature and landscapes for practical planning processes and project decisions (Table 2.4-6).

Table 2.4-6. Conditions of participatory methods for interdisciplinary evaluations of nature and landscapes for practical planning processes and project decisions (Bischoff et al., 2001, modified)

Conditions of participatory methods
for interdisciplinary evaluations of nature and landscapes

- the procedure must be open to exchange, learning, negotiation, and decision processes
- decision processes must be transparent at an early stage
- participants must have a real influence on decisions
- all participators must have a benefit and fulfil their duties
- participation must take place during all important planning stages
- personal acting possibilities must be made clear
- participators must have the chance to keep up their interests
- the participation procedure must be fair
- there must be free access to all information
- different social and other groups and individuals, as well as, organized and non-organized interests must be supported to have equal chances to participate
- the use and publication of participating results must be clear and open based on an early agreement of the participators

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The Participatory Rural Appraisal (cf. Korf, 2002; Pölking et al., 2002), as a further development of the Rapid Rural Appraisal (cf. Groombridge and Jenkins, 1996; Stoll, 1999), emphasizes an actively taking over of responsibility for problem analysis and planning by the people concerned. Furthermore, survey and planning processes ought to be participative, but also incorporate other parts within project cycles, for instance, monitoring schemes and evaluations (Stoll, 1999). Different participatory methods have been developed (Table 2.4-7; cf. Oppermann, 2000; Horelli, 2002; Mönnecke, 2004).

Table 2.4-7. Overview of participatory methods on local levels and examples of their application for interdisciplinary evaluations of nature and landscapes for practical planning processes and project decisions (Stoll, 1999, modified)

Participatory methods on local levels and examples of their application
for interdisciplinary evaluations of nature and landscapes

Methods	Subjects	Applications
Individual, guideline orientated interviews	• all subjects	• individual inhabitants/key

		persons are interviewed about their experience and knowledge
Group discussions	• all subjects, especially concerning specific problems, social relations, and planning purposes	• moderations of visualized communicative exchanges between certain groups of inhabitants, including final summaries and analysis
Drawing of social land maps, as well as, developing models	• concerning available resources, social relations, specific interests, involved persons, different conflicts, and historical developments	• inhabitants draw their regional developments, including involved persons, conflicts, etc., followed by discussions
System and flow charts	• impacts and changes of spatial natural conditions due to different land uses	• analysis of elements and relations within systems, as well as, prognosis of future developments
Cross-sectional movements and drawings (transects)	• general analysis of situations of communities or regions, land uses, problems and opportunities of local activities	• visits of spatial conditions with locals in small groups for discussions of crucial and critical aspects, as well as, to design development maps and models
Institutional diagrams (Venn- and Chapati-diagrams)	• institutions and persons and their relations	• persons and institutions are presented as different large circles in different distances according to their

		importance and social distances
Local work shops	• discussions of local conditions and planning of activities	• meetings for one or several days with locals
Role plays and simulations (theatre)	• behaviour of different people, as well as, future developments and their consequences	• problems and results are performed including following discussions and feedback

The described methods shall serve, *inter alia*, for diagnosis of current situations and characterizations of (social) structures, for identifications of problem solutions, for analysis of communicative, interactive, and decision making processes, as well as, participatory planning of interdisciplinary evaluations of nature and landscapes. Moreover, the possibility to reduce evaluation problems of new land uses of nature and landscapes is increased, when local communities are actively included (Stoll, 1999).

Different social participation methods can have the following advantages and disadvantages for interdisciplinary evaluations of nature and landscapes of practical planning processes and project decisions (Table 2.4-8; cf. Fürst, 2002).

Table 2.4-8. Advantages and disadvantages of different social participation and public relations methods for interdisciplinary evaluations of nature and landscapes of practical planning processes and project decisions (Petts, 1999, modified)

Social participation and public relations methods for interdisciplinary evaluations of nature and landscapes

Methods	Advantages	Disadvantages
Mode 1: information provision		
Leaflets	• can be aimed at a specific audience • relatively cheap to produce and to distribute • can be used to inform people of basic issues and as means to lead-in to the subject • improves public	• may appear to reach a widespread audience, but can be treated as junk-mail • no direct response mechanisms for questions or concerns • will inevitably raise more questions than

	availability of information	answers • difficult to evaluate
Advertising	• relatively cheap • effective to introduce an issue	• limited scope to convey messages
Local newspapers	• readily available • relatively cheap • readers see editorial matter as an independent source of information	• limited audience • no direct response to questions • there may be problems with editorial control • ineffective in achieving public involvement
Television and radio	• can convey powerful images • high familiarity of the medium • potential to reach a very large audience	• expensive to organize, to produce, and to transmit programmes • one-off coverage of issues • potential lack of control • requires careful planning
Video	• can convey powerful images, such as computer aided designed views to illustrate the character and scale of a proposed facility • can be innovative and eye-catching • can be used at viewer's convenience • complete editorial control	• relatively expensive • access to a limited audience, i.e. those watching videos • unlikely to be regarded as independent: information may be dismissed as too biased to be of value
Exhibitions	• if staffed, provide one-to-one contact • flexible in content and design • can provide useful feedback about concerns • good for a specific target group, such as residents around a proposed site • particularly effective, if staffed	• generally limited attendance and thereby low coverage of the potential audience • attracts only a small subset of a wider population
Telephone helplines	• relatively easy access for those interested or concerned	• if pre-recorded then limited flexibility or chance to obtain

	• if staffed, feedback is possible • useful to promote a feeling accessibility	feedback • pre-recorded information is limited to simple facts
Newsletters	• allows ongoing contacts and may help to promote trust • flexible, i.e. it can be designed to meet the changing needs of the audience • possible feedbacks • can be useful to support liason groups	• may not be perceived as independent, therefore possible lack of information credibility • only a relatively small proportion of a population will bother to read a newsletter
Mode 2: information collection and feedback		
Interviews	• open up opportunities for later contacts and participation • can identify different values and concerns	• time-consuming • can result in bias, if not carried out by independent people • difficult to get a representative sample of people
Surveys	• can get specific and detailed information • have been used in Environmental Impact Assessments in relation to socio-economic, landscape, and visual impacts, as well as, perceptions	• can be expensive, especially if a representative sample is required • can also result in bias, if not undertaken by independent people • must be random to ensure validity and reliability • provide only a snapshot of views at one point in time
Mode 3: consultation		
Public meetings	• if run well, for instance, by an independent and respected person, public meetings can be a useful way to meet more members of the community • good for opinion	• few solution findings at detailed level • difficult to control • possible mass effect

	developments and conflict detections • attendance can generate respect	
Panel discussions	• good overview of different arguments • direct response to different questions of the audience based on different opinions, if allowed • relatively inexpensive	• few constructive dialogues • danger of few contacts of the audience to the podium • presentation of also unverifiable information • no solution finding process
Lectures	• good overview of facts in short time periods • clarification of questions of content • relatively inexpensive	• relatively low exchange of different opinions • few clarifications of conflicts
Small group meetings	• good for listening and responding to concerns • can promote trust and respect between individuals and groups • good for discussing complex issues • good to find detailed solutions	• time-consuming and expensive, if a representative sample is required • require to be participatory legitimized by the public concerned
Mode 4: expert knowledge		
Community advisory groups	• access to key stakeholders and community leaders • allows explorations of key issues and concerns • exposes the real complexity of environmental management issues • can promote trust • highlights the process of decision making, as well as, the outcome • allows to find more detailed solutions based on expert knowledge and experience	• need careful planning and independent control • participants require a clear remit from the outset • time-consuming • requires significant commitment from participants • relatively expensive • outcome can be manipulated due to selection of experts • few democratic control • danger as substitute of public participation • low conflict solutions of

		non-participants
Workshops – full- or half-day	• relatively easy to organize • can be targeted at specific stakeholder groups • can examine specific issues in detail from a variety of alternative perspectives • allow some feedback • medium expensive	• one-off events are limited in subject coverage • unlikely to reach a wide audience • danger of just expert meetings and low innovative solution findings

2.4.6 Conclusive summary

Our personal and group perception, motives, and values determine our relation and behaviour towards nature and landscapes, but also our individual and collective evaluation of elements, structures, and functions of nature and landscapes for practical planning processes and project decisions with an impact on them. Our behaviour is firstly motivated by satisfying personal needs. These personal needs are influenced by social values, which are expressed in norms of the relevant group. Individuals incorporate public values and norms during their socialization. Thus, there is an interactive exchange and development of values by individuals and the society as a group.

Our practical behaviour towards nature and landscapes depends also on personal knowledge, acting opportunities, and rewards. Communication processes play a decisive role in participatory evaluation processes of nature and landscapes and the support of their resulting measures. Apart from the cognitive aspects, it is as important to develop connections of feelings with nature and landscapes, as well as, other humans for encouraging own actions, including the awareness of their impacts on nature and landscapes. People need to be convinced of actions, neither manipulated nor forced, to insure long-term lasting implementations of evaluation results of elements, structures, and functions nature and landscapes.

Nature and landscapes serve as crucial meeting points for social contacts. The social neighbourhood is of decisive importance for children and elder people, but also for more mobile social groups, which spend parts of their daily life in these neighbourhoods. Furthermore, parks contribute to the integration of people into the society and the surrounding neighbourhood. Therefore, nature and landscapes can have especially important social values for all social groups, which need special recognition, because they are out of responsible actions within their society.

However, children and teenager have to deal with public spaces, which are mostly planned and designed for the demands of adults, either for working, consuming or relaxing. Moreover, there is a growing social separation of districts in cities of lower living qualities concerning green spaces and building standards to districts of higher income. Nevertheless, when neighbours are encouraged to take over responsibility of their living grounds, public care about surrounding areas increases as much as they have contributed to it by their own hands and creativity.

Individual behaviour towards nature and landscapes and evaluations of their elements, structures, and functions can be influenced by different intervention techniques. There is an early socialization process necessary at schools, kindergartens, and at home, as well as, wide orientated information campaigns together with specific sympathy carriers for target groups. Initiators are vital until it becomes a trend or life-style element for a significant part of the society, despite their contribution might not yet have a crucial effect on nature and landscapes for the time being.

Social life-styles and milieus influence our evaluation, behaviour, and relation to nature and landscapes, as well as, to other human beings. However, there is a social development of growing individualization in industrialized societies. Individual experience of life has become more and more just an entertaining short event. There are no longer silence, contemplation, and sensual reflection important for experience of the diversity and beauty of life. Mass media themselves have reacted to this sensational life-style by producing more emotional, shorter and more entertaining contributions, instead of longer, more substantial, and more silent reports. Almost everything becomes available as a consumer good on the market, including feelings and experience. However, this consumer society approach does not necessarily lead to more life quality. Social recognition in our industrialized societies is mainly focused on status and property, but much less on social and human values. Three different styles of experience in life can be distinguished, firstly the high cultural form, secondly the trivial form, and thirdly the suspense form.

On political levels, it is very difficult to implement long-term orientated targets of different behaviour towards nature and landscapes due to the dominance of short-term orientated goals for re-elections. Unfortunately, technical innovations have not sufficiently been combined with changes of social behaviour towards nature and landscapes in our societies, especially in industrialized countries and during the unguided process of globalization.

Participative processes and reductions of hierarchical decision structures help to find better solutions and to increase the acceptance of resulting measures of practical planning processes and project decisions of nature and landscapes. Especially those people need to contribute information, which are affected by changes of nature and landscapes as also pointed out in chapter 10 of Agenda 21 during United Nations' Conference on Environment and Development in Rio de Janeiro in 1992. Regional and local institutions of self-organized people can function as bottom up initiatives. Mediation, moderation, and co-operation methods can be very helpful to overcome social and other barriers, including individual resistances.

Therefore, changes of nature and landscapes always implicate to alter our social system and behaviour. Evaluations of the social values of nature and landscapes need to take into account personal demands, as well as, social pressures and opportunities. Whenever possible, the freedom to decide about own actions must be retained, as well as, the effects of personal actions need to be made transparent. There are different participation techniques to incorporate the knowledge and creativity of the people concerned in interdisciplinary evaluations for practical planning processes and project decisions, as well as, to communicate social aspects of future developments of nature and landscapes.

However, social values must be always seen in a culture-historical context. They change by social groups, location, and time period within a society. Social movements result in changes of values of nature and landscapes themselves. Our personal attitudes towards nature and landscapes cannot be evaluated without taking into account the culture-historical influences. Furthermore, our culture-historical developments and interacting influences on nature and landscapes have become a value themselves. An interdisciplinary evaluation of nature and landscapes would be incomplete without them. Therefore, the next chapter shall reveal in a very brief overview, which culture-historical developments nature and landscapes have made in Central Europe, and how the relation of the human species has changed to nature and landscapes during the past. There shall be also common methods mentioned to map culture-historical elements of nature and landscapes, as well as, to reveal the values of traditional human cultural heritage within modern times.

2.5 Culture-historical values

2.5.1 Cultural position of the human species

The human species differs mainly from other organisms in the way, that we have evolutionary developed human consciousness, which allows us to reflect about our behaviour towards our environment. Thus, the human species behaves differently to animals and plants, which act just according to instinctive and to educated behaviour. Furthermore, we have the power and above all the great responsibility for the current status and future development of nature and landscapes (cf. chapter 2.2 Ethical values on page 29). However, humans have developed in different cultural relationships to each other and to nature and landscapes during thousands of years (cf. Bayerl and von Borries, 1998).

The diversity of human consciousness, characters, experience of life, and life circumstances (life-styles) cannot be seen separated from time periods and cultural areas. They result in a variety of different associations, as well as, in different human consciousness and activities within nature and landscapes (Meier and Erdmann, 2003). Our opinion of the world, our cultural consciousness, and thereby our consciousness of nature and landscapes change during time periods, i.e. during the spirit of the age (Rudolf, 1998). Therefore, we need to take into account culture-historical guidelines to determine a concept for our relationship to nature and landscapes and to consider them for current evaluations of elements, structures, and functions of them, as well as, for future developments.

2.5.2 Culture-historical developments and movements

Culture-historically the human species started to try to control and to influence nature and landscape as a food and living resource from ages of hunting and collecting to settle down for agriculture (cf. Bayerl and von Borries, 1998; Seiler, 1999). Nowadays, Central Europe is almost completely determined by the culture-historical harvesting of nature and landscapes by the human species (cf. Ellenberg, 1988). Primary woodland was historically the dominant natural cover of Central Europe. However, it was widely cut down for construction works and used as firewood since the Middle Ages. Forests have been replanted for industrial use; meadows have been used for livestock and farmland for agriculture for centuries. Several species have used these and other new human influenced habitats as cultural followers (cf. Blab, 1993; Arlt and Eggers, 1997; Mühlenberg and Slowik, 1997; Kowarik and Sukopp, 2000, 2002; Kowarik, 2003). Currently there are only about 30 % of Europe's nature and landscapes covered by more or less human influenced woodland (Kaule, 1991; Oetmann-Mennen and Begemann, 1998).

About 10.000 years ago, humans started to change nature and landscapes completely by inventing agriculture and keeping life stock. The settling of Central Europe increased significantly during the 12th century, which reduced primary woodland extensively. The second big clearance period started in the 14th century and continued until the 16th century (Wegener, 1998). From the Middle Ages on, the extension of agriculture in Europe caused mosaic structures of landscapes and habitats up to the 19th century (Oetmann-Mennen and Begemann, 1998; WBGU, 1999a). Local natural resources were the limiting productive factors for a variable use adapted to local conditions and a guarantee for the development of these traditional cultural nature and landscapes (Demuth, 2000).

Therefore, the shape of our landscapes and the content of species are results of the culture-historical use of the countryside in Central Europe. Nowadays, Central Europe contents mainly of secondary woodlands, human influenced water sites, more or less intensive farmlands, and urban agglomerations. The number of species emerged by the diversity of habitats created by the human species developed to its maximum at the beginning of the industrial revolution during the 19th century (Plachter, 1991a; Becker, 1997). Furthermore, several plant and animal species have been introduced to urban agglomerations during culture-historical developments of cities worldwide (cf. Kowarik, 1990, 1998b, 2001, 2003; Sukopp 1990; Wittig, 1991, 2002; Blab, 1993; Klausnitzer, 1993; Sukopp and Wittig, 1998).

The organized nature conservation movement in Germany roots back to the conservative social movement at the end of the 19th century. Nevertheless, the tradition of landscape beautification ("Landesverschönerung") in Germany is even older and goes back to the beginning of the 19th century, which had the intention to enhance the effectivenes of land uses in agriculture and forestry including an aesthetic aspect, to apply the art of gardening ("Gartenkunst"), and to cause architectural improvements (cf. Däumel, 1961; Runge, 1998b). The Home Protection Association ("Bund Heimatschutz") was founded in 1904 rising up to 27,000 members in Germany in 1916. The music professor Ernst Rudorff was one of their speakers, who warned of the negative consequences of industrialization processes deteriorating our natural heritage of the countryside (cf. Boesler, 1996; Bayerl and von Borries, 1998; Haubl, 1998; Runge 1998b; Schröder and Hartje, 2001; Deutscher Rat für Landespflege, 2003; Radkau and Uekötter, 2003; Wächter, 2003; von Haaren, 2004a; Ott, 2004; Schmoll, 2004). The task of the Home Protection Association was to protect the German home in its naturally and historically developed peculiarity against denigration according to § 1 of its statutes (Schmoll, 2004). Nature conservation contrasted with the dominant view of nature and landscapes in modern societies as an object of instrumental reason by a consciousness that implies more than the aimed purpose to use them. Nature and landscapes became an object to be preserved during changes of industrialization, urbanization, rationalism, democratization, and individualization that are understood in total as modernization (Schmoll, 2004).

The 1920s and 1930s brought a further development of the biological approach to nature conservation and the designing attitude, respectively, which lead to an organizational separation of home protection from nature conservation (Körner and Eisel, 2003), despite an aesthetically based landscape protection attitude and a nature conservation approach based on biologically classified criteria were only two of six working fields of the Home Protection Association, including other cultural heritage, such as historic monuments, folk art, and customs (Schmoll, 2004). However, the German Nazis mislead the homeland approach combined with a traditional family role approach. In addition, they increased the division of our countryside by starting the massive construction of motorways (cf. Schmoll, 2004). The end 1940s were concerned with recovering from the war. Many destroyed areas needed to be rebuild. Plants and animals could more or less freely develop, especially in heavily destroyed cities between the ruins. The countryside was still depending on manpower and lower machine input.

Western and Eastern Germany developed a highly intensive agricultural practice in the 1950s and 1960s (cf. Jedicke, 1990; Kaule, 1991; Plachter, 1991a; Becker, 1998; Jessel and Tobias, 2002). The "green revolution" of the 1960s intended to bring worldwide industrialization into farming. On either sides of the wall, nature and landscapes were uniformed by using heavy machines, fertilizer, as well as, pesticides on large farmlands. The consequences were overproduction in the European Union, loss of small farms and countryside migration, uniformity of landscape structures and contents, destruction of typical habitats and loss of farmland species, as well as, production of low quality mass food.

During the 1960s and 1970s, more neglected and thereby naturally growing areas in cities in Western Germany were destroyed during a new approach to nature and landscapes of being in order, which lead to the programme “Our village should become more beautiful!” (“Unser Dorf soll schöner werden!”) (cf. Blab, 1993). In Eastern Germany, in many parts more naturally grown areas in cities could last until reunification in 1990 due to mismanagement.

During the 1980s, a growing ecological movement developed in Western Germany, which lead to the foundation of the German Green Party, the Ministry of the Environment in 1986 and the incorporation of environmental objectives into programmes of each Western German party at least on paper. In Eastern Germany, ecological underground movements caused substantially the overcome of the Eastern German government.

However, natural habitats in cities in Eastern Germany have been heavily destroyed due to new constructions after reunification in 1990, for example at the unified capital Berlin, while short time orientated unstable investments still have priority to sustainable development. On the other hand, industrial, military and other urban grounds and buildings in Eastern Germany have been given up, which are more or less concreted and partly contaminated (cf. NABU, 2003; Rat für Nachhaltige Entwicklung, 2004). Nature conservation has rapidly become a neglected issue in political decisions and public consciousness (Empacher et al., 2002; BMU, 2004; cf. chapter 1.3 Public consciousness of environmental protection on page 15), while people have withdrawn from public movements in general to concentrate on private family life and to prevent personal unemployment. Thus, Germany’s parliament almost completely abolished for instance the legal requirement to substitute losses of nature and landscapes by construction works in cities in 1993.

Nature conservation has again become a subject of professionals in charge of various backgrounds, who are self-declared experts for the public demands and opinions on nature and landscapes. Institutionalized governmental and non-governmental nature conservationists without enough control of the basis seem to be more interested in personal career, history of institutions, and different protagonists than in developing analytical categories and strategies to effectively localize nature conservation within the different demands of modern societies (cf. Schmoll, 2004). However, this seems to be an illness of every established movement of more self-orientated than subject-orientated leaders, which is not sufficiently controlled by public democratic mechanisms.

At the beginning of the 21st century, the social net has been further cut down in Germany between those who have an appropriate job and those who are fighting to survive, which influences also the possibility to participate in democratic decision processes either by the lack of energy for it or by not being consulted within a professional duty process. This effects also interdisciplinary evaluations of nature and landscapes for practical planning processes and project decisions.

Only recently, a starting integrated approach to nature conservation has been promoted in Germany, but still on expert level (e.g. WBGU, 1999a; Vogtmann, 2003), which is significantly influenced by the interdisciplinary attitude of the Convention on Biological Diversity (United Nations, 1992; BMU, ?; cf. chapter 7 Conclusions on page 313) . Another attempt is to develop local Agendas 21 (Böhme et al., 2002), which was initiated during United Nations Conference on Environment and Development in Rio de Janeiro in 1992 (Quarry, 1992; BMU, 1997), but it seems to be rather questionable of having significant practical influence on political decisions in Germany due to the mentioned lack of sufficient democratic control mechanisms for the time being.

2.5.3 Culture-historical guidelines

Environmental groups and scientists in Germany have proposed more traditional approaches to farming throughout the 1990s. The culture-historical way of traditional, so called "ecological farming" of the 19th century, provides high quality food, diverse landscapes, and sufficient income also for smaller farms. There have been model guidelines[8] developed to change industrial agricultural productions to dynamic, extensive, and traditional cultural use of nature and landscapes in Central Europe (cf. Demuth and Fünkner, 1997; Herrmann, 2003; Stolton et al., 2003; Vogtmann, 2003). However, just since the end of the 1990s, the European Communities have finally made significant changes from subsidizing intensive farming to support more ecological farming (cf. Eysel, 2000; Eysel et al., 2002; Ganzert et al., 2003; Herrmann, 2003), which allows to diversify the income sources of farmers (cf. Knickel, 2002; Henne et al., 2003; section 2.4.4 Social life-styles and milieus on page 60). For example, farmers could serve as a focal management point for recreation of citizens at the countryside (cf. Hoisl et al, 2000).

For cities in Central Europe, there has not yet been set out a comparable guideline for nature and landscapes by our societies based on our culture-historical developments, despite many model guidelines content also culture-historical aspects (cf. section 6.2 Model guidelines on page 303). Cities content of a range of culture-historically important green spaces, for example, historic gardens and parks, back and front gardens, cemeteries, allotments, avenues of trees, wall vegetation, settlement greenery, spontaneous grown fields, etc. (overview in Böhme and Preisler-Holl, 1996; of avenues of trees in Baumann et al., 2000; of historical gardens and parks in Germany in Bund Heimat und Umwelt in Deutschland, 2001). Nevertheless, there are criticisms of nature

[8] Model guidelines of nature and landscapes describe conditions, which shall be achieved for particular regions. They are orientated towards natural potentials and specifics of these areas, which depend on their natural conditions and culture-historical developments (Finck, 1993).

conservationists that intensive gardening of green spaces in cities deteriorates the value of these green spaces for inhabitants and users, which was culture-historically a symbol of a relation of the human species to nature and landscapes in harmony. Spontaneous parts would symbolize the reconciliation of culture and nature. The ruling relation to nature and landscapes would be one of the crucial reasons for the ecological crisis of the human species, whereas spontaneous nature in cities would symbolize simultaneously a better future (cf. Wächter, 2003).

2.5.4 Estrangement from nature and landscapes

However, in modern concreted cities and at the industrialized countryside, there are little human contacts to nature and landscapes in a natural form. It is our decision as a part of our culture how we behave towards nature and landscapes and evaluate their elements, structures, and functions for practical planning processes and project decisions in our historical period. Nature and landscapes are our cultural home (cf. Miller, 1998; Eser, 1999; Hoils et al., 2000; Gebhard, 2001; Spiegel, 2001; Schmoll, 2004), irrespectively if in cities or at the countryside. The current and future status of nature and landscapes is part of our cultural identity (Group of experts, 1997). There are different culture-historical approaches to nature and landscapes, which influence the evaluation of their elements, structures, and functions for practical planning processes and project decisions (Table 2.5-1).

Table 2.5-1. Cultural approaches towards nature and landscapes during different historical epochs, which influence the evaluation of their elements, structures, and functions (Rink, 2002, modified)

Different culture-historical approaches to nature and landscapes	
Rational approaches of culture-historical epochs	Emotional approaches of cultural-historical epochs
• anthropocentric	• ecocentric
• the human species has the power to design nature and landscapes	• God or natural self-development powers design nature and landscapes
• the natural chaos ought to be overcome	• the natural self-development forces of nature and landscapes shall be supported
• the human nature, i.e. emotions, shall be culturally controlled	• cultural limitations of feelings ought to be lifted

• emphasis on human mind	• emphasis on feelings
• nature and landscapes are mainly seen as a resource	• nature and landscapes have an own life and value
• examples: the Renaissance, the Enlightenment, the classic period, the industrial revolution, the new objectivity of the 1920s, and the Restoration period of the industrial society of the 1950s and 1960s	• examples: the baroque, the Storm and Stress period, the Romantic period, the German scouts period, the expressionism, the National Socialism, the society of cultural conflicts and experience since the end of the 1960s

There has been a long-term development of estrangements from nature and landscapes. Individualization is an aspect of modernization processes, which began at the early modern age continuing up today. It began with the urbanization, which lead to a separation of cities and the countryside. In consequence, citizens have separated from farmers of the countryside, who produce the food for them (Haubl, 1998). Feudalism was the dominant social structure at the countryside in Central Europe up to the 19th century. From about 1850 and partially earlier on, agricultural reforms on social and technical levels were undertaken to intensify agriculture. By the end of the 19th century, significant scientific-technical innovations and socio-economic progresses caused different time rhythm and life spans (Becker, 1998).

The industrialization of the 20th century contributed to this development. The scientific-technical development has not only significantly changed nature and landscapes directly, but also the human relations to them and to each other, which determines our evaluations of their elements, structures, and functions for the human being and on their own. Our body has become more and more unimportant during modern working processes, while machines substitute human muscle power. Nevertheless, people can revitalize direct contacts to nature and landscapes. For example, it is possible to feel the strength of climbing up mountains by us and to discern the mountainous landscape with all our senses. The cultural period of romantic landscape paintings of the 17th and 18th century was a reaction and an aesthetic compensation of the growing distance to nature and landscapes during the industrialization. On the other hand, the French garden architecture of the 18th century expresses the desire of completely rational power about nature and landscapes, whereas English garden architecture focuses on the concept of integrating the human being more sensible into nature and landscapes (cf. Haubl, 1998; Hellbrück and Fischer, 1999).

Culture as an expression of whole human creativity is traditionally regionally limited depending on particular conditions of nature and landscapes (cf. Hellbrück and Fischer, 1999). However, nowadays multi-media and Internet access in industrialized countries, as well as, international labour transfer at global markets have changed our personal cultural attitude to nature and landscapes. Nature and landscapes can be discovered on globally either directly by people, who can afford to travel to it or less difficult by multi-media resources. Experience of nature and landscapes during our every day life has changed, but also expectations of their contents.

In modern societies there is a tendency for a general loss of the sensibility to nature and landscapes. Culture has been reduced to pure intellectual education and art, which neglect every day contacts to nature and landscapes. A scientific attitude has taken place, which has lead to the degradation of the sensuous contact to nature and landscapes (cf. Bölts, 1995; Rudolf, 1998; Becker, 2000; Wächter, 2003). Our every day life in industrialized countries is highly separated from experience in nature and landscapes (cf. Demuth and Fünkner, 1997). Particularly in cities, humans have lost their close contacts to nature and landscapes of the traditional farming life-style. However, the life-style distance to nature and landscapes has also consequences for the inner distance to nature and landscapes and for human relations themselves. The rational approach has conquered emotions and sensuality (cf. Wächter, 2003). Our relationship to nature and landscapes is also part of our relationship to ourselves, because they always influence each other (cf. Gebhard, 2001).

Nevertheless, it seems to be that to distinguish between “we” and “they” belongs to the basic human constants (Reusswig, 2002). Culture-historical elements of nature and landscapes allow identifications with certain life-styles (cf. chapter 2.4 Social values on page 50); at least what people assume how it would be. For example, the culture-historical use of nature and landscapes is used in advertisements to combine products with certain life-style feelings, such as Marlboro cigarettes with the traditional cattle farming of the human being within undeveloped nature and landscapes of the countryside in the United States.

Furthermore, nature and landscapes can symbolize traditional culture-historical tales, for example, woodlands are culture-historically combined with Trolls in Scandinavia or Rübezahl in Germany. The reason is a different psychological perception of nature and landscapes due to personal, culture-historical, and social circumstances (cf. chapters 2.4 Social values on page 50 and 2.3 Psychological values on page 38, respectively).

2.5.5 Human cultural heritage

In addition, human customs and cultures have been developed and passed on to following generations for hundreds and thousands of years. For example, 5,000 to 7,000 languages are spoken on five continents nowadays (Posey, 1999). Furthermore, human societies are a culture-historical heritage themselves. For instance, it is estimated that there are currently at least 300 million indigenous people on earth, who speak 4,000 to 5,000 of the 6,000 languages. Traditional ecological knowledge and practices serve to effectively manage and conserve nature and landscapes (Posey, 1999; cf. Meyer, 2001). However, globalization and industrialization have already caused severe changes of nature and landscapes and our culture-historical relations to it (cf. sections 3.2.8.4 Globalization on page 221, 2.4.2 Social functions of nature and landscapes on page 56, as well as, 2.4.4 Social life-styles and milieus on page 60, respectively; Millennium Ecosystem Assessment, 2005a).

United Nations Educational, Scientific and Cultural Organization (UNESCO) adopted the Convention Concerning the Protection of the World Cultural and Natural Heritage in 1972 to set up a global network of World Heritage Sites (UNESCO, 1997; Göbel and Saling, 2001). A new category of the World Heritage Site, the "cultural landscape", recognizes the complex interrelationships between the human species and nature in the construction, formation, and evolution of landscapes (Posey, 1999).

The Convention on Biological Diversity recognizes in its preamble "the close and traditional dependence of many indigenous people and local communities embodying traditional life-styles on biological resources, and the desirability of sharing equitably benefits arising from the use of traditional knowledge, innovations and practices relevant to the conservation of biological diversity and the sustainable use of its components". According to article 8 "In-situ Conservation" letter j of the Convention on Biological Diversity, "Each Contracting party shall, as far as possible and as appropriate, subject to its national legislation, respect, preserve and maintain knowledge, innovations and practices of indigenous and local communities embodying traditional life-styles relevant for the conservation and sustainable use of biological diversity and promote their wider application with the approval and involvement of the holders of such knowledge, innovations and practices and encourage the equitable sharing of the benefits arising from the utilization of such knowledge, innovations and practices" (United Nations, 1992; BMU, ?). However, apart from integrating these culture-historical values into interdisciplinary evaluations of nature and landscapes, it depends highly on practical implementations of benefit sharing, if nature and landscapes on their own and the depending people can profit of them (cf. ten Kate and Laid, 2000; Sutherland, 2000; Wolfrum et al., 2001; Niekisch, 2003).

Moreover, according to article 10 "Sustainable Use of Components of Biological Diversity" letter c of the Convention on Biological Diversity, "Each Contracting party shall, as far as possible and as appropriate, protect and encourage customary use of biological resources in accordance with traditional cultural practices that are compatible with conservation or sustainable use requirements" (United Nations, 1992; BMU, ?).

In addition, according to article 18 "Technical and Scientific Cooperation" number 4 of the Convention on Biological Diversity, "The Contracting Parties shall, in accordance with national legislation and policies, encourage and develop methods of cooperation for the development and use of technologies, including indigenous and traditional technologies, in pursuance of the objectives of this Convention. For this purpose, the Contracting Parties shall also promote cooperation in the training of personal and exchange of experts" (United Nations, 1992).

Traditional knowledge, innovations, and practices are far more than a simple compilation of facts. It is the basis for local-level decision-making in areas of contemporary life, including natural resource management, nutrition, food preparation, health, education, as well as, community and social organization. However, traditional ecological knowledge is not constant, but holistic, inherently dynamic, and permanently evolving through experimentations and innovations, fresh insights and external stimuli. It is transmitted in many ways. Most is done through repeated practice, apprenticeship with elders and specialists. For example, poems and music are important pathways (Posey, 1999).

In developing countries, many ancient indigenous agricultural and sustainability systems have survived until the colonial period. These systems are complex, based on sophisticated ecological knowledge and understanding, highly efficient and productive, and inherently sustainable. Classic examples are the raised bed systems used for millennia by traditional farmers of tropical America, Asia and Africa. Known variously in Meso-America as "chinampas", "waru waru", and "tablones", these were extremely effective for irrigation, drainage, soil fertility maintenance, frost control, and plant disease management. In India, peasants grow over forty different crops on localities that have been cultivated for more than 2,000 years without a drop in yields, yet have remained remarkably free of "pests" (Posey, 1999).

Moreover, in Brazil, Shanley, and Galvao show that Amazon Cablocos can earn two to three times more from subsistence use of the forests than from the meagre income from timber sales. Another important area in which local knowledge plays a major role is in traditional medicines and health systems, for example, Ayurvedic and traditional Chinese medicines. A fundamental concept in traditional health systems is that of balance between mind and body, given that both are linked to community, local environments, and the universe. Up to 80 % of the non-industrial earth's population still relies on traditional forms of medicines. Many indigenous groups are returning to their ancient medicines and incorporating traditional forms of treatment into their health service programmes. Even in industrialized countries, more and more people are turning to alternative health treatments. For example, Americans spend more on complementary approaches than on hospitalization, while Australians pay out more on alternative medicines than pharmaceuticals (Posey, 1999).

2.5.6 Methods in their culture-historical context

Cultural elements of nature and landscapes can be mapped according to their historical functions, structural forms, and spatial relations for interdisciplinary evaluations for practical planning processes and project decisions on a certain spatial and time scale (overview in Burggraaff and Kleefeld, 1998; cf. Fink et al., 1989; Ringler, 1997; Knospe, 2001; Peters, 2001). Our culture-historical use of nature and landscapes has direct influences on our perception, consciousness, and integration into nature and landscapes. The content of signs or symbols of historical relics in nature and landscapes of past events can be decoded by people, if they have the necessary perceiving competence. We also positively value nature and landscapes that have a high content of historical structures and elements, which are positively related to us on different levels. There are potentials of experience, knowledge, and identifications, as well as, aesthetic potentials, when historical and spatial differences of socially constituted nature and landscapes are decoded during our processes of perceptions. Therefore, it is decisive to have a deep knowledge about the cultural history and dynamic of nature and landscapes for their evaluations at a certain location and time period (cf. Becker, 1998; Seiler, 1999; chapter 2.3 Psychological values on page 38). Our culture-historical nature and landscapes content of deeply rooting symbolic emotional elements, such as memories of our childhood, identification features, and home feelings (cf. Demuth, 2000; Schmoll, 2004).

2.5.7 Conclusive summary

The human species differs from other organisms by its evolutionary developed consciousness to be able to decide about its own behaviour towards nature and landscapes. Therefore, we have the power and above all the great responsibility for the current status and future development of nature and landscapes. The diversity of human consciousness, characters, experience of life, and life circumstances (life-styles) is closely combined with our culture-historical background. Humans have developed in different cultural relationships to each other and to nature and landscapes during thousands of years. Therefore, we need to take into account culture-historical guidelines to determine a concept for our relationship to nature and landscapes and to consider them for current evaluations of elements, structures, and functions of them, as well as, for future developments.

Central Europe’s nature and landscapes are culture-historically almost completely dominated by harvesting and other uses of the human species. For example, originally dominant primary woodland was widely cut down for construction works and used as firewood since the Middle Ages, which has caused a mosaic of meadows, agricultural fields, human influenced water sites, urban agglomerations, and traffic connections. The shape of our landscapes and the content of species as cultural followers are a result of the human influence on urban and rural habitats.

There is a long culture-historical tradition of the nature conservation movement in Germany, which dates back to the beginning of the 20th century. The tradition of landscape beautification (“Landesverschönerung”) in Germany goes even back to the beginning of the 19th century. The German Nazis increased the division of our nature and landscapes by the massive building of motorways in the 20th century, which was followed by an intensification of agriculture in the 1950s and 1960s that caused also a concentration of farmers in Eastern and Western Germany, respectively. Several species found ecological niches in the ruins of the destroyed cities in Germany after the Second World War.

However, there were also many habitats lost in cities during the process of refurbishing of houses and new constructions without sufficiently considering green spaces in Western Germany since the 1950s and 1960s, as well as, in Eastern Germany especially after reunification in 1990. Just at the end of the 20th century, the European Communities have begun to alter the process of overproduction towards a more ecological and social farming policy at the countryside. Traditional (ecological) farming has become a model guideline to produce high quality food, diverse landscapes, and sufficient income also for smaller farms. However, there is no comparable guideline for culture-historical developments of nature and landscapes in our cities yet, despite many model guidelines also content culture-historical aspects.

An estrangement has taken place of human contacts to nature and landscapes in a natural form in modern concreted cities and at the industrialized countryside, which influences our behaviour to nature and landscapes and evaluation of their elements, structures, and functions for practical planning processes and project decisions. The industrialization of the 19th century contributed to this development. Scientific-technical developments and globalization have not only significantly changed nature and landscapes directly, but also human relations to them and to each other. Nevertheless, nature and landscapes have still important traditional symbolic culture-historical values for our perception, apart from their current and historical condition to a high content as a result of the human influence. Elements of nature and landscapes allow identifying with certain life-styles, feelings, and intellectual associations.

Human customs and cultures belong to the culture-historical heritage of nature and landscapes as much as the human species is part of our biosphere. For example, 5,000 to 7,000 languages are spoken on five continents nowadays. Traditional ecological knowledge and practices can serve to effectively manage and conserve nature and landscapes in a dynamically evolving process. UNESCO has set up a worldwide net of World Heritage Sites including a category of “cultural landscape”. The Convention on Biological Diversity recognizes traditional cultural practices. In developing countries, many ancient indigenous agricultural and sustainability systems could be revitalized.

Therefore, it is important to register and to map cultural elements of nature and landscapes according to their historical functions, structural forms, and spatial relations for practical planning processes and project evaluations. It is decisive to gather a deep knowledge about the cultural history and dynamic of nature and landscapes to understand and to evaluate them. Furthermore, it is decisive to locate the culture-historical value of nature and landscapes and to assess current developments for leading our cultures in an interacting process with nature and landscapes into the future.

We have seen that the different values of nature and landscapes depend highly on the culture-historical context that determines and expresses the relation to nature and landscapes within a certain period of time and location. However, the human being itself can crucially influence the developing consciousness and behaviour towards nature and landscapes within a culture-historical period. Education and personal experience beginning at the early childhood determine decisively our personal relations and evaluation of certain elements of nature and landscapes, which are reflected in the planning processes and project decisions of the society as a whole. Education is a never-ending learning process of ourselves and our relation to nature and landscapes. Therefore, different elements, structures, and functions of nature and landscapes can serve of more or less value for educational purposes. The following chapter shall discuss the conditions of learning processes and educational methods, which can lead to a better understanding of nature and landscapes and our influences on them to provide contributing actions for practical planning processes and project evaluations.

2.6 Educational values

2.6.1 Educational tasks

Education for current and future generations is another import value of nature and landscapes. It is the basis to understand natural processes, as well as, culture-historical developments. It is important for our consciousness and practical behaviour towards nature and landscapes. Furthermore, education influences our personal and group evaluation of elements, structures, and functions of nature and landscapes for practical planning processes and project decisions.

Moreover, education is a basic condition to participate in knowledge, which is necessary to take part in social groups for being recognized by the society also in practical actions (cf. Faber and Manstetten, 2003). Knowledge opens chances and opportunities to participate in democratic opinion processes (Erdmann and Wehner, 1996). Therefore, one main educational task from kindergarten to university is to enable people to live together in our common world (cf. Faber and Manstetten, 2003). The human species needs social exchanges for learning processes. The ability of confident relations to other humans is the basis for a healthy learning process. Moreover, the human species has a social nature, which is able to learn and to have relationships depending on education (Erdmann and Kastenholz, 1992). An individual life-style is developed in social interactions, which is the basis for every behavioural motivation (Erdmann and Grunow-Erdmann, 1993), but also for the subjective evaluation of nature and landscapes (cf. section 2.4.4 Social life-styles and milieus on page 60). Socio-emotional abilities and community feelings must be developed, differentiated, and shaped in content in interpersonal relationships, similar to the language acquisition of the innate ability to speak, if innate human opportunities shall not wither away (Haltner-Mylaeus and Mylaeus, 1992).

Three levels of education can be considered: intellectual, emotional, and behavioural (Beer, 1984). Emotional and rational relations to nature are best initiated in early years of childhood (Group of experts, 1997). Especially Children are still open and interested in nature and landscapes. This openness becomes reduced in later development periods, for instance, during teenager ages, when young people are more concentrated on themselves. The sensibility and thereby creativity of children can only be found at few adult groups, such as artists (Schemel, 1998). However, it is astonishing how teenager can become enthusiastic for nature and landscapes after initially hesitating. Also adults, who seem to have grown out of the necessity to learn and to develop themselves and who are occupied by their profession and families, feel a demand of experience of nature and landscapes, when they have the opportunity and when they are lead to overcome artificially constructed barriers to nature and landscapes, as well as, to their own abilities (Rudolf, 1998).

Education allows us to understand the different dependences and relations of our societies towards nature and landscapes (cf. chapter 2.5 Culture-historical values on page 73). Education shall develop the sensibility and responsibility for nature and landscapes, as well as, the human species (cf. chapter 2.2 Ethical values on page 29; Erdmann, 2001). It has the duty to provide knowledge in developing values depending on facts, and to encourage self-orientated thinking for solving complex problems (cf. Erdmann and Kastenholz, 1992; Erdmann and Grunow-Erdmann, 1993; Baier, 1996; cf. chapter 2.7 Scientific values on page 100). The ability to communicate, to co-operate, to participate, to think creatively and to work in different socio-cultural environments is as much important as the pure knowledge of facts (cf. Vieth, 1999; Erdmann, 2001, 2002a), as well as, the basic ability to observe and to approach (Dierßen, 1993; Rudolf, 1998). It is as important to impart scientific facts as humanistic values, for example, social responsibility, sympathy, non-violence, and equality. Ethical questions should take a major part in theory and practice of education. There is a necessity to develop a feeling of responsibility for the society and nature and landscapes in education (Erdmann and Kastenholz, 1992; cf. chapters 2.2 Ethical values on page 29 and 2.4 Social values on page 50, respectively). This refers also to education at home within the family, at school and afterwards at university, as well as, during vocational training (cf. Erdmann, 2001).

Formal education of nature and landscapes at institutions allows more directed teaching and controls, for example, at kindergartens, schools, universities, and vocational training institutions (e.g. Pappler and Witt, 2001). Whereas informal education enables more freely to discover the different features of nature and landscapes away from social and learning pressure, as well as, systematic learning barriers at public places, for example, at museums, zoos, botanical gardens, and exhibition centres (cf. Bitgood, 2002; Röchert, 2003). For instance, annually about 20 million people visit botanical gardens in the European Union, thereof approximately 14 million in Germany (Hurka, 2000).

In addition, education of nature and landscapes can be also carried out in private surroundings, for instance, within guided groups by NGOs in the field, or less formal together with the family, friends, or even on our own.

2.6.2 Educable behaviour

However, understanding and knowledge are not the only necessary components for practical behaviour towards nature and landscapes (Group of experts, 1997; Kruse-Graumann, 1996, 1997; cf. chapter 2.2 Ethical values on page 29 and 2.4 Social values on page 50, respectively). Knowledge of the right behaviour is not a sufficient, but a necessary condition for environmental behaviour (Schahn, 1993). Behaviour orientated education needs additionally motivating and responding elements that can be monetary or not (Fietkau and Kessel, 1984; Kruse-Graumann, 1996; Group of experts, 1997; Schahn, 1993; Hellbrück and Fischer, 1999; Hübner, 2002). From the pedagogic point of view, rewards are much more effective than penalties (Group of experts, 1997; Matthies and Homburg, 2001; Hübner, 2002). Penalties can also cause reactive aggressions. Their function to suppress immediately certain behaviour towards nature and landscapes makes only sense, if an alternative possible behaviour shall be developed (Hellbrück and Fischer, 1999). In addition, penalties cannot positively involve the knowledge, motivations, and creativity of people in participatory evaluation processes of nature and landscapes for practical planning processes and project evaluations (cf. section 2.4.3 Social participation on page 59), which can provide long-term behavioural changes by internal personal and external motivations of the society (cf. section 2.4.1 Social aspects of our perceptions, evaluations, and behaviour on page 50).

Nevertheless, our law system is traditionally mainly concentrated on ineffective penalties for protecting nature and landscapes. The attitude to control everybody is impractical. Education has the duty to make nature and landscape understandable, to develop personal feelings for it and to motivate for actions. Furthermore, it is necessary to develop new relationships between the human species and nature and landscapes, to find a life-style, which is compatible with it (cf. section 2.4.4 Social life-styles and milieus on page 60), and to find fields of personal actions in the society (Bölts, 1995).

Environmental behaviour depends on external circumstances, but also on individual conditions. Education has to take into account personal interests, which concern life quality, self-realization, health, family and children, comfort, and financial advantages (Bölts, 1995; cf. section 2.4.1 Social aspects of our perceptions, evaluations, and behaviour on page 50). Crucial factors for environmental behaviour are specific experience and personal situations, the consciousness of the effectiveness of our own actions, the ability to analyse problems in their complexity, and the possibility to take over responsibility (cf. Bölts, 1995; Baier et. al, 1996; Erdmann, 2001; chapter 2.2 Ethical values on page 29).

Furthermore, for real changes of our behaviour towards nature and landscapes and considerations of their comprehensive values to the human being and on their own, it is important to develop critical consciousness and personal courage. All approaches of environmental education must be seen in the individual psychological, cultural and social contexts (cf. Bölts, 1995; Kals, 1996; chapters 2.3 Psychological values on page 38, 2.5 Culture-historical values on page 73, and 2.4 Social values on page 50, respectively). The willingness and ability of socio-cultural evaluations of knowledge about nature and landscapes needs to be supported by emancipation, participation of the taught people, personal autonomy and responsibility in teaching courses (Erdmann, 2001). Positive practical examples are often more effective than theoretical models or pure moral forces. Moreover, the personality of educating persons is decisive to serve as a good example (cf. Erdmann and Kastenholz, 1992; Erdmann and Grunow-Erdmann, 1993; Erdmann, 2001) also in the wider public by VIPs (cf. chapter 2.4 Social values on page 50).

2.6.3 Personal contacts

Nature and landscapes play a crucial role in life for education, especially of children. The early starting personal human contact to nature and landscapes is decisive for the ability to develop a sensibility and the knowledge to perceive and to consider all different values of nature and landscapes for practical planning processes and project decisions. The family is the first society of children. It has an intense model forming character for later situations in life, also in relation to nature and landscapes and the subjective evaluation of their elements, structures, and functions (cf. section 2.4.4 Social life-styles and milieus on page 60). The whole value attitude is mainly established during the first years of our life. This happens not only by proclamations of values, but also by social behaviour towards children and other family members. Apart from the family, there are all educational persons and personal relations important, which can be supportive or corrective for young people. Children and young people need to learn to use their own rights and freedom, but also to accept and to respect the rights of other people, and to take over social responsibility (Erdmann and Grunow-Erdmann, 1993), also for the value of nature and landscapes on their own. Early contacts to nature and landscapes are a condition for developing consciousness and acting potentials to care about nature and landscapes itself (Schemel, 1998)

Children develop from the beginning on an individual behavioural guideline during a creative performance, which points the way and style for their life questions to be dealt with. During the years, children orientate themselves more and more towards own tasks and values. This development line is reflected in what a child wants to achieve, what it minds, how it expresses, what it appreciates, and what it is angry about. Briefly, there is a development of a red line during all life expressions of children. This individual lifeline, i.e. life-style, can be influenced by education. During this process, the young person can learn to take over responsibility and to participate increasingly in solving problems to be dealt with according to his age level. As an adult, this personality will easier take own initiative to solve important problems of the human species and not getting stocked in verbal declarations of “we should” or “we have to”. However, if these basic emotional consciousness and value relations also to nature and landscapes have not been developed, children and adults can show destructive, inhuman, and negative tendencies to the environment, as well as, a shortage of courage for constructive co-operations (Haltner-Mylaeus and Mylaeus, 1992, 1996). They become desensitized to the fellow men (Probst, 1993), as well as, for the different values of nature and landscapes to the human being and on their own. Therefore, education for different behaviour towards nature and landscapes is always based on education for humanity (Haltner-Mylaeus and Mylaeus, 1992, 1996).

Apart from the opportunity to view elements of nature and landscape, children must have also the chance to actively examine and to alter them (Schemel, 1998). Children need uncontrolled playgrounds, where they can experience nature and landscapes on their own (Blinkert et al., 1993; Gebhard, 1998, 2000, 2001; Schemel, 1997, 1998; Table 2.6-1), which allows developing a personal contact to their elements, structures, and functions. Perception of reality ought not to be limited to models and theories, but it must be possible to experience nature and landscapes simply untaught and unsystematically (Dierßen, 1993). Knowledge needs to be acquired by personal experience, which is based on practical experimental acting, as well as, affective and associative experience. However, education about nature and landscapes by active acting opportunities needs individual free space to develop self-motivated learning abilities (Erdmann, 2001).

Practical learning experience has the advantage to pure cognitive learning forms that it always involves different senses, which fosters memory and learning abilities. Contents of our consciousness are mainly moulded by affects and emotions. Therefore, experience in nature and landscapes can be of great importance for motivation and enthusiasm of people (Probst, 1993). As more education institutions prepare and impart their educational contents in a practical way at an early stage, as well as, as much they are orientated towards acting opportunities and particular target groups, as more the intended learning success will be effective and sustainable (Erdmann, 2001).

Participating processes of children’s parents are important to get their support for these grounds of spontaneous self-experience of nature and landscapes (cf. Reidl et al., 2003).

Table 2.6-1. Examples of possible experience of children in nature and landscapes (Reidl et. al, 2003, modified)

Examples of possible experience of children in nature and landscapes

Part of nature and landscapes	Activities	Experience
Soil	• to wade in mud	• to feel soft and wet soil • to experience the combination of soil and water
	• to form with soil, sand, and stones	• to express creativity with natural materials • to experience different conditions of soils, such as smell, colours, weight, consistency, malleability, and permeability
	• to dig and to burrow in soil	• to experience structures and features of soils
	• to slide down slopes of soil	• to touch the bare soil • to experience the resistance of soils
	• to play with a ball on soils	• to get used to irregular grounds
Water	• to move and to wade in water	• to experience water at your own body
	• to spray water around	• to experience the impact of wetness
	• to divert water	• to experience the malleability and creative use of water
	• to pile up water	• to observe the pressure of water
	• to let swim ships in water	• to experience the current of water

	• to construct rafts and to let them swim	• to experience the load-bearing capacity of water
Plants	• to watch, to smell, and to touch plants also in a larger spatial connection	• to experience sensibly plants and landscape scenery
	• to collect plants and flowers	• to arrange plants in different compositions • to realize the distribution and variety of plants
	• to harvest fruits and to eat them	• to perceive fruits by all senses
	• to hide behind plants • to construct hiding-places and retreat areas	• to use plants for shelter
	• to build a camp out of plants	• to use plants for accomodation
	• to cut and to carve parts of plants	• to change and to form plants creatively • to learn motor skills
	• to beat plants	• to experience the sensitivity of plants
	• to construct small objects out of plants	• to experience the malleability of plants and their use
	• to climb on trees	• to use plants as climbing objects and to experience their natural risks
	• to plant, to sow and to water plants	• to experience how to grow and the requirements of plants • to develop personal relations to plants
	• to hang on tree branches and to trample on plants	• to experience the elasticity of trees and herbaceous plants
	• to tighten a rope between trees	• to use plants as an anchorage

	• to make fire out of dead wood	• to use wood as an enery resource • to learn to handle danger
Animals	• to watch, to hear, to smell, and to touch animals	• to develop contacts to animals • to learn sensible behaviour towards animals
	• to watch animals in their habitats	• to experience animals in their habitat context
	• to pursue animals and to catch them	• to experience the reactions and behaviour of animals
	• to take care of animals	• to develop personal relations to animals
	• to construct habitats of animals	• to learn habitat requirements of animals • to creatively design
Landscapes	• to drive by bike and to walk in landscapes	• to experience the variety of reliefs and landscapes • to develop an orientation sense
	• to play hiding and catching in landscapes	• to experience structures of landscapes
	• to take artificial objects with you in landscapes	• to learn to use technical elements in landscapes
	• to play with other children and to meet adults in landscapes	• to experience the behaviour of other children and adults in landscapes • to develop human relations and personal relations to landscapes

Experience in nature and landscapes is an essential condition for developing psychological, physical, intellectual, and social qualities of humans during personal development. The reason can be found in various stimulations of nature and landscapes (cf. chapter 2.3 Psychological values on page 38) and the necessity to try out different ways of solutions and to improvise, i.e. mental and practical flexibility, as well as, creativity, and thinking in complex processes. However, these educational opportunities have been significantly reduced in our industrialized societies also in environments, which are used by adults every day (cf. chapter 2.5 Culture-historical values on page 73). Artificial playgrounds for children often do not sufficiently provide these educational opportunities of different experience. Sterile, pre-fabricated playgrounds cannot substitute green spaces of different opportunities for personal experience of nature and landscapes. Trees, flowers, animals, as well as, abiotic and biotic processes cannot be substituted by consumer goods, hi-tech-games, and television programmes (cf. Pappler and Witt, 2001; Probst, 1993; Rudolf, 1998; Schemel, 1997, 1998).

Many experience of the environment is not made directly any more by children, but through television. The loss of nature and landscapes as playgrounds reduces the possibility to make social experience in groups, for example, to handle aggressions, to discover closeness, to subordinate and to dominate. Consequences of these changed living circumstances of children and teenager can be psychomotoric problems and different social behaviour as a result of development delays and deteriorations. There are symptoms such as concentration problems, hyperactivity, restricted body control, and limited faculty of perception. In addition, there can be lower cognitive abilities due to one-sided spaces of movements and experience. Focusing on cognitive learning at schools is firstly not based on sensual experience in the environment. The contact deficits can lead to generally passive and frightened attitudes towards social environments and even to life-long learning difficulties and behavioural disorders. In extreme cases, they can support criminality (cf. Pappler and Witt, 2001; Wormer, 1998).

Furthermore, experience of nature and landscapes can substantially mould first feelings and primary contacts for a long time. If this necessary experience is missing in the environment of children and teenagers, there can be development disorders and socialization deficits, but also disrespectful treatments of nature and landscapes in the future (cf. Wormer, 1998). Physical and psychological development damages can be the result of insufficient and monotonous experience of nature and landscapes during children's age, which can hardly be compensated by other stimulating substitutional environments nor made up in later life periods. For example, concentration difficulties, contact deficiencies, less self-confidence, and low initiative are deficits of insufficient contacts to nature and landscapes also of adults (Schemel, 1998).

Moreover, self-made experience supports developments of self-confidence, judgement abilities, and responsibility of children and young people (Schemel, 1997). Practical experience of nature and landscapes and education of knowledge of them can also reduce the fear to certain of their elements, structures, and functions, and it can allow better handling risks, for example, concerning mucous animals, sharp plants, deep cliffs, dark caves, storms, etc. (cf. Seiler, 1999). Further important characteristic components of experience of nature and landscapes are openness, the unexpected, surprising, and not being planned. Experience stimulates our fantasy and it opens acting opportunities. It stimulates memories and thereby the reflection of our own life and life developments. One sign for the elementary need of human experience and adventures in nature and landscapes is the successful use in advertisements (Probst, 1993).

For example, wastelands are favourite places, where children can play unattended and experience nature and landscapes on their own (Kowarik, 1993; Probst, 1993; Gebhard, 1998, 2000, 2001; Korpela, 2002). Surveyed playgrounds, even adventure playgrounds, are already a symptom of our hostile cities. Self-experience, secrets, experimental relations to reality are often lost for too much controlled urban developments. It is the freedom, which makes nature and landscapes so attractive. This freedom allows acquiring nature and landscapes truthfully. There is a personal relationship to nature and landscapes developing, when personal needs can be fulfilled and our own fantasy and dreams can wander (Gebhard, 1998, 2000, 2001).

Ecological education for children needs to be integrated in their social context (Bölts, 1995; Heiland, 1999). Personal human contacts of young children and security are decisive to get access to nature and landscapes. The close contact of children to natural processes is important for the development of creativity, especially between five and 12 years of childhood. Children’s experience of nature and landscapes is decisive for their positive consciousness to them later on (cf. Gebhard, 1998, 2001), and personal evaluation of their elements, structures, and functions for practical planning processes and project evaluations. Children develop values and incorporate norms and behaviour during this early socialization (Heiland, 1999). Nature and landscapes are permanently new, but they provide also the experience of continuity and security. The diversity of forms, materials, and colours is stimulating for fantasy. It encourages examining the world and us. Strolling around in nature and landscape can satisfy human desires of freedom and wildness, which can rarely be experienced elsewhere (cf. Gebhard, 1998, 2001; Kowarik, 2004).

Contacts to domestic animals can be most important for preparing relationships to humans during late childhood, pre-adolescence, and elder age. They provide company, familiarity, emotionality, control, care, and communication. Sometimes, domestic animals receive a status like family members. Childless couples can have domestic animals as substitutes for children. Occasionally, the relation to domestic animals becomes so close that their dead is mourned like the one of a close relative (Haubl, 1998; cf. Seiler, 1999). Domestic animals can contribute to develop social behaviour, responsibility, and consciousness of animal life. Furthermore, they are also used for therapeutic purposes (cf. Gebhard, 2001).

Moral consciousness of children is mainly developed in contacts to family and friends (Billmann-Mahecha et al., 1998). Human contacts to nature and landscapes can contribute to develop an ethical sensibility. Respectful treatment, care, and searching for solutions, which have a minimum deteriorating influence on nature and landscapes, have an effect also on behaviour between humans (Seiler, 1999). Public education can start for children, for instance, at school gardens or woodland schools of direct experience and knowledge of the different values of nature and landscapes to the human being and on their own.

However, there are current and past deficits in ecosystem teaching at schools in Germany that need to be altered. Species knowledge and the importance of species for ecosystems are reduced in favour of principal and general system related reflections about ecosystems. In addition, dynamic development aspects of ecosystems are underrepresented (cf. Trommer, 1998; section 3.2.3.3 Mosaic Cycle Hypothesis on page 152). Moreover, other disciplines do not necessarily have the ecological competence as the basic science biology (cf. Trommer, 1998).

At teenager ages, public education of the different values of nature and landscapes to the human being and on their own, as well as, the ways to become active for them can be extended by nature conservation activities or within nature conservation organizations, before adults continue their experience at allotments or through political activities (cf. Schleicher, 1997).

2.6.4 Learning methods

There are several educational fields and methods that are ranging from theoretical analysis and presentations to practical work within nature and landscapes (cf. Erdmann and Draths, 1992; Albin, 1997; Giesel et al., 2000). There are also different didactic concepts, which focus on personal experience in nature and landscapes. There is an intention to include ecological ideas into the practical life-style and the environment of schools (Bölts, 1995; Table 2.6-2). Therefore, learning processes need clear institutional and structural educational frameworks and professional management (cf. Sutherland, 2000), as well as, practical fields in the society of individual experience outside limiting educational systems, such as environmental movements, self-experience opportunities and other dynamic democratic basis groups as emphasized by the ecological pedagogic approach (cf. Erdmann and Draths, 1992). Learning paths for practical experience in nature and landscapes are an example (cf. Nettke, 2000); experience in the wild another one (Meyer et al., 2002).

Table 2.6-2. Different learning approaches of the different values of nature and landscapes (Erdmann, 2002b, modified)

Learning approaches of the different values of nature and landscapes

- learning from experience (situation orientated)
- learning from acting (action orientated)
- comprehensive learning (integration of all subjects and fields)
- responsible learning (value orientated in consciousness and behaviour)
- future related learning (anticipation and participation)

Therefore, firstly it is necessary to provide learning mechanisms, which allow developing knowledge, values, consciousness, attitudes, and capabilities of elements, structures, and functions of nature and landscapes. Moreover, children shall be encouraged to see the environment from different perspectives, for example, from physical, geographic, biological, sociological, economic, political, technological, historical, aesthetic, ethical, and spiritual dimensions. Finally, teaching must awake the perception and inquisitiveness of children for the environment to challenge them and to participate actively in solving environmental problems (Heiland, 1999). Information about nature and landscapes must be promoted vividly. Pictures, symbols, relations and practical examples can help a lot to illustrate complex processes of nature and landscapes and long-term developments (cf. Schahn, 1993; section 6.4 Visualizations on page 307). Playgrounds for children must be centrally located to their homes, easily accessible and safely linked. They need to be of minimum size and experience quality, as well as, protected from disturbing influences, for example, noise and dust. Especially in urban areas, there is a high demand of linked green spaces for children, teenager and adults (cf. Wormer, 1998).

In general, functional education is more effective than intentional education, also of the different values of nature and landscapes. The first concerns all circumstances with an influence on education by their existence in current living processes. The latter focuses on directed attempts by an educator to influence personal education. Therefore, functional education is a component of experience in every day life, whereas intentional education can be more or less integrated in daily practice, depending on the particular case. Human behaviour is mainly orientated in structures. It is open to intentional learning processes, if every day life is supported by it or at least, if every day life does not become more difficult by it (Heiland, 1999, cf. chapter 2.2 Ethical values on page 29).

In addition, education of nature and landscapes has to be comprehensible, practicable, and group orientated (Bölts, 1995). Information must be precise, easy understandable, personalized, and lively (Kruse-Graumann, 1997). It requires also confidence in environmental politics (Bölts, 1995). Effective support can be achieved by personality, especially if the communicator has confidence in the public. The foot in the door strategy starts with small efforts of a different approach to nature and landscapes, before greater responsibilities can be taken over (cf. Kruse-Graumann, 1997, 2000).

Furthermore, education of environmental questions and ecological values should be accessible for all generations. It needs a lifelong education of all social groups of the different values of nature and landscapes to the human being and on their own. Sustainable development is only possible of the society as a whole (Hale, 1999) of participatory planning processes and project decisions. Therefore, interdisciplinary evaluations of nature and landscapes need also to take into account the mentioned conditions of educational values of nature and landscapes.

2.6.5 Conclusive summary

Education of nature and landscapes is the important basis to understand natural processes and historical developments for our consciousness of nature and landscapes and practical behaviour towards them in general. Furthermore, the early starting personal human contact to nature and landscapes is decisive for the ability to develop a sensibility and the knowledge to perceive and to consider all different values of nature and landscapes for practical planning processes and project decisions. Knowledge opens chances and opportunities to participate in democratic opinion processes and to be integrated in social groups. Experience in nature and landscapes is an essential condition for developing psychological, physical, intellectual, and social qualities of humans during personal development, also for taking over responsibility for the value of nature and landscapes on their own.

Education of nature and landscapes from kindergarten to university has the task to enable people to live together in our common world. Three levels of education can be differentiated: intellectual, emotional, and behavioural. Educational methods shall allow developing the sensibility and responsibility for nature and landscapes, as well as, the human species. Education has the duty to provide knowledge in developing values depending on facts, and to encourage self-orientated thinking for solving complex problems. Nevertheless, the ability to communicate, to co-operate, to participate, to think creatively, and to work in different socio-cultural environments is as much important as the pure knowledge of facts. Socio-emotional abilities and community feelings must be developed, differentiated, and shaped in content in interpersonal relationships. Especially Children are still open and interested in nature and landscapes. This openness becomes reduced in later development periods. Therefore, this openness must be used at early stages to teach an awareness and self-responsibility for the different values of nature and landscapes to the human species and on their own.

However, knowledge of the right behaviour is not a sufficient, but a necessary condition for environmental behaviour for practical planning processes and project decisions. Behaviour orientated education needs additionally motivating and responding elements that can be monetary or not. From the pedagogic point of view, rewards are much more effective than penalties.

Environmental behaviour depends on external circumstances, but also on individual conditions. Education has to take into account personal interests, which concern life quality, self-realization, health, family and children, comfort, and financial advantages. Crucial factors for environmental behaviour are specific experience and personal situations, the consciousness of the effectiveness of our own actions, the ability to analyse problems in their complexity, and possibilities to take over responsibility. Therefore, all approaches of environmental education must be seen in the individual psychological, cultural, and social context.

The family has an intense model forming character for later situations in life, also in relation to nature and landscapes and the subjective evaluation of their elements, structures, and functions. The whole value attitude is mainly established during the first years of our life. Apart from the family, there are all educational persons and personal relations important, which can be supportive or corrective for young people. During the years, children orientate themselves more and more towards own tasks and values. A young person should learn to take over responsibility and to participate increasingly in solving problems to be dealt with according to his age level. As an adult, this personality will easier take own initiative to solve important problems of the human species.

Children need uncontrolled playgrounds, where they can experience nature and landscapes on their own, which allows developing a personal contact to their elements, structures, and functions. Perception of reality ought not to be limited to models and theories, but it must be possible to experience nature and landscapes simply untaught and unsystematically. As more education institutions prepare and impart their educational contents in a practical way at an early stage, as well as, they are orientated towards acting opportunities and particular target groups, as more the intended learning success will be effective and sustainable.

Artificial playgrounds for children often do not sufficiently provide these educational opportunities of different experience. Sterile, pre-fabricated playgrounds cannot substitute green spaces of different opportunities for personal experience of nature and landscapes. Furthermore, trees, flowers, animals, as well as, abiotic and biotic processes cannot be substituted by consumer goods, hi-tech-games, and television programmes. Many experience of the environment is not made directly any more by children, but through television. Physical and psychological development damages can be the result of insufficient and monotonous experience of nature and landscapes during children’s age, which can hardly be compensated by other stimulating substitutional environments nor made up in later life periods.

For example, wastelands are favourite places, where children can play unattended and experience nature and landscapes on their own. Nature and landscapes are permanently new, but they provide also the experience of continuity and security. The diversity of forms, materials, and colours is stimulating for fantasy. It encourages examining the world and us. Strolling around in nature and landscape can satisfy human desires of freedom and wildness, which can rarely be experienced elsewhere.

Contacts to domestic animals can be most important for preparing relationships to humans during late childhood, pre-adolescence and elder age. Moral consciousness of children is mainly developed in contacts to family and friends. Public education of direct experience of nature and landscapes can start for children, for instance, at school gardens or woodland schools of direct experience and knowledge of the different values of nature and landscapes to the human being and on their own. At teenager age it can be extended by nature conservation activities or at nature conservation organizations, before adults continue their experience at allotments or through political activities.

There are several educational fields and methods that are ranging from theoretical analysis and presentations to practical work within nature and landscapes. Formal education of nature and landscapes at institutions allows more directed teaching and controls. Whereas, informal education enables more freely to discover the different features of nature and landscapes away from social and learning pressure, as well as, systematic learning barriers. In general, functional education is more effective than intentional education. The first concerns all circumstances with an influence on education by their existence in current living processes. The latter focuses on directed attempts by an educator to influence personal education.

Learning processes need clear institutional and structural educational frameworks and professional management, as well as, practical fields in the society of individual experience outside limiting educational systems, such as environmental movements, self-experience opportunities and other dynamic democratic basis groups. Information about nature and landscapes must be promoted vividly. Pictures, symbols, relations and practical examples can help a lot to illustrate complex processes of nature and landscapes and long-term developments. In addition, education for nature and landscapes has to be comprehensible, practicable, and group orientated. Information must be precise, easy understandable, personalized, and lively.

Furthermore, education of environmental questions and ecological values should be accessible for all generations. It needs a lifelong education of all social groups of the different values of nature and landscapes to the human being and on their own. Sustainable development is only possible of the society as a whole. Therefore, education is of great importance for developing an awareness and sensibility of the different values of nature and landscapes for practical participatory planning processes and project decisions.

The scientific discovery and knowledge of the complex contents and interactions of nature and landscapes and the human being are a basic condition for their education and for their evaluation in general. Nature conservation is an applied science of a spatial and time related planning process, which depends on subjective evaluations of nature and landscapes in a democratic decision process based on the objective knowledge of the different elements, structures, and functions of nature and landscapes (cf. chapter 1 Introduction on page 12).

Therefore, research in natural sciences and humanities and their appropriate methods provide the source for interdisciplinary evaluations of nature and landscapes for resulting practical planning processes and project decisions with an impact on them. Consequently, the following chapter shall reveal the scientific value of nature and landscapes and considerations about methodical applications as the last component of a comprehensive framework of values for interdisciplinary evaluations.

2.7 Scientific values

2.7.1 Scientific backgrounds

All kind of scientists have analysed nature and landscapes for different purposes for all times of human history. Firstly, there are applied sciences, which are searching for direct or indirect benefits of nature and landscapes. Secondly, there are theoretical sciences, which investigate the current and future status of nature and landscapes, its components, and relations just for questioning the sense of life on their own. The freedom of sciences is a fundamental right according to article 5 paragraph 3 of the German constitution (Bundeszentrale für politische Bildung, 2002).

In practice, different scientific fields are unequally supported by economic, structural, and personal aids by the state, private companies, and institutions, respectively, depending on different research priorities. For example, research in biotechnology is generally seen as much more important and therefore much better funded than nature conservation, despite they are both applied sciences. One reason can be found in the difficulty to evaluate public goods and to consider long-term benefits in politics (cf. chapter 2.1 Economic values on page 19 and 2.2 Ethical values on page 29, respectively). This refers even more to theoretical sciences, when it is not clear, at which time and to which extend the human species will benefit (e.g. economically) of the research results.

2.7.2 Scientific survey and analysis methods

Basically surveys of nature and landscapes start with an overview of the current situation of abiotic and biotic features. Data collections are needed of historical and current developments derived from primary and secondary information. Nature and landscapes need often to be described in verbal and plan form. Each scientific group needs its own indicators for the different values of nature and landscapes, which are mentioned above. For instance, there are several ecological and biodiversity indicators (cf. Zisenis, 1993; Köppel et al., 1998; for biodiversity e.g. Jedicke, 2000; Delbaere, 2002; Delbaere et al., 2002; Choudhury et al., 2004; for environmental technology indicators e.g. Giegrich and Knappe, 2004; for global climate changes e.g. EEA, 2004).

However, the selection of certain indicators already includes an assumption of its validity for the condition of nature and landscapes, i.e. that the indicator would truly reflect the situation, and thereby an evaluation of reasons for impacts (cf. Empacher and Wehling, 2002; chapter 3.1 General conditions of evaluations on page 106). The duration of each survey depends scientifically on the evaluated subjects, practically on the time, money, and scientific support available (Riecken, 1992). Moreover, there is monitoring data necessary for comparisons (cf. section 6.3 Monitoring on page 304).

Furthermore, there is a danger that continuously more abstract models based on statistical analysis and scenarios substitute scientific and personal experience in the field, which can lead to assumptions of unreal conditions of nature and landscapes (Rudolf, 1998). For example, meta-population sizes can vary because of changing interspecific and intraspecific competition, habitat conditions, genetic circumstances, demographic events, and anthropogenic influences (Statistisches Bundesamt and Bundesamt für Naturschutz, 2000; Martin, 2002; cf. PVAs in section 3.2.2 Rarity and endangerment on page 114; section 3.2.4.5 Methodical difficulties on page 174; Figure 2.7-1).

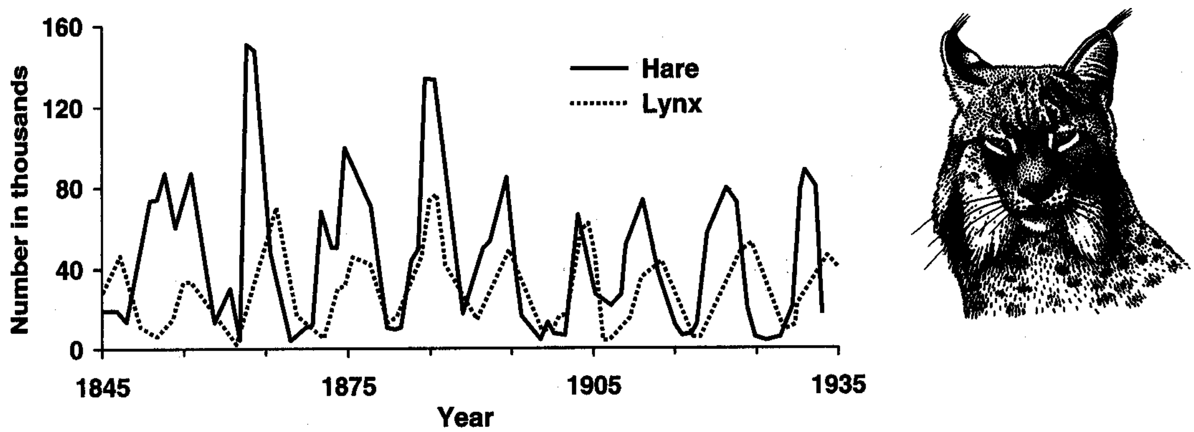

Figure 2.7-1. Predator-prey fluctuations of population sizes of the Lynx (*Lynx spp.*) and the Snowshoe hare (*Lepus americanus*) that are based on pelt records of the Hudson Bay Company (Frankham et al., 2002) reproduced by kind permission of Cambridge University Press, Cambridge, UK

Therefore, it is scientifically necessary to survey the ground for several years. However for Environmental Impact Assessments (EIAs) in practice, there is often not enough time for it. Furthermore from the scientific point of view, all animal groups should be surveyed, analysed, and evaluated, because each group occupies different ecological niches and therefore contributes differently to the ecosystem as part of the value to the human being and on their own on individual and community level. However, only keystone indicator groups can practically be selected (cf. section 3.2.4.3 Keystone species on page 171). Experimental Model Systems (EMS) attempt to combine the advantages of field studies with model studies. Model species, which can be methodically good controlled, are investigated within structurally very simplified model landscapes (Halle, 2002).

Furthermore, also plants can vary significantly in their biomass and population sizes from year to year, for example, population fluctuations of Chiltern Gentian (*Gentianella germanica*), Fringed Gentian (*Gentianella ciliata*), and Fragrant Orchid (*Gymnadenia conopsea*) on chalk grasslands nearby Göttingen in Germany (cf. Statistisches Bundesamt and Bundesamt für Naturschutz, 2000).

Scientific research shall result in better understanding of nature and landscapes, analysis of historical processes, and prognosis of future developments. In addition, abstract models of nature and landscapes (cf. Gurney and Nisbet, 1998; Poschmann et al., 1998; Peters, 1999; J∅rgensen and Bendoricchio, 2001; Turner et al., 2001) and simplified scientific rules are important results of scientific analysis. Therefore, evaluations of nature and landscapes must concentrate on specific elements, structures, and functions of nature and landscapes and their interacting relations. Certain general criteria are necessary for interdisciplinary evaluations of nature and landscapes of the comprehensive values mentioned above. These criteria must be applied by value discipline specific survey and analysis methods to gather the necessary data for practical planning processes and project evaluations.

2.7.3 Conclusive summary

Nature and landscapes have a scientific value for all sciences, irrespectively if they are carried out applied or just as basic research, respectively. However in practice, certain applied sciences are better funded than others, for example, biotechnology more than nature conservation, natural sciences generally more than humanities. The reason might be found in the unpredictable (economic) outcome of theoretical sciences for politicians, and investing companies, which calculate in shorter time periods.

There is a danger, that the freedom of scientific research and its creativity becomes rather limited by just focusing on applied sciences, which guarantee a certain short-time-scale orientated income for specific groups (cf. chapter 2.1 Economic values on page 19). This is neither appropriate to cover future developments of our nature and landscapes, nor to sustain a stable income of companies and employees, nor to innovate new scientific developments for our societies.

Especially the humanities should be more supported and integrated in interdisciplinary research and education of natural sciences to be able to face current and future developments of nature and landscapes and our societies (cf. chapters 1 Introduction on page 12 and 8 Outlook into future research on page 321, respectively). For example, ethnosciences investigate systematically traditional human knowledge systems of nature and landscapes, and embrace the familiar fields of ethnobotany, ethnozoology, ethnoecology, ethnobiology, and others (Posey, 1999). The science bionics deals with systematic transformations of problem solutions of nature and landscapes in human techniques (cf. WBGU, 1999a; Baumgärtner, 2002; Nachtigall, 2002; Nader, 2002).

Natural sciences and humanities need to apply own survey and analysis methods according to the same framework of criteria for interdisciplinary evaluations of nature and landscapes.

2.8 Conclusions

Nature and landscapes have different values for the society and on their own. They need to be clearly separated for developing a systematic framework of interdisciplinary evaluations of nature and landscapes to be able to weigh them up against each other for practical planning processes and project decisions.

In general, we can distinguish between anthropocentric values, which are purely concentrated on the benefit to the human being, and the human consciousness that there is an ethical value of nature and landscapes on their own (Table 2.8).

Table 2.8. The different values of nature and landscapes (Zisenis 1993, 1998, 2005, modified)

Values of nature and landscapes	
• ethical	• economic • psychological • culture-historical • social • educational • scientific

However, these values cannot be considered isolated. They depend on and influence each other. In a mainly economically dominated society, private material economic values of the public good nature and landscapes seem to be overvalued in comparison to the material and immaterial use of nature and landscapes for the public. Current economic evaluation approaches neither sufficiently cover the immaterial values of nature and landscapes, nor they have been successful to alter the exploitation of nature and landscapes and the human being in the long-term on earth. They do not provide an ethical consciousness that respects that nature and landscapes have also a value on their own, but also neglect the different values and conditions of the interacting influences between the human species and nature and landscapes.

Despite an interdisciplinary evaluation by the human being will be always incomplete and subjective, it can structure systematically the different values of nature and landscapes in a comprehensive framework. However, even if there were a common ethical approach that respects also the value of nature and landscapes and their components on their own as a leading principle for every day decisions of planning processes and project evaluations with an impact on nature and landscapes, this would not guarantee an equally balanced consideration of all demands of the society and nature and landscapes on their own. Psychological values of nature and landscapes depend highly on our subjective perception of beauty, inspiration, and satisfaction, i.e. an aesthetic and health value by all senses depending on a cognitive evaluation process of current and historical experience and development of the human body and the society as a whole.

Therefore, social values, structures, and norms also influence the subjective perception and evaluation of elements of nature and landscapes. First of all, basic human material and immaterial demands need to be fulfilled. Furthermore, the consciousness of a specific ethical approach to nature and landscapes is a result of an educational learning, socialization, and emotional binding process within a certain culture-historical period. Moreover, the interacting influences of the human being on nature and landscapes have become manifested in structures and functions as a culture-historical value themselves. Our practical behaviour towards nature and landscapes depends on acting limits, knowledge, and responding motivations of more or less participative contributions to planning processes and project decisions.

Natural sciences and the humanities allow investigating the basic knowledge for the different values of nature and landscapes to the society and on their own. Each scientific discipline has already developed appropriate methods to survey and to analyse the different values of nature and landscapes, as well as, the determining backgrounds and interacting relations of their subjective evaluation. These survey and analysis methods of the different scientific disciplines partly overlap, such as socio-economic methods, as well as, their leading values for the same elements, structures, and functions of nature and landscapes. For example, there are socio-economic methods to determine the material economic and the immaterial psychological recreational values of green spaces.

However, there is a common framework of the same evaluation criteria necessary for each discipline to be able to get comparable results for a participative weighing up process of the society in practical planning processes and project evaluations with an impact on nature and landscapes. General conditions of evaluations need to be discussed, as well as, already proposed evaluation criteria critically assessed to develop a condensed framework of criteria to be applied according to the different values for interdisciplinary evaluations of nature and landscapes. In addition, the next third chapter shall arrange and discuss mainly species and population ecological survey and analysis methods, as well as, concepts to the particular criteria within an ecosystem context due to the author's scientific biological and nature conservation background to provide the evaluation ground for the application of the particular criteria according to the leading different values.

3. Criteria for evaluations of nature and landscapes

After this research has discussed the different values of nature and landscapes and some of their common survey and analysis methods of the specific scientific disciplines in the second chapter Different values of nature and landscapes on page 19, this third chapter starts with an overview of general conditions of evaluations, which is followed by a discussion of proposed criteria by several authors to condense them to a comprehensive selection for comparable evaluations.

In addition, remarks of the practical use of the condensed criteria in accordance with the different values will be given in this third chapter, as well as, some general methodical concerns to apply the criteria. Biology is the study of living organisms (Allen, 1990), which historically integrated mainly physics, chemistry, and mathematics in investigating living processes of nature and landscapes (cf. Klötzli, 1993). For practical reasons, biologists have distinguished nature and landscapes' living contents in definitions of species, populations, and ecosystems. Ecology is the branch of biology dealing with the relations of organisms to one another and to their physical surroundings (Allen, 1990). Therefore, this chapter lays also an incomplete foundation of selected mainly species and population ecological survey and analysis methods, as well as, concepts within an ecosystem context to the particular criteria of the condensing framework. It is the author's intention to set a starting point to systematize the wide spectrum of different especially ecological methodical proposals, which is a criticized scientific and practical deficit by different authors in chapter 1.2 Deficits of current evaluation methods on page 12.

This basic framework of criteria shall be used by each discipline according to the mentioned values. However, it is not possible to relate particular criteria to the different values by general application schemes of certain survey and analysis methods in detail, because the appropriate methods and indicators must be selected by each discipline after pre-studies depending on the particular case of nature and landscapes on specific spatial and time-scales (cf. Dierßen, 1999). In addition, it would exceed the intention and the possibilities of the interdisciplinary approach of this research, also as a single person, to try to cover all disciplines by providing methodical standards for them or even just ecological methodical standards.

3.1 General conditions of evaluations

In general, evaluations must be objective, reliable and validate (Bechmann, 1988a; Schröder, 1996; Gareis-Grahmann, 1997; Maderthaner, 1999; Köhler et al., 2002). Objective means in this context of evaluations of nature and landscapes that there are always the same outcomes of used values, criteria, and measurement methods under similar conditions, independent of the particular scientist. Nevertheless, evaluations are subjective, time and spatial related. Reliable considers that the used criteria and measures reflect exactly, i.e. trustworthy the situation, whereas validate refers to the relevance (significance) of the used criteria and depending measurement methods to the related values. Moreover, evaluations must be also flexible, transparent, and practical (Demuth and Fünkner, 1997; Demuth, 2000), as well as, efficient (von Haaren, 2004c). Flexibility is necessary to be able to evaluate different conditions of nature and landscapes. Transparency enhances the acceptance of evaluations for the public, and provides the basis for an information exchange and common decision process. Practicability is decisive to be able to implement evaluations at particular cases. Efficiency refers to the available spatial and time resources.

In addition, evaluations should be universally applicable (Romahn, 2003), comparable (Haber et al., 1988), and sensitive (Zehlius-Eckert, 2001; Table 3.1-1).

Table 3.1-1. General conditions of criteria for evaluations of nature and landscapes (cf. Bechmann, 1988a; Haber et al., 1988, 1993; Demuth and Fünkner, 1997; Gareis-Grahmann, 1997; Placke and Scherfose, 1998; Maderthaner, 1999; Demuth, 2000; Zehlius-Eckert, 2001; Köhler et al., 2002; Romahn, 2003; von Haaren, 2004c)

Evaluation conditions of criteria	
• objective	• comparable
• reliable	• flexible
• validate	• practical
• transparent	• efficient
• universally applicable	• sensitive

However, despite there are quite sufficient proposals for collecting and storing data (cf. Reynolds, 1998), there are still significant deficits of how to evaluate and to present results in planning processes (Placke and Scherfose, 1998). Thus, evaluations of the same subjects and alternatives can result in different evaluations and orders, if they (Bechmann, 1988a):

- have different descriptions of the same subjects (different models of facts)

- represent different aims, or weight these aims differently, or interpret their contents differently
- have different considerations of targets and facts in evaluation systems of different methods or evaluation rules.

Therefore, evaluation systems should content of models of facts (specific requirements of facts), target and value systems, as well as, evaluation methods and rules, which are transparent and comprehensible for external observers (Bechmann, 1988a). In general, evaluations should fulfil the following conditions (Bechmann, 1988a):

- to provide as far as possible exact and accurate models of facts
- to provide as far as possible exact and explicit target and value systems that reveal the used values of the evaluations, the relations between the different values and their weighting to each other, as well as, the representatives of the value systems
- to result in consistent orders of the evaluated alternatives
- to have formally consistent and comprehensible evaluation structures.

Moreover, there are additional minimum conditions of evaluations of nature and landscapes, which ought to (cf. Bastian und Schreiber, 1999):

- be logically constructed, unambiguous, and meaningful as a basis
- correspond to the regarded nature and landscape parts, evaluation criteria, and desired exactness
- consider newest research and current evaluation criteria
- validate scientifically input figures and ecological relations
- consider all relevant factors and conditions
- measure all necessary data within justifiable time limits
- be secure, comprehensible, and flexible
- differentiate sufficiently the results
- present vividly and clearly the evaluation steps
- be practical, justifiable, and relevant for planning processes.

Furthermore, evaluations of nature and landscapes need to analyse current and historical situations and to evaluate future changes of certain projects. For example, the Environmental Impact Assessment (EIA) approach tries to evaluate impacts of certain plans and projects on humans, including human health, animals, plants, and biological diversity, soils, water, air, climate, and landscapes, cultural heritage and other goods, as well as, their interactions (cf. Sporbeck et al., 1997; Storm, 1988; SenStadt, 1999; Rassmus et al., 2003; Bundesministerium der Justiz, 2005). However, current EIAs just cover some of the values of nature and landscapes mentioned above and provide some criteria for their evaluation (cf. chapters 2.8 Conclusions on page 103 and 5 Empirical study of Environmental Impact Assessments (EIA) on page 282).

In addition, evaluations of nature and landscapes for planning purposes should include concrete terms and prognosis of (cf. Riecken, 1995):

- determining ecological factors
- deficits and handicaps
- spatial and functional relations
- assumed reactions of biocoenosis, habitats, as well as, spatial and functional relations to changes of nature and landscapes.

Moreover, pre-studies are decisive conditions of evaluations of nature and landscapes (Table 3.1-2; cf. Haber et al., 1993; European Commission, 2001b).

Table 3.1-2. Functions of pre-studies for evaluations of nature and landscapes (Bernotat et. al., 2002a, modified)

Functions of pre-studies	
• to summarize facts • to put together normative conditions • to develop model guidelines • to derive concrete problems and questions	• to screen appropriate evaluation methods • to prove the usability of available data • to investigate information requirements • to determine the extend of investigations

Last not least, personal experience and creativity of the researcher are import components for decisions about appropriate methods for surveys and for developments of theories (cf. Jessel, 1998).

3.2 Criteria for evaluations of nature and landscapes

3.2.1 Selection of different proposed criteria

This research study intends to provide comprehensive criteria for evaluations of nature and landscapes, which are used to apply the superordinated values, which are described in chapter 2 Different values of nature and landscapes on page 19. Consequently, these criteria shall serve to classify the various elements of nature and landscapes to apply the different values for interdisciplinary evaluations by scientific discipline specific survey and analysis methods. There are already several criteria proposed by different authors (e.g. Ratcliffe, 1977a, 1977b;

Auhagen and Sukopp, 1983; Johnston, 1990; Plachter, 1991b, 1994; March, 1993; Caldecott et al., 1994; Bastian, 1997; Dierßen and Roweck, 1998; Schäfer et al., 2001). Ratcliffe has developed different criteria for the assessment of rural areas (cf. Ratcliffe, 1977a, 1977b). Naturalness, rarity, and typicalness can be found in Plachter's criteria naturalness/degree of human impact, rarity and endangerment, and representativeness (cf. Plachter, 1991b, 1994). Ratcliffe has proposed additional criteria of intrinsic value and recorded history. Intrinsic value refers to the subjectively personal value of nature and landscapes to someone, for example, a certain tree in a garden that has been planted by someone and therefore comprises a personal relationship of the planter. Ratcliffe's proposed criterion recorded history points out the historical human component of nature and landscapes, for example, that a tree was planted to commemorate a certain historical event. Plachter's criterion usability covers these two criteria, which express types of usages of nature and landscapes for the purposes of the human species. However, Plachter does not adopt Ratcliffe's criterion fragility, but he adds ecological function and restoration ability (cf. Plachter, 1991b, 1994).

In addition, I prefer the term re-establishment ability instead of restoration ability used by Plachter (cf. Plachter, 1991b, 1994) to prevent the danger of assuming that nature and landscapes could be technically reconstructed (cf. Gilbert and Anderson, 1998). Structures and species of ecosystems of nature and landscapes develop during natural succession processes[9]. They cannot be developed as engineering projects (Zisenis, 1993; cf. Nettmann, 1992), also on genetic level (cf. Kowarik and Sukopp, 2000). In addition, the term re-establishment is used in this research instead of regeneration to include also human activities on purpose in the re-establishment of parts of nature and landscapes, such as cultural objects created by the human species.

Ratcliffe's further criterion potential value, i.e. "that certain sites could, through appropriate management of even natural change, eventually develop a nature conservation interest substantially greater than that obtained at present" (Ratcliffe, 1977a, 1977b) is a hypothetical projection into the future, which involves too many variables to be able to be considered. For example, if a certain green space will be colonized by particular species or used by certain people depends on so many influences that are not sufficiently calculable for the future.

In addition, Ratcliffe suggests diversity and position in an ecological/geographical unit as criteria. However, they can only be used to measure other criteria, but they are not criteria themselves (Zisenis, 1993; cf. sections 3.2.3.4 Indicator species of naturalness on page 153, 3.2.4.1 Indicator species on page 159, and 3.2.6.2 Vulnerability factors on page 187, respectively).

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[9] Successions are directional processes of colonization and extinction of species in a given site, which are caused by biotic (autogenous) or abiotic (allogenous) forces in ecosystems (Dierßen, 2000a).

Dierßen and Roweck propose in addition to rarity, endangerment, vulnerability, representativeness, hemeroby[10], also diversity, age, and trophic conditions (Dierßen and Roweck, 1998). However, the latter three are also measures of conditions of nature and landscapes, but not criteria for their evaluations.

London Ecology Unit's criteria representation, habitat rarity, species rarity, inability to be recreated, and typical urban character (Marsh, 1993) are covered by typicalness, rarity and endangerment, re-establishment ability, and typicalness, respectively. Species and habitat richness are forms of diversity, but not criteria themselves, as well as, size and geographical position just describe criteria. Culture/historic character is not a criterion either, but a value of nature and landscapes. Access, use, and aesthetic appeal are measurable expressions of the criterion usability. Potential is a too vague future orientated criterion as discussed above. Therefore, it is not used in this research (cf. Zisenis, 1993).

Placke and Scherfose summarize a number of evaluation criteria, which are used in ten management plans: rarity, endangerment, (species) diversity, representativeness, completeness, naturalness (hemeroby), replaceability (ability to regenerate/re-establishment ability), sensitivity (stability/elasticity), development potential, and structural diversity (Placke and Scherfose, 1998). Rarity and endangerment, naturalness/degree of human impacts (hemeroby), and re-establishment ability are the same criteria as mentioned by Placke and Scherfose. Representativeness is covered by typicalness and sensitivity by vulnerability. Development potential is excluded as a criterion, because of the unpredictable circumstances that refer also to Ratcliffe's criterion potential value as discussed above. (Species) diversity and structural diversity are measures of objective conditions of nature and landscapes, but not criteria themselves as also discussed above.

Moreover, there are the following objectives and values suggested of species protection for the urban development of Berlin (Auhagen and Sukopp, 1983):

- preservation of functions of ecosystems
- conservation of adaptative evolutionary potential
- preservation of so far unknown usability potential
- recreation and protection of natural heritage.

In addition, values of species protection in the centre of urban areas are according to Auhagen and Sukopp (Auhagen and Sukopp, 1983):

- stability of ecosystems
- biological pest control
- biological filter decontamination

[10] Hemeroby expresses the degree of human impacts (cf. Rackham, 1980; Ellenberg, 1988; Gilbert, 1991; Peterken, 1991; Kowarik, 1999; section 3.2.3.4 Indicator species of naturalness on page 153).

- humus production on agricultural and forestry areas
- potential use as biological indicators.

All these mentioned values of nature and landscapes are covered by the criteria usability and ecological function for present opportunities or future possibilities, except of protection of natural heritage, which is a culture-historical reason itself (Zisenis, 1993).

Johnston focuses on values of urban habitats for people for emotional, intellectual, social, and physical (recreational) benefits (Johnston, 1990), which are basic values or sensory feelings or intellectual stimulations as a reaction of conditions of nature and landscapes, respectively, but not criteria for their evaluation.

Furthermore, Schäfer et al. provide an overview of values, criteria, and measurement methods of different authors, which can be classified as following. The corresponding values and criteria of this research are noted in brackets (Table 3.2-1).

Table 3.2-1. Values, criteria, and measurement methods for evaluations of nature and landscapes of different authors (Schäfer et. al, 2001, modified)

Values	Criteria	Measurement methods
• culture-historical values (*culture-historical values*)	• rarity of habitat types in relation to landscape areas (*rarity*) • rarity of species and of societies (*rarity*) • naturalness (*naturalness*) • sensitivity to polluting impacts (*vulnerability*) • ecologically protective functions of abiotic factors (*ecological functions*) • habitat type and species representativeness (*typicalness*) • synecological value in habitat linking systems (*ecological	• sizes of habitats • specific area conditions • species and structural diversity • occurrence at nature regions • management and use intensity • maturity • degree of perfection

functions)
- spatial and time ability of replacements (*re-establishment ability*)
- degree of endangerment of species and habitats (*rarity and endangerment*)
- potential of naturalness (*naturalness*)
- potential of nature conservation (total *values of nature and landscapes*)

In addition, Caldecott et al. point out representativeness, complementary, and insurance or redundancy as criteria. The latter shall indicate the need for some duplication in the coverage to offset risks of planning failures, project failures, and other factors, such as climate changes (cf. Caldecott et al., 1994). Representativeness and complementary are covered by typicalness, whereas insurance and redundancy to reduce risks of extinctions are part of estimations on measurement levels (cf. sections 3.2.2.4 Minimum Viable Metapopulation (MVM) concept on page 126 and 3.2.2.5 Population Vulnerability Analysis (PVA) on page 131, respectively), but not criteria themselves.

Moreover, McNeely et al. suggest distinctiveness, threat, and utility (McNeely et al., 1990; Caldecott et al., 1994). Distinctiveness is covered by rarity and typicalness. Threat relates to endangerment, and utility is similar to usability.

Consequently, the different used criteria can be condensed to the following selective framework (Table 3.2-2).

Table 3.2-2. Condensed number of criteria for evaluations of nature and landscapes (Zisenis 1993, 1998, 2005, modified)

Criteria	
• rarity and endangerment • typicalness • vulnerability • usability	• naturalness/degree of human impacts • re-establishment ability • ecological functions

However, there are concepts, methods, and indicators necessary to measure these evaluation criteria according to the superordinating values for interdisciplinary evaluations of practical planning decisions and project assessments. Living organisms are the basis of our life, apart from the abiotic components. Ecology is the biological subdiscipline to discover and to explain their interrelations within ecosystems. The different values of nature and landscapes manifestate in their biological and non-biological components, including the relations to the human being.

Therefore, it is first of all important to get to know, which biotic and abiotic elements exist at a certain area within a certain time period and what are the influences on their survival and development for interdisciplinary evaluations. A main part of Environmental Impact Assessments (EIA) consists of surveys and analysis of biotic and abiotic components, and their dynamic interrelations (cf. chapter 5 Empirical study of Environmental Impact Assessments (EIA) on page 282). The biodiversity of fauna and flora can be roughly located on species, population, and ecosystem levels (cf. section 3.2.2.3 Biological diversity on page 123). The following sections will provide a discussion of selected mainly species and population ecological survey and analysis methods, as well as, concepts within an ecosystem context related to the particular criteria of the condensing framework. It is the attempt to systematize and to allocate these methodical concerns to the different evaluation criteria. Systematically, there is an order starting from genetic and species level to populations and whole ecosystems.

Moreover, it is also the intention to reveal the significance of these common theories and methods for nature conservation purposes, which is expressed in the assignment to the different applied evaluation criteria. Therefore, a lot of data will be provided from different sources to allow arranging the relevance of the different criteria within a Central European or even global context.

3.2.2 Rarity and endangerment

Different values of nature and landscapes depend on the frequency of existence of certain elements of nature and landscapes. Concerning species, rarity and endangerment can be combined criteria, but rare organisms can be just at the border of their species range (Pullin, 2002). However, the latter case might become an evolutionary advantage, if these species populations are better adapted to different changing conditions of nature and landscapes. For example, if climatic changes pushed away the populations of the main distribution areas, they could be the decisive gene pools for recolonizations (cf. Mühlenberg and Slowik, 1997). Furthermore, rarity can be also a biological way of species to prevent selection pressure of predators. In addition, rarity can be an ecological way to provide enough resources, for example, territories of low population density of species on the top of food-chains (cf. Plachter, 1991a; Wulf, 2001). Nevertheless, many rare organisms are also endangered, because they do not have buffer populations.

3.2.2.1 Red data lists

Red Data lists express the degree of endangerment of plant and animal species, as well as, of their habitats. They are one of the most traditionally used methods for evaluations of nature and landscapes. Meanwhile, they cover most organism groups and habitats (overview for Berlin in Auhagen et al., 1991; worldwide in Groombridge, 1994; for Germany in Jedicke, 1997a; for German speaking countries in Central Europe in Köppel et al., 1999; for the USA in Stein, 2002; for recently extinct organisms CREO, 2004). Red Data lists are based on surveys, analysis of data from collections and literature, as well as, expert knowledge. Often expert groups decide about final classifications of species in Red Data lists (Jessel, 1998).

The conditions of cultural landscapes about 1850 are the agreed starting-point of Red Data lists of plants in Europe, not the original world of plants without influences of the human being (cf. chapter 2.5 Culture-historical values on page 73). There is only enough information for comparisons for the last 150 years (Sukopp, 1998). However, reforestation and secondary succession are one of the most important reasons for endangered open land species and biocoenosis, which increasingly happened during the 18th century (Wulf, 2001).

Nevertheless at the mid 19th century, the total amount of native and introduced fern and vascular plant species reached its postglacial maximum in Germany. For 4,000 years, the number of established fern and vascular plant species has grown in Germany, but since about 150 years, it has been falling. Since this period, important reasons for their decrease in open fields are cultivation of wetlands, introduction of mineral fertilizer, chemical pesticides, and intensification of agriculture, as well as, higher air pollution due to industrialization. Despite most plant species became already extinct before the

Second World War, an overall reduction of plant species can be noticed in Germany since 1950 (Korneck et al., 1998; Figure 3.2-1).

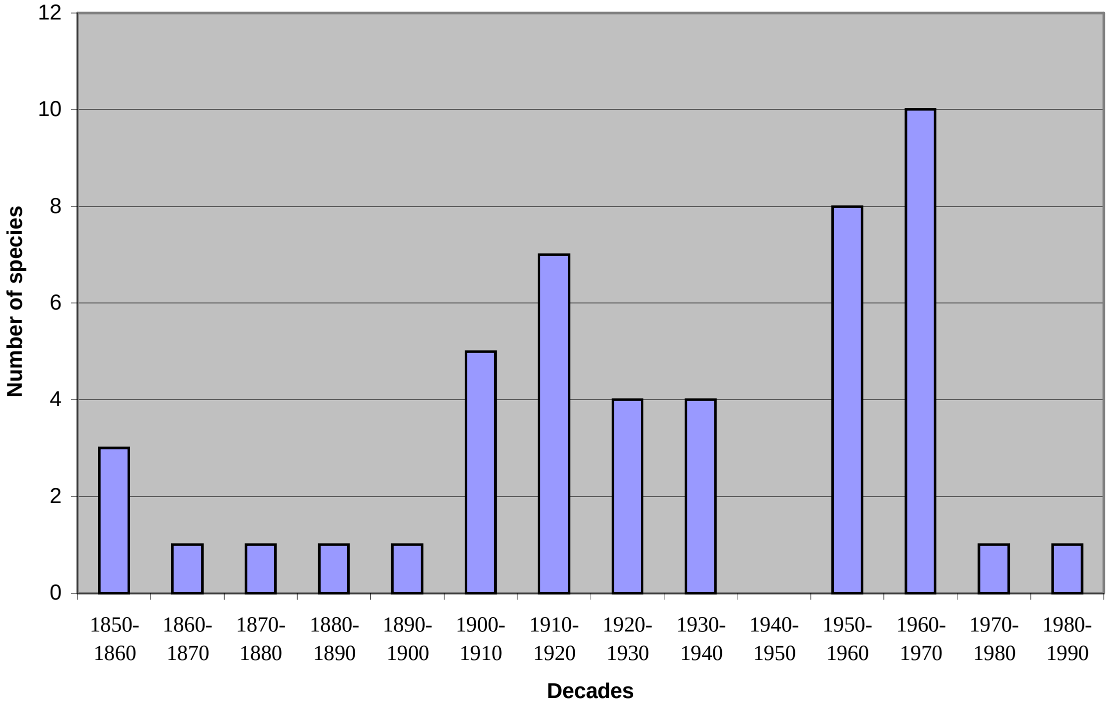

Figure 3.2-1. Amount of extinct and disappeared fern and vascular plant species in Germany between 1850-1990 (Korneck et al., 1998)

The World Conservation Union (IUCN) classifies basically in extinct, endangered, vulnerable, rare, indeterminate, and insufficiently known (Groombridge, 1992) or even more detailed (Table 3.2-13; cf. Sutherland, 2000; Pullin, 2002).

Table 3.2-3. IUCN categories of Red Data lists (cf. IUCN Species Survival Commission, 1994)

Categories of IUCN Red Data lists	
• extinct	• vulnerable
• extinct in the wild	• lower risk
• critically endangered	• data deficient
• endangered	• not evaluated

Practically, there is a combination of population decrease, rarity, and endangerment factors, which categorizes Red Data list species (cf. Auhagen et al., 1991; Stein, 2002). Furthermore, rarity and endangerment refer to specific regions. For example, species can be classified as endemic in relation to certain political borders or to geographical regions (Groombridge, 1994). In fact, 64 endemic plant species have already become extinct in Europe, and 45 % of all butterfly species, 38 % of bird species, 24 % of plant species and subspecies, as well as, 5 % of mollusc species are considered to be threatened (European Commission, 2001a).

There is a simplified tendency that most endangered species are those, which depend on specific habitat requirements (Jedicke, 1997a):

- water habitats of high water quality, low or not polluted (algae, mayflies, fishes, dragon-flies, water mosses, partly amphibians and "reptiles" [11])
- dry and warm habitats (bees, crickets, "reptiles")
- surface structures, which have low pollution input by the air, especially rocks, partly open soils, and more complex ("higher") plants (mosses, lichens)
- very specific habitat characteristics, for example, dead wood (buck beetles (*Cerambycidae*))
- requirements on spatial and time levels of habitats and their characteristics during specific development periods and times of the year (species of all organism groups, which depend on different habitats).

There are particular reasons for the endangerment of ferns and flowering plant species (Table 3.2-4; cf. Jedicke, 1997b; Korneck et al., 1998), as well as, for animals in Germany (cf. Blab, 1993; Mühlenberg and Slowik, 1997; for birds in Stickroth et al., 2003).

Table 3.2-4. Reasons for the endangerment of ferns and flowering plant species in Germany ordered according to affected plant species of Red Data lists (Korneck and Sukopp, 1988)

Reasons	Amount of affected Red Data Book plant species in Western Germany
Cultivation changes	305
Dismissal of cultivation	284
Elimination of specific habitats	255
Filling up of habitats or construction works	247
Drainage	201
Soil nitrification	176
Mining and digging out	163
Mechanical impacts	123
Impacts like "weeds" removal, clearing, and burning	115
Collecting	103

[11] "Reptiles" is put in quotation marks, because this group does not belong to one monophyletic taxon (cf. Sedlag and Weinert, 1987), i.e. they did not split up out of one species of evolutionary origin.

Water way improvements and maintenance	68
Stopping soil wounding	59
Introduction of exotic species	43
Soil and air pollution	38
Lakes and river nitrification	36
Lakes and river pollution	35
Creation of artificial ponds and canals	27
Use of herbicides, and clearing of seeds	26
Urbanization of small towns	22
Abolishment of certain field crops	8
<u>Causes</u>	
Agriculture	513
Forestry and hunting	338
Tourism and recreation	161
Extraction of natural resources and small opencast mining	158
Business, settlements, and industries	155
River management	112
Lake management	79
Traffic and transport	71
Waste and sewage disposal	71
Military use	53
Sciences, education, and culture	40
Food and pharmacy industry	8

In Germany, the highest amounts of endangered fern and vascular plant species are Mediterranean, oceanic, and continental species, which are at their border of distribution and which are mostly growing at extreme habitats. Especially light adapted plants of nutrient poor grounds belong to them. About a quarter of endangered fern and vascular plant species in Germany are growing on dry or medium dry grasslands. Natural and species poor habitats content the highest amounts of endangered species, such as oligotrophic waters and bogs, whereas in comparison, woodland plant species are not as much endangered in Germany (Korneck et al., 1998). Nowadays, most of the endangered plant associations of our cultural landscapes are bound to oligohemerobic and mesohemerobic habitats (Dierßen and Reck, 1998b).

In total, there are 3319 fern and vascular plant species in Germany (3001 natives and archeophytes, 318 neophytes: definitions cf. 4.1 Definitions on page 226). 943 of them, i.e. 28.4 % are on Red Data lists, whereas 47 fern and vascular plant species, i.e. 1.4 % are meanwhile already extinct (Figure 3.2-2). Furthermore, 924 species are endangered on more than 50 % of their dispersal ranges in Germany. More than 620 fern and vascular plant species have become extinct at one Federal State of Germany at the minimum (Korneck et al., 1998).

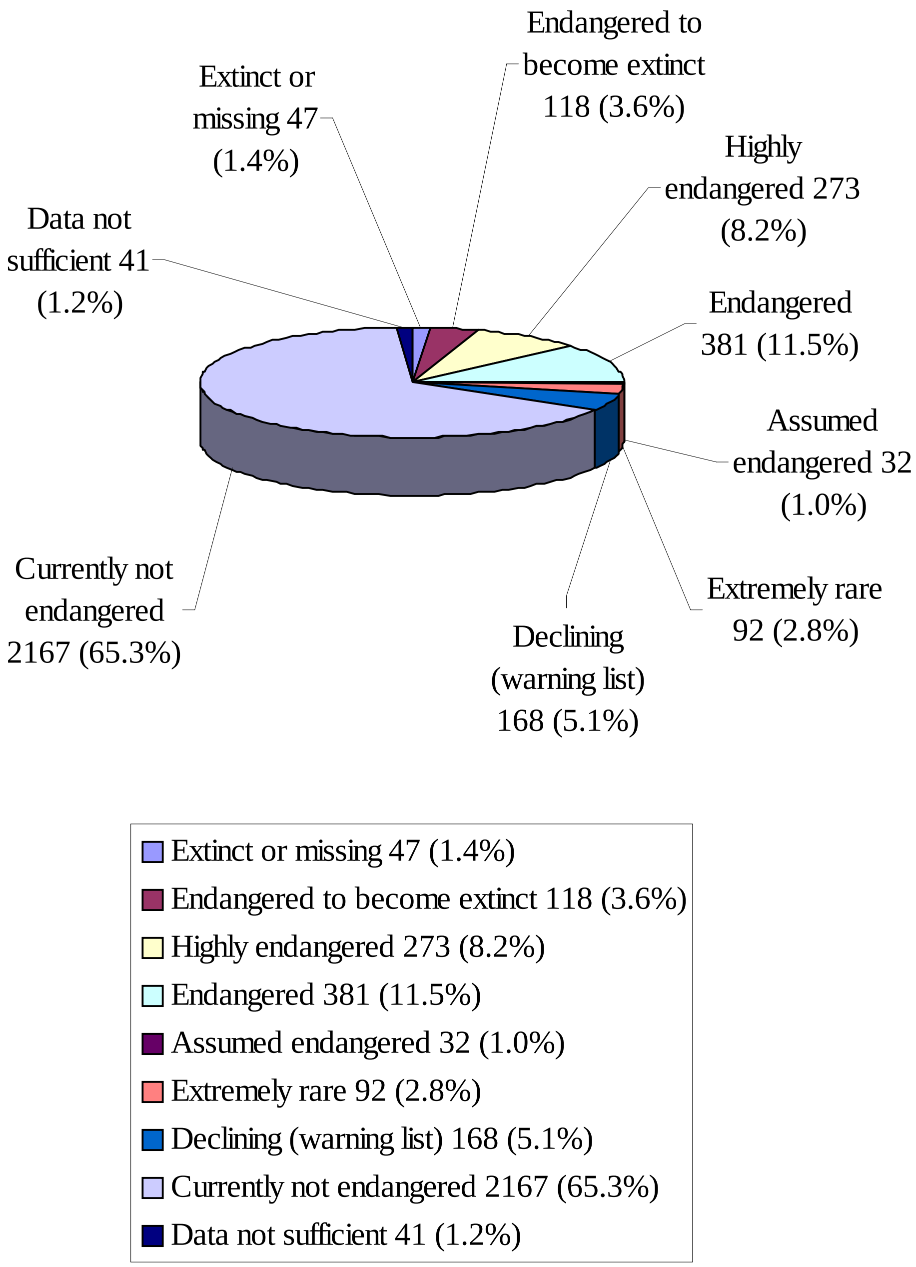

Figure 3.2-2. Endangerment of fern and vascular plant species in Germany (Korneck et al., 1998)

Moreover, the number of endemic and threatened "higher"[12] plant and vertebrate species, respectively, differs significantly on country levels on earth (Figures 3.2-3, 3.2-4, 3.2-5, and 3.2-6).

[12] "Higher" plant and vertebrate species is put in inverted commas, because it values less complex species lower than more complicated ones. However, each species that is fit enough to exist is equally successful to survive (cf. Rudolf, 1998), i.e. more complex vascular plants species and vertebrates, as much as, less complex micro-organisms. Therefore, species classifications in certain monophyletic groups or taxa (cf. Sedlag and Weinert, 1987) are more appropriate to describe the evolutionary situation.

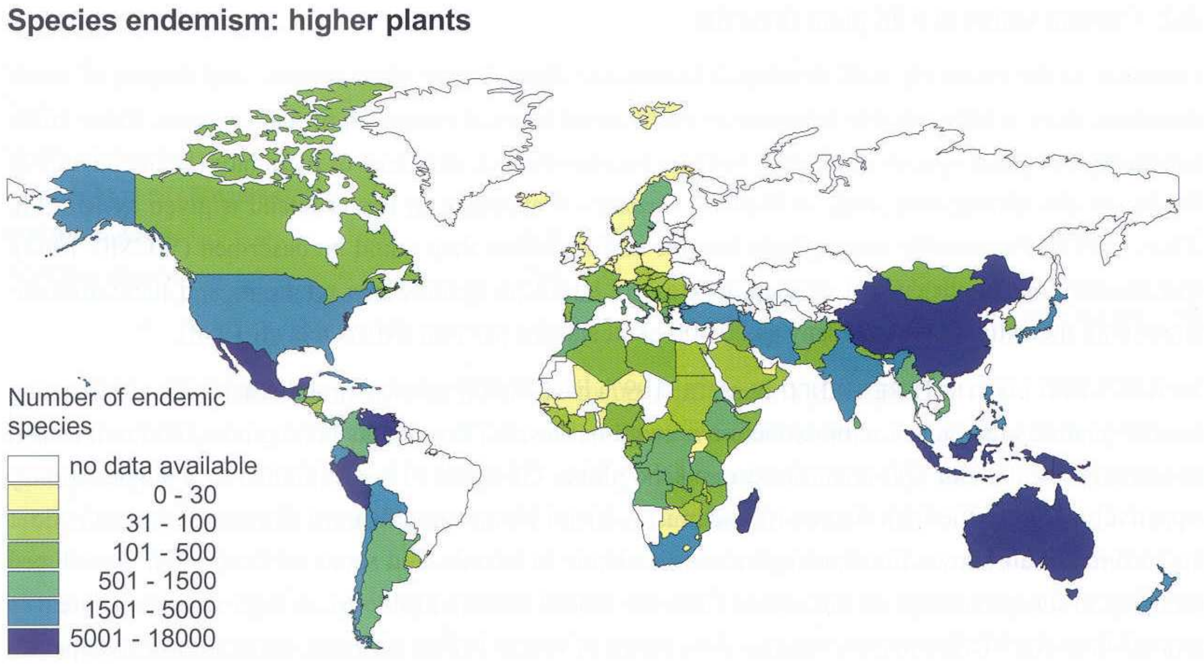

Figure 3.2-3. Number of endemic plant species in different countries on earth (Keller et al., 2002) reproduced by kind permission of Springer Science and Business Media, Heidelberg, Germany

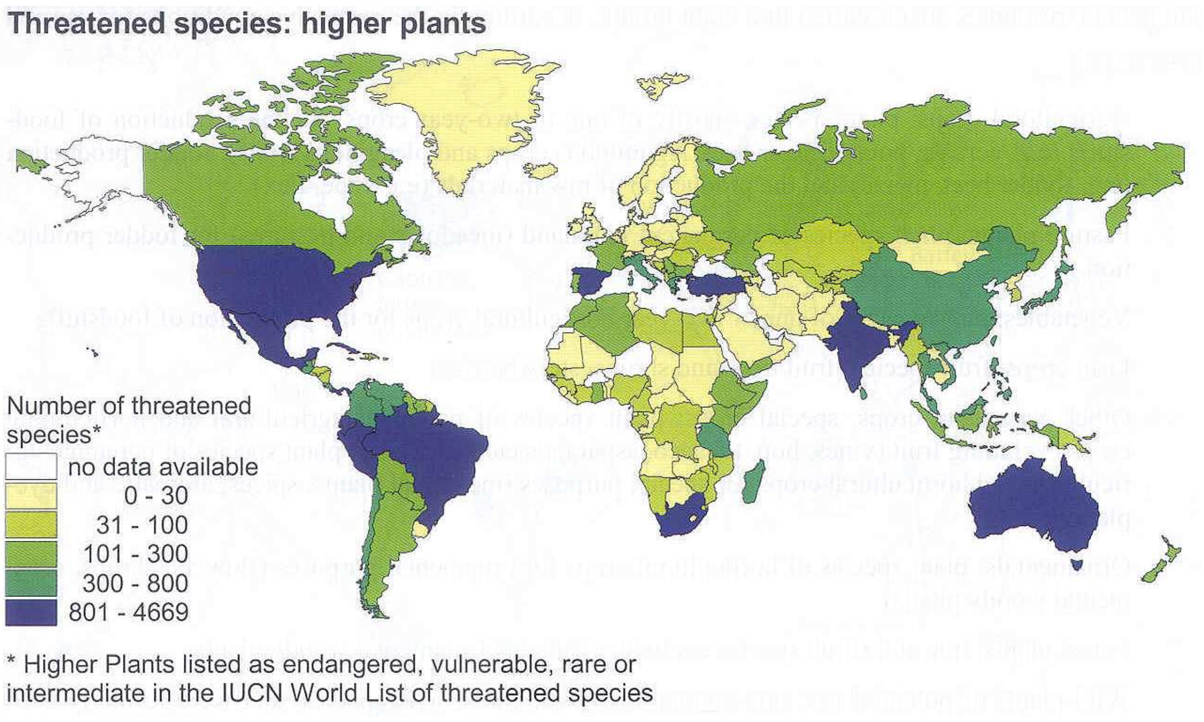

Figure 3.2-4. Number of threatened "higher" plant species in different countries on earth (Keller et al., 2002) reproduced by kind permission of Springer Science and Business Media, Heidelberg, Germany

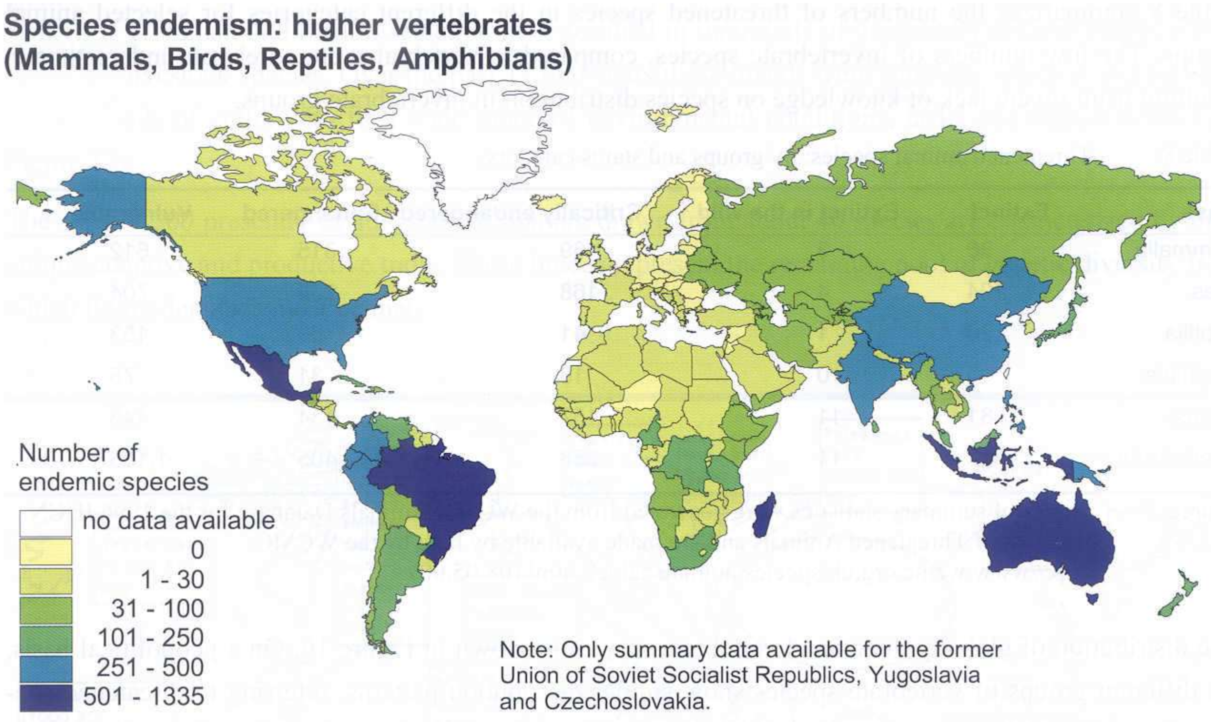

Figure 3.2-5. Number of endemic vertebrate species in different countries on earth (Keller et al., 2002) reproduced by kind permission of Springer Science and Business Media, Heidelberg, Germany

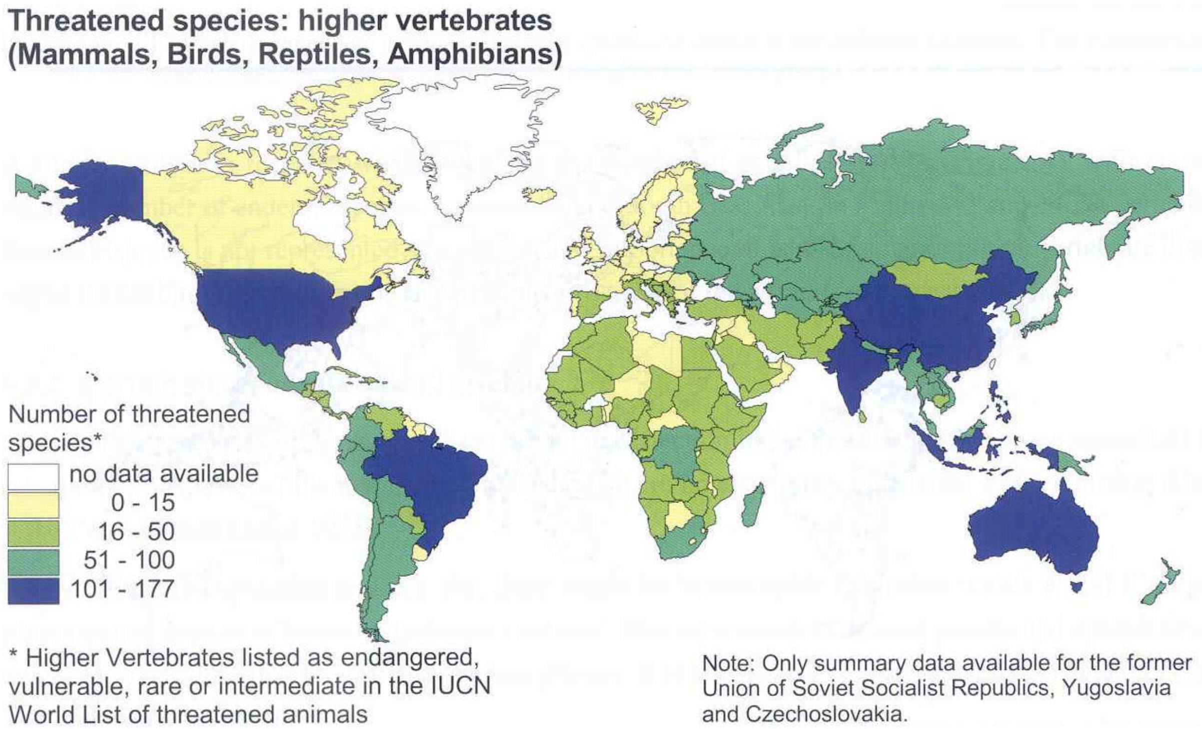

Figure 3.2-6. Number of threatened "higher" vertebrate species in different countries on earth (Keller et al., 2002) reproduced by kind permission of Springer Science and Business Media, Heidelberg, Germany

Natural processes provide habitats for species. However, many habitats and species have become rare and endangered due to the loss of natural processes (cf. Blab, 1993; Korneck et al., 1998). For example, there are only about 1 % natural riversides left at the German river Rhine (Ott, 1998). Agricultural intensification has reduced wetland areas in Europe by some 60 % in the last decades. Worldwide, a total of 11,046 species of plants and animals face a high risk of extinction in the near future, in almost all cases as a result of human activity. That means one in four mammal species and one in eight bird species.

Furthermore, 37 % of domestic animals are endangered. International trade in wildlife is recognised as the cause of global threat for 30,000 species. In the Amazon alone, the total area deforested per year has increased from 30,000 km² in 1975 to at least 600,000 km² at present, while an area twice as large is affected biologically (European Commission, 2001a). For example, 95 % of the native varieties of wheat have been lost in Greece in just 40 years. This may reduce potentials for the future selective breeding of crops and livestock better adapted to new, as yet unpredictable, environmental conditions (Groombridge and Jenkins, 1996).

The World Conservation Monitoring Centre considers also the following threats to endangered species and habitats worldwide (Table 3.2-5).

Table 3.2-5. Worldwide threats to endangered species and habitats (Groombridge, 1992)

Worldwide threats to endangered species and habitats

- habitat loss or modification, often associated with habitat fragmentation (reasons include pastoral development, cultivation and settlement, forestry operations and plantations, fire, and pollution)
- overexploitation for commercial or subsistence reasons, including meat, fur, hides, collection of live animals for pet trade and plants for horticultural trade
- accidental or deliberate introduction of exotic species, which may compete with, prey on or hybridise with native species
- disturbance, persecution and uprooting, including deliberate eradication of species considered to be "pests"
- incidental take, particularly the drowning of aquatic reptiles and mammals in fishing nets
- disease, both exotic and endemic, exacerbated by the presence of large numbers of domestic livestock or introduced plant species
- limited distribution, which may compound the effects of other factors.

Moreover, there is an additional method to use Blue Lists, which register those Red Data list species that show a durable overall stabilization or increase in abundance at the considered region. Blue Lists shall allow to positively document species developments (Gigon et al., 1998; Gigon and Langenauer, 1999; Langenauer and Gigon, 1999) and thereby to allow encouraging their support by positive news for public relations (cf. chapter 2.6 Educational values on page 85).

3.2.2.2 Species definition

However, there is a difficulty of how species are defined and distinguished for interdisciplinary evaluations of nature and landscapes. A species is a reproductive group of subpopulations of its own gene pool, which fits into a specific niche in nature (Sedlag and Weinert, 1987). Ecological niche can be defined as the functional ability of species to survive under ecological and competitive circumstances (cf. Gutmann, 1998; Irmler, 1998; Kratochwil and Schwabe, 2001). Therefore, the occupation of an ecological niche depends on the number and the abundance of species in the surrounding ecosystems (Irmler, 1998). The evolutionary concept considers that there are monophyletic taxa of species. Each of it splits into two new species during reproductive isolation and evolutionary selection of new mutations in different environments. Traditionally, morphological characteristics have been the most important measures for the differentiation of species and subspecies (cf. Sedlag and Weinert, 1987). Nowadays, genetic components have become more important, as more as biological technologies have developed (cf. Sutherland, 2000; Tiedemann, 2001; Frankham et al., 2002, 2004; Gaston and Spicer, 2004).

Moreover, there are also ecological, ethological, and chemical features used to distinguish different species (cf. Sedlag and Weinert, 1987).

3.2.2.3 Biological diversity

However, if we consider the concept of diversity of nature and landscapes, each individual is unique and contributes to global diversity. Furthermore, there is a range of biological diversity from global earth level via ecosystem complexes, ecosystems, landscapes, metapopulations, populations, species, subspecies, individuals, parts of individuals, cells, gene nets, alleles, to genes (cf. Haber, 2003). Each component implies effected values for practical planning processes and project evaluations with an impact on nature and landscapes.

Biological diversity on earth is politically considered as genetic diversity, species diversity, and ecosystem diversity (United Nations, 1992; BMU, ?; Pearce and Moran, 1994; Jax, 2003; Kaule, 2003). Genetic diversity represents the heritable variation within and between populations of organisms. In 1992, the contributors of the United Nations' Conference on Environment and Development have signed the Convention on Biological Diversity and thereby put up a Global Diversity Strategy in Rio de Janeiro. There are about 1.7 million species described on earth of estimated five to nearly 100 million different species in total (Figure 3.2-7; overview of species diversity in Groombridge, 1992; Groombridge and Jenkins, 2000; CBD, 2001a). Approximately 90 % of all non-described species are assumed to live in tropical rain forests. Of all described species, there are 36 % plant species, more than 90 % fern species, 75 % moss species, and more than 40 % arthropod species located in the tropics. Most of them are arthropod species, but bird species count only for about 2 %, amphibian species for 5 %, "reptile" species for 5 %, and mammal species for 5 %, as well as, fish species for 10 % (Deutscher Bundestag, 1990).

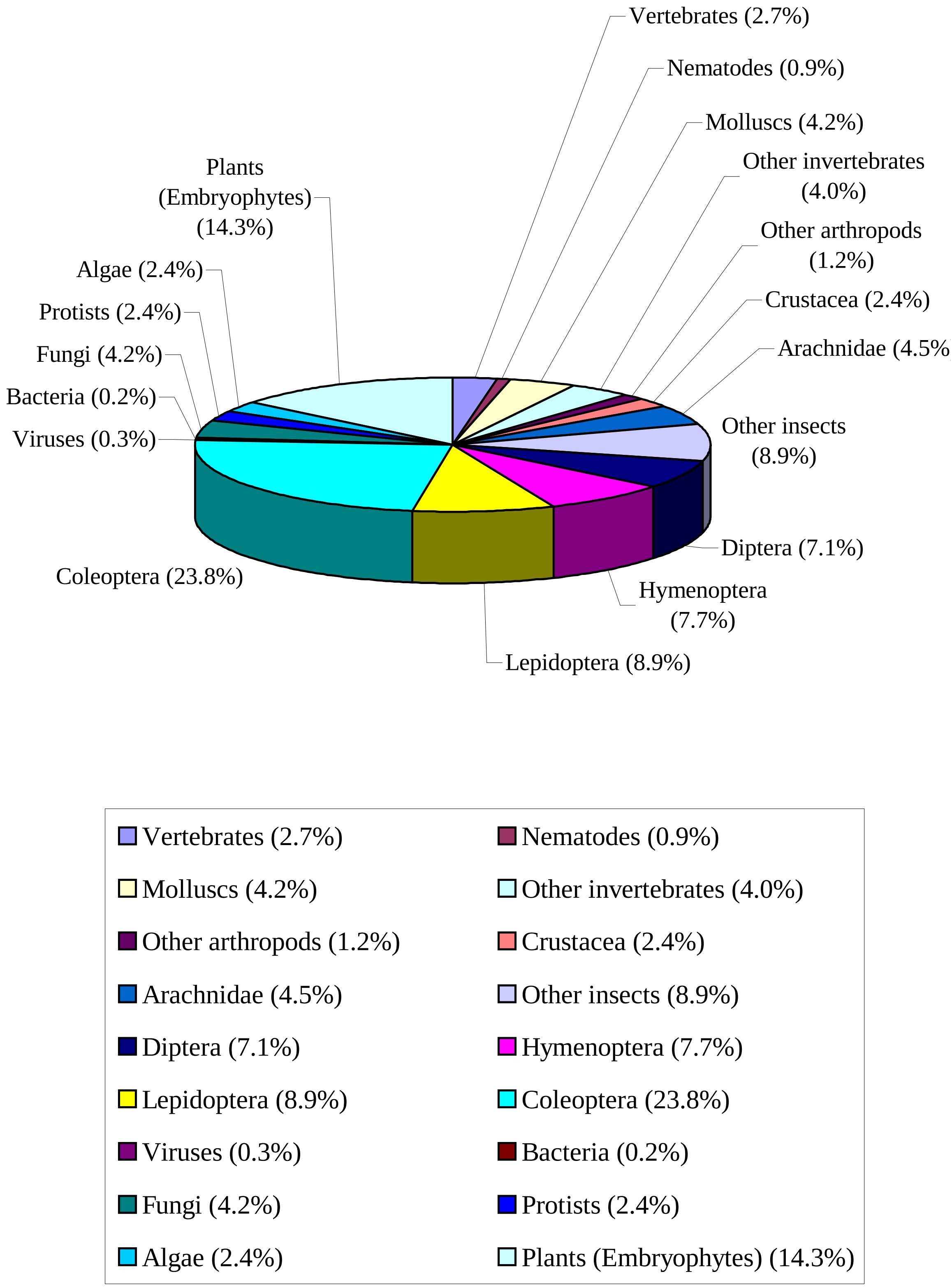

Figure 3.2-7. Proportions of described major species groups on earth (Groombridge, 1992)

Species diversity in Germany is relatively low in comparison to tropical countries (Table 3.2-6). Databanks provide an overview, for instance, of genetic diversity in Germany (cf. Münch, 2002), biological collections in Europe (cf. Güntsch et al., 2001), and the Biodiversity Conservation Information System (BCIS) on global level (cf. Busby, 2001).

Table 3.2-6. Selected species diversity in Germany in comparison to tropical countries (Deutscher Bundestag, 1990)

	Federal Republic of Germany	Peninsular Malaysia	Ecuador
Size	249,630 km²	131,587 km²	281,341 km²
Species			
Mammals	94	>200	280
Birds	305	675	1,447
„Reptiles“	12	270	345
Amphibians	19	90	350

In addition, there is a simplified tendency of the number of species depending on the following habitat conditions (Groombridge and Jenkins, 2000; Caldecott et al., 2002):

- warmer areas support more species than colder ones
- wetter areas support more species than drier ones
- less seasonal areas support more species than very seasonal ones
- areas at lower elevation content of more species than higher ones
- areas with varied topography and climatic conditions support more species than uniform ones
- larger areas support more endemic species than areas, which are contiguous or close to other similar areas
- the longer an area has been isolated, the higher is the number of endemic species likely to be found.

Furthermore, current trends in livestock breeding lead to significant losses of genetic diversity. About 30 % of 4,500 breeds worldwide are endangered, i.e. they content less than 1,000 breeding females or less than 20 breeding males. Breeds are dying out at a rate of six per month. Just in Europe, already nearly half of the breeds of the beginning of the 20th century are considered to be extinct. It is the highest proportion of all continents (Keller et al., 2002). This tendency of species losses refers also to cultivated plants due to agricultural intensification and globalization combined with economic dependences on few species (cf. WBGU, 1999a; Millennium Ecosystem Assessment, 2005b).

There are three main reasons for the loss of genetic diversity (Blab and Klein, 1997):

- reductions of natural (primary) habitats and their substitution by cultural habitats
- breaking down of historical cultural landscapes by more effective management forms (industrialized agriculture, urbanization, extension of infrastructure, etc.)
- genetic depletion of cultivated, as well as, wild species.

There have been attempts to localize centres of species richness and endemic diversity on earth, which shall also function as an evolutionary potential (cf. Groombridge, 1992, 1994; Caldecott et al., 1994; Groombridge and Jenkins, 2000; Klingenstein et al., 2003a; Gaston and Spicer, 2004). However, species richness is not a criterion itself. It is just a measure of objective conditions of nature and landscapes, which helps to apply the mentioned criteria and values of nature and landscapes (cf. section 3.2.1 Selection of different proposed criteria on page 108). In addition, an evolutionary potential depends on several unpredictable future conditions of nature and landscapes. Species richness might be a quantitative, but not a qualitative and therefore valuable measure for possible evolutionary developments.

Moreover, there is also the term of geodiversity, which refers to the fact that geological and edaphic diversity often correlates with biological diversity (cf. Jedicke, 2001). In addition, there is cultural diversity of indigenous people (cf. section . In fact, six of nine countries, which together account for 60 % of human languages, have also exceptional numbers of unique plant and animal species. Nearly 2,500 languages are in an immediate danger of extinction, and even higher numbers are losing their context in nature and landscapes that keep them as vibrant languages (Posey, 1999).

In addition, different ecosystems and their structural, functional, and informative contents, as well as, their internal and external interactions can become rare and endangered ecological functions; overview in Groombridge, 1992, 1994; Groombridge and Jenkins, 2000; CBD, 2001a; Mulongoy and Chape, 2004.

3.2.2.4 Minimum Viable Metapopulation (MVM) concept

The decisive measure for being endangered should be the possibility of long-term survival of species. For each organism group, there are key measures necessary according to the specific biology of them, which consider, *inter alia*, the following aspects (Table 3.2-7).

Table 3.2-7. Measurement aspects of endangered metapopulations (Jedicke, 1997a, modified)

Measurement aspects of endangered metapopulations

- current status of population development (e.g. total amount of individuals, metapopulation size, distribution in the area, and exchange of masses)
- past decrease and increase, respectively (e.g. metapopulation development, tendency of metapopulation changes, habitat restrictions, loss of habitat types)
- prognosis of future development (e.g. threat of direct and indirect human impacts)
- occurring biological risk factors (e.g. few reproduction units, short survival periods of Diaspora and persistence units, limited dispersal ability, low metapopulation rejuvenation or low recolonization of new habitats, being stenotic, close connection to another reduced species, and danger of bastardization with a different, much more abundant and close related species).

Therefore, the Minimum Viable Metapopulation (MVM) concept considers that metapopulations, i.e. several subpopulations of one species that have more or less a reproductive exchange, need to have minimum numbers of fertile individuals in a common gene-pool to survive for subjectively determined periods, for example, for 200 years with a certain error probability of 5 %. MVMs require minimum areas of sufficient habitat quality and quantity (cf. Table 3.2-8; e.g. Soulé, 1986, 1987a; Mühlenberg et al., 1991; Soulé and Mills, 1992; Hanski and Simberloff, 1997; Heidenreich and Amler, 1998; Breininger et al., 2002; Frankham et al., 2002, 2004; Hanski and Gaggiotti, 2004). For retaining evolutionary potentials, only rough estimations can be given. Effective metapopulation sizes of 500-5,000 have been recommended, which correspond to total metapopulation sizes of 5,000-50,000 in the wild (Frankham et al., 2002, 2004).

Table 3.2-8. Minimum habitat sizes for metapopulations (Jedicke, 1990)

Species groups	Habitat sizes
Wolf (*Canus lupus*) at large woodland habitats	60,000 ha (600 km²)
Otter (*Lutra lutra*) at water habitats	14,000-20,000 ha water size or 50-75 km river banks
Capercaillie (*Tetrao urogallus*) at woodland habitats	5,000-10,000 ha
Large birds and mammals in general	100-10,000 ha

Black Grouse (*Lyrurus tetrix*) at bogs, heather habitats, and woodland edges in the mountains, respectively	2,500 ha
"Reptiles", especially Common Viper (*Vipera berus*)	1,000-2,000 ha
Toad (*Bufo bufo*) at spawn water habitats and connected woodland rich habitats	1,520 ha
Middle size birds	1,000 ha
Breeding birds in Europe in general	80-1,000 ha
Agile Frog (*Rana dalmatina*) at wetland meadows and woodlands	380 ha
Curlew (*Numenius arquata*) at wet grasslands	250 ha
Grass Frog (*Rana temporaria*) at wet habitats	200 ha
Waders in general at wetlands	200 ha
Typical soil fauna of broad-leaved woodland ecosystems	100 ha
Airworthy larger macro-fauna species (body sizes of 10-50 mm)	50-100 ha
Common Spadefoot (*Pelobatus fuscus*) at sandy soils	50 ha
Palmate Newt (*Triturus helveticus*), Alpine Newt (*Triturus alpestris*), and Smooth Newt (*Triturus vulgaris*) at more or less woodland rich wet habitats	50 ha
"Reptiles", small mammals, and small birds in general	20-100 ha
Tree Frog (*Hyla arborea*) at woodland and reed rich surroundings of ponds, etc.	28 ha
Spiders in woodland habitats in general	20 ha
Small mammals in general	10-20 ha
Walkable species of larger macro-fauna (body sizes of 10-50 mm)	10-20 ha
Snipe (*Gallinago gallinago*) at wet grasslands	10 ha
Hunting spiders on the ground at oak-hornbeam woodlands	10 ha (2,5-20 ha)
Hedge birds at field hedges	5-10 ha

Smaller macro-fauna (body sizes of 1-10 mm), sessile species of larger macro-fauna (body sizes of 10-50 mm)	5-10 ha
Field Cricket (*Gryllus campestris*) at dry grassland habitats	3 ha
Meso-soil fauna (body sizes of 0.3-1 mm)	1-5 ha
Ground Beetles (*Carabidae*) at oak-hornbeam woodlands	2-3 ha
Butterflies, crickets	1 ha
Meadow Spittlebug (*Philaenus spumarius*)	1 ha
Micro-soil fauna (body sizes < 0.3 mm)	< 1 ha
Orchis latifolia at wet meadows and low-moor bogs	0.5 ha
Midwife Toad (*Alytes obstetricans*) at diverse wetland like habitats	0.1 ha 0.2
Hedge birds in general	5-10 m wide and 10 km long hedges, including edges

A widely used metapopulation modelling approach is the Incidence Function Model (IFM). This approach uses presence/absence data along with patch area and distance between patches to calculate the probability that a given patch will be occupied during a given time step in the model. Patch-specific rates of extinction and colonization are calculated based on observed occupancy, patch area, and isolation. The extinction rate is assumed to be dependent on patch area alone, not isolation (unless a rescue effect is included). The exact relationship between patch area and extinction is parametrized from survey data (Brigham and Thomson, 2003).

The Logistic Regression Model (LRM) is another way to model metapopulation dynamics. This approach, like IFM, uses presence/absence data, patch area, and isolation, but can also incorporate other environmental or demographic factors that may affect colonization or extinction. LRM is based on a state transition model in which two separate logistic regression models are run, one to predict extinction and one to predict colonization. In each model, the researcher can include any factors that might influence colonization or extinction with either categorical or continuous predictor variables. Once specified, the logistic regressions are used to project patch occupancy into the future. The future status of patches is calculated using multiple logistic regressions, based on the environmental predictor variables associated with each patch and the sum of its colonization and extinction probabilities. These probabilities can be summed for all patches to predict the future state of the metapopulation (Brigham and Thomson, 2003).

In addition, there are attempts to calculate minimum sizes of ecosystems (cf. Table 3.2-9; Bastian and Schreiber, 1999). In comparison with sectorial approaches like habitat or species protection, the advantage of an ecosystem approach is the possibility to identify the interactions between and within the different abiotic and biotic system compartments of nature and landscapes (Dierßen, 2000b). System theories allow investigating ecosystems causal analytic by simplified models without excluding functional relevances, which is often the case in detailed focused analysis of single disciplines. On a basis of such a system analysis, it is possible to simulate the impacts of changes of particular components to others and the system itself, as well as, to predict even relatively complex system structures of ecosystems depending on certain probabilities of the system (Fränzle, 1998).

Minimum sizes of ecosystems shall incorporate at least all species, which have an abundance of 60-70 %. Firstly, minimum sizes of ecosystems ought to be determined by those species groups, which have the maximum home and live ranges, for example, big fish, bird, and mammal species. Secondly, they shall incorporate the smallest area, which contents still the characteristic habitats of the specific ecosystem. As better metapopulations of ecosystems are connected, as less is the probability to become extinct (Jedicke, 1990).

Table 3.2-9. Minimum sizes of ecosystems (Jedicke, 1990, modified)

Size category	Ecosystem type	Minimum area
Large		
	Habitats of tree poor areas, for example, subatlantic low-moor bogs and high-moor bogs, subatlantic heathers, coast meadows, salt meadows, etc.	500-1,200 ha
	Average habitat areas, for example, dry grassland, woodland habitats, heathers, low-moor bogs, and high-moor bogs	200-800 ha
	Oligotrophic lakes, woodlands, bogs	100 ha
	Heathers, upper reaches of rivers	50 ha
Medium		
	Nutrient poor grasslands, wetland meadows, salty inland areas	10 ha
	Inland dunes, overflooded woodlands of rivers, herbaceous perennials	5 ha

	Dry grasslands, sand vegetation and rock vegetation	3 ha
Small		
	Lakes, ponds, sources, defiles, slope developments	1 ha
	Small habitats, for example, ponds, lakes, sources, etc.	10-100 m²
	Edge habitats, for example, woodland edges, river banks, reeds, streams, etc.	Extension of 5-10 km

Increased fragmentation generally does not cause an immediate loss of species, but a change in species frequencies. In the long-term, isolation below their MVMs can lead to local and even general extinction of metapopulations of species (Nagelkerke et al., 2002). If we consider the biological diversity concept mentioned above, each loss is a loss of unique biological diversity, irrespectively if it is caused on ecosystem, species, metapopulation, individual, or genetic level. For example, one single Fruit-fly (*Drosophila spp.*) has about 50,000 genes. At least 50 % of these genes are polymorph, which makes the individual absolutely unique (Naumann, 2002). Furthermore, despite several species have their distribution concentration in urban areas or even just only occur in urban areas (cf. section 3.2.4 Typicalness on page 159), biological diversity differs already in each urban area, but also in comparison to rural areas. Therefore, the argument does not convince, which is sometimes politically used that when we lose biodiversity on local levels, there might be still the species occurring at other places.

3.2.2.5 Population Vulnerability Analysis (PVA)

Population Vulnerability Analysis (PVA) is necessary for metapopulations of each species to evaluate risks of local extinction caused by different interacting reasons. It allows estimating the degree of endangerment of metapopulations of species (Figure 3.2-8).

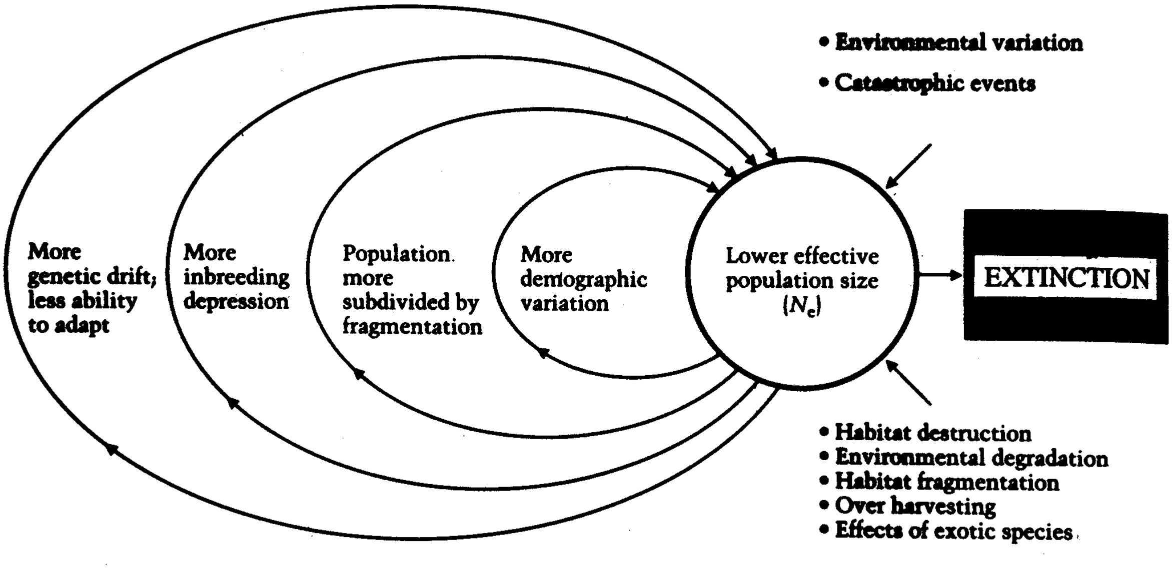

Figure 3.2-8. Reasons leading to extinction of species (Briggs and Walters, 1997) reproduced by kind permission of Cambridge University Press, Cambridge, UK

Computer models are used to simulate metapopulation developments due to the complexity of PVAs, which can be distinguished in four containing categories (Table 3.2-10).

Table 3.2-10. Contents of Population Vulnerability Analysis (PVA) (cf. Soulé, 1986, 1987a; Mühlenberg et al., 1991; Soulé and Mills, 1992; Young and Clarke, 1997; Amler et al., 1999; Frankham et al., 2002, 2004; Hanski and Gaggiotti, 2004)

Contents of Population Vulnerability Analysis (PVA)
• ecological circumstances (e.g. autecological and synecological requirements and conditions)
• genetic reasons (inbreeding and genetic drift in small populations, outbreeding effects of different genes of introduced individuals, etc.)
• demographic events (fluctuations of sex ratio, age structure, birth and death rates, etc.)
• stochastic fluctuations of environmental conditions (weather changes or catastrophes, for example, epidemic diseases, etc.).

There is detailed information necessary for practical implications of the PVA concept, which incorporates several aspects (Table 3.2-11). PVAs have been carried out, for example, of the African Elephant (*Loxodontus africanus*), the Puma (*Felis concolor*), the Bighorn Sheep (*Ovis Canadensis*), the Agil Mangabey (*Cercocebus galeritus*), the Spotted Owl (*Strix occidentalis*), and the Checkerspot Butterfly (*Euphydryas editha*) (cf. Vogel et al., 1996). In addition, PVAs have been carried out for animals of the Black-Footed Ferret (*Mustela nigripes*), the Florida Panther (*Puma concolor coryi*), The Lord Howe Island

Woodhen (*Gallirallus sylvestris*), the Chinook Salmon (*Oncorhynchus tshawytscha*), and for plants of the Furbish's Lousewort (*Pedicularis furbishiae*), as well as, the Matchstick Banksia (*Banksia cuneata*) (cf. Frankham et al., 2002, 2004). There are further examples of PVAs of plants (cf. Menges and Quintana-Ascencio, 2003).

Table 3.2-11. Different aspects of the PVA-concept (cf. Hovestadt et al., 1991; Mühlenberg et al., 1991)

Demographic aspects and historical development of metapopulations

- metapopulation size (total amount and effective metapopulation size of reproductive individuals)
- metapopulation structure (age, sex, and fertility)
- current distribution and abundance of individuals
- mortality and birth rates related to age, sex, and fertility (r : dN/dt = rN), and net reproduction rate depending on metapopulation density (R : N(t+1) = N(t) * R)
- individual reproduction successes depending on age groups and their variation
- demographic variations of reproduction ability, survival rate, age of first and last reproduction
- metapopulation developments during last decades
- maximum metapopulation sizes, which can be above long-term carrying capacity of habitats to serve as a reservoir for colonizations of habitats at other areas
- mating and breeding system (monogamy, polygamy, local fixation, brood care, etc.)
- estimation of inbreeding coefficient, genetic drift, and outbreeding effects to calculate the loss of genetic variability
- dispersal behaviour within habitats and metapopulations depending on sex, age, habitat quality, and metapopulation density
- structure of metapopulations (differences of populations, exchange of individuals between different populations, immigration and emigration rates, reproductive exchange, etc.)
- interactions to other species, competitors, predators, parasites, prey, and food plants

Area size requirements

- minimum social and reproduction unit to survive, as well as, smallest number of species, which form functionally social and reproductive units
- fluctuation rate and mean value of home ranges for social and reproductive units during seasonal variations
- life-range and competition to other species
- different used habitats for feeding, breeding, and resting, as well as, their differences depending on age, sex, and social status

Habitat quality

- primary habitat and available resources for reproduction and breeding activities
- type, size, quality, and distribution of micro-habitats, which influence the survival and reproduction of species
- dynamic of habitats (succession, disturbance, etc.)

Prognosis of future development of metapopulations

- evaluation of the mentioned aspects of metapopulations
- deterministic reasons for threats (habitat destruction, direct pursue, etc.)
- size, amount, and location of used habitats
- identification and mapping of appropriate habitats
- dispersal ability and maximum distance of appropriate habitats for interactions
- estimation of isolation effects due to fragmentation of habitats
- calculation of environmental changes and catastrophes (weather conditions, epidemic diseases, fire, storm, floods, etc.)

3.2.2.6 Practical applications of PVAs and MVMs

Essentially, PVAs of MVMs are based on empirical data, which is extrapolated for modelling theoretical chances of survival, as well as, minimum habitat sizes and quality needs as an expression of the degree of endangerment of certain metapopulations of species. However, for practical evaluations of nature and landscapes, PVAs and estimated MVMs often lack of appropriate accuracy and transparency due to too many variables, limited research resources, as well as, available time for evaluations. Statistical error probabilities and computer-based estimations seem to promise an accuracy that does not sufficiently correspond to real or to scientifically predictable developments.

For example, population densities vary depending on structures and functions of habitats, i.e. depending on resources, disturbances, interactions, forms of the areas and the degree of isolation (Wulf, 2001). The distribution of a suitable habitat does not remain constant through time, particularly in species that track the distribution of successional habitats. In addition, metapopulation processes are stochastic, which limits predictability (Thomas and Hanski, 2004). The Incidence Function Model (IFM) and the Logistic Regression Model (LRM) ignore local dynamics and focus instead on turnover rates throughout the metapopulation. Species modelled with this approach should idealized have dynamics dominated by extinction and colonization events, not local dynamics (Brigham and Thomson, 2003).

Moreover, PVAs and MVMs are conceptionally concentrated on the survival of (meta-) populations, but not on risks to lose important genetic diversity within them. Natural selection of different behaviour is not considered in PVAs and MVMs, which might prevent losses of genetic diversity (cf. Sachteleben and

Riess, 1997). If data is available on the relationship between population size, genetic diversity, and fitness, this data can be used to generate a more explicit model of genetic effects. Unfortunately, such data seldom exists. Nevertheless, there are several different approaches for incorporating genetics into a PVA (Brigham and Thomson, 2003).

Furthermore, the approach to base evaluations on the degree of endangerment of populations entirely on Minimum Viable Metapopulations is misleading, if their influencing parameters cannot be accurately estimated (Table 3.2-12; cf. section 3.2.7 Ecological functions on page 191).

Table 3.2-12. Difficult calculable influences of minimum habitat sizes for metapopulations (Mühlenberg and Slowik, 1997, modified)

Difficult calculable influences of minimum habitat sizes for metapopulations

- ecological interactions between populations of different species
- diffuse input of substances, for example, by air
- changes of habitats between minimum habitats, which have direct and indirect influences, for example, higher isolation or disturbances
- changes of minimum habitat conditions, for example, caused by external global climate changes or internal succession

Therefore, many criticisms of PVAs have advocated a greater emphasis on experimental approaches that directly explore the factors limiting (meta-) populations, as an alternative to rely entirely on modelling (Brigham and Thomson, 2003). Instead, there are suggestions to focus more on the diagnosis of reasons for declines of MVMs, as well as, on predictions of necessary measures to increase metapopulations (cf. Sutherland, 2000).

Nevertheless, PVAs are necessary to provide guidelines for minimum habitat sizes and qualities for metapopulations (cf. Opdam, 2002). Therefore, there are minimum quality demands necessary on available resources and time-scales for PVAs, which result in different degrees of accuracy.

3.2.2.7 Ex-situ and in-situ conservation

The Convention on Biological Diversity intends to preserve rare and endangered biological diversity ex-situ, i.e. outside their natural habitats, and in-situ, i.e. at conditions where genetic resources exist within ecosystems and natural habitats, and, in the case of domesticated or cultivated species, in the surroundings where they have developed their distinctive properties (United Nations, 1992; BMU, ?; overview for plants and animals in CBD, 2001a).

However, outbreeding and inbreeding effects limit ex-situ conservation to support metapopulations of rare and endangered species in the wild. Animals at zoological gardens and aquaria generally suffer of inbreeding and genetic drift effects. Evolutionary processes are interrupted, such as natural selection, reproduction, competition, migration, and passed on behaviour. Moreover, different genetic material of formerly separated gene pools can be mixed together. Individual gene pools are lost and genes can be fixed that are likely to reduce fitness in different environments in the wild (cf. Plachter, 1991c; Schreiber, 1997; WBGU, 1999a; Sutherland, 2000; Frankham et al., 2002, 2004; Keller et al., 2002; Pullin, 2002; Klingenstein et al., 2003a). Thus, reintroduction even of native species can decrease fitness of occurring populations of species.

Moreover, outbreeding effects can reduce fitness of local species, when species of other regions are introduced that are adapted to different environmental conditions (cf. Frankel and Soulé, 1981; Soulé, 1986, 1987a; Hovestadt et al., 1991; Soulé and Mills, 1992; Frankham et al., 2002, 2004; Pullin, 2002). For example, when the Tatra Mountain Ibex (*Capra ibex ibex*) became extinct due to overhunting in the Czech Republic, Ibexes were successfully translocated from nearby Austria. However several years later, Ibex subspecies were added from other origins to the Tatra population, the Turkish Bezoars (*Capra ibex aegagrus*) and the Nubian Ibex (*Capra ibex nubiana*) from Sinai. Their offspring was fertile, but rutted already in early autumn, instead in the winter as the native Ilex. Thus, the mixed population gave birth in February during the coldest month of the year, which resulted in extinction of the entire population (Keller et al., 2002).

In addition, outbreeding depression can occur, when coadapted gene complexes[13] are interrupted that express favourable phenotypes by introducing new genes. This has been detected in copepods, mice, and in the highly outcrossing legume *Chamaecrista fasciculate* (Frankham et al, 2002, 2004), but also in Chiltern Gentian *(Gentianella germanica)* (Matthies, 2000). Furthermore, this type of outbreeding depression can also occur in crossings between different populations adapted to the same environmental conditions, if alleles of coadapted gene complexes are arranged in new recombinations. Outbreeding depression happens more frequently when crossings occur between populations that have undergone significant adaptation to local conditions and when dispersal is limited. Not surprisingly, most evidence for outbreeding depression comes form plants with these characteristics. Dispersal rates are often lower of plants than in animals, especially of inbreeding species (cf. Frankham et al, 2002, 2004). In addition, organisms cannot be preserved in their ecological systems ex-situ, because food-chains and symbiosis are interrupted (cf. Keller et al., 2002).

On the other hand, there is evidence of also positive hybridizations and introgressions for evolutionary fitness in certain cases (cf. Arnold, 1997).

[13] Coadapted gene complexes are groups of loci, which interact in expressing certain phenoptypes that are favourable for survival (epistatic interactions) (cf. Frankham et al., 2002).

Furthermore, introgressions and bastardizations can be seen as a significant evolutionary process itself for developing new species and genetic constellations (cf. Hellweg, 2000; Kowarik and Sukopp, 2000). It depends on the particular case, if the positive or negative effects predominate.

Nevertheless, animal cells, embryos, and gametes stored in genome resource banks (cryopreservation) can provide genetic material for future use (cf. Niemann et al., 1997; Frankham et al., 2002, 2004), as well as, to freeze pieces of plant tissues using cryopreservation techniques (Briggs and Walters, 1997). Ex-situ animal conservation programmes have been carried out for several species (Table 3.2-13).

Table 3.2-13. Examples of ex- situ animal conservation programmes (cf. Keller et al., 2002; Frankham et al., 2002; Pullin, 2002)

Examples of ex-situ animal conservation programmes

- Kouprey (*Bos sauveli*)
- Mongolian or Asian Wild Horse (*Equus przewalkii*)
- Arabian Oryx (*Oryx leucoryx*)
- American Bison (*Bison bison*)
- European Bison or Wisent (*Bison bonasus*)
- Hawaii Goose (*Branta sandvicensis*)
- Aye-aye (*Dauentonia madagascariensis*)
- Black-footed Ferret (*Mustela nigripes*)
- California Condor (*Gymnogyps californianus*)
- Golden Lion Tamarin (*Leontopithecus rosalia chrysomelas*)
- Sumatran Rhino (*Dicerorhinus sumatrensis*)
- Père David’s Deer (*Elaphurus davidianus*)
- Large Blue butterfly (*Maculinea arion*)
- Guam Rail (*Gallirallus owstoni*)
- Lord Howe Island Woodhen (*Gallirallus sylvestris*)

Many plant species are polyploid (Briggs and Walters, 1997). Therefore, they might be less affected by losses of genetic diversity than other species. However, inbreeding effects of plants have been recognized in several cases (cf. Hanski, 1999; Dudash and Fenster, 2000; Oostermeijer, 2000, 2003), and plants at botanical gardens, botanical museums, and universities are as much excluded of selective evolutionary processes in the wild than animals (cf. Hurka, 2000). Ex-situ conservation of plants is carried out at seed and pollen banks, field gene banks, i.e. an area of land in which collections of growing plants have been assembled, and in vitro storage, i.e. storage of germplasm at laboratory conditions (cf. Groombridge, 1991; WBGU, 1999a; Sutherland, 2000; Keller et al., 2002; Pullin, 2002). However, not all plant species can be stored in seed banks, as about 15 % of “higher plants” – many from tropical forests – have recalcitrant seeds that lack seed dormancy and/or cannot withstand desiccation. Such seeds germinate immediately in the wild (Briggs and Walters, 1997).

Nevertheless, as many as 80,000 plant species are cultivated in Botanical Gardens worldwide (Keller et al., 2002; Klingenstein, 2002). There are approximately 2,000 botanical gardens on earth, about 400 in Europe, and nearly 95 in Germany (Klingenstein, 2002; Klingenstein et al., 2003a). For example, The Royal Botanical Gardens at Kew in London, UK, keeps about 38,000 plant species (Keller et al., 2002), which are about 10 % of all plants species on earth (Briggs and Walters, 1997). 50,000 plant species (25 % of all vascular plant species) are growing on about 1,300 ha in total size of all botanical gardens in Germany (Klingenstein, 2002); 100,000 of 250,000 known vascular plant species on earth (Klingenstein et al., 2003a).

There are examples of reintroduced plants, which were cultivated in botanical gardens, such as the Central African giant cycad *Encephalartos laurentianus* (*Zamiaceae*), the *Hopea hainanensis* of Hainan Island in China, the Toromiro (*Sophora toromiro*) (*Fabaceae*) of the Pacific island Rapa Nui (Easter Islands), and the Presidio Clarkia (*Clarkia franciscana*) in California, USA (cf. Keller et al., 2002). Furthermore, there are also attempts to carry out ex-situ conservation of micro-organisms and fungi in banks (cf. Groombridge, 1991, 1994; Oetmann, 2000; Keller et al., 2002). Moreover, the World Federation for Culture Collection (WFCC) represents the majority of ex-situ microbial resource centres. Five hundred of these are listed in its World Data Centre for Micro-organisms (WDCM) of more than 250,000 cultures of all kinds (CBD, 2001a).

Despite all problems of ex-situ conservation, this approach can contribute to support rare and endangered species in cases, when their wild populations are reduced to such minimum sizes of being endangered to become extinct. In addition, they can be useful, when it is necessary to recolonize former distribution ranges, which cannot be overcome anymore due to isolation barriers. Functions of zoological and botanical gardens can be summarized as following (Table 3.2-14; Klingenstein et al., 2003a).

Table 3.2-14. Functions of zoological and botanical gardens (Keller et al., 2002, modified)

Functions of zoological and botanical gardens
• educational source and opportunity to promote public and political awareness for the conservation of wild fauna and flora
• last chance for species, which have no immediate survival probability in nature and landscapes
• limited substitutes for the development of care and management techniques of wild populations and research of them
• demographic and genetic reservoirs for new populations for reintroductions into the wild for newly (re-)colonized areas

It depends on each particular case, if introduced genetic material causes more negative outbreeding effects or if it prevents inbreeding effects and genetic depression of homozygotic negative recessive alleles due to higher genetic variability (cf. Bender, 1991; Arnold, 1997; Mitton, 1997). This is not only a quantitative, but also a qualitative question of introduced genetic material. There is only a general rule possible, that as faster metapopulations are influenced by natural or human factors to introduce new genetic material or to reduce it in isolation, respectively, as more newly introduced genetic material is likely to be of negative effects (cf. Bender, 1991). This refers also to the dangers of biotechnology, which changes genetic components in time periods that would normally take thousands of years of natural selection processes.

In addition, human influenced genetic changes can also be caused directly by selective harvesting, for example fishing or hunting, or indirectly by environmental pollution, as well as, introduced parasites and diseases (Schreiber, 1997). For example, genetic erosion of plant races for agriculture has occurred in southern Italy to about 73 % due to agricultural intensification between 1950 and the 1980s (cf. Keller et al., 2002). The increasing globalization involves the danger of further pushing away regionally important products and use forms, thereby certain species, breeds, and sorts (Oetmann-Mennen, 1999; Oetmann, 2000).

Genes are organized in a net. Therefore, the expression of one gene can vary even if both individuals have the same genes but in different “genetic architecture” (cf. Berry, 1983, 1992; “epistatic interactions”: Frankham et al., 2002, 2004). This refers to almost all parts of nature and landscapes, because no area is exactly the same. Different areas have different genetic biodiversity (cf. Pullin, 2002). However, measures of genetic diversity are just quantitative. They do not tell us something about their quality for survival of current and future metapopulations under different circumstances.

3.2.2.8 Measurement methods

For practical planning decisions and project assessments with an impact on nature and landscapes, it is necessary to measure the occurrence and development of species and metapopulations, as well as, their habitats at certain spatial- and time-scales to allow statements of their rarity and endangerment within the context of their particular values to the society and on their own. Therefore, this section discusses some survey and analysis methods, and concepts on genetic, species, and metapopulation levels, as well as, of their habitats to be able to apply the criterion rarity and endangerment according to the interdisciplinary framework of different values.

3.2.2.8.1 Calculation methods of genetic diversity

Genetic diversity can be measured in different ways (cf. Table 3.2-15, Frankham et al., 2002, 2004). In general, insects and plants carry the highest degree of heterozygous alleles, except for self-fertilizing organisms. Genetic diversity is lower for birds and mammals. Island populations and specialized organisms have the lowest degree of heterozygous alleles (cf. Hovestadt et al., 1991). Moreover, the degree of heterozygous alleles is much lower in populations of bigger, more mobile animals than in populations of small, relatively immobile animals (Bender, 1991).

Table 3.2-15. Different measures of genetic diversity (Templeton, 1994)

Genetic diversity	
Measures	Explanations
Percent of polymorph loci (*P*)	A locus is commonly defined as polymorph, if the frequency of its most common allele is less than 0.95. If *p* loci out of *n* are polymorph, the percentage of polymorph loci is simply $P = 100 \times (p/n)$.
Number of alleles (*N*)	The number of alleles at a particular locus.
Heterozygosity (*H*)	Observed heterozygosity is the probability that an individual will be heterozygous at a locus. It can only be applied to diploid genetic elements, and it is even then not suitable for all situations. For example, in a population of 100 % self-fertilizing plants, observed heterozygosity will be close to zero for all loci, regardless of how many alleles they have or the frequency of those alleles. Expected heterozygosity (the more commonly used measure) is the probability that two copies of a locus drawn at random from the gene pool have different allelic states. It can be applied to both diploid and haploid genetic elements, such as mitochondria DNA.
Average number of nucleotide differences (*K*)	Restriction site and DNA sequence techniques allow estimating the average number of nucleotide differences between two genes drawn at random.
Number of segregating sites (*S*)	This refers to the number of restriction sites or nucleotides that are polymorph in the DNA region under study.

In addition, key parameters of genetic diversity can be measured also in karyotypic variation, mitochondria DNA divergence, microsatellites, and protein polymorphism. Protein electrophoresis is only applicable to those sections of DNA within the genome, which code for the production of proteins (usually soluble enzymes). However, there are a number of new techniques, such as DNA fingerprinting, the Polymerase Chain Reaction (PCR), restriction site mapping, and DNA sequencing, which have greater resolution in comparison to protein electrophoresis. Furthermore, some of them can be applied to both coding and non-coding sections of DNA to allow investigations of the entire genome rather than just a small subset (cf. Groombridge and Jenkins, 1996; Frankham et al., 2002, 2004; Weigend, 2002; Gaston and Spicer, 2004).

The Random Amplified Polymorph DNA (RAPD) fingerprinting method allows to copy and to visualize DNA sequences using PCR, depending on their size. Therefore, there are comparisons possible to assess genetic variability, population structures, and effects of isolation mechanisms (cf. Amler et al., 1999; Frankham et al., 2002, 2004; Weigend, 2002; Gaston and Spicer, 2004). For example, genetic relationships and diversity of animals can be measured in samples of blood, urine, cell material of single hair roots, bones, and intestinal cells in excrements (Immel et al., 2001).

However, the probability to detect genetic polymorphism, i.e. the degree of polymorph alleles at different loci, increases by the number of examined individuals. Furthermore, another disadvantage is the fact that low polymorph alleles count as much as high polymorph alleles in the sum. Nevertheless, polymorph analyses allow getting an overview of the genetic variability of the whole population, especially when it is separated in small subpopulations. In addition, polymorph analysis can be applied to species, which have low degrees of heterozygous alleles as results of inbreeding effects or self-fertilizing reproduction (cf. Hovestadt et al., 1991).

As mentioned above, it depends on the particular case, if higher degrees of heterozygous alleles improve the possibility of long-term survival, because of theoretically higher flexibility to selective environmental changes or to genetic drift due to higher genetic variability. However, low genetic variability is often combined with metapopulations of species, which have been drastically reduced to small populations in the past (bottleneck effect). Their genetic poorness reduces the probability of long-term survival as a population, despite we need to keep in mind that selection takes place on individual levels, which effects the population as a whole (cf. Bender, 1991; Mitton, 1997; Schreiber, 1997; Günther and Assmann, 2000; Frankham et al., 2002, 2004).

3.2.2.8.2 Estimations of metapopulations

Relative abundances of metapopulations can be estimated per time units, for example, by numbers of individuals or relative density. There are different common traps and catching methods, as well as, analysing indices. Whereas, estimations of absolute metapopulation sizes require additionally standardized counting of certain spatial areas, for example, along certain transects or at representative patches. Other ways to estimate absolute numbers are marking and recapture methods (cf. Mühlenberg, 1993; Amler et al., 1999).

There are a lot of different appropriate methods for surveying flora and vegetation[14] of plant communities (cf. Ellenberg, 1955; Dierßen, 1990; Dierschke, 1994; Glavac, 1996; Glawion and Klink, 1999; Traxler, 1998), and of different animal groups (overview in Finck et al., 1992; Riecken, 1990, 1992, 2002; Trautner, 1992; Institute of Environmental Assessment, 1997; Brinkmann, 1998; Coch, 1999; Statistisches Bundesamt and Bundesamt für Naturschutz, 2000; Schlumprecht, 2002; Stickroth et al., 2003), respectively (for flora, fauna and vegetation together cf. Janetschek et al., 1982; Jedicke, 1994; Schlumprecht, 1999; Sutherland, 2000; Kratochwil and Schwabe, 2001). The best way to reduce errors of estimations is teamwork to help and to check each other (Traxler, 1998).

Population growth and its variability are theoretically determined by reproduction and immigration on the one hand, and mortality and emigration on the other (cf. section 3.2.7.4 Habitat island theory on page 200). Regression analysis allows estimating these relations, if correlations are linear. However in practice, population growth decreases at certain density levels, for example, due to limiting resources that can cause reductions of fecundity (negative density dependence). Whereas the positive density dependence (or Allee effect) refers to increasing population growth at certain sizes, for instance, due to positive effects of better mating success, higher group protection, and more successful foraging in groups (cf. Amler et al., 1999; Morris and Doak, 2002).

Furthermore, environmental autocorrelations can affect population growth significantly. Positive correlations occur when adjacent years in a sequence tend to be more similar than it would be expected in a completely random sequence, for example, when wet years tend to follow wet years, and dry years dry. Negative correlations occur, when adjacent years differ more than it would be expected by chance, for instance, when dry years follow wet years, and vice versa (cf. Amler et al., 1999; Morris and Doak, 2002).

In addition, migration rates and activity ranges influence MVMs significantly, for example, to connect different subpopulations or to reach certain habitats (cf. Table 3.2-16; Haber et al., 1993; Bastian and Schreiber, 1999).

[14] Flora is considered as the sum of plant species of specific areas (Sedlag and Weinert, 1987; Wittig, 1991, 1998, 2002) and of specific habitat types (Wittig, 1991, 1998, 2002). Whereas, vegetation refers to the sum of plant communities of specific areas (Sedlag and Weinert, 1987; Wittig, 2002) and of specific habitat types (Wittig, 2002).

Table 3.2-16. Estimated average mobility and activity ranges of different species of a certain research area (Amler et al., 1999)

Activity ranges	**Mobility**		
	Little (<= 0.5 km)	Medium (0.5-2.5 km)	High (> 2.5 km)
Little (some m²)	Gastropoda (*Trochoidea geyeri*), (*Helicopsis striata*), (*Candidula unifasciata*)	Saltatoria (*Oedipoda caerulescens*), (*Stenobothrus lineatus*), (*Platycleis albopunctata*)	
	Araneae (*Oedipoda germanica*), (*Phaneroptera falcata*)	Cicadina (*Ribautodelphax pungens*), (*Adarrus multinotatus*)	
		"Reptilia" (*Podarcis muralis*), (*Lacerta agilis*)	
Medium (some ha)		Lepidoptera (*Glaucopsyche arion*)	Lepidoptera (*Chazara briseis*), (*Melitaea didyma*)
High (some km²)			Anura (*Bufo calamita*)
			Aves (*Lanius excubitor*), (*Lullula arborea*)

Furthermore, human land uses can be decisive dynamic ecological factors for species dispersal, especially in agriculture and trade (Bonn and Poschlod, 1998).

3.2.2.8.3 Methods to survey movements and migrations of animals

Telemetric methods are a good way to follow individual movements as a basis for estimations on metapopulation level (Amler et al., 1999). Telemetric methods can be combined with satellite supported habitat analysis to detect species movements and dispersals (cf. Kenneweg et al., 2000; Van den Bossche, 2001; Culik, 2001; Klaus et al., 2001; De Metrio et al., 2001; ∅ien and Aarvak, 2001). Radar and aircrafts can be used to survey migrations of birds (cf. Lesheim, 2001). For passively dispersed organisms, such as seeds and many planktonic larvae, models of air or water motions can yield predictions of expected dispersal distances (Morris and Doak, 2002). In addition, genetic data allows to compare different gene pools of MVMs and to indicate migration or isolation for longer time periods (cf. Amler et al., 1999; Morris and Doak, 2002). Moreover, there are the following methods to estimate dispersal and exchange movements (Table 3.2-17).

Table 3.2-17. Methods to estimate dispersal and exchange movements (Gruttke et al., 1998)

Methods to estimate dispersal and exchange movements
i) marking and recatching methods
Marking and recatching methods are often applied, but they demand a great deal of work. Coloured codes are frequently used for marking. However, these coloured markings do not last very long. In addition, it is possible to fix long lasting scars, scratches, or holes with small soldering irons, micro-drills, or micro-grinders, for example, using dentists' tools.
ii) telemetric methods
Mostly applied are "harmonic radars", which is a system of passively reflecting diodes that are fixed on animals. In addition, there are microwaves senders, which are used in combination with receivers. However, there are also active senders in use that are fixed on arthropods.
iii) selective traps of directions
Long lasting traps are filled with conserving liquids or used as live-traps, which are located as barriers in movement corridors. Cross traps can be used to allow analysing trap contents in all directions. However, the researcher needs carefully to consider the high catching effects of traps on the surveyed populations.
iv) analysis of genetic differences
Electrophoresis or DNA-fingerprinting methods are frequently applied to find out spatial patterns of alleles and their gradients. These methods are mostly used to reconstruct historical dispersal processes.
v) analysis of long-term data in time rows
These time rows are based on long-term catching data or systematic recognitions of spatial grids at research grounds. This method can be also applied to small and fragile species, which cannot be marked or fixed with senders. In addition, it is an appropriate method for rare organisms.

In addition, polymorph gene markers have been used for birds to find out life-ranges, spatial habitat uses, and particular behaviour (cf. Schreiber, 1997).

3.2.2.8.4 Habitat models

Quantitative and qualitative analysis of habitats are additionally important parts of PVAs. Habitat models are developed in different ways (Table 3.2-18).

Table 3.2-18. Development methods of habitat models (Amler et al., 1999)

Habitat models
• statistical correlations of habitat parameters and estimated metapopulation sizes • comparisons of uses and availability of habitat structures • experimental changes of habitat parameters

In particular, there have been attempts to model species-habitat-relations by computer based simulations, such as the Habitat Suitability Index (HIS-Models) as a part of the Habitat Evaluation Procedures (HEP) (cf. Table 3.2-19; Storch, 1996; Altmoos, 1999; Schröder, 2000, 2002; Mückschel et al., 2002; Zebisch, 2002, 2004).

Table 3.2-19. Methods for building habitat models (Elith and Burgman, 2003)

Method	Minimum species data
Habitat suitability indices	• expert opinion
Hulls and kernels	• presence
Bioclimatic envelopes (e.g. ANUCLIM)	• presence
Simple multivariate distance methods	• presence
Ecological niche factor analysis (ENFA)	• presence
Canonical correspondence analysis (CCA)	• presence-absence
Generalized linear models (GLMs)	• presence-absence
Generalized additive models (GAMs)	• presence-absence
Decision trees	• presence-absence
Neural networks	• presence-absence
Genetic algorithms	• presence (but uses pseudo-absences)

However, habitat models can just serve as statistical estimations of indicator species occurrences depending on certain parameter of nature and landscapes. They do not provide answers to population dynamics. In addition, they can just reflect certain aspects of suitable habitats during life cycles of species. Furthermore, a well-experienced local human expert might predict habitat dependences better than computer based habitat models. Habitat models just describe theoretical species-habitat-relations. Therefore, it is always necessary to analyse these results taking into account experimental and empirical ecological research results of habitat preferences of species (cf. Schröder, 2000).

Moreover, habitat models are generally based on simplified relations of animals and their habitats. Their relationships can vary significantly on spatial and time levels (Storch, 1996). Therefore, habitat models just reflect data material in spatial and time limits during the undertaken survey, i.e. at a certain region for a certain period, for example, one vegetation period. Receiver-Operating-Characteristic-curves (ROC-curves) are used to estimate the validity of habitat models. Nevertheless, habitat models are especially efficient for keystone species, which have specific habitat demands, low mobility, and high detection rates in the field (Schröder, 2002).

3.2.2.8.5 Statistical methods for analysis of fauna and flora

There is a range of statistical methods for fauna and flora (cf. McGarigal et al., 2000; Donovan and Welden, 2001). For example, multivariable statistical analysis can be helpful to classify species data and to relate it to habitat conditions (cf. Table 3.2-20; Traxler, 1998; Gruehn, 2000; McGarigal et al., 2000).

Table 3.2-20. Overview of statistical methods for analysis of flora and vegetation (Maas, 2000, modified)

Flora and vegetation levels	Parameters	Statistical analysis methods
Plant organs	• presence • size • number	• descriptive statistics • parametric or non-parametric statistics • randomization tests
Individual plants	• presence • size • number • density	• descriptive statistics • parametric or non-parametric statistics • randomization tests

Plant populations	• life-cycle stage	• life-table analysis • sensitivity analysis
Vegetation communities	• frequency • dominance	• classification tests • ordination tests • randomization tests

Direct gradient analysis allows relating occurring species to measured or to classified ecological features at certain areas, for example, the Principal (Main) Component Analysis (PCA). Whereas indirect gradient analysis intend to relate qualitative and quantitative data of occurring species to area conditions and ecological gradients without directly measuring them, for instance, the Redundancy Analysis (RDA). Moreover, there are linear relations of continuously growing or decreasing occurrences of species related to ecological conditions, or unimodal relations of firstly increasing, but then decreasing species occurrences. Correspondence Analysis (CA) and Canonical Correspondence Analysis (CCA) are used for unimodal models. The Detrended Correspondence Analysis (DCA) and the Detrended Canonical Correspondence Analysis (DCCA) are corrected methods of spatial contortions of species and area distributions at two-dimensional spaces. Furthermore, there are also cluster analyses beside this ordination analysis, which allow classifying species in groups depending on their similarities (cf. Mühlenberg, 1993; Dierschke, 1994; Fründ, 1995; Hakes, 1996; Nipkow, 1997; Spang, 1999; McGarigal et al., 2000; Platen, 2000; Riecken, 2000a; Kratochwil and Schwabe, 2001).

3.2.2.9 Conclusive summary

Rarity and endangerment can be combined criteria to serve to value the different elements, structures, and functions of nature and landscapes. However concerning species, rare organisms can be just at the border of their species range. The latter case could even become an evolutionary advantage, if these species populations are better adapted to different changing conditions of nature and landscapes. Furthermore, rarity can be also a biological way of species to prevent selection pressure of predators. Nevertheless, many rare organisms are also endangered, because they do not have buffer populations.

A way to categorize species and habitats according to the criteria rarity and endangerment are Red Data lists. Often expert groups decide about final classifications of species and habitats in Red Data lists, which reduces the transparency and objectivity of the applied criteria rarity and endangerment. The World Conservation Union (IUCN) classifies basically in extinct, endangered, vulnerable, rare, indeterminate, and insufficiently known.

There is a simplified tendency that most endangered species are those, which depend on specific habitat requirements. However, there is an additional method to use Blue Lists, which register those Red Data list species that show a durable overall stabilization or increase in abundance at the considered region. Blue Lists shall allow to positively document species developments and thereby to allow encouraging their support by positive news for public relations.

Nevertheless, there is a difficulty of how species are defined and distinguished to apply the criteria rarity and endangerment on species level. If we consider the concept of diversity of nature and landscapes, each individual is unique and contributes to global diversity. Biological diversity on earth is politically considered as genetic diversity, species diversity, and ecosystem diversity.

There have been attempts to localize centres of species richness and endemic diversity on earth, which shall also function as an evolutionary potential. However, evolutionary potential depends on several unpredictable future conditions of nature and landscapes. Species richness might be a quantitative, but not a qualitative and therefore valuable measure for possible evolutionary developments. Moreover, there is also the term of geodiversity, which refers to the fact that geological and edaphic diversity often correlates with biological diversity. In addition, different ecosystems and their structural, functional, and informative contents, as well as, their internal and external interactions can become rare and endangered.

The different values of species to the society and on their own are decisively connected with their long-term survival. Rare and endangered species, as well as, their habitats and functions of ecosystems might be lost depending on the particular evaluation case during a certain spatial- and time-scale, if there are not certain measures taken to preserve them. The Minimum Viable Metapopulation (MVM) concept attempts to calculate the minimum numbers of fertile individuals in a common gene-pool to survive for subjectively determined periods, for example, for 200 years with an error probability of 5 %. MVMs require minimum areas of sufficient habitat quality and quantity. In addition, there are attempts to calculate minimum sizes of ecosystems. Increased fragmentation generally does not cause an immediate loss of species, but a change in species frequencies. If we consider the biological diversity concept above, each loss is a loss of unique biological diversity, irrespectively if it is caused on ecosystem, species, metapopulation, individual, or genetic level.

Population Vulnerability Analysis (PVA) is necessary for metapopulations of each species to evaluate risks of local extinction caused by different interacting reasons. There is detailed information necessary for practical implications of the PVA concept concerning ecological circumstances, genetic reasons, demographic events, and stochastic fluctuations of environmental conditions. Therefore, PVAs have been carried out just for a limited number of species.

However, PVAs and estimated MVMs often lack of appropriate accuracy and transparency due to too many variables, limited research resources, as well as, available time for evaluations. PVAs and MVMs are conceptionally concentrated on the survival of (meta-) populations, but not on risks to lose important genetic diversity within them. Natural selection of different behaviour is not considered in PVAs and MVMs, which might prevent losses of genetic diversity.

Therefore, many criticisms of PVAs have advocated a greater emphasis on experimental approaches that directly explore the factors limiting (meta-) populations, as an alternative to rely entirely on modelling. Nevertheless, PVAs are necessary to provide guidelines for minimum habitat sizes and qualities for metapopulations to preserve biological diversity in-situ, i.e. inside their natural habitats. They can be a very helpful method to measure the criteria rarity and endangerment for practical planning processes and particular project decisions.

Furthermore, outbreeding and inbreeding effects can limit ex-situ conservation. On the other hand depending on the particular case, hybridizations and introgressions can be seen as a positive evolutionary process for developing new species and different genetic constellations. Nevertheless, ex-situ keeping of species or the storage of their reproduction material can contribute to support rare and endangered species in cases, when their wild populations are reduced to such minimum sizes of being endangered to become extinct.

Nature and landscapes and their interactions can also become rare and endangered on genetic biodiversity level. The values to the society and on their own of genetic diversity can be measured in different ways. Genes are organized in a net. Therefore, the expression of one gene can vary even if both individuals have the same genes but in different “genetic architecture” (“epistatic interactions”). However, measures of genetic diversity are just quantitative. They do not tell us something about their quality for survival of current and future metapopulations under different circumstances.

Migration rates and activity ranges influence MVMs significantly. There are a lot of different appropriate methods for surveying flora and vegetation of plant communities, and of different animal groups. Habitat models are used for quantitative and qualitative analysis of habitats as additionally important parts of PVAs. However, habitat models can just serve as statistical estimations of indicator species occurrences depending on certain parameter of nature and landscapes. They do not provide answers to population dynamics.

Consequently, there are different methods and models to apply the criteria rarity and endangerment, but of lower and higher accuracy due to the complexity of influencing variables and dynamic processes. Therefore, the focus in nature conservation should be on providing large habitats that allow natural and human influenced dynamics, and to integrate species metapopulations and their habitat demands in human land use processes of ecosystems.

3.2.3 Naturalness/degree of human impacts

3.2.3.1 Culture-historical and current naturalness

Central Europe’s nature and landscapes are historically and currently mainly dominated by human cultural land uses (cf. chapter 2.5 Culture-historical values on page 73). There are only few natural landscapes left in Central Europe, for example, the Alps in some parts. Even on earth level, there are only very limited pure natural ecosystems left, for instance, the Antarctic and the Arctic (Table 3.2-21).

Table 3.2-21. Rough estimations of human influences on nature and landscapes worldwide (WBGU, 1999a, modified)

Continent	Size in km²	Not influenced in %	Partly influenced in %	Dominated by the human species in %
Europe	5,759,321	15.6	19.6	64.9
Asia	53,311,557	42.2	29.1	28.7
Africa	33,985,316	48.9	35.8	15.4
North America	26,179,907	56.3	18.8	24.9
South America	20,210,346	62.5	22.5	15.1
Australia	9,487,262	62.3	25.8	12.0
Antarctica	13,208,983	100.0	0.0	0.0
Earth in total:	162,052,691	51.9	24.2	23.9
Earth in total with the exception of cliff and ice areas, as well as, infertile land:	134,904,471	27.0	36.7	36.3

About 25 % of our nature and landscapes on earth have been transferred to agricultural fields by now, while only 10 % of the original nature and landscapes have been left on earth (Mückschel et al., 2002).

Therefore, naturalness has historical and current components. Historical naturalness refers to the original naturalness without any human influence, whereas current naturalness focuses on natural developments of nature and landscapes without actual human influence (cf. Kowarik, 1998, 1999, 2005; Kaiser, 1999).

3.2.3.2 Potentially Natural Vegetation (PNV)

Moreover, there is the theoretical concept of the Potentially Natural Vegetation (PNV), which refers to the vegetation that would theoretically develop under current conditions naturally without present human influences (cf. Kowarik, 1987; Kaiser and Zacharias, 1999). It includes also neophytes, i.e. historically unnatural plant species (cf. Kowarik, 1987; cf. section 4.2.1 Neophytes on page 232). The PNV is used as a reference to estimate the degree of current naturalness of the present vegetation (Gruehn and Herberg, 2000; Wulf, 2001).

However, the PNV-concept does neither include future succession nor forthcoming human influences by definition (cf. Kowarik, 1987; Kaiser and Zacharias, 1999). Practically, vegetation develops in general during succession stages to woodlands in Central Europe, except at extreme habitats, for example, above tree lines, in water, or at too strongly contaminated sites (cf. Ellenberg, 1988; Lässig and Schönenberger, 1997; Mühlenberg and Slowik, 1997). Therefore, other authors intend to predict future vegetation changes by including a natural succession process into PNVs for evaluations of nature and landscapes (cf. Gruehn and Herberg, 2000).

In addition, it is almost or even impossible to create comparative maps of PNVs, if there are no sufficient reference sites of potentially natural vegetation available. This can be the case in areas, which have been managed by the human species for a long time, such as marches, and extremely human changed soils, for example, at overburden slagheaps, and tips. Moreover, maps of PNVs cannot substitute those maps, which reveal current features of abiotic components, for example, soils, climate, as well as, water, energy, and staff balances (Wulf, 2001). Nevertheless, maps have been drawn up for PNVs of Europe (cf. Bohn et al., 2000).

Furthermore, in practice nature and landscapes develop in a permanent never ending dynamic process of human and non-human interactions. For example, naturalness in forests is a process-related measure that develops in relation to time span, as well as, intensity of anthropogenically undisturbed woodland dynamics. Its material expression is found in a continuously changing set of species and structures resulting from these dynamics (Westphal et al., 2004; cf. Rapport and Moll, 2000; Weidemann and Koehler, 2004).

Especially ecological and evolutionary development stages are limited to a certain historical period. For example, mutations are non-predictable random events. If a mutation provides a selection advantage, it can cause the irreversible loss of other less competitive mutations (Peil, 1991). Thus, living organisms transform as subjects permanently parts of their environment as objects and they form with them a developing and changing unit (von Uexküll, 1991). As more complex nature and landscapes becomes, as less it is possible to predict natural succession stages in detail. Therefore, succession is defined as an ecological process, which leads to irreversible changes in the composition of biocoenosis and thereby connected biotic and abiotic features of biogeocoenosis[15] (Weidemann and Koehler, 2004).

3.2.3.3 Mosaic Cycle Hypothesis

The Mosaic Cycle Hypothesis attempts to consider that there can be different development stages (succession stages) parallel running of the same or different vegetation types at large areas, which start and end naturally caused by environmental impacts, for example, fire, wind, climatic, and influences of animals (cf. Figure 3.2-9; Plachter, 1991a; Remmert, 1991; Riecken, 1992, 1996; Klötzli, 1993; Mühlenberg, 1993; Kratochwil and Schwabe, 2001; Mönig, 2001). This theoretical background is important to consider natural processes of ecosystems in our evaluations of nature and landscapes for practical planning processes and project decisions. Natural processes have different functions to provide habitats for species (cf. Blab, 1993; Korneck et al., 1998), but also as a natural turnover and successional development of ecosystems (cf. Hauke, 1998; Riecken et al., 1998), including the interrelating functions for the human being and the value on their own.

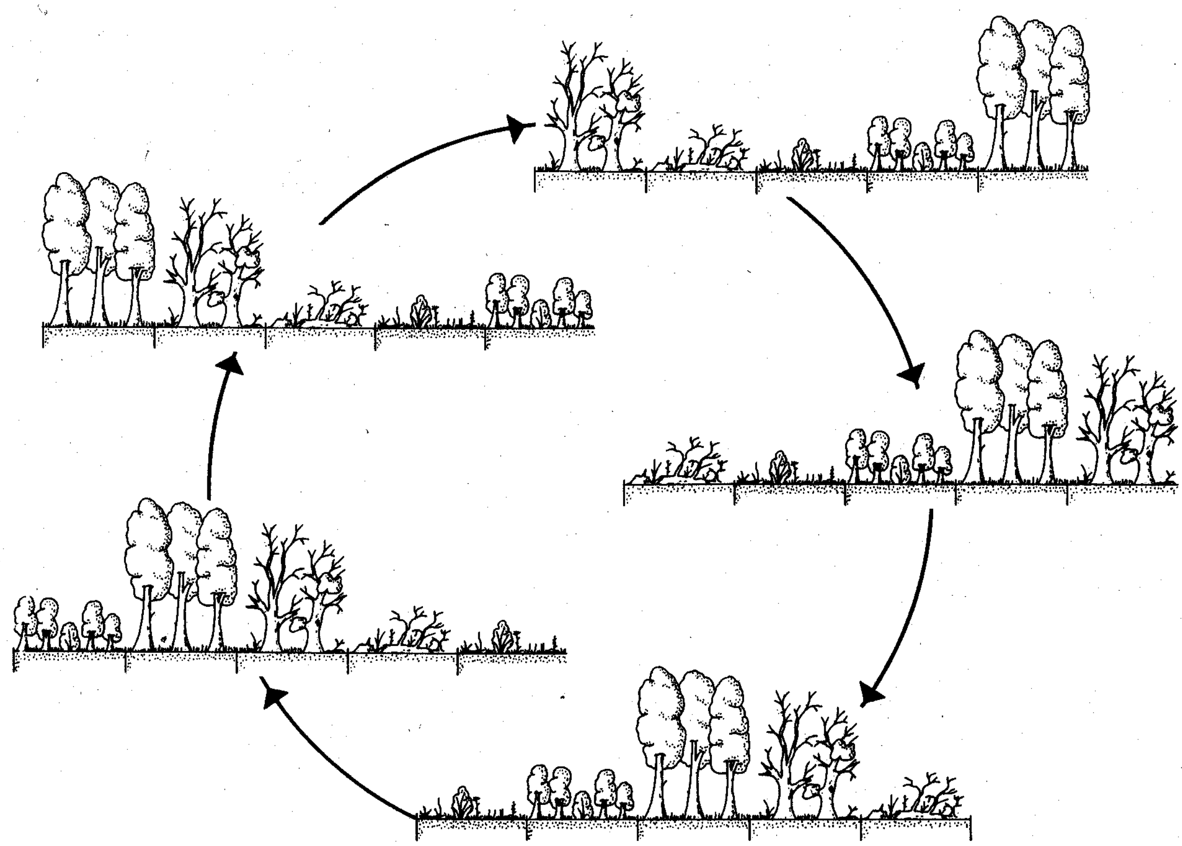

Figure 3.2-9. Dynamic developments of woodlands as a result of a hypothetically assumed mosaic cycle of different succession stages (Riecken, 1992)

[15] Biogeocoenosis is a spatial and time differentiated complex ecosystem (Sedlag and Weinert, 1987).

For example, heathlands of Heather (*Calluna vulgaris*) shall show dynamic mosaic cycles of about 30 to 60 years (Riecken, 1996). Moreover, in contrast to the Mosaic Cycle Hypothesis, the further developed Patch Dynamics Concept describes dynamic succession processes, which can be cyclic or not and based on endogenous or exogenous factors. In addition, the Patch Dynamics Concept is not based on an assumed overall balance of different succession stages like the Mosaic Cycle Hypothesis (Kratochwil and Schwabe, 2001).

However, it might be a misunderstanding to presume that there would be a natural cycle of the same conditions of succession stages in nature and landscapes at a certain spatial and time range. As discussed in section 3.2.3.2 Potentially Natural Vegetation (PNV) on page 151, nature and landscapes are in a permanently interacting dynamic process of their elements, which practically does not enable to return to a historically natural condition, either due to ecological and evolutionary interacting processes or due to more or less human influences in practice (cf. section 3.2.5 Re-establishment ability on page 177).

Furthermore, an overall balance of different succession stages can hardly be concluded in practice. Apart from the described irreversible and unpredictable dynamic processes, it seems to be impossible to determine spatial and time system borders of our ecosystems, which shall have different succession stages in balance.

3.2.3.4 Indicator species of naturalness

The occurrence of certain indicator species allows revealing historical and current human influences on nature and landscapes (cf. Table 3.2-22; Rackham, 1980; Ellenberg, 1988; Blab, 1993; Gilbert, 1991; Peterken, 1991; Kowarik, 1998, 1999, 2003; Kratochwil and Schwabe, 2001; section 3.2.4 Typicalness on page 159).

Moreover, successional changes of whole taxocoenosis can indicate ecotoxicological influences on ecosystems based on experiments, which can be also used for monitoring schemes (Weidemann and Koehler, 2004).

Table 3.2-22. Hemeroby scales including examples of vegetation and habitat types in Central Europe, as well as, hemerobic plant and animal indicator species (Kowarik, 1990, 1999; Kratochwil and Schwabe, 2001; modified)

Hemerobic degree		Examples of vegetation and habitat types	Examples of hemerobic indicator species
H0	Ahemerobic	• almost not existing in Central Europe (only at parts of high mountains)	• Three-toed Woodpecker (*Picoides tridactylus*)
H1	Oligohemerobic	• virtually not influenced primary woodlands, growing bogs, vegetation of rocks and sea-shores	• *Carex chordorrhiza*, Round-Leaved Sundew (*Drosera rotundifolia*), Common Cotton Sedge (*Eriophorum angustifolium*), *Lycopodium annotinum*, *Salix mysinifolia*, and Cranberry (*Vaccinium oxycoccos*) • Black Stork *(Ciconia nigra)*
H2	Oligohemerobic to mesohemerobic	• few drained wetlands, woodlands of extensive management, old secondary woodlands, and certain wet meadows	• *Agrostis canina*, Bog Arum (*Calla palustris*), *Carex elongata*, Bogbean (*Menyanthes trifoliata*), Green-winged Orchid (*Orchis morio*), Royal Fern (*Osmunda regalis*), Water-purslane (*Peplis portula*), and *Stipa capillata*
H3	Mesohemerobic	• forests of extensive management, secondary woodlands, dry grasslands and meadows of extensive management	• Sneezewort (*Achillea ptarmica*), Moschatel (*Adoxa moschatellina*), *Briza media*, *Luzula luzuloides*, and *Peucedanum oreoselinum* • Woodlark (*Lullula arborea*)

Hemerobic degree	Examples of vegetation and habitat types	Examples of hemerobic indicator species
H4 Mesohemerobic to β-euhemerobic	• forests of intensive management, disturbed secondary woodlands, nutrient poor grasslands of few spontaneous vegetation	• Basil Thyme (*Acinos arvensis*), Wild Strawberry (*Fragaria vesca*), (*Hieracium umbellatum*), Small Balsam (*Impatiens parviflora*), and Meadow Buttercup (*Ranunculus acris*)
H5 β-euhemerobic	• young forest plantings, intensively managed grasslands, spontaneous (ruderal) herbaceous perennial, highly disturbed nutrient poor grasslands	• Agrimony (*Agrimonia eupatoria*), Meadow Crane's-bill (*Geranium pratense*), *Leucanthemum vulgare*, *Scilla siberica*, and Red Clover (*Trifolium pratense*) • White Stork (*Ciconia ciconia*)
H6 β-euhemerobic to α-euhemerobic	• extensively managed field vegetation, meadows of high content of spontaneous (ruderal) vegetation, lawns, perennial vegetation of high trampling pressure	• Bugle (*Ajuga reptans*), Common Whitlowgrass (*Erophila verna*), *Gagea pratensis*, Dove's-food Crane's-bill (*Geranium molle*), *Juncus tennuis*, and Thyme-leaved Speedwell (*Veronica serpyllifolia*)
H7 α-euhemerobic	• vegetation of intensively managed gardens, fields, fruit-growings, and wine-growings, gappy vegetation of high trampling pressure	• Cornflower (*Centaurea cyanus*), Petty Spurge (*Euphorbia peplus*), Read Dead-nettle (*Lamium purpureum*), Common Millet (*Panicum miliaceum*), and Groundsel (*Senecio vulgaris*) • Rook (*Corvus frugilegus*)

Hemerobic degree	Examples of vegetation and habitat types	Examples of hemerobic indicator species
H8 α-euhemerobic to polyhemerobic	• intensively managed field vegetation, annual vegetation of high trampling pressure, pioneer vegetation of high disturbance	• *Amaranthus blitoides*, Henbane (*Hyoscyamus niger*), *Kochia scoparia*, Narrow-leaved Pepperwort (*Lepidium ruderale*), Branched Plantain (*Plantago indica*), *Potentilla supina*, and Tall Rocket (*Sisymbrium altissimum*)
H9 Polyhemerobic	• vegetation of highly disturbed habitats (railways, rubbish sites, piles, and street vegetation of high salt input, etc.)	• *Amaranthus albus*, *Chenopodium botrys*, *Cynodon dactylon*, *Eragrostis minor*, *Salsola kali subsp. ruthenica*, and *Vulpia myuros* • Swift (*Apus apus*), Collared Dove (*Streptopelia decaocto*)
- Metahemerobic	• contaminated or concreted sites of no vascular plants	• no vascular plants

We can naturally expect a definite diversity of certain species at certain habitat types within an analysed area of nature and landscapes, depending on different variables including the degree of human influence (cf. section 3.2.6 Vulnerability on page 186). For example, chalk grasslands have a naturally higher species diversity than heathlands (Bastian and Schreiber, 1999). Moreover, higher species diversity within naturally species poor high-moor bogs might just be caused by peat harvesting, or nutrient poor habitats might just be eutrophicated due to human influences (Plachter, 1991a), which allows unnatural species to compete successfully and to colonize these habitats (cf. Blab, 1993). Species diversity is also relatively low in woodlands on acid soils (Pfadenhauer, 2002). Low plant and animal diversity are characteristic for oligotrophic waters. Therefore, species diversity can only be estimated depending on quantitative surveys related to certain area sizes (Kratochwil and Schwabe, 2001) and habitat qualities on specific time-scales.

3.2.3.5 Conclusive summary

Central Europe's nature and landscapes are historically and currently mainly dominated by human cultural land uses. Naturalness has historical and current components. Historical naturalness refers to the original naturalness without any human influence, whereas current naturalness focuses on natural developments of nature and landscapes without actual human influence. Hemeroby expresses the degree of human impacts.

There is the theoretical concept of the Potentially Natural Vegetation (PNV) to estimate the potentially vegetation of current conditions without present human influences as a reference for current naturalness. However, practically vegetation develops in general during succession stages to woodlands in Central Europe, except at extreme habitats. Therefore, some authors intend to predict future vegetation changes by including a natural succession process into PNV for evaluations of nature and landscapes. In addition, nature and landscapes develop in a permanent never ending dynamic process of human and non-human interactions. Especially ecological and evolutionary development stages are irreversibly limited to a certain historical period.

The Mosaic Cycle Hypothesis attempts to consider that there can be different development stages (succession stages) parallel running of the same or different vegetation types at large areas, which start and end naturally caused by environmental impacts. Therefore, it provides an important theoretical background to consider natural processes of ecosystems in our evaluations of nature and landscapes for practical planning processes and particular project decisions. However, as more complex nature and landscapes becomes, as less it is possible to predict natural succession stages in detail. Therefore, succession is defined as an ecological process, which leads to irreversible changes in the composition of biocoenosis. An overall balance of different succession stages can hardly be concluded in practice.

Certain indicator species are used to reveal historical and current human influences on nature and landscapes. Moreover, successional changes of whole taxocoenosis can indicate ecotoxicological influences on ecosystems based on experiments. We can naturally expect a definite diversity of certain species at certain habitat types within an analysed area of nature and landscapes, depending on different variables including the degree of human influence (hemeroby).

However, species diversity can only be estimated depending on quantitative surveys related to certain area sizes and habitat qualities on specific time-scales. The term diversity is related to natural diversity in correlation with the degree of human impacts, but it cannot be used as an isolated criterion for evaluations of nature and landscapes itself. For example, higher species diversity within naturally species poor high-moor bogs might just be caused by peat harvesting, or nutrient poor habitats might just be eutrophicated due to human influences, which allows unnatural species to compete successfully and to colonize these habitats.

Nevertheless, the human species must decide to which extend it wants to allow natural developments and processes of nature and landscapes of particular cases at a certain spatial- and time-scale. For example, a study on the visitors' opinion has revealed two clearly separated fractions for the management of the partly abandoned Nunhead Cemetery in London, UK, in 1993. Those, who prefer "naturalness" and "closed woodlands", i.e. current natural succession without management intervention of the secondary naturally grown woodland, and the others, who want to stop and to remove the naturally overgrowing Ivory (*Hedera helix*) from old gravestones. The reasons can be found in recreational and aesthetic purposes, but also in the purpose to visit particular graves according to this participatory opinion poll of direct users (Zisenis, 1993), i.e. the criterion "naturalness" as a management guideline is valued positively or negatively depending on, *inter alia*, the subjective psychological perception and personal social relations to Nunhead Cemetery and its elements by the direct visitors in 1993 (cf. chapters 2.3.2 Psychological perceptions on page 40 and 2.4.2 Social functions of nature and landscapes on page 56, respectively). Furthermore, also the other evaluation criteria apart from "naturalness" were applied to the whole range of different values of Nunhead Cemetery to the public directly and indirectly concerned, as well as, on its own to complete this interdisciplinary evaluation example for practical management decisions (Zisenis, 1993, 1996, 1998).

However practically in Central Europe, there is almost no place any more of historical naturalness without human influences to a certain degree. The PNV-concept provides a theoretical methodical assumption, which vegetation would theoretically occur at the time being without present human influences as an expression of current naturalness for practical planning processes and project evaluations. However, it does not allow future predictions of vegetation developments in detail neither by natural succession nor forthcoming human influences. Irreversible processes of natural succession of ecosystems and their components cannot be predicted in detail anyway. Therefore, monitoring schemes are necessary to provide spatial and time related reference scales of similar species compositions and developments of natural processes in ecosystems to apply the criterion naturalness for interdisciplinary evaluations of nature and landscapes (cf. section 6.3 Monitoring on page 304). Certain species can indicate the existing and desired degree of human impacts (hemeroby) for practical planning decisions and project assessments, which has the advantage to integrate also future successional developments, in contrast to the PNV-concept (cf. Wulf, 2001), but not exactly in detail predictable species compositions and abundances, as well as, irreversible structural and functional relations of ecosystems (cf. section 6.1 Mathematical and descriptive methods on page 299).

3.2.4 Typicalness

3.2.4.1 Indicator species

The criterion typicalness refers to a typical condition of nature and landscapes and the interactions of their elements on a certain spatial- and time-scale. For practical evaluations of nature and landscapes, we need indicator species to estimate typical current and historical conditions, as well as, future developments in the context of a certain area and during a particular time period of a value to the human being and on their own. There are different indicator species groups, as well as, appropriate methods of their measurements (Table 3.2-23; overview for animals: Riecken, 1990, 1992; Nagel, 1999; Kratochwil and Schwabe, 2001; Bernotat et al., 2002b; Schlumprecht, 2002; Stickroth et al., 2003; for plants: Ellenberg et al., 1992; Müller-Hohenstein and Beierkuhnlein, 1999; Müller-Motzfeld et al., 2002; bibliographic overview for animals and plants: Carl and Jessel, 1998). However for typical material, energetic, and informative processes and structures of ecosystems, there are further indicators necessary than species (cf. section 3.2.7 Ecological functions on page 191; overview in Delbaere, 2002; Delbaere et al., 2002; Choudhury et al., 2004; Wiggering and Müller, 2004).

Table 3.2-23. Rough estimation of the suitability of different species groups as indicators according to practical requirements in Germany (Bastian and Schreiber, 1999, modified).

Species groups	Mobility	Population fluctuations per year	Scientific biological and biogeographical knowledge	Data availability for comparisons	Distribution and abundance of species groups	Standardized measurement methods	Taxonomic knowledge and availability of literature for species identifications	Available scientists	Time needed for i) species identifications and ii) surveys
Snails (*Gastropodae*)	low	medium	high	high	high	high	high	medium	i) medium ii) medium
Earthworms (*Annelidae*)	low	medium	high	medium/ high	high	high	high	medium	i) medium ii) medium
Spiders (*Arachnidae*)	low/high	medium/ high	medium	medium/ low	high	high/ medium	medium	medium/ low	i) medium/ high ii) high
Crickets (*Saltatoriae*)	medium	high	high	high/ medium	medium	medium	high	high	i) high/ medium ii) medium
Ground beetles (*Carabidae*)	medium	medium/ high	high	high	high	high	high	high	i) medium ii) medium
Other beetles (*Coleoptera*)	medium/ high	high/ medium	medium	low/ medium	high	medium	low/ medium	medium/	i) medium/ high, ii) high

Species groups	Mobility	Population fluctuations per year	Scientific biological and biogeographical knowledge	Data availability for comparisons	Distribution and abundance of species groups	Standardized measurement methods	Taxonomic knowledge and availability of literature for species identifications	Available scientists	Time needed for i) species identifications and ii) surveys
Butterflies (*Lepidoptera*)	high	high/ medium	high/ medium	high	high	medium/ low	high/ medium	high	i) high ii) medium/ high
Hover-flies (*Syrphidae*)	high	high	medium	low	high	medium	medium	low	i) medium/ high ii) high
Amphibians (*Amphibia*)	medium	medium	high	high	medium/ low	medium	high	high	i) medium ii) low
“Reptiles” (*Reptilia*)	medium	low/ medium	high	high	low	low	high	high	i) high ii) low
Birds (*Aves*)	high	low/ medium	high	high	medium/ high	high	high	high	i) medium/ high ii) low
Small mammals (*Mammalia*)	medium	medium	high	high	high/ medium	medium	high	high/ medium	i) medium/ ii) high
Big mammals (*Mammalia*)	high	low	high	high	medium/ low	low/ medium	high	high	i) medium ii) low

Depending on the particular case, indicator species need to be selected in pre-studies in relation to specific spatial and time-scales (cf. chapter 3.1 General conditions of evaluations on page 106 and chapter 6.2 Model guidelines on page 303, respectively). There is still an intense research deficit to which extend and how sharply indicator species can reveal certain typical conditions of nature and landscapes (cf. chapter 8 Outlook into future research on page 321). Nevertheless, in general there are different information sources to identify indicator species of specific conditions of nature and landscapes on different levels (Table 3.2-24).

Table 3.2-24. Information sources to identify indicator species (Ellenberg, 1988; Bastian and Schreiber, 1999; modified)

Information sources to identify indicator species
• scientific literature of particular behaviour and habitat requirements of species, their distribution and abundance on different spatial levels, as well as, their sensitivity to specific influences • empirical information of local experts about species • own investigations on the ground to estimate abundances, as well as, ecological requirements of species • laboratory research of environmental tolerances and competitions with other species

For different habitat types, typical biocoenosis of certain ecological guilds[16] can be expected, which can be related to certain indicator functions of these species (Reck, 1995). Typical biocoenosis are based on spatial species compositions, habitat structures, and functional relations, as well as, dynamic developments of habitats and species (cf. Riedl, 1995). Animal species show trophic (e.g. phytophages), structural (e.g. net-spiders), and microclimatic (e.g. grasshoppers) relationships to plants, as well as, combinations of them (Kratochwil and Schwabe, 2001). For example, different typical bird communities can be expected in relation to certain habitats of nature and landscapes in certain regions during specific periods of the year (cf. Flade, 1995, 2000; Heidt and Flade, 1999; Stickroth et al., 2003).

However in general, animals are less dependent on floristic components, but more conditional on structural forms of nature and landscapes (Nagel, 1999). There are significant ecological differences between plant associations and biocoenosis of animals (Table 3.2-25).

[16] Ecological guilds are understood as functional species groups, which use certain resources in similar ways (Reck, 1995).

Table 3.2-25. Characteristics of zoocoenosis in comparison to plant associations (Kratochwil and Schwabe, 2001)

Characteristics of biocoenosis

- zoocoenosis do not have dominant associations, which are easily to detect (except sessile zoocoenosis); there are always trophic dependences on other organisms
- zoocoenosis have higher species and life-form numbers than phytocoenosis
- zoocoenosis have qualitatively and quantitatively very different life-form groups (synusis)
- many animal species have different morphological stages (semaphorontes) during their life-cycle
- animals are generally mobile with a few exceptions; thus they demand different habitat resources at different places (e.g. nutrition, micro-habitats, resting, sleeping, and nesting places), and many animal species are seasonal migrators and often change strata
- several animal species have short life-time periods and activity periods during the year
- zoocoenosis have more complex relationships than phytocoenosis due to their higher number of species, already concerning predator-prey relations, as well as, parasite-host or parasitoides-host relationships

Practically, it is never possible to survey the whole zoocoenosis. Often there are only activity densities detectable at definite places for specific time periods (Kratochwil and Schwabe, 2001). Furthermore, we should be aware that missing of certain species of typical biocoenosis at specific areas of nature and landscapes can have several reasons and needs further investigations for evaluations. Nevertheless, missing of certain typical species or ecological guilds can indicate certain historical or current influences on nature and landscapes.

3.2.4.2 Typical urban species

In urban agglomerations, we can find typical urban species, which have adapted to the urban conditions during evolutionary processes. Some of them do not occur any more at the countryside depending on their degree of dependence on urban habitats. Therefore, these typical urban species have different values for the society and on their own depending on the particular evaluation case, but they can be also used as indicators of typical urban conditions of nature and landscapes for interdisciplinary evaluations.

On plant species level, we can distinguish between urbanophilic, urbanoneutral, and urbanophobe species (Wittig, 1991, 1998, 2002). Their distribution can vary from city to city (Table 3.2-26).

Table 3.2-26. Plant species distribution types at urban areas in Central Europe (Wittig, 1991, 1998)

Urbanophilic	Urbanoneutral	Urbanophobe
• plant species of distribution concentrations in urban areas, which do not occur in rural areas (extreme urbanophilic), and those which have distribution concentrations in urban areas, but also occur in rural areas (moderate urbanophilic)	• plant species of wide ecological amplitudes (ubiquitous[17] species), which occur in urban, as well as, in rural areas	• plant species at nutrient poor to moderate nutrient rich habitats (oligotrophic to mesotrophic habitats), unregulated rivers and lakes, wetlands, and nutrient poor soils, as well as, those plant species, which are sensitive to mechanical disturbances (trampling, spilling, hoeing, etc.).
• extremely urbanophilic plant species depending on specific urban habitat conditions, for example, high degrees of disturbances and dry-warm climatic conditions. They can be distributed on the whole urban area (holourbanic plant species), they can be restricted to industrial and traffic areas (industriophilic plant species), or they can be limited to railways and harbours (orbitophilic plant species). For example, there are some plant species restricted to historic	• many root crop wild plants, for example, Gallant Soldier (*Galinsoga parviflora*), trample plants, for instance, Greater Plantain (*Plantago major*) and Knotgrass (*Polygonum aviculare agg.*), plant species of park grasslands, and some nitrophile edge plant species, as well as, some pioneer tree species, for example, Silver Berch (*Betula pendula*) and Goat Willow (*Salix caprea*)	• extremely urbanophobe are nearly all orchids, most lilies, and many sedges

[17] Ubiquitous species are generalists, which occur everywhere in different habitats without being fixed to a particular site (Sedlag and Weinert, 1987).

monuments and excavation sites in Rome, *inter alia*, Caper (*Capparis spinosa*)

- moderate urbanophilic are, for example, the Common Evening-primrose (*Oenothera biennis*) and *Hordeum murinum*

- moderate urbanophobe are many woodland plant species, for example, Wood Anemone (*Anemone nemorosa*), some reed plant species, for instance, Reed Canarygrass (*Phalaris arundinacea*), and many meadow plant species, for example Field Eryngo (*Eryngium campestre*).

Moreover, there are also animal species, which depend in their distribution on urban agglomerations. In general, five different types can be differentiated of animals living in anthropocoenosis (Table 3.2-27).

Table 3.2-27. Different types of animals living in anthropocoenosis (Klausnitzer, 1993)

Obligatory synanthropogeny (eusynanthropogeny)

- species, which occur in one climatic region at the minimum just under anthropogenic conditions. In extreme cases, these are species, which only occur in urban agglomerations of the human species. For example, the House Sparrow (*Passer domesticus*), Feral Pigeons as the feraled form of the Rock Dove (*Columba livia*), and the Collared Dove (*Streptopelia decaocto*) are eusynanthropogenic.

Facultative synanthropogeny (hemisynanthropogeny, oligosynanthropogeny)

- species, which have optimal development conditions in urban agglomerations of the human species. However, there are also existing metapopulations outside anthropocoenosis, which can immigrate.

Permanent synanthropogeny

- species, which have their whole live development cycle in anthropocoenosis.

Temporary synanthropogeny (xenanthropogeny)

- species, which live just during certain periods or at certain conditions in anthropocoenosis, for example, during overwintering. Those species do not build up own populations in anthropocoenosis.

Partly synanthropogeny

- species, which live during certain periods of their life-cycle in anthropocoenosis, perhaps even in daily changes. During other times, they belong to different communities.

It is typical for urban agglomerations that new bird communities develop (aviocoenosis), which do not occur outside urban areas. Urbanization of animals in general is often combined with behavioural adaptation to urban conditions, for example, of birds (*Aves*), membrane-winged insects (*Hymenoptera*), and beetles (*Coleoptera*). A typical example is the Blackbird (*Turdus merula*). Either animal species can use new anthropogenic licenses rapidly when they develop, or they adapt time by time during evolutionary processes, which are based on selection, mutations (Klausnitzer, 1993), reproduction, migrations, competition, and passed on behaviour.

Moreover, urban areas are ecosystem complexes, which content of several different habitat types due to various uses of nature and landscapes. Therefore, habitat diversity and species diversity are typically higher than in rural areas of comparable sizes (cf. Table 3.2-28; Sukopp et al., 1984; Sukopp, 1990; Blab, 1993; Sukopp and Wittig, 1998).

Table 3.2-28. Urban diversity of selected animal species and important ecological habitat requirements of their species groups, without evidence of their reproduction (Erz and Klausnitzer, 1998)[18]

Species groups	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**	**Amount of species**
Acari	-	+	+	-	+	-	+	+	+	+	-	-	200
Amphibia	-	-	-	-	+	-	-	-	-	-	-	-	10
Anobiidae	+	-	-	-	-	-	-	+	-	-	-	-	10
Aphidiidae	-	-	+	-	-	+	-	-	-	-	-	-	85
Apoidae	+	+	+	+	-	-	-	-	-	+	-	-	130
Araneae	+	+	-	-	+	-	-	-	-	+	+	+	450
Aves	+	-	-	-	+	-	+	-	-	+	-	-	200
Blattariae	+	-	-	-	-	-	+	+	-	-	-	+	7
Bostrichidae	-	-	-	-	-	-	-	+	-	-	-	-	3
Bruchidae	-	-	+	-	-	-	-	+	-	-	-	-	8
Byrrhidae	-	-	+	-	-	-	-	-	-	-	-	-	5
Caelifera	-	-	+	-	-	-	-	-	-	-	-	-	13
Carabidae	-	+	+	-	+	-	-	-	-	-	+	-	250
Catopidae	-	-	-	-	-	-	+	-	-	-	-	-	10
Cerambydidae	+	+	+	-	-	-	-	+	-	-	-	-	25
Chilopoda	-	+	-	-	+	-	-	-	-	+	+	-	15
Chrysididae	-	-	+	-	-	+	-	-	-	-	-	-	10
Chrysomelidae	-	-	+	-	-	-	-	-	-	-	-	-	50
Coccinellidae	+	-	-	-	+	-		+	-	-	-	-	35
Collembola	-	+	-	-	-	-	+	+	-	-	-	+	75
Cryptophagidae	-	-	-	-	-	-	+	+	-	-	+	-	25
Culicidae	-	-	-	-	-	-	-	-	+	-	+	-	22
Curculionidae	-	+	+	+	-	-	-	+	-	-	-	-	250
Dermaptera	-	-	-	-	+	-	-	+	-	-	-	-	4

[18] Amounts of species are rounded up and they differ from one urban area to another, but they provide an order of magnitudes (Erz and Klausnitzer, 1998).

Species groups	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Amount of Species
Dermestidae	+	-	-	+	-	-	+	+	-	-	-	-	35
Diplopoda	+	+	-	-	-	-	-	-	-	-	+	+	40
Diplura	-	+	-	-	-	-	-	-	-	-	-	-	13
Diptera synanthropogenic	-	-	-	-	-	-	+	+	-	-	-	-	25
Drosophilidae	-	-	-	-	-	-	+	+	-	-	-	-	12
Elateridae	-	+	+	-	+	-	-	-	-	-	-	-	50
Enchytraeidae	-	+	-	-	-	-	+	-	-	-	-	+	25
Ensifera	+	-	-	-	+	-	-	+	-	-	-	+	10
Evaniidae	-	-	-	-	-	+	-	-	-	-	-	-	3
Formicidae	+	+	-	-	-	-	-	+	-	-	-	-	20
Gastropoda	-	+	-	-	-	-	-	-	-	+	+	+	55
Heteroptera	-	+	+	+	+	-	+	+	+	-	-	-	55
Histeridae	-	-	-	-	+	-	+	+	-	-	-	-	15
Homoptera	+	-	+	+	-	-	-	-	-	-	-	+	450
Ichneumonidae	-	-	+	-	-	+	-	-	-	-	-	-	380
Isopoda	+	+	-	-	-	-	+	-	-	-	+	+	8
Isoptera	-	-	-	-	-	-	-	+	-	-	-	+	1
Latridiidae	-	-	-	-	-	-	+	+	-	-	+	-	20
Lepidoptera	+	-	+	+	-	-	+	+	-	-	-	-	1880
Lumbricidae	-	+	-	-	-	-	+	-	-	-	-	+	15
Lyctidae	-	-	-	-	-	-	-	+	-	-	-	-	5
Mammalia	-	-	-	-	+	-	+	+	-	+	+	-	22
Mantodea	+	-	-	-	+	-	-	-	-	-	-	-	1
Nemathelminthes	-	+	+	-	-	-	+	-	+	-	-	-	40
Opiliones	+	-	-	-	+	-	-	-	-	+	-	-	20
Ostomidae	-	-	-	-	-	-	-	+	-	-	-	-	1
Phthiraptera	-	-	-	-	-	-	-	-	+	-	-	-	25
Planipennia	+	-	-	-	+	-	-	+	-	-	-	-	60
Plathelminthes	-	-	-	-	-	-	-	-	+	-	-	-	6
Proctotrupoidae	-	-	+	-	-	+	-	-	-	-	-	-	200

Species groups	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Amount of species
Pseudoscorpiones	-	-	-	-	+	-	+	+	-	-	-	+	9
Psocoptera	-	+	+	-	-	-	+	+	-	+	-	+	65
Ptinidae	-	-	-	-	-	-	+	+	-	-	-	-	12
Reptilia	+	-	-	-	+	-	-	-	-	+	-	-	4
Scarabaeidae	-	+	+	-	-	-	+	-	-	-	-	-	18
Silphidae	-	-	-	-	-	-	+	-	-	-	-	-	5
Siphonaptera	-	-	-	-	-	-	+	+	+	-	-	-	10
Sphecidae	+	+	+	-	+	-	-	-	-	+	-	-	70
Staphylinidae	-	+	-	-	+	-	-	-	-	-	+	-	350
Symphyla	-	-	-	-	-	-	-	-	-	-	-	+	2
Syrphidae	-	-	+	+	+	-	-	-	-	-	-	-	80
Tachinidae	-	-	+	-	-	+	-	-	-	-	-	-	100
Tenebrionidae	-	-	-	-	-	-	+	+	-	-	+	-	10
Tenthredinoidea	-	-	+	-	-	-	-	-	-	-	-	-	300
Thysanoptera	-	-	+	-	-	-	-	-	-	-	-	+	35
Vespidae	-	+	-	-	-	-	+	+	-	-	-	-	10
Zygentoma	+	-	-	-	-	-	+	+	-	-	-	+	4
Sum of species													**6468**

I. Urban heat conditions
II. Urban soils
III. Urban humus layers
IV. Autochthonous plant species as nutrition
V. Hemerochorous plant species
VI. Predatory life-style
VII. Parasitoides
VIII. Use of outdoor organic wastes, also nests
IX. Storage and materials at intradomal spaces, homes
X. Parasites of warm-blooded animals
XI. Originally rock habitants
XII. Cave habitants, cellars
XIII. Glass houses

Urbanization leads in general to an increase of species diversity, but it is combined with a decrease of native species and archeophytes[19] (Table 3.2-29).

Table 3.2-29. Species classification of Berlin's flora, Germany, which has significantly become more abundant or rare, respectively, during the last 100 years (Kowarik, 1998b)

	Amount of species	Native	Archeophytes	Neophytes
Increasing	361	27 %	8 %	65 %
Decreasing	821	78 %	14 %	8 %
Endangered	525	80 %	11 %	9 %

Furthermore, different habitat types can be found together typically as habitat complexes of certain regions during specific time periods (cf. Riecken, 1996; Mühlenberg and Slowik, 1997; Ssymank, 2000). These habitat complexes allow mapping close connected habitat types and habitat structures in small-patched parts of nature and landscapes (Grabski-Kieron, 1999; cf. section 6.6 Habitat-mapping on page 309).

3.2.4.3 Keystone species

Keystone species (umbrella species) and groups of them are used as target species or flagship species for scientific reasons and advantages for public relations to indicate typical valuable conditions of nature and landscapes on certain spatial and time-scales. They can serve as indicatory species (groups) for practical planning processes and project decisions, because they typically occur at certain habitat and ecosystem conditions, i.e. they represent certain conditions of nature and landscapes at a specific area during specific time periods (cf. Figure 3.2-10; Soulé, 1987b; Mühlenberg and Hovestadt, 1992; Reck et al., 1994; Kratochwil and Schwabe, 1997; Mühlenberg and Slowik, 1997; Kaule, 2000; Kratochwil and Schwabe, 2001; Jessel and Tobias, 2002; Reck, 2004; examples for Germany in SRU, 2002).

[19] Archeophytes are defined as those species, which were introduced up to 1500 A.D., whereas Neophytes have been introduced after this period (Kowarik, 1990).

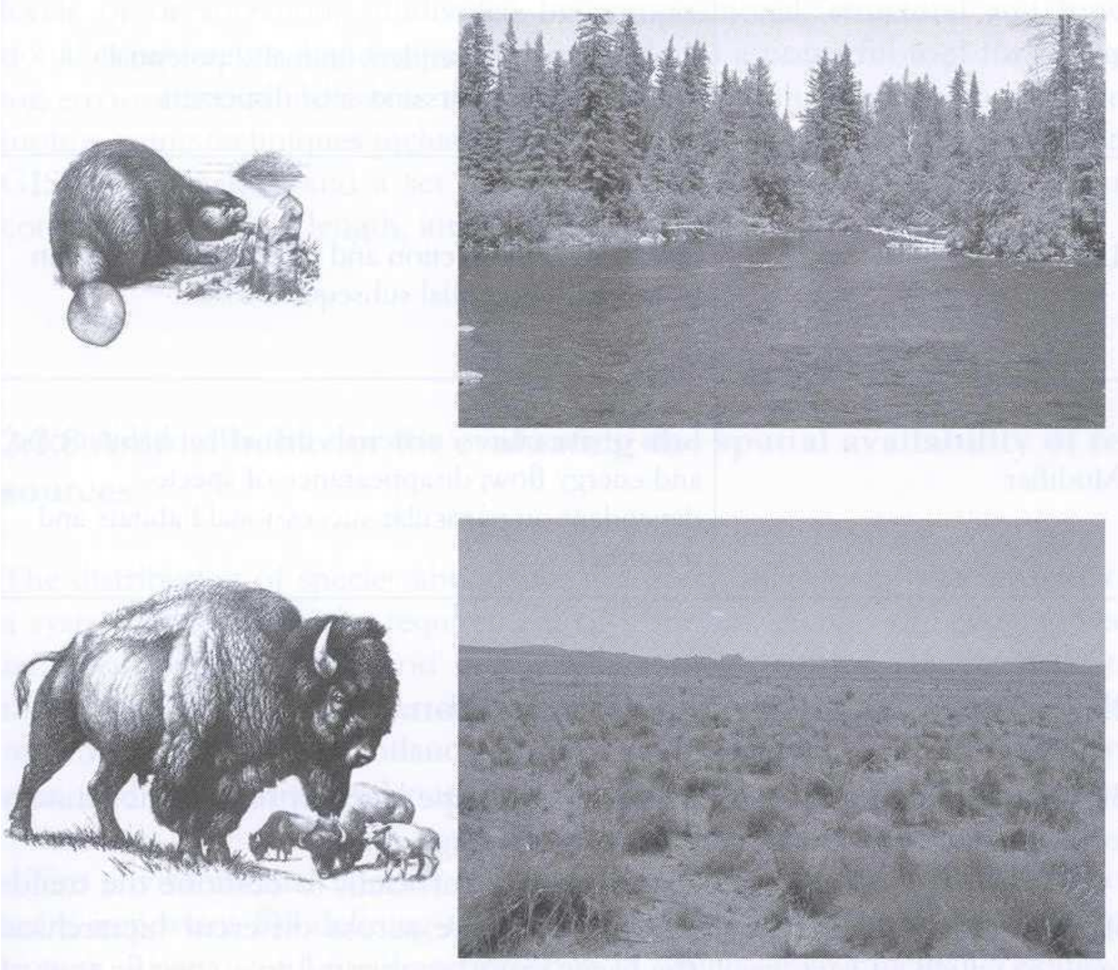

Figure 3.2-10. The Beaver (*Castor canadensis*) and the American Bison (*Bison bison*) as examples of Northern American keystone species of forests and grasslands, respectively (Barker, 1987, modified) reproduced by kind permission of Random House, Inc., New York, USA

However, keystone species or representative keystone groups unlikely indicate whole biocoenosis (Jessel and Tobias, 2002), but they indicate certain favourable, i.e. typical habitat conditions of them. Keystone species need to fulfil certain conditions to be suitable as target species and flagship species (Table 3.2-30).

Table 3.2-30. Characteristic features of flagship species of typical conditions of nature and landscapes (Mühlenberg and Hovestadt, 1992; Mühlenberg, 1993; Mühlenberg and Slowik, 1997; Grosser and Rötzer, 1998; Maino, 1998; Amler et al., 1999; Martin, 2002; modified)

Flagship species
• high demands on habitat quality and quantity of whole ecosystems or habitat complexes
• high dependence on habitat and ecosystem processes

- high sensitivity to changing influences
- high direct or indirect habitat dependences of many other organisms
- main distribution in our geographical regions
- relatively easy detection and analysis, as well as, good available research
- high popularity in human societies including symbolic values
- sufficient available financial, structural, and intellectual resources for management and public relations

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Therefore, keystone species and keystone groups can be used for nature conservation purposes to estimate typical habitat and ecosystem conditions, which are too complex to be surveyed and analysed for interdisciplinary evaluations of nature and landscapes in detail within the available time and resources. In addition, they need to be of positive value to the human society and on their own to be used for public relations for supporting planning processes and project decisions in favour of the representing values of these habitat and ecosystem conditions.

3.2.4.4 Typical evolutionary relicts

Moreover, there are also typical evolutionary relicts that represent certain time periods and regions of their distribution of different values of nature and landscapes to the society and on their own; the sole survivors of largely extinct taxonomic groups sometimes referred to as "living fossils", such as the Coelacanth (*Latimeria chalumnae*), a sea fish found off the south-east coast of Africa whose nearest relatives died out in the cretaceous period (>60 million years ago) (Figure 3.2-11), and the Tuatara (*Sphenodon punctatus*) from New Zealand, a primitive reptile which looks superficially like a lizard, but is a relict from the early beginnings of the reptiles in the Triassic (Pullin, 2002).

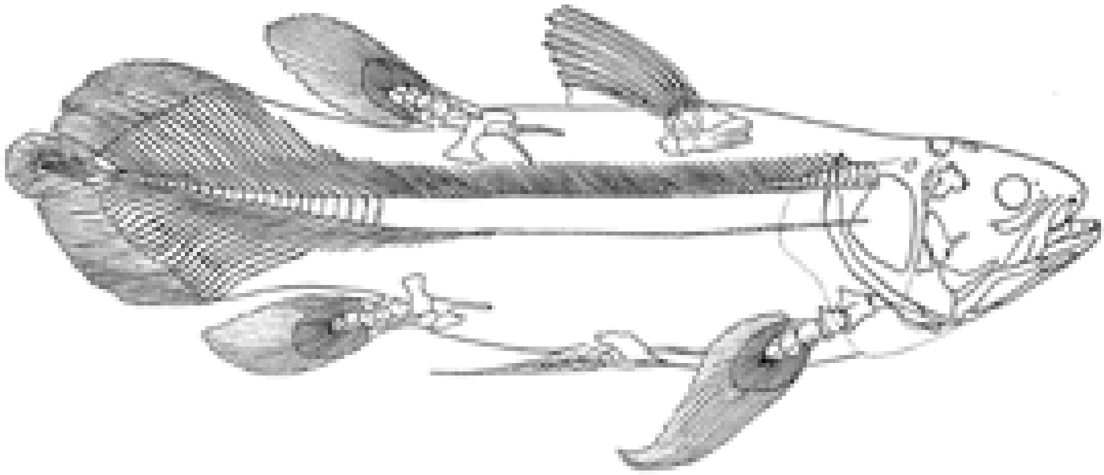

Figure 3.2-11. The “living fossil” Coelacanth (*Latimeria chalumnae*) (Museum für Naturkunde Berlin, 2004) and its skeleton (Wellnhofer, 2004)

3.2.4.5 Methodical difficulties

Different characteristics of animal species cause high technical efforts for surveys of indicator species. Most animals have individual mobilities and habitat changes during their lifetimes. For example, holometabolic insects occupy different habitats as eggs, larvae, puppets, and imagines, respectively. Moreover, animals can use seasonally different habitats, for example, migrating birds or mammals, fishes, and butterflies. They can have resting periods, for instance, during winter, diapauses, and aestivations. In addition, they can change their nutrition contents and amounts during different seasons and stages of life (Nagel, 1999).

Furthermore, standardized graphs are necessary for environmental indicator plants. Many plant organisms do not show linear relations between the intensity of pollutants and reactions or accumulations, respectively. For example, tolerance levels of lichens are based on data, which was collected at laboratories or at fields of monocultures or mixed cultures. In addition, results of monitoring field experiments of plants can be influenced by many reasons. For instance, lichens react highly dependant on their water contents. Pollutants can almost not affect dry lichens. Moreover, substrates of plants can enhance or buffer deteriorating influences of pollutants. Furthermore, also competitions between lichens are important (Müller-Hohenstein and Beierkuhnlein, 1999).

For animal species, there are basically two types of recording methods (Table 3.2-31).

Table 3.2-31. Types of recording methods for animal surveys (Bastian and Schreiber, 1999, modified)

Types of recording methods for animal surveys
• directly detecting visually, acoustically, or collecting by hand, which allows to estimate abundances and metapopulation sizes of certain areas of nature and landscapes in combination with standardized detecting methods, for example, transects, line taxations, and representative quadrates • detecting activity densities by traps, for example, nets, coloured dishes, Barber traps, which reveals qualitative data of animal species.

However, we need to consider that metapopulations of animal species can vary significantly from year to year. For example, metapopulations of arthropods vary often by factors of 100 or more, small mammals by factors of 10, snails by factors of 5, and small birds by factors of 3 (Mühlenberg, 1993). Metapopulation fluctuations are especially high at the border of distribution areas of species of less favourable conditions of nature and landscapes (Mühlenberg and Slowik, 1997).

Furthermore, many animal species have regionally differentiated habitat relations, as well as, reaction norms depending on, for example, climatic differences and ecological behaviour (Spang, 1999; Platen, 2000). In addition, also flora and vegetation can fluctuate significantly during the years (cf. Dierschke, 1994).

3.2.4.6 Conclusive summary

The criterion typicalness refers to a typical condition of nature and landscapes and the interactions of their elements on a certain spatial- and time-scale. For practical evaluations of nature and landscapes, we need indicator species to estimate typical current and historical conditions, as well as, future developments on certain spatial and time-scales. There are different indicator species groups, as well as, appropriate methods of their measurements. However for typical material, energetic, and informative processes and structures of ecosystems, there are further indicators necessary than species.

Depending on the particular case, indicator species need to be selected in pre-studies in relation to specific spatial and time-scales. For different habitat types, typical biocoenosis of certain ecological guilds can be expected, which can be related to certain indicator functions of these species. However in general, animals are less dependent on floristic components, but more conditional on structural forms of nature and landscapes.

Practically, it is never possible to survey the whole zoocoenosis. Furthermore, we should be aware that missing of certain species of typical biocoenosis at specific areas of nature and landscapes can have several reasons and needs further investigations for evaluations. Nevertheless, missing of certain typical species or ecological guilds can indicate certain historical or current influences on nature and landscapes.

There are typical urban species, which depend in their distribution on urban agglomerations. Urban areas are ecosystem complexes, which content of several different habitat types due to various uses of nature and landscapes. Therefore, habitat diversity and species diversity are typically higher than in rural areas of comparable sizes. Urbanization leads in general to an increase of species diversity, but it is combined with a decrease of native species and archeophytes. Furthermore, different habitat types can be found together as typical habitat complexes of certain regions during specific time periods. For instance, the Swift (*Apus apus*) is a typical urban species in Central Europe during summer times between May and August (Klausnitzer, 1993). Therefore, its arrival indicates a period of more freely social meetings and cultural activities outdoors in cafes, parks, street festivals, and at other places as a social and culture-historical value of this polyhemerobic[20] urban ecosystem complex, respectively (cf. sections 2.4.2 Social functions of nature and landscapes on page 56 and 2.5.3 Culture-historical guidelines on page 77, respectively), due to the higher temperatures, sunny days, and higher density of cultural activities depending, *inter alia*, on the location, infrastructure, and annual climatic conditions of the particular city.

Moreover, there are also typical revolutionary relicts of certain time periods and regions of their distribution, which can have different values to the human species and on their own, for instance, as a typical culture-historical example of a certain period and region, but also a scientific value as a missing link (cf. Sedlag and Weinert, 1987) of typical features of an evolutionary development.

For scientific reasons and advantages for public relations, keystone species and groups of them are used to indicate typical conditions of nature and landscapes on certain spatial and time-scales. However, keystone species or representative keystone groups unlikely indicate whole biocoenosis, but they indicate certain favourable habitat conditions of them. Therefore, again diversity is related to typical conditions of nature and landscapes at a certain period of time of a certain area, but not a criterion for evaluations of nature and landscapes itself.

Typicalness is a criterion that depends on indicator species and various other indicators of ecosystems to reveal typical current and historical conditions at a certain area. Keystone species and groups can help to evaluate and to promote planning processes and project decisions based on typical conditions of nature and landscapes on specific spatial and time levels.

For example, the typical habitat of the Black Storck (*Ciconia nigra*) are deciduous and mixed woodlands, including wetlands and a high amount of old

[20] Cf. definition of this degree of human influences (hemeroby) in section 3.2.3.4 Indicator species of naturalness on page 153, because the criteria “typicalness” and “naturalness/degree of human impacts”, respectively, occur together in this interdisciplinary evaluation example.

trees, as well as, well developed shrub and herb layers in Central Europe (Bezzel and Reichholf, 1991; Blab, 1993). The Black Storck indicates as an umbrella species a typical habitat condition of large mature old woodlands with lots of standing and lying dead wood that serves as habitats for many other species, including hole nesting birds and living bats, xylophagous[21] and other insects, ferns, and mosses (Blab, 1993). The Black Storck can also serve as a keystone species of Minimum Viable Metapopulations (MVM) to estimate minimum areas of this habitat type (Hovestadt, 1990; cf. section 3.2.2.4 Minimum Viable Metapopulation (MVM) concept on page 126), because it demands a very high habitat range and indicates the aging process of the woodland ecosystem.

Moreover, the Black Storck is very sensitive to structural and spatial changes, and its occurrence can be reasonably detected and analysed based on a good knowledge of its habitat demands. In addition, the Black Storck can serve as a flagship species of these typical habitat conditions of old oligohemerobic[22] woodlands, because it could be developed as a representative symbol for the different values of old woodlands to the human being and on their own of low degree of human influences. For instance, these old woodlands have immaterial symbolic and mystic psychological values (cf. section 2.3.3 Aesthetic analysis on page 41), but also recreational values, which can be evaluated apart from the immaterial psychological aesthetic value (cf. sections 2.3.1 Psychological benefits on page 38 and 2.3.4 Methodical applications on page 45) also in money as a material economical value (cf. section 2.1.2 Methodical aspects on page 20).

However in practice, different characteristics of animal species can cause high technical efforts for surveys of indicator species. Methodical difficulties to survey and to analyse metapopulation fluctuations limit the exactness of comparable data of typical conditions of nature and landscapes. Most animals have individual mobilities and habitat changes during their lifetimes. Many plant organisms do not show linear relations between the intensity of pollutants and reactions or accumulations, respectively. In addition, we need to consider that metapopulations of animal species can vary significantly from year to year. For example, metapopulations of arthropods vary often by factors of 100 or more, small mammals by factors of 10, snails by factors of 5, and small birds by factors of 3. Also flora and vegetation can fluctuate significantly during the years.

3.2.5 Re-establishment ability

3.2.5.1 Re-establishment conditions

In general, the re-establishment abilities of nature and landscapes depend, *inter alia*, on available grounds, artistic and technical opportunities, financial and

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[21] Eating or boring into wood (Allen, 1990).

[22] Cf. definition in section 3.2.3.4 Indicator species of naturalness on page 153.

material resources, political and social circumstances, as well as, colonization and development conditions.

However, we must be kept in mind that many species rich habitats can only develop nearby corresponding populations (Kaule, 1991), if isolation barriers can be overcome, and if development conditions are appropriate. Furthermore, similar species competitions and structural habitat conditions must exist, if re-establishments of similar species compositions and abundances shall be expected. Therefore, the same part of nature and landscapes can hardly re-establish, just a similar one at the best (Table 3.2-32).

Table 3.2-32. Examples of habitats, which cannot re-establish any more during current conditions in Central Europe (Jedicke, 1990, modified)

Natural habitat types, which do not have sufficient development conditions any more

- primary woodlands including azonal types (for example, riverside woodlands)
- transitory (slope)-moor bogs and high-moor bogs
- mesotrophic and oligotrophic low-moor bogs (except eutrophic low-moor bogs in rich regions of moor bogs)
- sources and sources marshes
- natural lakes and natural lake shores
- natural rivers and natural streams, including their temporarily overflooded grounds, woodlands, and reeds
- primary vegetation on rocks
- natural salt water meadows and coast dunes
- rock caves

Secondary habitat types, which do not have sufficient development conditions any more or which last too long to develop

- semi-naturally temporarily overflooded river and stream sides, including wetland meadows, woodlands, and reeds
- old secondary vegetation on rocks
- old wall hedges and old field stone walls
- oligotrophic and mesotrophic grasslands (for example, chalk grasslands, sand grasslands, non-alpine Mat-grass (*Nardus stricta*)-grasslands, Purple Moor Grass (*Molinia caerula*)-grasslands on old soil profiles (older than 50 years))
- heathlands on soil profiles older than 50 years
- inland salt vegetation
- semi-natural woodlands
- specific historical woodland management forms

Habitats of old settlements

- historical urban woodlands, parks, and cemeteries
- old trees, tree groups, and avenue trees
- old (small) ponds

- old natural stone walls and brick walls of climbing and grout vegetation

Extraordinary geomorphologic sites and unique cultural sites

- dolines
- graves
- relicts of higher agricultural fields

Areas of specific conditions

- ecosystems, where Red Data species occur in such isolation that a population rise or recolonization is unlikely
- areas of recognized national and international importance (they are normally included in the categories mentioned above)

For example, historical gardens are characterized by a certain garden architecture. Re-establishment requires a lot of funding and resources. It is only possible, if plans of the old garden architecture and their contents are still preserved, as well as, the human skills are passed on and available. Missing sculptures must be remodelled. Buildings must be refurbished or removed, respectively, trees and bushes planted, old paths and flowerbeds reconstructed. If there are still enough seeds in the ground, extensive management of meadows can allow regrowing plant species, which have historically lived on the ground on a wider scale. Moreover, there is the possibility of recolonization of organisms, depending on isolation and development conditions of the ground. Another example are old cemeteries, which cannot re-establish any more. Their graves are unique artworks of the period of time. Each represents the honour of a unique life (cf. Zisenis, 1993, 1998).

Furthermore, natural structure and diversity of ecosystems cannot be achieved by planting or by introduction of species. Nature and natural processes are too complex for humans to be simulated or to be reproduced (Table 3.2-33; Zisenis, 1993; sections 3.2.3.2 Potentially Natural Vegetation (PNV) on page 151 and 3.2.3.3 Mosaic Cycle Hypothesis on page 152, respectively). Apart from their extremely complexity, there may occur unexpected effects and rare events at any time due to the high amount of linkages and indirect effects in ecosystems of nature and landscapes. This renders it impossible to analyse and to know all details (J∅rgensen and Müller, 2000). Ecological uncertainty is inevitable because organisms, their structures and behaviours, and their ecological contexts are permanently changing (Breckling and Dong, 2000; cf. 6.1 Mathematical and descriptive methods on page 299).

Table 3.2-33. Evaluation limits of ecosystems of nature and landscapes (Jaeger, 2000; modified)

Characteristics of ecosystems	Consequences for evaluations	Examples
High complexity	• makes it impossible to completely determinate interacting mechanisms and their possible reactions to influencing impacts by a limited number of measurements	• woodland ecosystems and their reactions to material inputs
No clear borders	• makes it unclear to differentiate ecosystems spatially, time based, and functionally, because they do not distinguish themselves from their environment like organisms	• to separate ecosystems within landscapes
Long reaction periods	• long accumulation, latency, and reaction times make it difficult to distinguish different influencing impacts	• reactions of woodlands to higher mean temperatures and higher carbon dioxide concentrations • accumulation of materials in soils, and soil regenerations
Permanent succession	• permanent dynamic developments of ecosystems do not allow outbalanced situations and to estimate relaxation periods of external	• compensation of impacts

	influencing impacts	
No reproducible experimental conditions	• makes it difficult to simulate assumptions of conditions in detail	• evolutionary experiments with species • climatic experiments
Perception difficulties	• difficult direct sensitive perceptions of changes	• material inputs • species and metapopulation changes • dynamic processes

3.2.5.2 Isolation barriers

Our nature and landscapes have become highly isolated and fragmentized during industrialization in Central Europe in the 19th and 20th century. Intensive land use by the human species (agriculture, forestry, hunting, fishing, etc.), constructions of transport ways (motorways, railways, airports, harbours, etc.), and buildings in urban and rural areas have changed our nature and landscapes dramatically (cf. Figure 3.2-12; chapter 2.5 Culture-historical values on page 73).

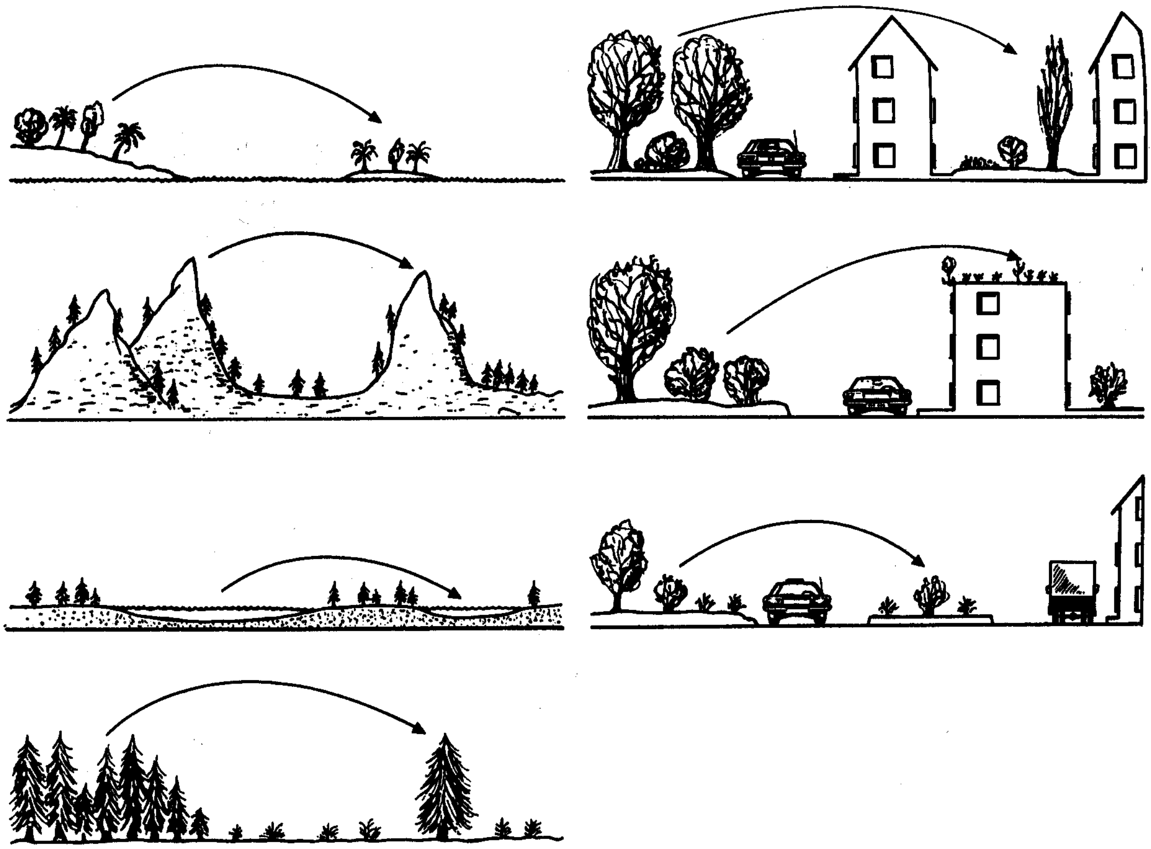

Figure 3.2-12. Examples of different kind of habitat isolations (Klausnitzer, 1993)

However, there are only few species groups, which are mobile enough to overcome isolating barriers of habitats (Table 3.2-34; cf. Jessel and Tobias, 2002; section 3.2.7 Ecological functions on page 191).

Table 3.2-34. Maximum possible recolonization distances through small patches and/or large nature reserves (Jedicke, 1990)

Species	Maximum distance
Water birds (flying adult groups)	100 km
Wading birds (of more than 200 ha large wetlands)	30-50 km
Small birds (medium recolonization distances)	10-25 km
Medium large birds	5-10 km
Birds of hedges and woods at fields	5-10 km
Animals of river benches (of the same river)	5 km
“Reptiles”	1-5 km

Fauna of bogs	5 km
Crickets (*Saltatoria*)	1-2 km
Solitary bees and certain wasps (*Hymenoptera*)	1 km
Fauna of woodland habitats	0.8 km
Arthropods living above soil grounds of Norway Spruce-woodlands (*Picea abies*)	0.5 km

Many endangered species are stenotic[23] (cf. section 3.2.2 Rarity and endangerment on page 114) and they have only low colonization abilities. Therefore, substitutive habitats are often only colonized by common euryotic species[24] at the beginning (Jedicke, 1990; Riedl, 1991).

3.2.5.3 Re-establishment periods

Furthermore, there are many habitats, which are able to re-establish just during long time periods or even not at all any more (cf. Tables 3.2-33 and 3.2-35; Haber et al., 1993; Jedicke, 1994; Schweppe-Kraft, 1997; Bastian and Schreiber, 1999).

Table 3.2-35. Development periods of habitats (Kaule, 1991)

<u>1,000 – 10,000 years</u>

- high-moor bogs
- low-moor bogs of high peat level
- woodlands on old soil profiles, for example, podsoles and some gleys

<u>250 – 1,000 years</u>

- low-moor bogs
- transitory-(slope-)moor bogs
- secondary development on temporarily overflooded riverside grounds, as well as, ponds
- hedges on old stone walls
- dry grasslands and heathlands

<u>150 – 250 years</u>

- woodlands on hot soils (keuper)

[23] Stenotic species are highly specialized on specific habitat conditions. For example, they feed just on certain plants or animals (cf. Klötzli, 1993).

[24] Euryotic species are habitat generalists. They can live, breed, and feed under different habitat conditions (cf. Klötzli, 1993).

- woodlands on soil profiles of high nutrients turnover
- some riverside woodlands
- most hedges
- some low-moor bogs and transitory-(slope-)moor bogs

<u>50 (80) – 150 years</u>

- species poor, few differentiated hedges (if not planted on nutrient rich soils)
- bushes and dry grasslands like vegetation on stone piles and quarries
- grasslands and other silting up ecosystems on (small) ponds
- willow bushes
- species rich meadows cut twice a year

<u>15 – 50 years</u>

- gappy vegetation on rocks
- bushes on wastelands
- broom heathlands on wastelands
- species poor meadows
- herbaceous perennial
- unified species rich grasslands and herbaceous perennial vegetation on embankments
- ditch edges (if alternately cleared)
- eutrophic and mesotrophic secondary lakes

<u>1 – 15 years</u>

- secondary grasslands on sand of flora and fauna of inland dunes (occurrence equally on sand pits, military exercise grounds, and moto-cross sites)
- some ditches
- ruderal (spontaneous) vegetation[25]

However, it would not be correct to conclude that it might be not worth to prepare conditions for the re-establishment of the habitats mentioned above. At least, similar living conditions for a part of species and comparable functional ecosystem processes can be achieved. Nevertheless, in general preservation of habitats should be preferred to re-establishment activities due to the discussed problems (Jedicke, 1990).

[25] Ruderal vegetation is spontaneously growing on unmanaged grounds, which have formerly been intensively used or changed by the human species, for example, unused sites of industrial areas or railways at cities (cf. Sukopp, 1990; Sukopp et al., 1994; Wittig, 1991, 2002).

3.2.5.4 Conclusive summary

Re-establishment abilities of nature and landscapes depend on various conditions and available resources, for example, on available grounds, artistic and technical opportunities, financial and material resources, political and social circumstances, as well as, colonization and development conditions. In practice, the same part of nature and landscapes can hardly re-establish, just a similar one at the best.

Furthermore, natural structure and diversity of ecosystems cannot be achieved by planting or by introduction of species. Nature and natural processes are too complex for humans to be simulated or to be reproduced. Apart from their extremely complexity, there may occur unexpected effects and rare events at any time due to the high amount of linkages and indirect effects in ecosystems of nature and landscapes. Ecological uncertainty is inevitable because organisms, their structures and behaviours, and their ecological contexts are permanently changing.

In particular, there are only few species groups, which are mobile enough to overcome isolating barriers of habitats for recolonizations. Furthermore, there are many habitats, which might be able to re-establish just during long time periods or even not at all any more. For instance, Nunhead Cemetery is a typical Victorian cemetery of about 25 ha size in the widely concreted London Borough of Southwark (UK). It is mainly covered by secondary naturally grown woodland since it was closed for burials in 1969, but partly cleared for new burial grounds in the late 1970s. Nunhead Cemetery was founded in 1840 and laid out as a fine example of Victorian landscape architecture of cemeteries. In addition, Nunhead Cemetery has many elaborate monuments and gravestones that reflect about 150 years of art history and unique individual life. It likely contains the largest area of the most advanced successional stage of secondary woodland of any cemetery in Britain. However, its elaborate monuments and landscape architecture cannot be reconstructed any more, because financial and artistic resources are not available. The re-establishment ability of its secondary woodlands of similar species composition and strata structure is impossible due to the lack of former development conditions, and high degree of isolation from potential recolonization areas. Therefore, Nunhead Cemetery is an example of especially a high culture-historical value of a Victorian cemetery, because it practically cannot re-establish any more, neither its landscape architecture, nor its unique monuments and old gravestones, nor its specific species composition and strata structure of the secondary woodland ecosystem in the London Borough of Southwark in the UK (Zisenis, 1993, 1996, 1998).

However, despite the same conditions of nature and landscapes cannot be achieved any more in an irreversible dynamic process of developments of ecosystems, it can be worth to provide conditions for the re-establishment of similar species, habitats, structures, and functions. Nevertheless, in general preservation of habitats and functional ecosystem processes should be preferred to re-establishment activities due to the discussed problems.

3.2.6 Vulnerability

3.2.6.1 Species, habitat, and ecosystem vulnerability

Nature and landscapes and their depending values to the human species and on their own react differently to external and internal impacts depending on their specific vulnerability (overview in Storm, 1988; Sporbeck et al., 1997; SenStadt, 1999; Rassmus et al., 2003). Also the human species itself is vulnerable to impacts of nature and landscapes, for example, noise and polluted air (cf. Barsch et al., 2003). There are habitats and ecosystems, which are more vulnerable to certain impacts than others, especially when they have rather limited buffer capacities. For example, bogs are extremely vulnerable to nutrients, such as nitrogen deposits from the air or drainage, because their growing plants are just able to compete with other plants species under low nutrient contents and acid wetland circumstances. Peat mosses (*Sphagnum spp.*) release acids into the water to keep up ph-levels of about 4 or lower. However, drainages for peat harvests allow oxidizing plant material to minerals. If this comes together with nutrient input from the air, pioneer trees and bushes are starting to grow, typical bog species disappear and different species can settle down (cf. Blab, 1993). In contrast, there are grasslands on nutrient rich and medium wet soils in many urban areas, which are not as vulnerable to nutrients than bogs (cf. Blume, 1998). Moreover, Nordic boreal woodlands on acid grounds are more vulnerable to acid rain than woodlands in semi-arid zones, which have buffering soils (cf. Zierdt, 1997). The Antarctic and the Arctic are highly vulnerable ecosystems and thereby their depending different values to the human species on their own, because of the easily melting glaciers due to pollution by air and climate change (e.g. Deutscher Bundestag, 1992, 1995). Tropical rainforests are very vulnerable to clear cutting and even selective tree removal, because of the low nutrient content in the soil, which is easily washed out by erosion (Deutscher Bundestag, 1990; Klötzli, 1993) and the partly scarce distribution of species (Deutscher Bundestag, 1990). Furthermore, some tree species of the top layer of tropical rainforests just flower after decades, such as the light red Meranti (*Shorea spp.*) in Malaysia after approximately 50-70 years and an age of ripeness after about 100 years depending on the particular habitat conditions. Cutting below their regeneration cycle leads to dying out of the species at a certain region in the long-term. In addition, if there are too many fertile species cut down, this can lead to genetic erosion (cf. section 3.2.2.7 Ex-situ and in-situ conservation on page 135), i.e. reductions of the genetic diversity (Deutscher Bundestag, 1990).

Therefore, in general there are buffer zones necessary for protective areas, which however can only partly reduce imissions by the air (Table 3.2-36; cf. Haber et al., 1993; Riecken, 1996).

Table 3.2-36. Necessary buffer zones for protective areas (Jedicke, 1990, modified)

Habitat type	Width
Reed banks and large sedges (*Carex spp*.)	> 5 m
Small sedges (*Carex spp.*)	> 10 m
Deep high-moor bogs	30-80 m
Flat high-moor bogs above fine sand layer, deep low-moor bogs	120-150 m
Source-bogs, wet woodland-bogs	> 350 m
Woodland edges as important ecotone[26] hunting areas for birds of prey	
• distances to streets	100 m
• distances to leisure and recreation centres	500 m
• distances to parking spaces and recreation grounds of high disturbing levels	1000 m
General distances to model aircraft airports	400 m
Small habitats in general	> 20-30 m
Larger wetland habitats in general	> 100-200 m, partly > 500 m

3.2.6.2 Vulnerability factors

On metapopulation level, vulnerability becomes crucial when metapopulations fall below their MVMs. Therefore, there are different ecological circumstances, changes of the environment, demographic or genetic effects, which can lead to extinction. Individual risks can be estimated by PVAs (cf. section 3.2.2 Rarity and endangerment on page 114). Isolation and fragmentation of habitats are critical factors for MVMs (cf. Table 3.2-37; sections 3.2.5 Re-establishment ability on page 177 and 3.2.7 Ecological functions on page 191, respectively),

[26] An ecotone is understood as a transitionary zone between two different ecosystem types (cf. Kratochwil and Schwabe, 2001).

for instance, when they cause inbreeding and genetic drift effects or demographic risks of extinction (cf. section 3.2.2 Rarity and endangerment on page 114).

Table 3.2-37. Consequences of habitat fragmentations for species (Mühlenberg, 1997; Mühlenberg and Slowik, 1997; modified)

Consequences of habitat fragmentations for species
• reductions of former habitat sizes • limitations of migration and dispersal abilities • influences on territorial behaviour and reproduction • isolation effects, including genetic effects (inbreeding, genetic drift) • edge effects (e.g. different climatic conditions, predators and diseases, competitions, disturbances).

In general, specialized species are more affected by habitat fragmentations than habitat generalists, which can easier switch to other places within left habitats (cf. Hovestadt et al., 1991; Tscharntke, 1998). In addition, big species of large home ranges are in general more affected than smaller species, which need smaller habitats. Furthermore, species on the top of food-chains are easier affected by habitat fragmentations than on lower levels (cf. section 3.2.4.3 Keystone species on page 171). Moreover, mutualism[27] is generally combined with higher vulnerability to fragmentation. Low dispersal abilities are another factor of higher vulnerability to habitat fragmentations (cf. Tscharntke, 1998).

Habitat fragmentations also cause changes at habitat edges, because of disturbances from surrounding grounds, for example, by pollution, different climatic conditions, mechanical disturbances, and immigrations of other competing species. Furthermore, habitat fragmentations of woodlands generally cause an increase of predator pressures at edges (cf. Jedicke, 1990; Hovestadt et al., 1991; Mühlenberg and Slowik, 1997; Yahner and Mahan, 2002). The woodland edges effect can still be noticed within an inner distance of up to 15 m for plants and up to 40 m for arthropods (Hovestadt et al., 1991). Traffic infrastructure causes significant losses of animal species by direct collisions with vehicles and indirectly as isolation barriers (European Commission, 2000; Pallag et al., 2000; Roll, 2004). Genetic analysis can reveal in particular to which extend metapopulations are separated by habitat fragmentations (Schreiber, 1997; cf. section 3.2.2 Rarity and endangerment on page 114).

Diversity may reduce vulnerability on genetic level of MVMs, because there is a higher probability in MVMs that favourable recessive alleles become expressed under changing selective conditions, i.e. they are more flexible to

[27] Mutualism is a general term that defines all interactions between species, which have an advantage for one or all partners, but do not cause disadvantages for the other side (Martin, 2002).

changes of the environment (cf. section 3.2.2 Rarity and endangerment on page 114). However on species level, there is no evidence for general correlations between species numbers and vulnerability.

A high number of different species may indicate more complex relationships in ecosystems, but not necessarily higher (inner) stability. There are also species poor, but ecologically stable ecosystems of nature and landscapes, for example, banks of Common Reed (*Phragmites australis*), European Beech (*Fagus sylvativa*) woodlands on acid soils, and boreal coniferous woodlands. Absolute numbers of species alone do not tell us about qualitative conditions of ecosystems. The number of species must be always seen in relation to specific types of ecosystems, to their particular succession stages, to intensities of human influences (hemeroby) on them, to their spatial locations, and to their particular nature regions. Species poor ecosystems might be stable for long times, for example, high-moor bogs, and sources (cf. Plachter, 1991a; Bastian, 1997; Bastian and Schreiber, 1999).

Furthermore, stability of ecosystems is mostly only a theoretical assumption. In practice, there are more or less dynamic succession developments as described in the Mosaic Cycle Hypothesis for woodlands and in the Patch Dynamics Concept (cf. Wulf, 2001; section 3.2.3.3 Mosaic Cycle Hypothesis on page 152). Nevertheless, there are attempts to calculate critical loads of ecosystems, i.e. critical levels of quantitative amounts of pollution depositions that are not expected to have harmful consequences for certain sensitive structures or functions of ecosystems of nature and landscapes due to buffer, percepting, storing, and transfering capacities (Hain and Schönthaler, 2004; for woodland and aquatic ecosystems, respectively, e.g. Bolte et al., 2001). However concerning landscape scenery, high relief, vegetation density, and patchiness are generally less vulnerable to visual influences (cf. Demuth, 2000) of the same size dimensions.

3.2.6.3 Conclusive summary

Nature and landscapes react differently to external and internal impacts depending on their specific vulnerability. There are habitats and ecosystems, which are more vulnerable to certain impacts than others. Also the human species itself is vulnerable to impacts of nature and landscapes. Therefore, in general there are buffer zones necessary for protective areas.

On metapopulation level, vulnerability becomes crucial when metapopulations fall below their MVMs. There are different ecological circumstances, changes of the environment, demographic or genetic effects, which can lead to extinction. Individual risks can be estimated by PVAs. Isolation and fragmentation of habitats are crucial factors for MVMs. In general, specialized species are more affected by habitat fragmentations than habitat generalists. Big species of large home ranges are in general more affected than smaller species, which need smaller habitats. Species on the top of food-chains are easier affected by habitat fragmentations than on lower levels. Moreover, low dispersal abilities are another factor of higher vulnerability to habitat fragmentations.

Diversity may reduce vulnerability on genetic level of MVMs, because there is a higher probability in MVMs that favourable recessive alleles become expressed under changing selective conditions, i.e. they are more flexible to changes of the environment. However on species level, there is no evidence for general correlations between species numbers and vulnerability. A high number of different species may indicate more complex relationships in ecosystems, but not necessarily higher (inner) stability.

Furthermore, stability of ecosystems is mostly only a theoretical assumption. In practice, there are more or less dynamic succession developments as described in the Mosaic Cycle Hypothesis for woodlands and in the Patch Dynamics Concept. Nevertheless, there are attempts to calculate critical loads of ecosystems.

In conclusion, vulnerability of biological diversity cannot be exactly estimated, but there can be indicators and models developed, as well as, monitoring data used to detect the influencing processes of changes of nature and landscapes within particular areas and time periods. There are methods, concepts, and measurement indicators of population ecology and ecosystem research. However in practice, the precautions principle should be a leading guideline to prevent deteriorations of elements, structures and functions of nature and landscapes and thereby their different values to the human being and on their own.

Therefore, Environmental Impact Assessments (EIA) are carried out to estimate the impacts of projects and plans in advance, which take into account the different vulnerabilities of certain elements of nature and landscapes as a value to the human being and on their own at a certain area and during a specific time span (cf. chapter 5 Empirical study of Environmental Impact Assessments (EIA) on page 282). For example, the psychological value of the landscape view might be less vulnerable to a development plan of new building grounds, when these buildings will not be allowed to be constructed higher as a surrounding woodland cover. However, landscape scenery can be more vulnerable to the same buildings on an open field depending on the subjective perception and assessment by people.

Furthermore, a connecting street enlargement can be assessed positively as a development progress by traffic planners and users, because it indicates typically an infrastructure development of the region and allows saving transport time by driving faster as an economic value, but also implying an improved psychological and social life quality. However, the inhabitants of the adjacent cities might assess the same enlarged street project as an even more severe disturbing noisy and polluting element of their neighbourhood, which reduces their social and psychological life quality, as well as, the economic value of their real estates. This can be especially the case, if the traffic typically increases during the years, because more vehicles will use the faster and easier street connection through the cities. These inhabitants are much more vulnerable to noise and pollution by the increased traffic than people, who just pass by in their vehicles. Therefore, traffic projects are often combined with noise and pollution reducing measures to treat the symptoms.

Therefore, the criterion vulnerability of certain elements, structures, and functions of nature and landscapes is necessary to estimate in advance and in retrospective the impacts of new developments for future planning processes and project decisions on the different values to the human being and on their own.

3.2.7 Ecological functions

3.2.7.1 Different ecological functions

Nature and landscapes have various ecological functions on all levels for the human being and on their own (overview in Winkelbrandt et al., 1995; for animals in Holtmeier, 1999; Kratochwil and Schwabe, 2001; for hoofed animals of Central Europe in Wokac, 1999). There are different methods to measure their biotic and abiotic parts, as well as, their functions on ecosystem level[28], so called "ecosystem services" (cf. Constanza et al., 1997; Daily et al., 1997; World Resources Institute, 2000; Millennium Ecosystem Assessment, 2005a, 2005b; Millennium Ecosystem Assessment Board, 2005), which are based on "ecosystem functioning" (c.f. Naeem et al., 1999) or "ecosystem functions" (c.f. Constanza et al., 1997)[29].

For instance, there are abiotic ecological functions to reduce noise and wind erosion, to filter and to buffer substances, to store energy, to recharge ground water, to regulate water drainage, to provide clean air, to influence climatic conditions ranging from local to global levels (overview in Marks et al., 1992; Zepp and Müller, 1999; Jessel and Tobias, 2002; Barsch et al., 2003; von Haaren, 2004f; Makala and Makala, 2004a, 2004b; Sander, 2004a, 2004b), and to regulate nutrient balances (cf. Spang, 1999), as well as, biotic ecological functions to provide habitats of species (overview in Groombridge, 1992; cf. Kratochwil and Schwabe, 2001; conceptional in Barkmann, 1999; J∅rgensen and Mitsch, 2000; Müller and Windhorst, 2000; Barkmann et al., 2002b; Windhorst et al., 2004).

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[28] The approach of "ecological integrity" attempts to preserve the capability of nature and landscapes as a natural basis for human life in the long-term by protecting those ecosystem processes and structures, which are necessary conditions for the self-organization ability of ecosystems (Barkmann et al., 2002a).

[29] The superordinated term "ecological functions" of nature and landscapes is used for this evaluation criterion to incorporate also the ecological functions below ecosystem level for the human being and on their own, for example, of metapopulations, species, and, individuals, as well as, of non-living parts of nature and landscapes.

3.2.7.2 Examples of ecological functions

Ecosystems have decisive important ecological functions for material and energy movements and storages, respectively (cf. Wulf, 2001). For example, woodlands influence our climate in different ways. They increase transpirations, buffer extreme climatic conditions, reduce horizontal wind motions, and improve vertical aerial exchanges (cf. Deutscher Bundestag, 1990). Cold and fresh aerial exchanges can significantly reduce climatic and pollution impacts (cf.; von Stülpnagel et al. 1990; Horbert, 1992; Menz, 1999; Mosimann et al., 1999). On species level, some structures of nature and landscapes function as habitats for a wide range of animal species (choriotopes). For example, fruit bodies of fungi host about 1,400 beetle species, especially Rove Beetles (*Staphylinidae*) of the group *Gyrophaena spp*., and approximately 160 different True Flies (*Diptera*) (Kratochwil and Schwabe, 2001).

In addition, woodlands filter dust and regenerate groundwater. Woodlands protect soils against erosion. Furthermore, woodlands content habitats for several species (cf. Deutscher Bundestag, 1990). There are about half a million spiders on one hectare woodland soil, which digest approximately 100 kg insects during summer times (Haubl, 1993). On global level, woodlands are of extraordinary value to prevent climate changes on earth. Woodlands on earth content of about 950-1.650 billion tonnes of dry plant biomass in total, which corresponds to 475-825 billion tonnes carbon dioxide (Deutscher Bundestag, 1990). Moreover, ecological functions of green spaces are much higher in comparison to asphalt (Table 3.2-38). Green spaces have important climatic functions for local inhabitants, especially at urban areas (Kuttler, 1998).

Table 3.2-38. Ecological functions of 100 m² asphalt in comparison to 100 m² green space (SenStadtUm, 1989)

	Asphalt	Green space
Hydrology		
Ground water production per year	• 0 l	• 14,000 l
Surface drainage of rainwater per annum	• 54,000 l	• 500 l
Climate		
Evapotranspiration during a hot summer day	• 0 l	• 200 l

[30] The approach of “ecological integrity” attempts to preserve the capability of nature and landscapes as a natural basis for human life in the long-term by protecting those ecosystem processes and structures, which are necessary conditions for the self-organization ability of ecosystems (Barkmann et al., 2002a).

Maximum surface temperature during a hot summer day	• up to 60°C	• 30°C
Dust filtration ability per day	• 2.5 g	• 90 g
<u>Soil</u>		
Soil organisms of the top soil layer	• almost no soil life	• 10^{14} bacterium, 10^{14} fungi, 5,000,000 Collembolans, 1,000,000 Rotators, 10,000 earthworms

At functional ecosystem level, food-chains of all life on earth are ultimately dependant on micro-organisms. About 85 % of the earth's vascular plants form mycorrhizas with fungi (Groombridge, 1992). On species level, organisms have different functions in ecosystems of nature and landscapes (Table 3.2-39; cf. Kratochwil and Schwabe, 2001; Filser, 2003; Weisser and Siemann, 2004).

Table 3.2-39. Examples of ecological functions of organisms (Jones et al., 1996, modified).

Organisms	Occurrence examples	Activities	Ecological functions
American Alligator (*Alligator mississipiensis*)	Everglades National Park	• create wallows	• retain water in droughts, provide refuges for fish, fish eating birds, etc.
European Rabbits (*Oryctolagus cuniculus*) and Eurasian Badgers (*Meles meles*)	Europe	• dig extensive burrows (rabbit warrens, badger setts)	• burrows are occupied by other species, e.g. the Red Fox (*Vulpes vulpes*) and many invertebrates
Marine phytoplankton	Gulf of Maine	• blooms of phytoplankton particles scatter and absorb light in upper layers of water column	• enhance warming of surface waters that may initiate development of thermocline
Microalgea in sea ice	Antarctica	• scatter and absorb light within ice and underlying seawater; reduce strength of ice	• enhance melting and break up of ice
Freshwater phytoplankton	Lake St. George, Ontario	• intercept light in upper water column; small algal species are more effective than large species	• light interception leads to shallower mixing depths, lower metalimnetic temperatures and lower heat contents of water column

Organisms	Occurrence examples	Activities	Ecological functions
Cyanobacteria and other non-vascular plants	Desert and semi-desert soils	• exude mucilaginous organic compounds	• glue the organisms, organic matter and soil particles together to form a microphytic crust; change infiltration, percolation, retention, and evaporation of water; reduce soil erosion; affect seedling emergences
Bog mosses (*Sphagnum spp.*)	Northern and Western Britain	• build "blanket" and "raised" bogs via accumulated peat	• major changes in hydrology, pH, and topography
Submerged macrophytes	Freshwater lakes, ponds, and rivers	• grow to create weed beds	• attenuate light; steeping vertical temperature gradients; retard flow; enhance sedimentations; oxygenate rhizospheres
Forest trees (broad-leaved and coniferous)	Hubbard Brook Experimental Forest, New Hampshire	• shed branches and trunks into streams	• create debris dams; alter morphology and stability of stream channels, storage and transport of dissolved organic matters and sediments; different tree species may create dams, which differ in persistence

Organisms	Occurrence examples	Activities	Ecological functions
More complex plants	Ubiquitous	• dead leaves etc. accumulate litter	• alter microenvironment of soils; change surface structures, affecting drainages, and transfer of heat and gasses; act as physical barriers for seeds and seedlings; numerous impacts on structure and composition of plant communities
Terrestrial plants in 29 families of > 1,500 species	Ubiquitous	• grow structures (modified leaves, leaf axils, etc.) that impound water	• create small aquatic habitats, which supports a highly specialised insect fauna
Marine meiofauna (protists and representatives of many invertebrate phyla)	Ubiquitous	• biodepositions, bioturbations, porewater circulations, and faecal pellet productions	• change physical, chemical and biological properties of sediments; change directions and magnitudes of nutrient fluxes; increase oxygenation of sediments
Marine burrowing macrofauna	Ubiquitous	• burrow into redistribute sediments; bioturbations; burrow ventilations	• create dynamic sediment mosaics; actively transport solutes into burrows; increase oxygenation of sediments; stimulate microflora; increase decomposition rates
Marine zooplankton	Ubiquitous	• filter living, dead organic and inorganic (e.g. clay) particles, and concentrate into faecal pellets	• sinking faecal pellets, important in vertical transports and exchange of elements and organic compounds in oceans

Organisms	Occurrence examples	Activities	Ecological functions
Fiddler Crap (*Uca pugnax*)	New England, salt marsh	• dig burrows	• increase soil drainages and oxidation-reduction potentials; increase decomposition rates and primary production at intermediate tidal heights
European Periwinkle (*Littorina littorea*)	New England, rocky beach	• bulldoze sediments from hard substrates	• prevent sediment accumulations and hence growth and establishment of algal canopies; algae further increase sedimentation rates; faunal compositions markedly different with and without snails
Snails (*Echondrus spp.*)	Negev desert	• eat endolithic lichens and the rock they grow on	• increase rates of nitrogen cycling, soil formations and rock erosions
Bagworm caterpillars (*Penestoglossa spp.*?)	Golden Gate, Highlands, South Africa	• eat endolithic lichens and construct larval shelters ("bags") form quartz crystals	• small increase in erosion rates, nutrient cycles and soil formations
Mound-building termites (*Isoptera*)	Widespread in tropics and subtropics	• mound and subterranean gallery constructions; redistribution of soil particles	• change mineral and organic compositions of soils; alter hydrology and drainage

Organisms	Occurrence examples	Activities	Ecological functions
Earthworms (*Lumbricidae, Megascolecidae*)	Ubiquitous	• burrowing, mixing and casting	• change mineral and organic compositions of soils; affect nutrient cycling; alter hydrology and drainage, affect plant population dynamics and community compositions
Blind Mole Rats (*Spalax ehrenbergi*)	Israel	• digging and tunnelling	• move large quantities of soils; increase aerations; create distinctive ecosystems
Mole rats (*Bathyergidae*, several genera)	South African lowland fynboss	• digging and tunnelling	• create impressive, cratered landscapes, effects on soil formations, plant productivity and species compositions
Prairie dogs (*Cynomys spp.*)	North American short and mixed grass prairie	• continual intense disruption by burrowing, creating soil mounds	• change physical and chemical properties of soils persisting for 100-1,000s of years
Pocket Gophers (*Geomys bursarius*)	North American grasslands and arid shrublands	• construct tunnels and move soils to surface mounds	• alter patterns and rates of soil developments, nutrient availabilities and microtopographies; change plant demographies, diversity and primary productivities; affect behaviour and abundances of other herbivores

Organisms	Occurrence examples	Activities	Ecological functions
Indian Crested Porcupine (*Hystrix indica*)	Negev desert	• digging for food	• dig up to 2-3 holes m^{-2}; diggings accumulate organic matters, runoff water; create favourable sites for seed germinations
African Elephants (*Loxodonta africana*)	East African woodland and savannah	• physical disturbances and destructions of trees and shrubs	• widespread vegetation changes; alterations of fire regimes; effects on food supply and population dynamics of other animals; ultimately changes in soil formations, riparian zones, and biogeochemical cycles
Crustose Coralline Algae (*Porolithon, Lithophyllum*)	Coral reefs	• overgrow and cement together detritus on outer algal ridges of barrier reefs	• break force of water and protection of corals against major wave actions; effective via own bodies and secretion of "cement"
Ribbed Mussels (*Geukensia demissa*)	Rhode Island *Spartina* salt march	• secrete byssal threads, and form dense mussel beds	• on marsh edges, dense beds of mussels and byssel threads bind and protect sediments and prevent physical erosions and disturbances, e.g. by storms

In addition, species can have several functions in complex ecological systems, for instance, as parts of the food-chain. For example, there are fruits and nectar-eating bats in tropical countries, which serve as important pollinators for many tree species, as well as, disseminators for their seeds (Keller et al., 2002). Furthermore, species are parts of material and energy networks (Pahl-Wostl, 1998; Bonkowski and Scheu, 2004; Hartley and Jones, 2004; Masters, 2004).

3.2.7.3 Indicators of ecological conditions

There are several indicators, which allow measuring ecological conditions of nature and landscapes (cf. section 3.2.3.4 Indicator species of naturalness on page 153). Natural indicators have the advantage that they reflect long-term conditions in contrast to measurement rows. However, their validity is limited to certain regions due to competitive influences (Zierdt, 1997). For example, indicator values of plants in Central Europe can be used to estimate ecological conditions of light, temperature, continentality, moisture, soil acidity and lime content, nitrogen content, salt content, and resistance to heavy metals as expressions of their “ecological behaviour”. The term “ecological behaviour” takes into account that plants occur at certain places due to their competition to other plants at certain ecological conditions. In other words, plants occur in nature and landscapes not at their optimum ecological preferences, but in plant associations due to competitions with other plants. Their distribution depends on regional abiotic and biotic ecological conditions (Ellenberg et al., 1992). Furthermore, plant indicator values should be used as guidelines of ecological behaviour, but not as exact measurements (cf. Kowarik and Seidling, 1989; Ellenberg et al., 1992). Therefore, it is the most important function of methods for plant sociological analysis to reveal vegetation structures in their complexity and their dependence on certain factors of their distribution during progressive times (cf. Hakes, 1996).

On ecosystem level, there are different ecological indicators that cover abiotic and biotic components, as well as, their interactions (overview in Delbaere, 2002; Delbaere et al., 2002; Wiggering and Müller, 2004).

In particular, there are different concepts to design and to manage nature reserves to keep up the ecological functions of nature and landscapes as a habitat for biocoenosis and (meta-) populations of species within ecosystems (cf. section 3.2.2 Rarity and endangerment on page 114), which shall be discussed in the following sections.

3.2.7.4 Habitat island theory

Species-area relationships of isolated parts of nature and landscapes have been described in the island theory (equilibrium theory), which was developed at real islands and transferred to habitat islands at the continent. It is assumed that dynamic balances of dying out and immigrating species determine the number of current species at habitat islands, respectively (species turnover). In general, species turnover increases by the complexity of organisms. Species turnover can be estimated annually of about 1,000 % for protists, 10-100 % for terrestrial arthropods, and 1-10 % for terrestrial vertebrates and vascular plants (Hovestadt et al., 1991).

As less there are distances between habitat islands (distance effect) and as bigger they are (species-area relationship), as more species they inhabit. In general, it is less likely that species die out, when habitat diversity and metapopulation sizes increase by spatial extensions of habitat islands. However, if distances between habitat islands increase, the possibility of immigrating species decreases. Bigger and closer habitat islands have lower dying out rates and higher species balances than smaller habitat islands of comparable distances due to higher dying out rates. Growing distances between bigger habitat islands allow less species to immigrate. Therefore, species balances are lower when distances between habitat islands increase (cf. Figure 3.2-13; Sedlag and Weinert, 1987; Plachter, 1991a; Sutherland, 2000; Kratochwil and Schwabe, 2001; Wulf, 2001; Martin, 2002; Gaston and Spicer, 2004).

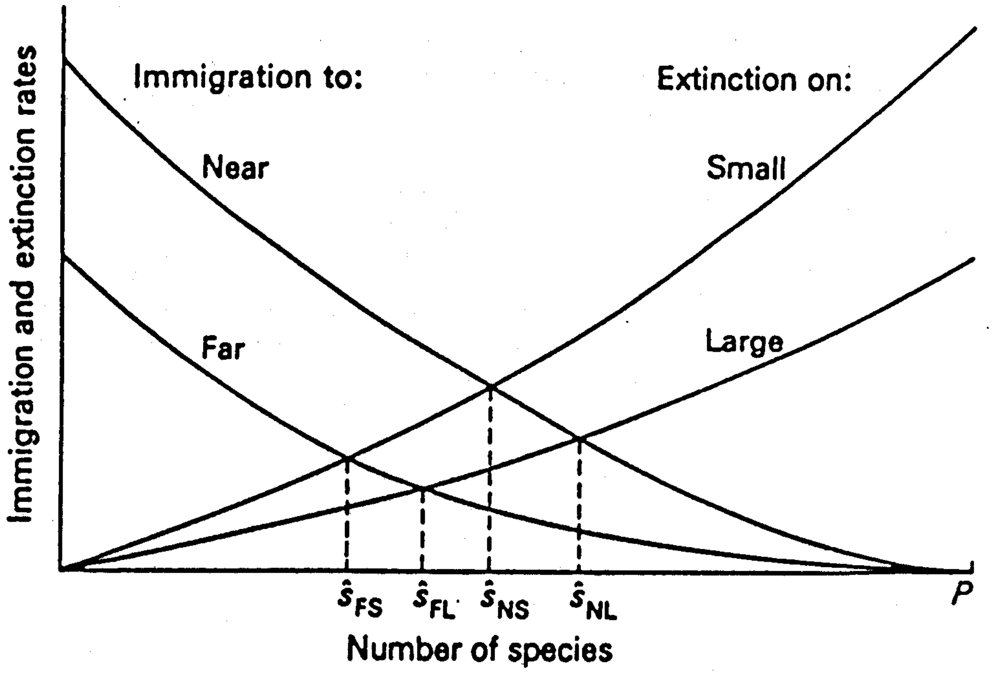


Figure 3.2-13. Model of species balances depending on distances and sizes of habitat islands (Williamson, 1981) reproduced by kind permission of Oxford University Press, Oxford, UK

The relationship between distances and sizes of habitat islands to species balances can be also described by the following formula (Table 3.2-40).

Table 3.2-40. Formula for calculations of relationships between distances and sizes of habitat islands to species balances (Jedicke, 1990; Gaston and Spicer, 2004)

$$S = C \times A^z$$

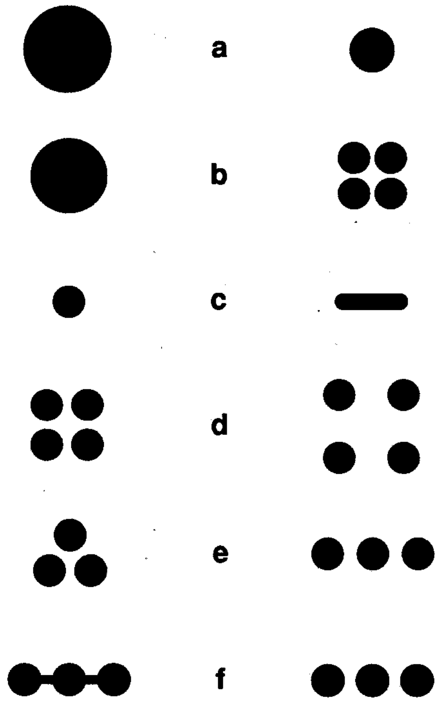
$$\log S = z \times \log A + \log C$$

S = Number of species	C = Species density per area size
A = Habitat island size	z = Empirical degree of species isolation

Furthermore, lower distances of habitat islands allow more transitional species to immigrate, which just appear temporarily due to uncomfortable survival conditions in the long-term. Therefore, habitat islands, which were recently isolated, should have temporarily more species than their size allows. Linked habitat islands should have species balances between isolated and unified habitats (Hovestadt et al., 1991).

3.2.7.5 SLOSS debate

Therefore, in general habitat islands of nature and landscapes ought to be as big as possible (Wulf, 2001). They should be linked together by habitat corridors or habitat patches, and they ought to be close together. Furthermore, the habitat boundaries should be shaped in a way that habitat edge effects are reduced to prevent competition with other species that are more competitive at edge conditions (Figure 3.2-14).



a - habitats should be as big as possible to increase population sizes
b - unified habitats are better than separated ones of the same size to reduce negative edge effects, such as competition with edge species (single large or several small debate: SLOSS)
c - habitats should have as much reduced boarder surfaces as possible to minimize negative edge effects
d - habitats ought to be as close together as possible to allow population stabilizations by migrations
e - habitats should be arranged at minimum distances for migrations
f - habitats ought to be linked together by corridors or patches for migrations

Figure 3.2-14. Theoretical population rules for habitat designs derived from the island theory (Hanski and Simberloff, 1997, modified) reproduced by kind permission of Elsevier

However, it depends on the particular case, if a single large or several small habitats are better (SLOSS debate; Figure 3.2-14; cf. Kratochwil and Schwabe, 2001; Halle, 2002). The island theory alone cannot provide sufficient answers to this problem, neither to form, number, nor location of habitats of the same size in total (cf. Hovestadt et al., 1991; Kaule, 1991; Wulf, 2001).

3.2.7.6 Practical applications of the island theory

In practice, habitat islands differ significantly from real islands (Table 3.2-41; cf. Kratochwil and Schwabe, 2001).

Table 3.2-41. Differences of habitat islands to real islands (Hovestadt et al., 1991; modified)

Differences of habitat islands to real islands

- ecological circumstances can change rapidly at habitat islands (habitat sizes, degree of isolation, habitat quality, environmental influences, etc.)
- there can be strong habitat edge effects of permanent species immigration, especially of habitat generalists
- there is often a lack of settlement sources of habitat specialists due to high habitat isolations
- there is a resulting dynamic imbalance of species at habitat islands

Therefore, the Minimum Viable Metapopulation-concept (MVM) and the Population Vulnerability Analysis (PVA) are more sufficient concepts to estimate minimum habitat sizes, as well as, to focus on finding out and altering the reasons for their decline (cf. section 3.2.2 Rarity and endangerment on page 114). Nevertheless for practical evaluations of nature and landscapes, the species focused island theory and the population focused MVM-concept must be combined.

3.2.7.7 Protected areas as habitat islands

There are about 111 protected areas of a size more than 2,000,000 ha on earth (overview in Groombridge, 1994; Figure 3.2-15).

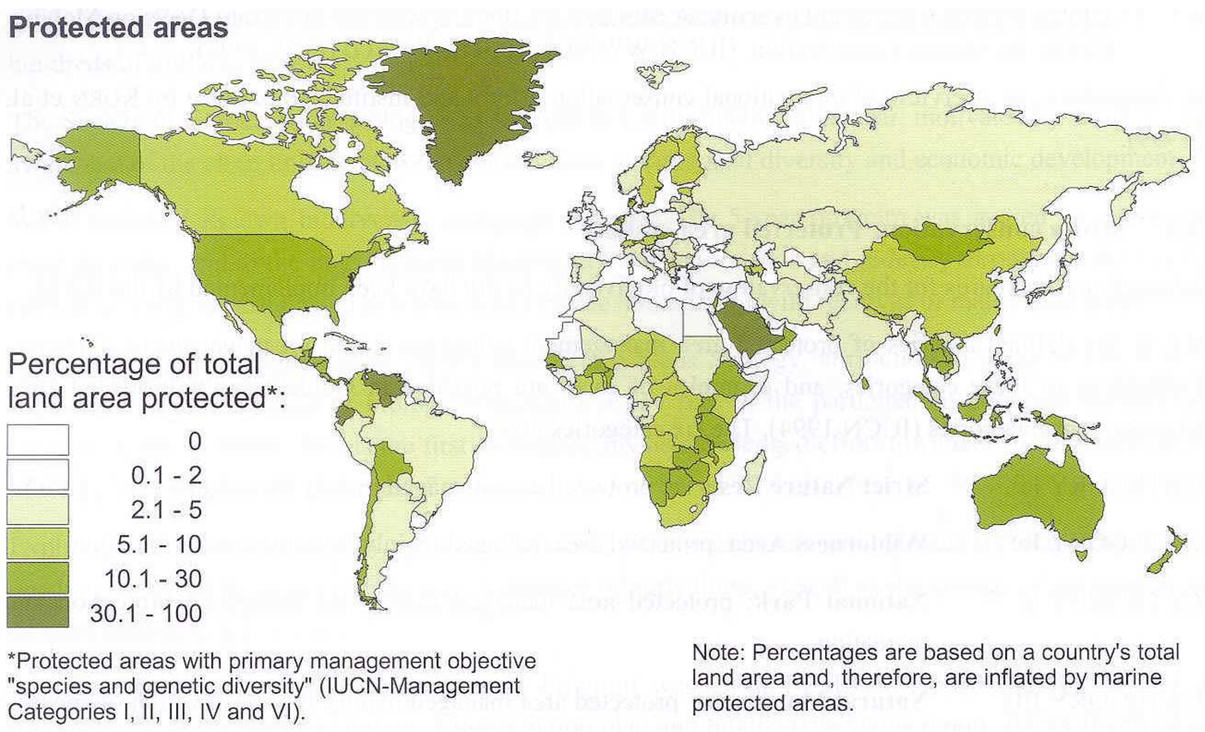


Figure 3.2-15. Relative sizes of protected areas for species and genetic diversity in different countries on earth (Keller et al., 2002, modified) reproduced by kind permission of Springer Science and Business Media, Heidelberg, Germany

The World Conservation Union (IUCN) categorizes nature reserves as following (Table 3.2-42).

Table 3.2-42. The World Conservation Union's (IUCN) categories of nature reserves and their main management goals (Keller et al., 2002; Schroeder-Wildberg, 2003; Mulongoy and Chape, 2004)

IUCN's categories of nature reserves	
Types of reserves (category)	Main management purposes of protected areas
Strict nature reserve (Ia):	• science
Wilderness area (Ib):	• wilderness protection
National park (II):	• ecosystem protection and recreation
Natural monument (III)	• conservation of specific natural features
Habitat/species management area (IV):	• conservation through management intervention
Protected landscape/seascape (V):	• landscape/seascape conservation or recreation
Managed resource protected area (VI):	• sustainable use of natural ecosystems

However, many countries of high degrees of diversity of habitats, species, and endemism protect relatively few proportions of their areas. There are ecological regions, for example, Central Europe and the Mediterranean, which are not suitably represented in the system of protected areas. In addition, practical protection of worldwide reserves is rather limited. For example, there are often no restrictions nor controls of land use processes, such as agriculture and forestry (cf. Keller et al., 2002).

Moreover, many of the protected areas on earth have been poorly planned or they have had their size and location constrained by political considerations, resulting in reserves, which are either isolated from other suitable habitats, or too small, or missing key components, or simply in the wrong place. Bias in selection of protected areas results in an understandable tendency to select areas, which are remote, unsuitable for commercial development and without a politically powerful opposition to protection (Mulongoy and Chape, 2004; cf. Gaston and Spicer, 2004). This refers also to national parks in the US, which are not large enough and sufficiently connected to preserve all mammal species that occurred during their foundation (WBGU, 1999a).

In addition, habitat islands must be large enough to allow natural dynamic processes, such as windthrow, overflooding, species related changes, and fluctuations of habitat requirements (cf. Table 3.2-43; Klein et al., 1997; Sutherland, 2000; Kratochwil and Schwabe, 2001; Kondratyev et al., 2002), as well as, evolutionary processes for new species developments.

Table 3.2-43. Examples of periodical and episodic natural habitat dynamic processes, respectively (Schröder et al., 1997, modified)

Examples of natural habitat dynamics	
• overflooding	• avalanches
• fires	• snow- and ice-breaking
• storms	• drift-ices
• lightnings	• dry/wet and hot/ cold periods
• slope and landslides	• epidemics

Most of Germany’s nature reserves are just too small for MVMs, but also do not allow dynamic succession turnovers on larger scales (cf. Hauke, 1998; Riecken et al., 1998). In Germany, 2/3 of all nature reserves are smaller than 50 ha and only about 11 % reach a size of more than 200 ha. In total, about 5,000 nature reserves cover approximately 2 % of Germany’s nature and landscapes (Ssymank, 1997; Table 3.2-44).

Table 3.2-44. Relative amounts of strictly protected areas in Germany in May 1998 (Hauke, 1998)

Federal states of Germany	Size in km²	National parks in %	Nature reserves in %	Nature reserves provisionally protected in %	Strictly protected areas in total in %
Baden-Württemberg	35,751	0	1.6	<0.1	1.6
Bayern	70,547	0.6	2.0	<0.1	2.6
Berlin	889	0	0.6	1.2	1.8
Brandenburg	29,481	0.5	2.2	?	>2.7
Bremen	404	0	3.0	<0.1	3.0
Hamburg	755	0.5	5.5	0	6.0
Hessen	21,114	0	1.3	0.4	1.7
Mecklenburg-Vorpommern	23,169	2.0	2.4	?	<4.4
Niedersachsen	47,606	0.8	2.7	0	3.5
Nordrhein-Westfalen	34,072	0	2.3	0.6	2.9
Rheinland-Pfalz	19,845	0	1.4	<0.1	1.4
Saarland	2,570	0	1.0	0	1.0
Sachsen	18,409	0.5	0.8	0.9?	2.2
Sachsen-Anhalt	20,446	0.3	1.5	1.2?	3.0
Schleswig-Holstein	15,739	0.8	2.6	0.1	3.5
Thüringen	16,175	0.5	1.2	1.4?	3.1

3.2.7.8 Habitat corridors and habitat patches

Interlinking habitat corridors and habitat patches can help to connect big habitat islands, if they are combined with general extensifications of land uses to reduce disturbances of the environment (cf. Jedicke, 1994; Jessel and Tobias, 2002; Opdam, 2002; Volg, 2003; Burkhardt et al., 2004). We can distinguish different types of habitat interlinks (cf. Table 3.2-45; Riedl, 1991).

Table 3.2-45. Different types of direct and indirect species and habitat linkages, respectively, as well as, examples of their ecological functions (Jedicke, 1990, modified)

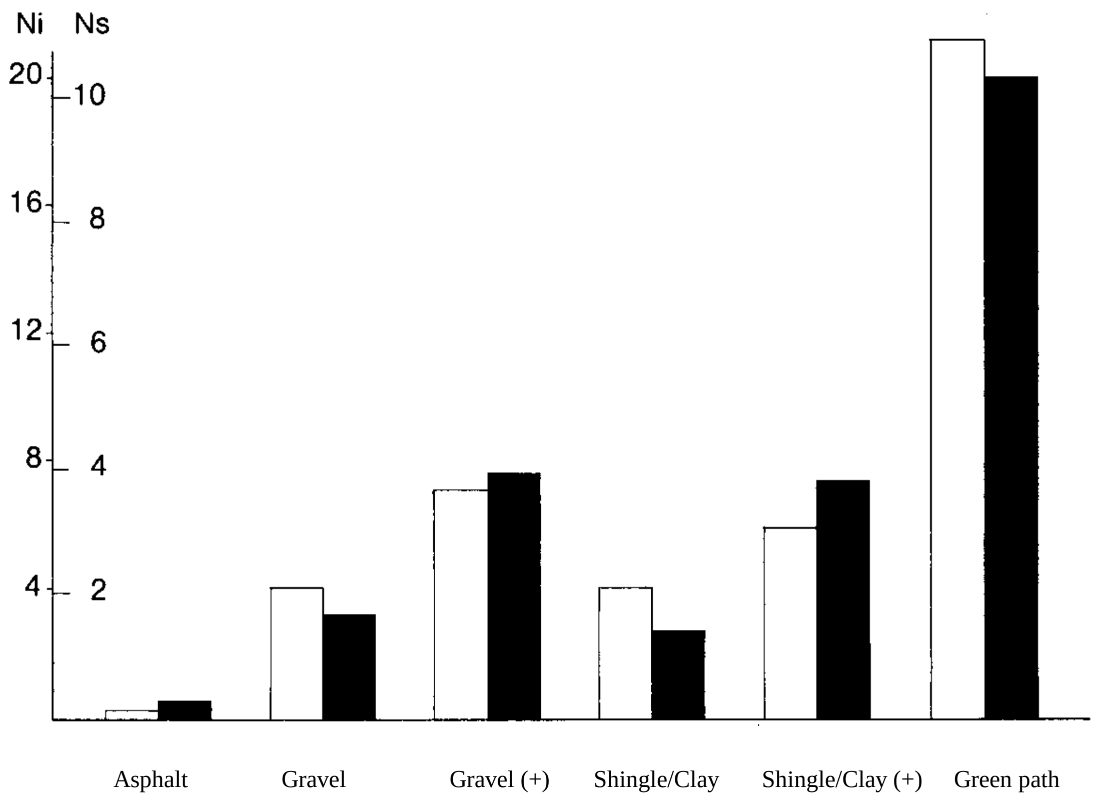
Direct linkages of species and habitat types	
Interlinks between species	Examples of ecological functions
• interlinks within metapopulations of one species (intraspecific and intrapopulation links)	• intraspecific nutrition competition, social accumulations, possibility of reproduction of bisexual species
• interlinks within different populations of one species (interspecific and interpopulation links)	• genetic exchange of different populations at different habitats
• interlinks between different species of different life-form types at the same habitat type (for example, between predators and prey, parasites and hosts, and plant feeding animals and their host plants)	• density regulation of prey and host species, nutrition regulation of predator and parasite species, pollen or seed distribution by relationships between animals and plants
• interlinks between different species at different habitat types (for example, animals, who feed in habitat A, but breed in habitat B)	• nutrition transfer of other habitat types, pollinating
Interlinks between habitat types	Examples of ecological functions
• interlinks of partly spatially isolated habitats of the same habitat type (for example, woodland edges interlinked by field hedges)	• increase of habitat sizes and home range sizes

• interlinks between habitats, which are connected by functional succession stages (for example, reed banks adjacent to wet herbaceous perennial and to waterside woodlands, or low-moor bogs adjacent to wet meadows and large sedge banks, or dry grasslands adjacent to Oak (*Quercus ssp.*)-Aspen (*Populus tremula*) bushes and Oak–Birch (*Betula ssp.*) woodlands)	• higher species numbers, which can transfer from one habitat to another along natural habitat zonations during periodic and aperiodic migrations according to their habitat requirements
• interlinks between habitats, which are not necessarily connected by functional succession stages, but which have at least some ecological components together (for example, adjacent medium dry grassland habitats and dry heather habitats, or high-moor bogs and transitional moor bogs, or Oak-Birch woodlands and European Beech (*Fagus sylvatica*) woodlands at extreme dry habitats, or humus rich, wet meadows and field edges on clay soils)	• enlarged home ranges for many species, which are not specialized on one particular habitat type
• interlinks between habitats, which are spatially connected due to geomorphologic or anthropogenic reasons, but which are not ecologically related (for example, woodlands and meadows adjacent to cliffs, or slope bushes adjacent to streams, or field hedges adjacent to agricultural fields, or Norway Spruce (*Picea abies*) woodlands adjacent to meadows)	• important for those species, which need different habitats during the year (for example, in summer and winter times), during the day (for example, for breeding and feeding), and at different development stages (for example, larval and adult)

Indirect linkages of species and habitat types
(by interlinking corridors or patches)

Interlinks between habitat types	Examples of ecological functions
• interlinks of populations of the same species between different habitat types	• increase of probability of genetic exchanges of populations as conditions for adaptation processes to changing environments
• interlinks of populations of different species between the same habitat types	• permanent exchange of populations of different species and interactive stabilization of specific species compositions
• interlinks of populations of different species between different ecologically not related habitat types	• exchange possibilities of habitat generalists, which are often important prey for specialists

However in practice, ecological functions of habitat corridors and patches just develop in long time periods or their ecological functions even cannot re-establish any more (cf. section 3.2.5 Re-establishment ability on page 177). Many organisms are not mobile enough to overcome isolation barriers to reach interlinking habitat patches, for example, molluscs, flightless arthropods, and protists (Figures 3.2-16 and 3.2-17; cf. overview in Mühlenberg and Slowik, 1997). Animal species differ very much in their habitat relations and distribution behaviours. Therefore, the effects of distribution corridors and patches must be analysed on species level. Moreover, habitat corridors and patches also need species related buffer zones (Mühlenberg and Slowik, 1997; Jessel and Tobias, 2002).



Ni – Number of individuals (white colour)   Ns – Number of species (black colour)

Figure 3.2-16. Isolation intensity of different paths according to recorded species (Jedicke, 1990)

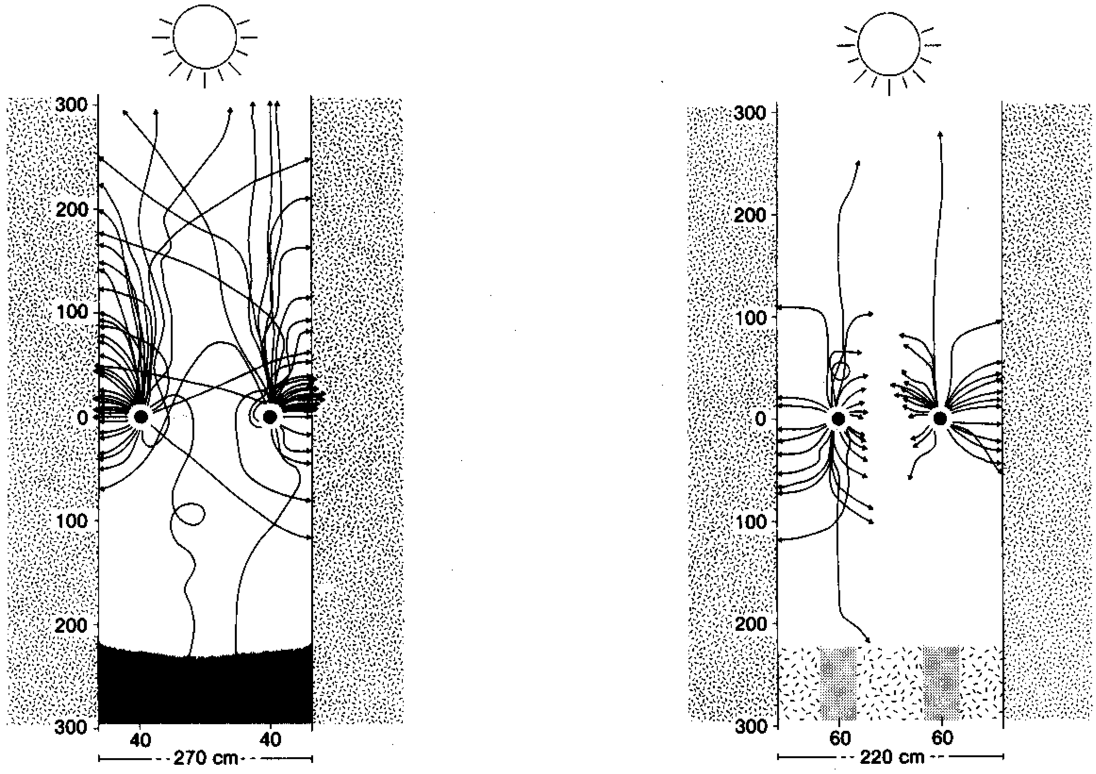


Figure 3.2-17. Mobility diagram of the wolf spiders' species *Pardosa amentata* on an asphalt path (left) and a green path (right), respectively (Jedicke, 1990)

Therefore, interlinking habitat corridors and patches must be of such high habitat quality and size that Minimum Viable Metapopulations can survive, reproduce and move forward during one or several generations to colonize other habitat islands. At least, they must serve as temporary habitats for mobile organisms, for example, birds, flying arthropods, and mammals, to feed and to rest until next habitat islands can be reached. Furthermore, habitat islands must be large enough and of such quality that overproduction of metapopulations becomes possible for (re-)colonizations of other habitat islands (cf. Plachter, 1991a; Gruttke et al. 1998). Especially stenotic species need specific habitat qualities for movements along habitat corridors and patches.

However, we need also carefully to consider problems of genetic outbreeding effects in relation to positive inbreeding prevention for each particular case, when we intend to connect habitats by corridors or patches (cf. section 3.2.2 Rarity and endangerment on page 114). Furthermore, there is the danger of competing generalists, predators, parasites, and pathogens that can immigrate, but also positively of mutualists[31]. In addition, migrations to unsupportable habitat conditions might even reduce metapopulations sizes by habitat corridors or patches. Moreover, we need to consider that habitat corridors and patches can cause isolation barriers for other species. Therefore, they need to be carefully

[31] Mutualists are different or the same species, which live together and co-operate for survival benefits on either interests (cf. Sedlag and Weinert, 1987).

planned by using keystone species (Wulf, 2001; cf. Halle, 2002; Jessel and Tobias, 2002; Pullin, 2002).

3.2.7.9 Conclusive summary

Nature and landscapes have various ecological functions on all levels of biological diversity for the human being and on their own. There are different methods to measure their biotic and abiotic parts, as well as, their functions on ecosystem level. For instance, their abiotic components provide basic living conditions, such as clean air, noise reduction, fresh water, fertile soils, and habitats for species. Ecosystems have decisive important ecological functions for material and energy movements and storages, respectively. In addition, species can have several functions in complex ecological systems, for instance, as parts of the food-chain.

There are several indicators, which allow measuring ecological conditions of nature and landscapes. Natural indicators have the advantage that they reflect long-term conditions in contrast to measurement rows. However, their validity is limited to certain regions due to competitive influences. For example, indicator values of plants in Central Europe can be used to estimate certain ecological conditions of nature and landscapes. On ecosystem level, there are different ecological indicators that cover abiotic and biotic components, as well as, their interactions.

The habitat island theory and other approaches are used to design and to manage nature reserves to keep up the ecological functions of nature and landscapes as a habitat for biocoenosis and (meta-) populations of species within ecosystems for practical planning decisions and project evaluations of the different values to the human being and on their own. In general, habitat islands of nature and landscapes ought to be as big as possible. They should be linked together by habitat corridors or habitat patches, and they ought to be close together. Furthermore, habitat boundaries should be shaped in a way to reduce edge effects to prevent competition with other species that are more competitive at edge conditions. However, it depends on the particular case, if a single large or several small habitats are better (SLOSS debate). The island theory alone cannot provide sufficient answers to this problem, neither to form, number, nor location of habitats of the same size in total.

In practice, habitat islands differ significantly from real islands. Therefore, the Minimum Viable Metapopulation-concept (MVM) and the Population Vulnerability Analysis (PVA) are more sufficient concepts to estimate minimum habitat sizes, as well as, to focus on finding out and altering the reasons for their decline. For instance, clear cutting of the naturally grown secondary Ash-Sycamore woodland (*Fraxinus excelsior-Acer pseudoplatanus* woodland) was carried out on the 25 ha large Nunhead Cemetery in the London Borough of Southwark (UK) as a management decision to create open glades and rides to increase overall habitat and species biodiversity during the late 1970s until at least the early 1990s. Consequently, the vulnerable closed woodland has become a highly fragmented habitat for their adapted inner woodland species on Nunhead Cemetery in favour of less endangered and typical open land and woodland edge species, such as butterflies. For example, spiders need in general 20 ha large woodland habitats at the minimum to establish Minimum Viable Metapopulations (MVMs) (Jedicke, 1990). This destructive management can be clearly assessed as being negative from the holistic ethical point of view, because the ecological habitat size functions for more endangered and typical inner woodland species are reduced, despite the overall species and habitat diversity, i.e. quantitative species and habitat number, has risen (Zisenis, 1993, 1996, 1998).

Nevertheless, there are about 111 protected areas of a size more than 2,000,000 ha on earth. However, many of the protected areas on earth have been poorly planned or they have had their size and location constrained by political considerations, resulting in reserves, which are either isolated from other suitable habitats, or too small, or missing key components, or simply in the wrong place. In addition, habitat islands must be large enough to allow natural dynamic processes, such as windthrow, overflooding, species related changes, and fluctuations of habitat requirements. For example, most of Germany's nature reserves are just too small for MVMs, but also do not allow dynamic succession turnovers on larger scales.

Interlinking habitat corridors and habitat patches can help to connect big habitat islands, if they are combined with general extensifications of land uses to reduce disturbances of nature and landscapes. However in practice, many organisms are not mobile enough to overcome isolation barriers to reach interlinking habitat patches, for example, molluscs, flightless arthropods, and protests. Therefore, interlinking habitat corridors and patches must be of such high habitat quality and size that Minimum Viable Metapopulations can survive, reproduce and move forward during one or several generations to colonize other habitat islands. However, we need also carefully to consider problems of genetic outbreeding effects in relation to positive inbreeding prevention for each particular case, when we intend to connect habitats by corridors or patches.

Thus, there are immense ecological functions of nature and landscapes on all levels of biological diversity. There are several natural indicators, but more theoretical habitat approaches to keep up their ecological functions as habitats for species. There is a danger that just drawings of assumed habitat island connections by corridors or patches of selected nature reserves would save the ecological functions to connect metapopulations in the long-term. Therefore in practice, it is again more important to safeguard the benefits of ecological functions of nature and landscapes by integrating them into human land use processes on a wider scale for a sustainable development.

3.2.8 Usability

Human use benefits of nature and landscapes are immense. Our whole life is based on them, by directly being dependant as a living organism and by indirectly benefiting of their biotic and abiotic products. There are extensive industrial and recreational uses of nature and landscapes. Species serve as food basis for the human being. Ecosystems provide basic living resources, including ecosystem services and goods derived from ecosystem functions (cf. Constanza et al., 1997; Daily et al., 1997; World Resources Institute, 2000; Millennium Ecosystem Assessment, 2005a, 2005b; Millennium Ecosystem Assessment Board, 2005; section 3.2.7 Ecological functions on page 191)[32] also for our health (cf. World Resources Institute, 1998). Developments of medical drugs depend on extracted substances from nature and landscapes. This section can only point out some examples.

3.2.8.1 Medical, chemical, and food resources

There are some 120 chemicals extracted in pure form out of about 90 species, which are used in medicines throughout the world (Groombridge, 1992). Of the estimated 10,000 to 20,000 plant species used medicinally, pharmaceutical properties of some 5,000 plant species have been laboratory tested (Groombridge and Jenkins, 2000). In poor nations, at least 75 % of all medical drugs are based on plants and animals (Groombridge and Jenkins, 1996). Amongst the top 150 most prescribed drugs in the USA, 56 % contain of compounds, which are attributable at some point in manufacture or design to animals (23 %), plants (18 %), bacteria (4 %), and fungi (11 %) (Groombridge and Jenkins, 2000). Animals are used as a basis for human medical research (cf. Baumgärtner, 2002). Natural colours are used for textile industry, for example, the blue Indigo for jeans of the Eastern Asian plant species *Indigofera tinctoria* (cf. Nader, 2002). In addition, the DNA polymerase enzyme Taq was extracted from a micro-organism collected from the Yellowstone National Park in the United States in 1966. It has been used in a range of biotechnological applications with annual sales exceeding 200 million US$. Cyclosporine came from a soil sample taken from Hardangervidda National Park in Norway in 1969. It was the 33rd topselling drug worldwide in 2000 with sales of 1.2 billion US$ (Mulongoy and Chape, 2004). The trade of ornamental plants counts annually for about 7.5 billion Euro in Germany (Grunewaldt, 2002). Plant medicines are sold at an annual volume of 6 billion US $ in Europe, 2.1 billion US$ in Japan, 1.5 billion US$ in North America. Germany contributes annually sales of 2.5 billion US$ to the European market (WBGU, 1999a). Pharmaceuticals, botanical medicines, major crops, horticulture, crop protection

[32] In contrast to the evaluation criterion „ecological functions“, the criterion „usability“ is related on products and other uses of nature and landscapes entirely for the human species.

products, applications of biotechnology in fields other than healthcare and agriculture, and cosmetics and personal care products count between 500 billion US$ and 800 billion US$ per year (ten Kate and Laird, 2002).

However, patents of biotechnological inventions increasingly limit the use of genetic resources (Oetmann, 2000). For example, the six biggest worldwide active agrochemical companies DuPont, Monsanto, Syngenta, Bayer, Dow, and BASF own about 90% of permitted transgenic plants for cultivation. They hold more than 50 % of all patents of transgenic plants in their ownership, and they undertake the majority of release experiments. The four biggest agrochemical companies DuPont, Monsanto, Syngenta, and Bayer are also the biggest seed companies on earth (Vogel and Potthof, 2003). Nevertheless, there is a Federal Information System of Genetic Resources of in-situ and ex-situ plants under development in Germany (Harrer et al., 2002) apart from other data banks of genetic resources of domesticated animals, crop plants, forestry plants, fishes, and micro-organisms at the Information Centre of Genetic Resources (IGR) in Germany (cf. Begemann et al., 2002).

Biodiversity of nature and landscapes maintain the long-term viability of agriculture and fisheries (cf. European Commission, 2001a). They are used indirectly as an attribute of natural ecosystems such as forests, grasslands, and seas, which protect watersheds, stabilize climate, and provide food. They also directly provide material that is used and traded by people, in form of timber, meat, fish, fruits, nuts, spices, vegetables, perfumes, seed oils, fodder, anti-microbial agents, and other pharmaceuticals, pesticides, food colorants, flavours, food preservatives, dyes, adhesives, resins, gums, waxes, and latexes (Caldecott et al., 1994). Women play an outstanding role in the use and protection of plant genetic diversity for food production. It can be assumed that 90 % of the seed in use comes from seeds and germ plasma cultivated, selected and preserved by women (Schäfer et al., 2002).

Of more than 250,000 flowering plant species, around 200 have been domesticated as food plants. There are 25-30 crops of major world importance (Groombridge, 1994; overview in Groombridge and Jenkins, 2000). Some 7,000 of the 270,000 described plant species have been collected or cultivated for consumption (Groombridge and Jenkins, 2000). There are about 0.25 million plants described of 0.3 to 0.5 million in total. Approximately 30,000 are eatable (Oetmann-Mennen and Begemann, 1998). People at one time or another have used 3,000 plant species for food. A major part of human nutrition is now provided by just 30 species of crop plants. However, supplies of new genetic material are needed for their resistance to diseases and for improvements of their productivity (Caldecott et al., 1994).

62 developing countries gather 20 % or more of their game meat demands in woodlands, 19 more than 50 % (Congo and Ghana 75 %, Ivory Coast 48 %, and 63 % Zaire) (Deutscher Bundestag, 1990). Breeds of domestic goat, sheep, cattle, pigs, and domestic fowl are cosmopolitan in distribution and the basis for most of the world’s agricultural animal food production. The four principal

mammalian livestock have diversified under more than 5,000 years of domestication and artificial selection into more than 2,000 recognised breeds, each with unique characteristics. Although, the intensification of production has gone hand in hand with narrowing of the genetic diversity, especially among cattle and pigs (Groombridge, 1994). Nowadays, there are about 21 animal species and 7.000 plant species used for nutrition and agriculture (not including farming of wild animals, and fishes). Mainly 10 animal species and about 30 plant species contribute to human nutrition on earth (Oetmann-Mennen and Begemann, 1998).

Furthermore, marine and inland fisheries exceed the principal domestic livestock in terms of production volume. Marine algae are also an increasingly important foodstuff, notably in the Far East. Their current annual world production counts for around two million tonnes. Marine organisms also provide extremely fruitful sources of pharmaceuticals and other materials used in medicines. However, in the past few decades many open-ocean resources have been gravely depleted leading to the collapse of a number of fisheries (Groombridge, 1994; cf. Oetmann, 2000).

Moreover, biological processes of nature and landscapes are decisive for our agriculture. Insects are important for flower pollinations of cultural plants. Their predators are used for their biological control by the human species. Humus is the basis for growing life as a biological product. Thereby, these organisms decontaminate and filter dust and water (cf. Kaule, 1991; Blab, 1993).

3.2.8.2 Technical constructions based on natural models

Evolutionary selection has optimized natural techniques in all fields of nature and landscapes, which the human species uses as models for own technical constructions. For example, ecological constructions of nature and landscapes serve as examples for efficient thermal and climatic isolation (cf. Figure 3.2-18; Heydemann, 1989, 1990). Another example of evolutionary optimized natural constructions is used by NASA, which has studied walking mechanisms of insects to use these construction principles for moon vehicles, landing facilities, and grasping arms (Nader, 2002).

Figure 3.2-18. Cellulose as natural foam of high thermal isolation and physical stabilization quality of a banana trunk (Heydemann, 1990)

Moreover, about 100 fungi and algae species are used to decompose at sewage treatment plants, and about 300 at refuse dumps in Germany (Kaule, 1991).

3.2.8.3 Particular uses of woodlands

There are various particular uses of woodlands that the human species benefits of either as a direct or indirect material or immaterial use or by profiting of different ecological functions (Table 3.2-46).

Table 3.2-46. Ecological functions and uses of woodlands (Deutscher Bundestag, 1990)

Field	Functions
Agriculture	• protection against erosion • protection of water resources • reduction of sedimentation at irrigation diges • habitats of natural predators of diseases and pests, as well as, pollinators • to allow harvesting on extreme grounds • gene pools for new breedings and new cultural species
Forestry	• permanent timber supply of sustainable harvesting • to provide fruits, nuts, honey, waxes, and other non-timber products • to preserve genetic diversity • resource of new forestry species
Nutrition	• plant nutrition • permanent protein resources of wild meat of sustainable hunting methods • resources for new cultural species and domestic species • woodland pastures and food resources for livestock
Industry	• to provide fresh water supply • natural pollution filters • raw materials for conventional and new industries
Energy	• to reduce periodical water drainages for electricity productions and to extend running terms by reducing sedimentations at water reservoirs • lasting fire wood supply of sustainable management methods
Health	• fresh water supply • resources for new and known medicines • physical and psychological spaces for relaxation and experience • to protect against noise, dust, and exhaust fumes
Emergency protection	• to protect against river overflooding • to protect against landslides and avalanches, especially at mountainous regions • to minimize extreme droughts
Transport	• to protect harbours and shipping canals to be covered with sand by reducing erosion and thereby sedimentations at watercourses

	• to protect streets by reducing side winds and dangers of snow-drifts and landslips
Tourism	• to protect wildlife and to preserve natural attractions

Furthermore, trees are used as natural resources for diverse products by the human species (Table 3.2-47).

Table 3.2-47. Trees used as natural resources (Groombridge and Jenkins, 1996)

Human used natural resources of trees

- timber (sawn-wood, veneers, poles, secondary wood products such as blackboards, chipboards)
- fuel (firewood, charcoal)
- fertilizer (slash-and-burn)
- fodder (branches, leaves)
- food (fruits, palm hearts, sago, exudates)
- medicines (roots, bark, leaves, flowers)
- others (rubber, oil, tannins, dyes, bark-cloth)
- pulp (for paper)

There are calculations to monetary usability benefits of single trees, such as some of the ecological performances and uses of one individual of the European beech (*Fagus sylvatica*) per year (Table 3.2-48).

Table 3.2-48. Some monetaried ecological functions and uses of one European beech (*Fagus sylvatica*) in one year (Heydemann, 1997)

One European beech (*Fagus sylvatica*) of 25 m height, 4,000 m³ crown volume, and 314 m² base	Ecological performances monetaried in Euro
Timber growth	• 12,5 € for 75 kg per year
Sugar production	• 20 € for 25 kg per year
Humus generation	• 5 € for 50 kg per year
Oxygen emissions	• 112 € for 730,000 l per year
Carbon dioxide fixations	• 75 € for 730,000 l per year

Filtrated dust	• 215 € for 90 kg per year

3.2.8.4 Globalization

The usability of products of nature and landscapes is influenced by worldwide economic structural changes due to globalization in different ways. There is an increased freedom of consumers and producers to choose between different products and production methods due to cheaper international transport and trade, increasing amounts of products and production varieties due to higher competition, as well as, more technological innovations due to international technological exchanges. However, the usability can also decrease, when international specializations and monopolizations force producers to give up traditional production und use forms due to standardized production processes in internationally more competitive companies, which push away spatially located products and traditional consumer habitats and create economic dependences (cf. Schwaab, 2001). This economic dependence refers especially to genetically modified organisms used in agriculture, such as soy beans in South America, which put small farmers at survival risks due to high costs for machinery, chemical inputs, and seeds (Pengue, 2004) . Furthermore, consumer derive goods and services from ecosystems around the world, with the costs of use largely separated from the benefits (World Resources Institute, 2000)

3.2.8.5 Conclusive summary

Human use benefits of nature and landscapes are immense. Our whole life is based on them, by directly being dependant as a living organism and by indirectly benefiting of their biotic and abiotic products. There are extensive industrial and recreational uses of nature and landscapes. Species serve as food basis for the human being. Ecosystems provide basic living resources. Developments of medical drugs depend on extracted substances from nature and landscapes.

This section can only point out some examples concerning medical, chemical, and food resources. In addition, evolutionary selection has optimized natural techniques in all fields of nature and landscapes, which the human species uses as models for own technical constructions. However concerning genetic resources, patents of biotechnological inventions increasingly limit their human use.

In particular, there are several ecological functions and uses of woodlands. Usability benefits of particular organisms can partly be calculated in money. However, the usability of products of nature and landscapes is influenced by worldwide economic structural changes due to globalization in different ways.

The culture-historical development of modern societies to use and to consume natural resources in an unrelated manner to the re-establisment abilities of nature and landscapes have lead to a severe decrease of the different economic and other usability values to the human being in many cases (cf. Matthews and Hammond, 1999). There is an acute evaluation deficit of the different short- and long-term usability values to the human species in practical planning processes and project decisions in favour of short time orientated economic profits for particular groups of the society (cf. section 2.1.1 Economic background on page 19). This refers especially to elements, structures, and functions of nature and landscapes as a public good, but reveals also democratic participation and control deficits (cf. sections 2.2.6 Conditions for practical applications of moral guidelines on page 32 and 2.4.3 Social participation on page 59, respectively).

Moreover, the deterioration of the usability values of nature and landscapes has also psychological and social reasons in educated values of humans and human behaviour in relation to nature and landscapes by our societies. Consuming has become an essential content of life for receiving practical psychological and social recognition. Buying products and thereby getting recognition has become a short-time substitute for other basic demands of life (cf. section 2.4.1 Social aspects of our perceptions, evaluations, and behaviour on page 50). There is a social trend that human feelings and relations become a tradable consumer good themselves, which is combined with an estrangement from nature and landscapes (cf. 2.5.4 Estrangement from nature and landscapes on page 78). The different usability values of nature and landscapes are reduced and replaced by symbolic psychological and social status and property values, which does not necessarily lead to more life quality (cf. 2.4.4 Social life-styles and milieus on page 60).

Thus, it is socially highly accepted and desired to increase certain economic development indicators by a consumer orientated life-style that however do not yet take into account the direct and indirect costs to the public and the immaterial values of using nature and landscapes. For instance, even a severe car accident with injuries increases the Gross National Product (GNP) in the short-term by producing a new car and the necessary health treatment of the injured people, but it can be valued negatively to the human being and nature and landscapes on their own on a wider evaluation perspective in the short- and long-term. Limited natural resources are consumed and people might be hindered in using nature and landscapes for their lifetime, apart from the current pain due to the accident.

Therefore, there is a general practical change of our technologically modern societies necessary from a development of a mainly short-time consuming orientated society and limited use of nature and landscapes towards a relation to nature and landscapes that allows using all different values of them in the short perspective and in the long-term. Usability values of nature and landscapes to the human species need to be taken into account for evaluations of particular cases in their complexity and long-term manner. Otherwise, decisions for particular exploitations or alternative uses would undervalue the multiple benefits of certain elements, structures, and functions of nature and landscapes in favour of single groups or persons.

3.3 Conclusions

For the investigation of the different values of nature and landscapes, there is a framework of the same condensed criteria necessary to gather objective, transparent, and comparable results. In the third chapter Criteria for evaluations of nature and landscapes on page 105, common ecological theories, concepts, and measurement methods mainly from species and population ecology within an ecosystem context have been discussed for each particular criterion to reveal their reliability and validity, as well as, their efficiency and sensitivity (cf. section 3.1 General conditions of evaluations on page 106).

The presented condensed criteria for evaluations of nature and landscapes of section 3.2.1 Selection of different proposed criteria on page 108 ought to be applied on the basis of the different values, which are summarized in chapter 2.8 Conclusions on page 103. However, each discipline must develop its own methods to measure their evaluation part of nature and landscapes according to the mentioned criteria. In an ideal case, there is a team of scientists of all disciplines to assess comprehensively the different values of nature and landscapes. Therefore, economists, philosopher, psychologists, social scientists, educationalists, culture-historians, and ecologists should come together to analyse and to evaluate nature and landscape according to the framework of this research. Irrespectively of their discipline, they ought to have the same framework of values and criteria to be comparable and comprehensive. This framework is applicable for urban, as well as, rural areas (Figure 3.3-1).

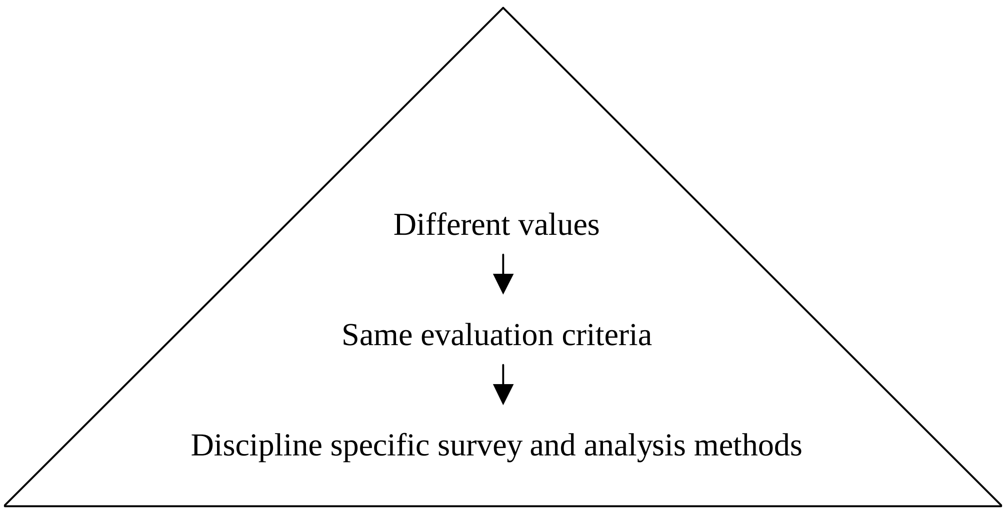


Figure 3.3-1. Levels of interdisciplinary evaluations of nature and landscapes

Moreover, a crucial part of evaluations of nature and landscapes consists of participation methods to involve the public concerned in the survey and decision process (cf. section 2.4.5 Sociological methods on page 63). Scientists have the duty to transport scientific knowledge and to integrate practical approaches to an extent of an overall view that allows implementations of concrete projects. This fundamental consciousness is based on a principle openness of scientists for proposals of practical experience and of an appropriate flexibility in project planning at the same time (Toussaint, 2002). A professional project management is a basic condition to secure these components (cf. Breitschuh and Feige, 2003).

Firstly, participation is scientifically necessary, because evaluations of nature and landscapes depend on individual preferences of the mentioned values. Secondly, practical experience and knowledge of the public help to find better decisions. Thirdly, implementations of evaluations depend highly on the acceptance and support of the public (cf. chapter 1.3 Public consciousness of environmental protection on page 15). Therefore, it is a democratic principal to let people participate, for instance, according to article 20 paragraph 2 sentence 1 of the German constitution, which emphasizes that “All power of the state originates in the public.” (Bundeszentrale für politische Bildung, 2002). The participation process ought to involve the people directly or indirectly concerned, but also the others, who have manifested their wills directly in public elections, indirectly in laws by parliament, and other democratic ways of opinion reflections of the society (cf. section 2.4.3 Social participation on page 59).

However, nature and landscapes themselves cannot directly be asked for their opinion. Therefore, it is an ethical duty to consider their assumed interests as much as possible. We can just indirectly try to analyse their conditions and take them into account in our evaluations and decisions. The holistic approach, which refers also to the non-living parts of nature and landscapes, is the most extensive expression of the value of nature and landscapes on their own. Therefore, it should take the part of nature and landscapes themselves in the appraising process of the different values (cf. section 2.2.7 Conclusive summary of ethical values on page 34).

For political decisions and practical implementations in planning processes and project evaluations, the different values and their applied evaluation criteria must be weighed up against each other, if they are contradictory (cf. Witschel, 1980; Jax, 2002). The discussion about a desired condition of nature and landscapes is always also a discussion of different life-style models and preferences within political systems (cf. Meier and Erdmann, 2003). For example, there must be a specific compromise for the management of certain historical gardens between the approach to preserve the rare and endangered garden architecture as an outstanding culture-historical example on the one hand, and the same historical gardens containing rare and endangered species as an ethical value on the other hand. Therefore, bushes might be cut into culture-historical forms, which are typical of these historical gardens, but meadows might be cut just twice a year to preserve habitats for rare and endangered plants and animals on the same ground. Often these plants and animals are even themselves typical indicators of historical gardens, because of the extensive[33] historical management (cf. Kowarik, 1998a, 2003).

A political and participatory weighing up decision would not be as clearly possible, for instance, between the ethical holistic approach and the culture-historical value, if we could not apply the same framework of criteria to classify the elements of nature and landscapes for interdisciplinary evaluations. Evaluation criteria must be a always considered in a certain spatial and time related context of values determined by the society and personal judgements, i.e. in this case the containing rare and endangered, as well as, typical elements of historical gardens of a culture-historical and ethical value, respectively. Evaluation criteria do not have a (normative) value on their own.

As an extreme example, cholera is an infectious and often fatal disease of the small intestine caused by the bacterium *Vibrio cholerea* (Allen, 1990). Despite it was a typically widespread human disease in Central Europe during a certain culture-historical period, and it has become a rare and endangered part of biological diversity due to successful eradication efforts, it is not considered as being desirable and of high value of nature and landscapes to the human being after a weighing up process with the ethical value of its own survival.

Therefore, it is not possible to develop and to apply generally valid evaluation schemes of the framework of condensed evaluation criteria according to the different values of nature and landscapes in detail. There are certain theoretical and practical examples necessary to relate the particular criteria to the different values by the specific survey and analysis methods of each discipline for weighing up their results in a participatory process for practical planning processes and project decisions. This research provides mainly ecological examples, concepts, and methods of applied criteria to evaluate nature and landscapes in Central Europe . However, it might be able to serve as an example for scientists of other disciplines to use the same comprehensive criteria and values as a framework for their interdisciplinary evaluations of nature and landscapes worldwide.

4. **Evaluation example of neobiota (non-native species)**

After the second chapter Different values of nature and landscapes on page 19 and the third chapter Criteria for evaluations of nature and landscapes on page 105 have revealed an interdisciplinary evaluation framework of comprehensive values and condensed criteria for their application, the fourth chapter shall now provide a general theoretical and a particular practical evaluation example of

[33] Extensive management refers to low human energy input and usage, i.e. low mechanical and chemical strains (trampling, cutting, as well as, use of fertilizer, herbicides, pesticides, etc.), in contrast to intensive management, for instance, in modern agriculture of industrialized countries.

neobiota to prove additionally their flexible and universal applicability (cf. section 3.1 General conditions of evaluations on page 106).

An introductory general part of this chapter shall precisely definite neobiota and justifies their relevance of occurrence in Central Europe within mainly the German species context. Therefore, a lot of data of their appearance is compiled from different sources, as well as, the general introduction processes of neobiota are revealed to prepare the background for and to justify the necessity of an evaluation of their impacts on nature and landscapes. This part is followed by an application of the proposed interdisciplinary evaluation framework of systematically examining the different values of neobiota to the human species and on their own by the condensed criteria to serve as a theoretical example.

However, there is also a practical evaluation example of neobiota necessary to demonstrate the ability of the interdisciplinary evaluation framework to allow, *inter alia*, efficient, sensitive, transparent, and comparable assessments of the particular values of certain elements, structures, and functions of nature and landscapes to the human species and on their own. Therefore, the neophyte London Plane-tree (*Platanus x hybrida*) shall serve to provide a conclusive practical example that the proposed interdisciplinary evaluation framework can be applied objectively, reliable, and validate to particular cases of nature and landscapes for practical planning processes and project decisions (cf. section 4.3.3 Practical example of the London Plane-tree (Platanus *x hybrida)* on page 274).

4.1 Definitions

Species are defined as native or indigenous in Central Europe, which have colonized nature areas without human influence after last ice age. Whereas, species are called non-native or non-indigenous (alien, exotic), which have settled an area due to direct or indirect human support or which have developed out of those species. The term neobiota covers non-native plants (neophytes), non-indigenous animals (neozoa), as well as, non-native fungi (neomycetes) (Kowarik, 2003), and other non-native organisms. Neozoa are wild living animal species, which have reached a certain nature area by direct or indirect human contribution after 1492 (Arbeitsgruppe Neozoa, 1996), where they have not been native before (Geiter et al., 2002). The year 1492 is used as a symbolic moment of the discovery of America by Columbus as a historical point of the modern age (Kinzelbach, 2001; Geiter et al., 2002). Furthermore, the year 1492 marks the epochal relevance of the modern colonization for the worldwide transfer of species (Table 4.1-1; Kinzelbach, 1996a; Kowarik, 2001; Klingenstein et al., 2003b).

Table 4.1-1. Classification by date of appearance of non-native species groups (Kowarik, 2001, modified)

Appearance classifications of non-native species		
Species groups	Until 1492	After 1492
Plants	Archeophytes	Neophytes
Animals	Archaeozoa	Neozoa
Fungi	Archaeomycetes	Neomycetes

Furthermore, non-native plant species can be distinguished depending on their degree of naturalization, period of immigration, and kind of introduction (Table 4.1-2; cf. Kühn and Klotz, 2002).

Table 4.1-2. Different classifications of non-native plant species according to their degree of naturalization, period of immigration, and way of appearance (Kowarik, 2003, modified)

Degree of naturalization of non-native plant species	
Established species[34]	Not established species
• Agriophytes occur within natural vegetation	• Ephemerophytes are wild growing, but inconsistent
• Epecophytes only occur in anthropogenic vegetation	• Ergasiophytes occur only cultivated
Period of immigration	
Until 1492:	Archeophytes (old adventive species)
After 1492:	Neophytes (new adventive species)
Way of appearance	
Akolutophytes	• appearing due to human changes
Xenophytes	• unintentionally transported
Ergasiophygiophytes	• intentionally introduced

[34] Established are those plant species, which have reproduced spontaneously at least two generations during 25 years at the minimum (Kowarik, 1991, 2003).

Established agriophytes and epecophytes, as well as, non-established ephemerophytes include 936 plant species in total in Germany (Figure 4.1-1).

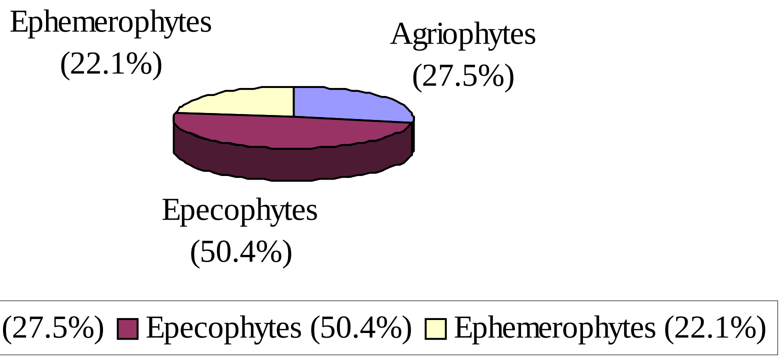


Figure 4.1-1. Relative amount of established agriophytes and epecophytes, as well as, non-established ephemerophytes of a total number of 936 plant species in Germany (Kühn and Klotz, 2002)

Anecophytes are defined as plant species, which have developed under human influences, including established cultural plant species and those plant species, which have developed out of neophytes or hybridized with them (Table 4.1-3; Kühn and Klotz, 1997). Moreover, there are suggestions to define new species as hemerobiota, which have developed out of domesticated wild populations, irrespectively at which time. They are categorized according to their species groups in hemerophytes, hemerozoa, and hemeromycetes (Gladis et al, 2003).

Table 4.1-3. Examples of established anecophytes and their origin in Central Europe (cf. Kühn and Klotz, 1997)

Examples of established anecophytes and their origin in Central Europe	
Developed out of neophytes	• Apple Serviceberry (*Amelanchier lamarckii*) and Dwarf Serviceberry (*Amelanchier spicata*) • many Evening-primroses (*Oenothera spp.*)
Hybridized with neophytes	• Peppermint (*Mentha x piperita*), Large Apple Mint (*Mentha x villosa*), and Sharp Toothed Mint (*Mentha x villosonervata*)

Introduced anecophytes as neophytes	• Tobacco (*Nicotiana tabacum*)
Spontaneously developed anecophytes	• *Eragrostis albensis*
Indigenous anecophytes	• Field Bindweed (*Convolvulus arvensis*) • Narrowleaf Hawksbeard (*Crepis tectorum*)

Concerning animals, there are 262 species at the minimum established of currently 1123 neozoa in Germany (Kinzelbach et al., 2003). Apart from clear definitions of neobiota, this section has revealed to which significant extend classified neobiota groups in general have become an established part of fauna and flora in Central Europe and in Germany. For evaluations of their different values to the human species and on their own, it is also important to know more about their ways of appearances and the significance of their particular proportion in plant, animal, and other organism groups to be able to decide about planning processes and project decisions that have an influence on their occurrence, which shall be provided by the next section.

4.2 Appearances

Different ways of appearances of neobiota can be distinguished due to biological invasions[35] and separated from indigenous species (cf. Table 4.2-1; Kinzelbach, 1996b for neozoa).

Table 4.2-1. Native indigenous species and non-native neobiota, respectively, which are distinguished according to immigration, introduction, transportation, dispersal, and development of their species, respectively (Kowarik, 2003, modified)

Origin of species	**Indigenous species**	**Neobiota**	**Examples**
<u>Immigration into areas</u>			
• permanent or periodical immigration into areas due to natural	X		• postglacial immigration of species during climatic warming up;

[35] Biological invasions are understood as biological processes of reproduction and dispersal of organisms at particular areas, which these species have not reached in natural ways before. There can be decades to centuries between the first spontaneous appearance and the start of another, more or less wide dispersal of invasions (“time lag”) (Kowarik, 1995, 2001, 2003; Kowarik et al., 2003a). Furthermore, the process of appearance caused either by direct or indirect human influences can be considered itself as a part of the biological invasion process.

distribution vectors, independent of anthropogenic support			periodical extension of birds and insects ranges, respectively
• permanent or periodical immigration into areas due to natural distribution vectors, depending on anthropogenic support		X	• immigration of species, which was allowed early by anthropogenic habitats, for example, the Spring Groundsel (*Senecio vernalis*) and the Collarded dove (*Streptopelia decaocto*); limnological taxa, which extend their ranges by canals
<u>Active introduction and passive transport into areas</u>			
• introduction into areas on purpose outside their original distribution ranges		X	• cultivated plants and domestic animals; foreign origin of native tree and shrub species, as well as, of fish species
• unintentional transportation into areas by human activities outside their original distribution ranges		X	• transported species, for example, wool adventive species, seeds and other transport accompanying flora; water organism ballasts; accompanying flora and fauna of introduced oysters
<u>Development within areas</u>			
• development in areas independent of human influences, or natural re-immigration in these areas, respectively	X		• species of originally natural landscapes, in Central Europe, mostly postglacial from refuge areas

• development out of indigenous species, for example, at cultivated landscape areas	X		• most Bramble sibs (*Rubus spp.*), many pasture and meadow sibs
• development caused by genetic processes under contribution of neobiota		X	• Common Cord-grass (*Spartina anglica*), *Fallopia x bohemica*, Hohtohelokki (*Oenothera coronifera*); many obligatory field herbs, such as the Field Poppy (*Papaver rhoeas*) and the Flax (*Linum usitatissimum*)
• development out of bred or genetically modified wild plants or wild animals		X	• traditionally bred fruit species, domestic animals, sorts of native pasture and meadow species; genetically modified organisms

There are several human influenced ways of immigration, introduction, transportation, and dispersal of neobiota (Tables 4.2-2; Wittenberg and Cock, 2001; Schrader, 2002b). Molecular biological methods can be used to determine the origin of neobiota (cf. section 3.2.2.8.1 Calculation methods of genetic diversity on page 140; Burgermeister et al., 2003; Hertel and Schneck, 2003).

Table 4.2-2. Selection of human influenced ways of immigration, introduction, transportation, and dispersal of neobiota (Kowarik, 2003)

Selection of human influenced appearances of neobiota	
• seed companions	• tree plantings along traffic routes
• transport companions	• biological engineering greenings
• aquacultures	• garden waste and others deposits
• ship traffic	• planting material
• canals	• soil and stone material

- air traffic
- car and train traffic
- gardening plantings
- hunting and apiculture
- nature gardens and hedge plantings
- botanic collections
- grass and meadow sowings
- anthropogenic changes of habitats
- agriculture and horticulture
- anthropogenic climatic changes
- forestry

4.2.1 Neophytes

Neophytes can be found in various plant species groups in Central Europe (Table 4.2-3).

Table 4.2-3. Plant species groups of neophytes in Central Europe (Kowarik, 2003, modified)

Plant species groups	Examples	Estimated species number in Central Europe
Algae	• *Biddulphia sinensis*, *Compsopogon hookeri*, *Sargassum muticum*, Mediterranean Sea: Caulerpa Seaweed (*Caulerpa taxifolia*)	• about 20 macro algae (North Sea)
Lichens	• *Anisomeridium nyssaegenum*, *Parmelia soredians*	• < 5 (?)
Mosses	• *Campylopus intro-flexus*, *Ortho-dontium lineare*, *Lunularia cruciata*	• < 15 species

Ferns	• Mosquito Ferns (*Azolla spp.*), the Meadow Spikemoss (*Selaginella apoda*)	• < 10 species
Vascular plants		• > 1000 species (about 700 established)

Furthermore, the amount of non-native plant species in Germany can be calculated as following (Table 4.2-4; for Austria in Blab et al., 2001).

Table 4.2-4. Amount of non-native plant species in Germany (Kowarik, 2003, modified)

German Flora		
Flora types	Amount of species	Relative amount
Indigenous	2078	76.8 %
Archeophytes and neophytes[36]	627	23.2 %
Archeophytes	247	9.1 %
Established neophytes	380	14.1 %
Extinct or disappeared species	47	1.7 %
Species endangered to become extinct	118	4.4 %
Totals:	2705	100 %

Regarding the way of introduction, the relative amount of introduced plant species in Germany can be calculated as following (Figure 4.2-1).

[36] 627 plant species (100 %) in total (not considering inconsistent species): 247 plant species (60.6 %) are azcheophytes (39.4 %), and 380 plant species are established neophytes. Moreover, 277 (44.2 %) of these 670 plant species are established archeophytes and neophytes (agriophytes) within natural vegetation, and 50 plant species (8.0 %) are specifically combated archeophytes and neophytes (Kowarik, 2003).

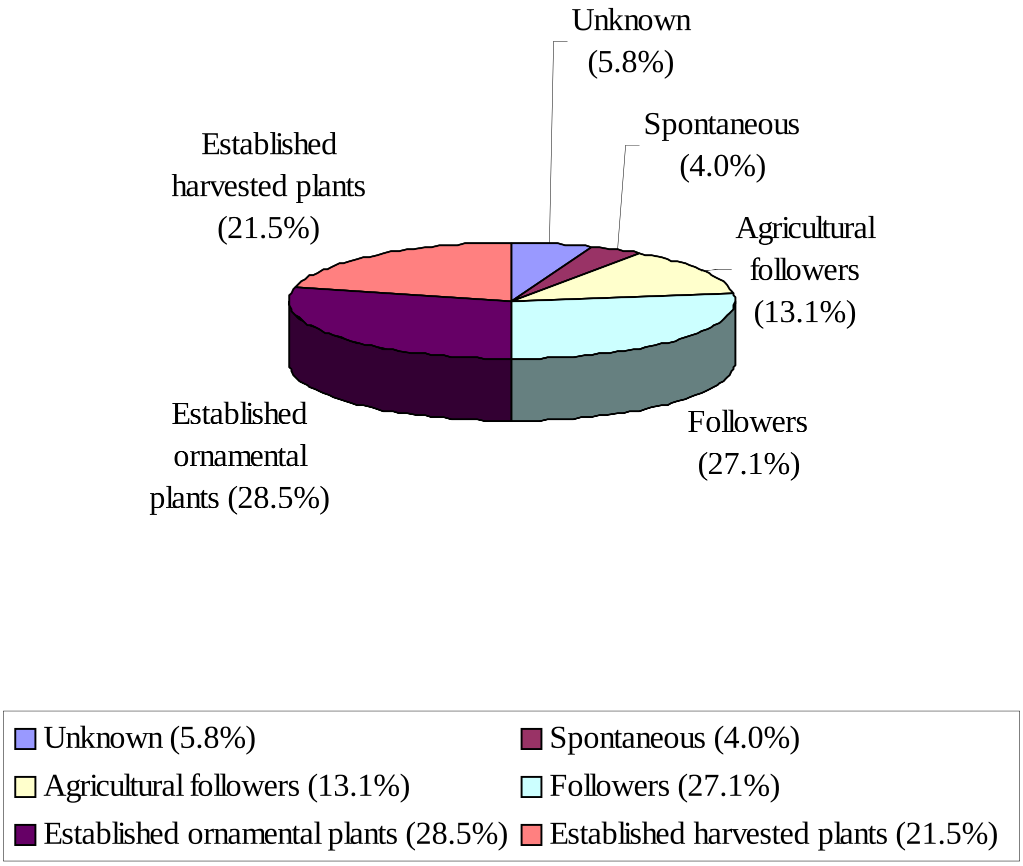


Figure 4.2-1. Relative amount of introduced plant species in Germany, which are inversely weighted according to their way of introduction (Kühn and Klotz, 2002, modified)

Most of these plant species have been introduced in Germany during the second half of the 19th century (Kühn and Klotz, 2002). However, only a few of all non-native shrub and vascular plant species have been able to establish themselves in Germany (Table 4.2-5).

Table 4.2-5. Number of non-native shrub and vascular plant species, which are established in Germany (Kowarik, 2003, modified)

Non-native shrub and vascular plant species in Germany				
Establishment stages of introduced or transported non-native species	Shrub plant species		Vascular plant species	
• dispersal has started	> 210	(> 6.7 %)	?	?
• extinct	> 34	(> 1 %)	?	?

• inconsistent	> 114	(> 3.6 %)	?	?
• established	> 64	(> 2 %)	627[37]	(5.2 %)
• established within natural vegetation	> 32	(> 1 %)	277	(2.3 %)
• specifically combated	about 10	(about 0.3 %)	about 50	(about 0.4 %)
• specifically combated not including agricultural wild plants	-	-	about 30	0.3 %
Totals:	> 3150	(100 %)	about 12,000[38]	(100 %)

4.2.2 Neozoa

Neozoa are found in Germany as following (Table 4.2-6).

Table 4.2-6. Number of non-native animal species in Germany (Geiter et al., 2002, modified)

Neozoa in Germany				
Species groups	Number of species		Therefrom established[39]	
Mammals (*Mammalia*)	22	(2.0 %)	11	(50.0 %)
Birds (*Aves*)	162	(14.4 %)	11	(6.8 %)
Reptiles (“*Reptilia*”)	14	(1.2 %)	0	(0.0 %)
Amphibians (*Amphibia*)	8	(0.7 %)	0	(0.0 %)
Bony fishes (*Osteichthyes*)	51	(4.5 %)	8	(15.7 %)
Arachnida (*Arachnida*)	32	(2.8 %)	10	(31.3 %)
Insects (*Insecta*)	536	(47.7 %)	115	(21.5 %)
Crustacea (*Crustacea*)	63	(5.6 %)	26	(41.2 %)

[37] 247 archeophytes and 380 neophytes (Kowarik, 2003).
[38] About 50,000 vascular plant species including botanical gardens (Kowarik, 2003).
[39] Established neozoa are defined as animal species, which have existed at an area in the wild during long time periods of at least 25 years, or, concerning species of shorter generation periods during at least three generations (Geiter et al., 2002).

Earthworms (*Annelidae*)	34	(3.0 %)	34	(100.0 %)
Other Arthropods ("*Articulata*")	20	(1.8 %)	7	(35.0 %)
Molluscs (*Mullusca*)	83	(7.4 %)	40	(48.2 %)
Segmented worms (*Aschelminthes*)	24	(2.1 %)	4	(16.7 %)
Flatworms (*Plathelminthes*)	36	(3.2 %)	8	(22.2 %)
Jellyfishes (*Cnidaria*)	7	(0.6 %)	5	(71.4 %)
Other groups	31	(2.8 %)	7	(22.6 %)
Totals:	1123	(100 %)	286	

4.2.3 Neomycetes and other non-native species

There occur also neomycetes and other non-native species, for example, which have been introduced by their host plants as parasites (Table 4.2-7).

Table 4.2-7. Examples of neomycetes introduced as parasites of neophytes in Central Europe (Kowarik, 2003, modified)

Neophytes as host species	Firstly reported	Neomycetes as their parasites	Firstly reported	Time lag of appearance
Small-flowered Evening-primrose (*Oenothera parviflora agg.*)	1614	*i)* *Peronospora arthurii* *ii)* *Erysiphe howeana*	1902	i) 288 years ii) 342 years
Yellow-sorrel (*Oxalis fontana*)	1807	*Ustilago oxalidis*	1956	120 years
Monkey Flower (*Mimulus guttatus*)	1830	*Peronospora jacksonii*	1927	138 years
Slender Rush (*Juncus tenuis*)	1834	*Uromyces silphii*	1981	147 years
Small Balsam (*Impatiens parviflora*)	1837	*Puccinia komarovii*	1933	96 years
Blue Lattuce (*Lactuca tatarica*)	1902	*Puccinia minussensis*	1921	19 years

Neophytes and neozoa have developed a significant share in fauna and flora in Europe, as well as, in Germany. There are several ways of appearances of them, including unintentional and intentional introductions, which have allowed neobiota to establish in our ecosystems. However, thereby the urgent question develops, which impacts on the different values of nature and landscapes do they have in general and in particular? Therefore, the next section will apply the proposed interdisciplinary evaluation framework of comprehensive values and condensed criteria to set a theoretical and a practical evaluation example of neobiota.

4.3 Evaluation

The Global Invasive Species Database provides information on more than 100 worldwide examples of successfully invasive non-native species[40] (Table 4.3-1; ISSG, 2003?; overview of more internet databanks in Wittenberg and Cock, 2001). For Germany, there is an Internet handbook under development that started with descriptions of 30 invasive non-native plant species (cf. Starfinger and Kowarik, 2003).

Table 4.3-1. 100 worldwide examples of successfully invasive non-native species (Lowe et al., 2003?, modified)

Examples of successfully invasive non-native species		
<u>Micro-organisms</u>		
	Avian Malaria (*Plasmodium relictum*)	Dutch Elm Disease (*Ophiostoma ulmi*)
	Banana Bunchy Top Virus (*Banana buchy top virus*)	Frog Chytrid Fungus (*Batrachochytrium dendrobatidis*)
	Chestnut Blight (*Cryphonectria parasitica*)	Phytophthora Root Rot (*Phytophthora cinnamomi*)
	Crayfish Plague (*Aphanomyces astaci*)	Rinderpest Virus (*Rinderpest virus*)
<u>Aquatic plants</u>		
	Caulerpa Seaweed (*Caulerpa taxifolia*)	Wakame Seaweed (*Undaria pinnatifida*)

[40] Invasive non-native species are defined as those non-native species, which endanger other species, ecosytems, or habitats (Kowarik et al., 2003a)

Common Cord-grass (*Spartina anglica*)	Water Hyacinth (*Eichhornia crassipes*)

Land plants

African Tulip Tree (*Spathodea campanulata*)	Leucaena (*Leucaena leucocephala*)
Black Wattle (*Acacia mearnsii*)	Melaleuca (*Melaleuca quinquenervia*)
Brazilian Pepper Tree (*Schinus terebinthifolius*)	Mesquite (*Prosopis glandulosa*)
Cogon Grass (*Imperata cylindrica*)	Miconia (*Miconia calvescens*)
Cluster Pine (*Pinus pinaster*)	Mile-a-minute Weed (*Mikania micrantha*)
Erect Pricklypear (*Opuntia stricta*)	Mimosa (*Mimosa pigra*)
Fire Tree (*Myrica faya*)	Privet (*Ligustrum robustum*)
Giant Reed (*Arundo donax*)	Pumpwood (*Cecropia peltata*)
Gorse (*Ulex europaeus*)	Purple Loosestrife (*Lythrum salicaria*)
Hiptage (*Hiptage benghalensis*)	Quinine Tree (*Cinchona pubescens*)
Japanese Knotweed (*Polygonum cuspidatum*)	Shoebutton Ardisia (*Ardisia elliptica*)
Kahili Ginger (*Hedychium gardnerianum*)	Siam Weed (*Chromolaena odorata*)
Koster's Curse (*Clidemia hirta*)	Strawberry Guava (*Psidium cattleianum*)
Kudzu (*Pueraria montana*)	Tamarisk (*Tamarix ramosissima*)
Lantana (*Lantana camara*)	Wedelia (*Wedelia trilobata*)
Leafy Spurge (*Euphorbia esula*)	Yellow Himalayan Raspberry (*Rubus ellipticus*)

Aquatic invertebrates

Chinese Mitten Crab (*Eriocheir sinensis*)	Mediterranean Mussel (*Mytilus galloprovincialis*)
Comb Jelly (*Mnemiopsis leidyi*)	Northern Pacific Seastar (*Asterias amurensis*)
Green Crab (*Carcinus maenas*)	Spiny Water Flea (*Cercopagis pengoi*)
Marine Clam (*Potamocorbula amurensis*)	Zebra Mussel (*Dreissena polymorpha*)

Land invertebrates

Argentine Ant (*Linepithema humile*)	Formoson Subterranean Termite (*Coptotermes formosanus shiraki*)
Asian Longhorned Beetle (*Anoplophora glabripennis*)	Giant African Snail (*Achatina fulica*)
Asian Tiger Mosquito (*Aedes albopictus*)	Golden Apple Snail (*Pomaceae canaliculata*)
Big-headed Ant (*Pheidole megacephala*)	Gypsy Moth (*Lymantria dispar*)
Common Malaria Mosquito (*Anopheles quadrimaculatus*)	Khapra Beetle (*Trogoderma granarium*)
Common Wasp (*Vespula vulgaris*)	Little Fire Ant (*Wasmannia auropunctata*)
Crazy Ant (*Anoplolepsis gracilipes*)	Red Imported Fire Ant (*Solenopsis invicta*)
Cypress Aphid (*Cinara cupressi*)	Rosy Wolf Snail (*Euglandina rosea*)
Flatworm (*Platydemus manokwari*)	Sweet Potatoe Whitefly (*Bemisia tabaci*)

Amphibians

Bullfrog (*Rana catesbeiana*)	Caribbean Tree Frog (*Eleutherodactylus coqui*)
Cane Toad (*Bufo marinus*)	

Fishes		
	Brown Trout (*Salmo trutta*)	Nile Perch (*Lates niloticus*)
	Carp (*Cyprinus carpio*)	Rainbow Trout (*Oncorhynchus mykiss*)
	Large-mouth Bass (*Micropterus salmoides*)	Walking Catfish (*Clarias batrachus*)
	Mozambique Tilapia (*Oreochromis mossambicus*)	Western Mosquito Fish (*Gambusia affinis*)
Birds		
	Indian Myna Bird (*Acridotheres tristis*)	Starling (*Trachemys scripta*)
	Red-vented Bulbul (*Pychnonotus cafer*)	
“Reptiles”		
	Brown Tree Snake (*Boiga irregularis*)	Red-eared Slider (*Trachemys scripta*)
Mammals		
	Brushtail Possum (*Trichosurus vulpecula*)	Pig (*Sus scrofa*)
	Domestic Cat (*Felis catus*)	Rabbit (*Oryctolagus cuniculus*)
	Goat (*Capra hircus*)	Red Deer (*Cervus elaphus*)
	Grey Squirrel (*Sciurus carolinensis*)	Red Fox (*Vulpes vulpes*)
	Macaque Monkey (*Macaca fascicularis*)	Ship Rat (*Rattus rattus*)
	Mouse (*Mus musculus*)	Small Indian Mongoose (*Herpestes javanicus*)
	Nutria (*Myocastor coypus*)	Stoat (*Mustela erminea*)

In addition, there are risk analyses of the possible changes of nature and landscapes by non-native species to implement § 41 paragraph 2 of Germany’s Federal Nature Conservation Act (cf. Kowarik et al., 2003a, 2003b) according to article 8 letter h of the Convention on Biological Diversity to “prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species” (United Nations, 1992; BMU, ?).

Nevertheless, the occurrence of neobiota as part of biological diversity cannot be considered a priori as being negative, because in certain cases dominant non-native species might be desired by people, for example, colourful non-native flowers or conifers in the garden can have a positive psychological aesthetic and recreational value for them, while untypical native species might be eradicated by the garden owners, i.e. these gardens can have a high degree of human influences (hemeroby) and a low content of native species, but still a high value for the garden owners. Therefore, the application of article 8 letter h of the Convention on Biological Diversity must be seen in the decisive light of article 1 of its preamble, which points out the intrinsic value of biological diversity and the ecological, genetic, social, economic, scientific, educational, cultural, recreational, and aesthetic values of biological diversity and its components (United Nations, 1992; BMU, ?).

Moreover, it seems to be arbitrary to evaluate the negative impacts on ordinary scales of the reduction of the abundances of other taxa by non-native species generally as high >50%, as medium 20-50%, and as low <20, as well as, building up own stands as high >50%, as medium 10-50%, and as low <10% (Kowarik et al, 2000a, 2003b), because there can be more or less severe impacts on the different components of nature and landscapes on lower or higher degrees of occurrence of non-native species, respectively, depending on the particular evaluation case at a certain area and time-scale. For instance, competing native species might be driven out below a certain level of their Minimum Viable Metapopulations (MVM), which can be estimated by Population Vulnerability Analyses (PVA) on certain spatial- and time-scales, but not generally quoted (cf. sections 3.2.2.4 Minimum Viable Metapopulation (MVM) concept on page 126 and 3.2.2.5 above Population Vulnerability Analysis (PVA) on page 131, respectively).

Furthermore, for instance the non-native neophyte Sycamore (*Acer pseudoplatanus*) was introduced into the UK hundreds of years ago (Rackham, 1980). However, it is a typically and naturally growing species on Nunhead Cemetery, London Borough of Southwark, UK, thereby most frequently occurring at early succession stages. Nevertheless, it has several values to the human species and on their own, for example, as a part of a naturally and typically grown dominant secondary Ash-Sycamore woodlands (*Fraxinus excelsior-Acer pseudoplatanus* woodlands) of high recreational and aesthetic psychological value, and important ecological functions as an economic value for producing basic living resources, such as clean groundwater, filtering dust, and noise reduction, as well as, the ecological functions of an ethical value as an important habitat for birds and several insect species on these grounds. Moreover, Nunhead Cemetery's secondary Ash-Sycamore woodlands (*Fraxinus excelsior-Acer pseudoplatanus* woodlands) are highly rare and endangered as a semi-natural woodland on local, regional, and national levels in Great Britain. Therefore, it is also an ethical duty as a value to the human species and on their own to do not intervene in natural ecosystem processes on Nunhead Cemetery of the growing non-native species Sycamore (*Acer pseudoplatanus*) as a general management decision, despite it contributes to build up the dominant Ash-Sycamore woodlands (*Fraxinus excelsior-Acer pseudoplatanus* woodlands) at this location during early succession stages (Zisenis, 1993, 1996, 1998).

Therefore, the proposed interdisciplinary evaluation framework of comprehensive values and condensed criteria of this research shall be instead applied to evaluate the different values of neobiota to the human species and on their own by a general theoretical and a particular practical example of neobiota. It starts with a systematic application of the framework of condensed criteria and current knowledge about their impacts, which is set into relation to the different values of them to the human species and on their own in the following section.

4.3.1 Criteria applied to neobiota

4.3.1.1 Rarity and endangerment

Neobiota can endanger indigenous species up to extinction in certain cases (Table 4.3-2; Figure 4.3-1).

Table 4.3-2. Examples of neozoa, which have significantly contributed to the extinction of certain bird and mammal species (Plachter, 1991a)

Contributively neozoa to extinction of native species		
Neozoa	Thereby extinct species	Former range
Goats or sheep (vegetation destructions)	*Caballus modestus*, *Colapter cafer rufipileus*	Catham Islands, Guadelupe
Rabbits (soil destructions)	*Caballus modestus*	Catham Islands
Feraled dogs	Tristan Island Cock (*Gallinula nesiotis nesiotis*)	Catham Islands
Feraled cats	Auckland Island Rail (*Rallus muelleri*)	Auckland Islands
	Microgoura choiseul-meeki	Choiseul Islands
	Bonin Wood Pigeon (*Columba versicolor*)	Bonin Islands
	Amytomis goyderi	Australia

	Western Barred Bandicoot (*Perameles bougainville fasciata*)	Australia
	Crocidura fuliginosa trichua	Christmas Islands
Feraled pigs	*Prosobonia teucoptera*	Society Islands
	Dodo Bird (*Raphus cucullatus*)	Maskarenen
Rats	Tahitian Red-billed Rail (*Rallus pacificus*)	Tahiti
	Laysan Rail (*Porzanula palmeri*)	Laysan
	Kosrae Starling (*Aplonis corvina*)	Karolinen
Foxes	Toolach Wallaby (*Wallaby greyi*)	Australia
Viverrids (Mungo)	*Pemula sandwichensis*	Hawaii
	Martinique [House] Wren (*Troglodytes musculus martinicensis*)	Martinique

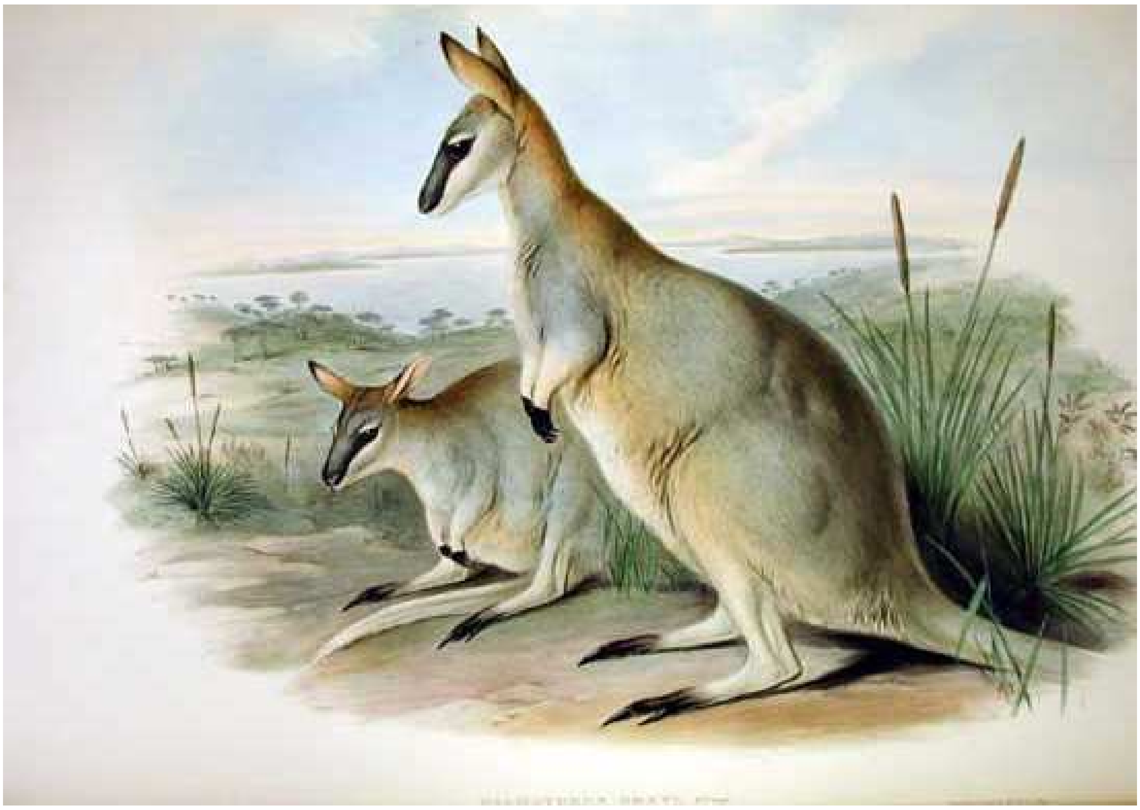


Figure 4.3-1. Extinct mammal species Toolach Wallaby (*Wallaby greyi*) due to introduced foxes and hunting pressure in Australia (Gould, 1863) reproduced by kind permission of Museum Victoria, Victoria, Australia

Introduced species count for 55 % of extinct island bird species that are 93 % of so far 188 worldwide (Kowarik, 2003). Globally, neobiota as predators or competitors are the second most important cause of extinction of molluscs (CBD, 2001b). In addition, neobiota threaten some 20 % of all vertebrate species, which are thought to be in danger of extinction (CBD, 1999).

Neobiota can cause (meta-) population decreases of native species up to extinction in certain cases, for example, due to habitat competition, predation, introduced diseases, and genetic changes, such as hybridizations. However, these impacts are often crucially based on habitat changes by the human species (cf. Boye, 1996; Eser, 1999; Korneck et al., 1998; Sukopp, 2001; Martin, 2002; Kowarik, 2003). There are several examples of hybridizations of domesticated species with native species of positive and negative impacts on nature and landscapes, respectively (cf. Gladis et al., 2003). Therefore, the member states of the Convention on Biological Diversity have agreed in article 8 letter h to "prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species" (United Nations, 1992; BMU, ?), which has resulted in a Global Strategy on Invasive Alien Species (CBD, 2000), as well as, in guiding principles for the implementation of this article 8 letter h of the Convention on Biological Diversity (CBD, 2002; cf. Wittenberg and Cock, 2001). In addition, there are risk analyses of invasive species (cf.

Wittenberg and Cock, 2001; Schrader, 2002a; Kowarik et al., 2003a, 2003b; section 4.3 Evaluation on page 237).

However, there is no known case for Central Europe, when a non-native species has caused the dying out of a native species (Klingenstein et al., 2003b; Kowarik, 2003). Neozoa often profit as much as neophytes more of human changes of nature and landscapes and biocoenosis, than being the reason itself (cf. Reichholf, 1996; Tittizer, 1996; Kowarik, 2003). Nevertheless, neophytes have contributed to the decrease of 43 endangered native species (6 %) in Germany (Kowarik, 2003).

On the other hand, neobiota can be considered as rare and endangered themselves, if they are currently established or if they were once (cf. Arbeitsgruppe Neozoa, 1996; Kowarik, 1991; Korneck et al., 1998). For example, many agricultural companions are neophytes. They have become rare and endangered during agricultural intensification, use of herbicides, chemical fertilizer, and high amounts of biological fertilizer, as well as, cleaning of seeds in Central Europe since the 19th century (cf. Plachter, 1991; Blab, 1993; Korneck et al., 1998; Kowarik, 2003). There are 13 endemic anecophytes in Germany, 7 of them in Central Europe, and 5 of them in Europe (Kühn and Klotz, 2002).

4.3.1.2 Naturalness/degree of human impacts

Naturalization is combined with a process of selection and adaptation to neobiota. It is just a question of time up to geological time spans, until neobiota will be an integrated part of ecosystems like native species. Neobiota are directly or indirectly supported by human influences either directly through active introduction and dispersal, as well as, passive transportation (Table 4.3-3), or indirectly by human activities that create favourable conditions for immigrations, and habitats for the development and dispersal of these new species. Furthermore, conventionally bred and genetically modified species, respectively, are another quality of directly created neobiota, because evolutionary processes are modified and extremely speeded up (cf. section 4.3.1.5.2 Genetically modified organisms on page 249).

Table 4.3-3. Selection of pathways for unintentional transport and intentional introductions of neobiota (European Commission, 2002b, modified)

Pathways for unintentional transport and intentional introductions of neobiota
• trade and movement of goods, e.g. neobiota and micro-organisms translocated in containers, planting media, untreated wood packaging, some food products • movement of people, including for tourism, through air, road, rail, and sea transport • shipping, e.g. ballast water, sediment, hull fouling, anchors • aviation in cargo, as well as, on and in the aircraft itself

- postal and courier services, including biological material purchased via the internet
- mariculture and aquaculture, e.g. fish, molluscs, crustaceans introduced for production; neobiota accompanying introduced species
- agriculture of crops and livestock, including direct introductions and accompanying neobiota
- shooting and angling, including game species and live fish and bait introduced for sport and restocking, and their accompanying neobiota
- aquaria, i.e. their deliberate discards and the discharge of neobiota with waste water
- release of pets or domestic animals
- horticulture and gardening, for instance, dispersal of material from tips and ponds
- habitat restoration and landscaping, e.g. use of non-native genotypes of native plants
- waste disposal and overflow, i.e. discharges of untreated effluent to aquatic systems
- infrastructure development and interbasin transfers of water
- large-scale movements of vehicles and equipment during development, as well as, famine relief programmes, and military operations

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From the historical point of view, neozoa, neophytes, and other neobiota after 1492 are unnatural by definition. However, from the point of view of natural developments at present times, neobiota after 1492 can be considered as being natural, when they have developed themselves at an area for the first time neither by being conventionally bred, nor genetically modified, nor actively introduced, nor passively transported by humans. Therefore, neobiota after 1492 are of current natural origin, when they have immigrated and dispersed by themselves at habitats of different degrees of human influences (hemeroby degrees), or when they have developed out those species (cf. sections 4.1 Definitions on page 226 and 3.2.3 Naturalness/degree of human impacts on page 149, respectively; Steiof, 2001). Alternatively, natural immigrations and developments out of those species due to habitat changes of nature and landscapes of certain degree of human influences (hemeroby) could be excluded from the definition of neobiota, because it can be considered as a natural evolutionary process (Steiof, 2001; cf. chapter 4.1 Definitions on page 226).

4.3.1.3 Typicalness

Many neobiota have become typical parts of nature and landscapes, for example, the Yew (*Taxus baccata*) on cemeteries (cf. Graf, 1986; Gilbert, 1991). The London Plane-tree (*Platanus x hybrida*) is typically planted along streets in cities in Europe, because of its resistance against salt, dust, and dry air (cf. Markstein et al., 1985), such as in London, Paris, Rome, and Berlin (cf. section 4.3.3 Practical example of the London Plane-tree (Platanus *x hybrida)* on page 274). The Collared Dove (*Streptopelia decaocto*) is another typical urban species of Central Europe that originates in Turkey, India (Klausnitzer, 1993), and Pakistan (Weigmann, 1996).

4.3.1.4 Re-establishment ability

Re-establishment abilities of neobiota depend, like for native species, on recolonization possibilities, isolation barriers, and time durations of developments of similar habitats. Furthermore, re-establishment abilities of neobiota are crucially connected with current and future direct and indirect human influences, already by definition of neobiota in this context. Biological reinvasions by biota are supported by similar or even the same human activities as for first invasions.

4.3.1.5 Vulnerability

4.3.1.5.1 Biological invasions

Biological invasions by neobiota are especially successful at areas, where similar competitors have not been historically evolved yet, for example, on islands. In general, neobiota are supported by natural or human habitat changes (Kowarik, 2003). Neobiota seem to have the biggest changing influences on geographically and evolutionary isolated ecosystems, for instance, at oceanic or terrestrial islands. In general, they seem to be more successful in those ecosystems that are primarily changed by human activities, although unchanged ecosystems are commonly affected as well. Another important factor is the degree of complexity of the host ecosystem, i.e. low-complexity ecosystems seem to be more vulnerable to biological invasions, as well as, those with a simpler ecological structure, *inter alia*, in terms of trophic interactions and competition, for example, islands and boreal woodlands more than tropical woodlands. Climate, soil, sediment and other abiotic similarities are also factors influencing biological invasions by neobiota (cf. CBD, 1999). However, there are examples of positive and negative correlations, respectively, between species diversity and invasions by neobiota depending, for example, on the complexity of trophic levels (cf. Levine et al., 2004).

Obviously, the vulnerability of ecosystems to invasions by neobiota depends on the availability of free ecological niches and the competitiveness with species of already occupied ecological niches (cf. Irmler, 1998; Pullin, 2002). As more as neobiota are adapted to abiotic and biotic conditions similar to their place of origin, as more vulnerable are ecosystems to invasions by them. Moreover, neobiota can develop a selection advantage in expressing genes at new grounds, which were not selected at the ground of origin due to different abiotic and biotic conditions.

Furthermore, the probability of a species to become invasive increases with the initial population size. Those species have greater chances to become established, which are introduced intentionally and cultivated (plants) or maintained under animal husbandry over a long period of time. Species, which have larger native geographic ranges, are more likely to be invasive than those with smaller ones. Taxa belonging to genera not represented in the native flora are more likely to be invasive than alien taxa with close relatives in the native flora. Moreover, species with specialized pollinators are unlikely to be invasive unless their pollinators are also introduced. A species that is invasive in one country or location should be considered at high risk of becoming invasive in an ecologically or climatically similar country or location. Successful invasions generally require that the new habitat conditions are comparable to those at the point of origin, especially in terms of climatic conditions (CBD, 2000).

Therefore, it becomes as more likely that biological invasions are successful, as more neobiota find similar environmental conditions to the areas of origin (cf. Geiter et al., 2002) that they are adapted to, as less there are competitors at new areas, and as supporting are human influenced habitat and dispersal conditions for them. The vulnerability of neobiota depends on the degree of their establishment, dispersal, and flexibility to habitat changes, like for their native counterparts. It can be assumed that stenotic neobiota are more vulnerable to habitat changes than euryotic species. For example, undergoing global climate change has one of the most important general influences in changing nature and landscapes on earth also concerning neobiota. Calculations figure on that the average temperature on earth will rise from 1.4°C to 5.8°C between 1990 and 2100, while greenhouse gases have reached their highest atmospheric concentrations for at least 420,000 years (Mulongoy and Chape, 2004; cf. WBGU, 1999a; CBD, 2003; Green et al., 2003).

In particular, human activities can initiate and enhance biological invasions in different ways (Table 4.3-4).

Table 4.3-4. Human activities, which support biological invasions by neobiota in Central Europe (Kowarik, 2003, modified)

Biological invasions by neobiota supported by human activities in Central Europe
• to change or to create new habitat conditions, which are necessary or contributing to the establishment or foundation of neobiota and their growth and dispersal
• to support initial populations by repeatedly secondary releases, for example, plantings, sowings, abandons, as well as, unintentionally transportations, and thereby contributing to the establishment of MVMs
• to overcome spatial isolation barriers of dispersal vectors by a wide spectrum of secondary releases
• to initiate genetic processes, which lead to sibs of higher invasive potential: reductions of geographical barriers can support hybridizations and introgressions[41], new habitat conditions can have beneficial effects on evolutionary adaptations, and conventional breeds and genetic modifications can result in new biota of higher invasive power

[41] Introgressions are genetic infiltrations by one species through another (Geiter et al., 2002).

On the other hand, native species are especially vulnerable to biological invasions by neobiota, when they are evolutionary not adapted to habitat changes and competition of these new species. There are some characteristics of biological invasions that depend on human changes to enter into new habitats (Table 4.3-5).

Table 4.3-5. Some characteristics of biological invasions that depend on human changes to enter into new habitats (Bazzaz, 1986, modified)

Some characteristics of biological invasions that depend on human changes to enter into new habitats
• high population growth rate • relatively short life-cycle • early reproductive maturity • autogamous[42], or wind-pollinated, or serviced by generalists • long-range seed dispersal capability • generalists (broad-niched) in resource use • high acclimation capabilities • rapid response to resource availability • high rates of photosynthesis, respiration, transpiration, and growth

Furthermore, neobiota can affect the genetic diversity of native species, for example, by hybridizing with them (cf. Korneck et al., 1998; Sukopp, 2001; Geiter et al., 2002; Kühn and Klotz, 2002; Kowarik, 2003). The latter can result in outbreeding depression, or it can cause genetic drift effects. However, biological invasions can be also seen as an evolutionary process of creating new species and species compositions in the long-term (cf. Arnold, 1997; Auge et al., 2001). Therefore, the vulnerability of ecosystems and species to neobiota depends on the particular case (cf. Kowarik et al., 2003b).

4.3.1.5.2 Genetically modified organisms

It is almost impossible to predict the effects of genetically modified organisms on nature and landscapes. Therefore, empirical experience of neobiota is used in models to estimate the vulnerability of nature and landscapes to genetically modified species (Geiter et al., 2002; cf. Kowarik, 1992; 2003; Lemke and Winter, 2001), for example, by using the Exotic Species Model (Kowarik, 2003). In addition, there are monitoring schemes necessary for their impacts on nature and landscapes (cf. Breckling and Züghart, 2001), as well as, environmental risk assessments of genetically modified organisms (cf. Gaugitsch, 2004).

[42] Self-fertilizing of plants (Allen, 1990).

Article 8 letter g of the Convention on Biological Diversity urges the signing member states to ”Establish or maintain means to regulate, manage or control the risks associated with the use and release of living modified organisms resulting from biotechnology which are likely to have adverse environmental impacts that could affect the conservation and sustainable use of biological diversity, taking also into account the risks to human health” (United Nations, 1992; BMU, ?).

However, processes in nature and landscapes are too complex to be able to predict developments of genetically modified species during new mutations, reproduction, competition, migration, and selection, as well as, changing human influences in the long-term (cf. Geiter et al., 2002; Vogel and Ober, 2005).

4.3.1.6 Ecological functions

Biological invasions can influence various ecological functions of nature and landscapes (Table 4.3-6; cf. Eser, 1999; CBD, 2001c; Kinzelbach et al. 2003; Kowarik et al., 2003b).

Table 4.3-6. Ecological, evolutionary, and biogeographical effects of biological invasions in Central Europe (Kowarik, 2003, modified)

Impact levels	**Process**	**Examples of impacts**
Individuals, populations	Interspecific competition	• reductions of abundances, disappearing of individuals, and parts of populations of waterside plants by Knotweed sibs (*Reynoutria spp.*), of woodland soil plants by the Black Cherry (*Prunus serotina*), of chalk grasslands by Goldenrods (*Solidago spp.*) and Sundial Lupin (*Lupinus polyphyllus*), of rock settlers by the Douglas Fir (*Pseudotsuga menziesii*), of the Red Squirrel (*Sciurus vulgaris*) by the Grey Squirrel (*Sciurus carolinensis*) • reduced biomass production of other species at dominant waterside herbaceous perennial, of cultivated plants due to wild plants of archeophytes and neophytes, respectively • reduced transition probabilities of life-cycles of other species, lower regeneration successes of Oaks (*Quercus spp.*) by shading of the Black Cherry (*Prunus serotina*) • disappearing (meta-) populations at overlapping habitat ranges of native Touch-me-not Balsam (*Impatiens noli-tangere*) by non-native Small Balsam (*Impatiens parviflora*)
	Herbivory	• decreased dune plants, as well as, pasture and meadow plants due to grazing of the European Rabbit (*Oryctolagus cuniculus*) • impaired regeneration of woody plants by Fallow Deer (*Cervus dama*) biting • the Musquash (*Ondatra zibethica*) as one reason of the reduction of reed banks • decreased water plants after grazing of Grass Carps (*Ctenopharyngodon idella*) • impaired cultivated plants by the San Jose Scale (*Quadraspidiotus perniciosus*), the European Corn Borer (*Ostrinia nubilalis*), the Colorado Beetle (*Leptinotarsa decemlineata*), and Roundback Slugs (*Arionidae*)

Impact levels	**Process**	**Examples of impacts**
	Predatoriness	• losses of sea and water birds by the Mink (*Mustela vison*) and altered behaviour of birds (predator preventing strategies) • supported predators, e.g. Foxes (*Vulpes spp.*), by occuring European Rabbit (*Oryctolagus cuniculus*) and the Common Pheasant/Ring-Necked Pheasant (*Phasianus colchicus*) • use of neobiotic plancton species by representatives of higher trophic levels at limnological waters and marine • reduced Earthworm (*Lumbricus terrestris*) populations by the New Zealand Flatworm (*Arthurdendyus triangulates*) (NW Europe) • supported water birds by nutrition availability of the Freshwater Molluscan Shells *(Dreissenidae*)
	Parasitism	• increased senescence and mortality of Elm species (*Ulmus spp.*) after attacks of the neomycete Dutch Elm Disease (*Ophiostoma ulmi*) and *Ophiostom novo-ulmi* • reduced biomass production of waterside herbaceous perennial by neophytic Cuscuta species, of cultivated and ornamental plants by neophytic Mildew species
	Allelopathy[43]	• assumed suppressed undergrowth by the Black Cherry (*Prunus serotina*), the Horse-Chestnut (*Aesculus hippocastanum*), the Tree-of-heaven (*Ailanthus altissima*), the Black Walnut (*Juglans nigra*), and the Turkish Wartycabbage (*Bunias orientalis*)
<u>Species, taxa</u>	Extension of ranges	• established and extended secondary ranges of neobiota, e.g. the Small Balsam (*Impatiens parviflora*) and its depending aphid *Impatientinum asiaticum*

[43] Allelopathy refers to enhancing or impeding biochemical processes between plants, respectively (Klötzli, 1993).

Impact levels	Process	Examples of impacts
	Decrease	• extinct indigenous taxa or limitations of their ranges (rather irrelevant on species level in Central Europe; however, there are no assumptions possible below the species level) • contribution to endangerment and decrease of indigenous taxa within their ranges, e.g. pushing away chalk grassland species by the False Acacia (*Robinia pseudoacacia*) and Lupin species (*Lupinus spp.*), the non-native Grey Squirrel (*Sciurus carolinensis*) as a reducing factor of the native Red Squirrel (*Sciurus vulgaris*) at Great Britain • endangered wild fruit sibs by hybridizations and back crossing with cultivated sibs • decreased typical shrub sibs at the area by hybridizations with plants of unknown and foreign origins • endangered White-headed Duck (*Oxyura leucocephala*) by hybridization with the Ruddy Duck (*Oxyura jamaicensis*) • decreased (rest-) populations of native animal species by mixing with released native species of foreign origin, e.g. the European Beaver (*Castor fiber*), Trouts (*Salmo spp.*), the Atlantic Salmon (*Salmo salar*), the Northern Pike (*Esox lucius*), and the Zander (*Lucioperca lucioperca*), or with released neozoa, the Mallard (*Anas platyrhynchos*) and wild goose (*Anser spp.*)
	Development of new sibs by hybridizations, introgressions, and mutations	• new developments of sibs by hybridization between non-native and native sibs, e.g. the non-native Giant Hogweed (*Heracleum mantegazzianum*) x the native Hogweed (*Heracleum sphonylium*), and between non-native sibs, *Fallopia x bohemica*, the Common Cordgrass (*Spartina anglica*) • hybridizations of species and groups of goose species (*Anser spp.*, *Branta spp.*) • development of anthropogenic sibs, e.g. Flax groups (*Linum usitatissimum*), Evening-primeroses (*Oenothera spp.*) sibs, herbizide resistent sibs of Goosefoot (*Chenopodium spp.*), Amaranth (*Amaranthus spp.*), and Fleabane (*Conyza spp.*)

Impact levels	Process	Examples of impacts
<u>Biocoenosis</u>	Extension of nutrition supply	• new biocoenotic relations by extended ranges of neomycetes and neozoa following their host and feeding plants, e.g. the fungi *Puccinia komarovii* and the aphid *Impatientinum asiaticum* on the non-native Small Balsam (*Impatiens parviflora*), as well as, supporting their predators • extended host spectra of phytophages (mostly polyphagous species), and support of their parasites, as well as, predators of them (extended abundances) • increased generation rows of the bug *Nysuis sencionis* by the Narrow-leaved Ragwort (*Senecio inaequidens*) • supported specific nutrition guilds, e.g. the use of extrafloral nectarean on the Indian Balsam (*Impatiens glandulifera*) • extended ranges of populations of parasites and their predators, e.g. the Narrow-leaved Ragwort (*Senecio inaequidens*) at mountain spoil banks, of non-native Small Balsam (*Impatiens parviflora*) at European Beech (*Fagus sylvatica*) woodlands • supported nitrophile plants by nitrogen binding of the False Acacia (*Robinia pseudoacacia*) and Lupin species (*Lupinus spp.*)
	Sedimentation	• supported silting up by strongly growing up neophytes, e.g. the Canadian Waterweed (*Elodea canadensis*) in lakes, Cord grasses (*Spartina spp.*) at the tidal shallows • changed sedimentation processes at rivers by strongly growing neophytes
	Erosion	• supported erosions at dikes and water sides by the Musquash (*Ondatra zibethica*) and neophytes of small undergrowth, e.g. Knotweed (*Fallopia spp.*) and Sunflower (*Helianthus spp.*) • fixed open sands by the Rugosa Rose (*Rosa rugosa*) and the moss *Campylopus introflexus*; bank fixation by the False Acacia (*Robinia pseudoacacia*)

Impact levels	Process	Examples of impacts
	Nutrition dynamic and soil chemistry	• changed nitrogen households by nitrogen fixing species, the False Acacia (*Robinia pseudoacacia*) and Lupin species (*Lupinus spp.*) • reduced ph-levels by coniferous plants, e.g. the Douglas Fir (*Pseudotsuga menziesii*) and the Eastern White Pine (*Pinus strobus*) • decomposed sheep dung at Australia after introduction of European earthworms
	Soil generation	• increase by pioneer settlers, e.g. the Narrow-leaved Ragwort (*Senecio inaequidens*) and the Butterfly Bush (*Buddleja davidii*) on mountain spoil banks • influenced humus generation by the False Acacia (*Robinia pseudoacacia*), Larchs (*Larix spp.*) and the Douglas Fir (*Pseudotsuga menziesii*)

On the other hand, neobiota can fulfil similar ecological functions as native species. For example, woodlands of neobiota can equally function as recharges for groundwater and air humidity, to protect soils against erosion, to reduce noise, to clean air and water, as well as, to provide habitats, for instance, for nesting native birds. Moreover, birds as neozoa themselves can contribute to the transport of seeds of native plants or they can function as predators of native insects. In addition, non-native insects can transport pollen of native plants, etc.

Furthermore, neobiota can also just fill up ecological niches, either when they arrive before native species can occupy them or will occupy these niches during evolutionary times of adaptation and selection processes, respectively. For example, Asters (*Aster spp.*) can provide additional nectar and pollen supply for some late flying wild bee species, such as Halictus (*Halictidae*), Bumble-bees (*Bombus spp.*), Hover-flies (*Syrphidae*), and many day flying butterfly species (*Lepidoptera*), especially Blues (*Lycaenidae*) (Kowarik, 2003).

It depends on the particular neobiota, which functions they fulfil in the ecological system. For example, there have been attempts to calculate the ecological function of trees as habitats for phytophagus insects and mites in Britain, which unfortunately do not distinguish between euryotic and stenotic species, i.e. species that depend on specific tree species and those, who could also live on others (Table 4.3-7). Furthermore, the study does not tell us, if these species are rare or endangered, or which ecological functions they have, for instance, within the food-chain.

Table 4.3-7. Numbers of species of phytophagus insects and mites associated with trees in Britain (Kennedy and Southwood, 1984; cf. Kelly and Southwood, 1999; Brandle and Brandl, 2001) reproduced by kind permission of Blackwell Publications, Oxford, UK.

	Acarina Eriophyidae	Coleoptera	Diptera Agromyzidae	Diptera Cecidomyidae	Heteroptera	Homoptera Auchenorhyncha	Homoptera Psylloidea	Homoptera Aphidoidea	Homoptera Aleyrodoidea	Homoptera Coccoidea	Hymenoptera Symphyta	Hymenoptera Cynipoidea	'macro' Lepidoptera	'micro' Lepidoptera	Thysanoptera	TOTALS
Acer campestre	5	2	0	5	2	3	1	5	1	0	2	0	8	16	1	51
*Acer pseudoplatanus**	5	2	0	3	1	4	1	4	1	0	2	0	5	15	0	43
*Aesculus hippocastanum**	2	0	0	0	0	2	0	1	0	2	0	0	1	1	0	9
Alnus glutinosa	6	16	1	2	14	12	2	4	0	0	21	0	28	32	3	141
Betula (2 spp.)	4	57	1	4	12	10	3	12	0	5	42	0	94	85	5	334
Carpinus betulus	1	5	0	3	1	7	0	1	2	0	2	0	7	21	1	51
*Castanea sativa**	0	1	0	0	0	0	0	1	0	0	0	0	0	9	0	11
Corylus avellana	4	18	0	7	16	0	0	1	2	0	8	0	18	30	2	106
Crataegus monogyna	5	20	1	4	17	6	4	7	1	5	12	0	64	60	3	209
Fagus sylvatica	4	34	0	6	4	3	0	1	1	2	2	0	24	17	0	98
Fraxinus excelsior	3	1	7	2	10	0	4	1	0	2	7	0	16	9	6	68
Ilex aquifolium	0	4	1	0	0	0	0	0	0	2	0	0	2	1	0	10
*Juglans regia**	3	0	0	0	0	0	0	2	0	0	0	0	0	2	0	7
Juniperus communis	1	2	0	5	6	0	0	1	0	0	1	0	4	11	1	32
*Larix decidua**	1	6	0	1	3	0	0	6	0	0	5	0	6	10	0	38
Malus sylvestris	0	9	2	2	18	2	1	7	0	2	2	0	21	50	2	118
Picea abies	0	11	0	3	9	0	0	14	0	0	10	0	6	16	1	70
Pinus sylvestris	1	87	0	2	15	2	0	7	0	1	11	0	10	31	5	172
Populus (4 spp.)	3	32	4	10	8	14	1	17	0	2	29	0	33	36	0	189
Prunus spinosa	6	13	0	2	4	7	1	17	0	0	7	0	48	43	5	153
*Quercus ilex**	0	0	0	0	0	0	0	1	0	0	0	0	0	4	0	5
Quercus (2 spp.)	2	67	0	7	38	21	1	15	1	5	17	53	106	83	7	423
*Robinia pseudoacacia**	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	2
Salix (5 spp.)	5	64	5	29	21	22	5	27	0	2	104	0	100	62	4	450
Sorbus aucuparia	2	8	0	3	0	3	1	2	0	0	6	0	2	31	0	58
Taxus baccata	1	0	0	1	0	0	0	0	0	1	0	0	1	2	0	6
Tilia (2 spp.)	4	3	0	5	7	5	0	2	0	0	2	0	15	10	4	57
Ulmus (2 spp.)	7	15	0	4	11	11	1	7	0	3	6	0	33	22	4	124

* Introduced tree species.

4.3.1.7 Usability

Our nutrition supply is almost entirely based on conventionally bred species, i.e. neobiota according to their definition (cf. chapter 4.1 Definitions on page 226). There are great hopes in biotechnology to create new genetically modified species, for instance, for food, medical drugs, and ecological processes (cf. Nader, 2002; Vogel and Potthof, 2003), for example, the latter for waste decompositions. However, there are also severe reservations that the extreme interventions into long-term evolutionary processes by biotechnological methods could be unpredictable harmful to the complexity of values of our nature and landscapes during future evolutionary developments. In addition, neobiota are used as biological material for different purposes, as well as, their ecological benefits in providing natural resources for the human species.

4.3.1.8 Conclusive summary

Neobiota can endanger indigenous species up to extinction in certain cases, for example, due to habitat competition, predation, introduced diseases, and genetic changes, such as hybridizations. However, these impacts are often crucially based on habitat changes by the human species. In addition, there is no known case for Central Europe, when a non-native species has caused the dying out of a native species. On the other hand, neobiota can be considered as rare and endangered themselves, if they are currently established or if they were once.

Naturalization is combined with a process of selection and adaptation to neobiota. It is just a question of time up to geological time spans, until neobiota will be an integrated part of ecosystems like native species. From the historical point of view, neozoa, neophytes, and other neobiota after 1492 are unnatural by definition. However, from the point of view of natural developments at present times, neobiota after 1492 can be considered as being natural, when they have developed themselves at an area for the first time neither by being conventionally bred, nor genetically modified, nor actively introduced, nor passively transported by humans.

Many neobiota have become typical parts of nature and landscapes. Re-establishment abilities of neobiota depend, like for native species, on recolonization possibilities, isolation barriers, and time durations of developments of similar habitats. Furthermore, re-establishment abilities of neobiota are crucially connected with current and future direct and indirect human influences.

Biological invasions by neobiota are especially successful at areas, where similar competitors have not been historically evolved yet, for example, on islands. In general, neobiota are supported by natural or human habitat changes.

Another important factor is the degree of complexity of the host ecosystem, i.e. low-complexity ecosystems seem to be more vulnerable to biological invasions, as well as, those with a simpler ecological structure. Obviously, the vulnerability of ecosystems to invasions by neobiota depends on the availability of free ecological niches and the competitiveness with species of already occupied ecological niches.

Furthermore, the probability of a species to become invasive increases with the initial population size. Successful invasions generally require that the new habitat conditions are comparable to those at the point of origin, especially in terms of climatic conditions. However, biological invasions can be also seen as an evolutionary process of creating new species and species compositions in the long-term.

Empirical experience of neobiota is used in models to estimate the vulnerability of nature and landscapes to genetically modified species. However, processes in nature and landscapes are too complex to be able to predict developments of genetically modified species during new mutations, reproduction, competition, migration, and selection, as well as, changing human influences in the long-term.

Biological invasions can influence various ecological functions of nature and landscapes. On the other hand, neobiota can fulfil similar ecological functions as native species. Furthermore, neobiota can also just fill up ecological niches, either when they arrive before native species can occupy them or will occupy these niches during evolutionary times of adaptation and selection processes, respectively.

Our nutrition supply is almost entirely based on conventionally bred species, i.e. neobiota according to the definition above. There are great hopes in biotechnology to create new genetically modified species, but there are also severe reservations that the extreme interventions into long-term evolutionary processes by biotechnological methods could be unpredictable harmful to the complexity of values of our nature and landscapes during future evolutionary developments.

However, applying criteria alone does not allow statements, if the changes of neobiota on certain elements, structures, and functions of nature and landscapes can be positively or negatively assessed in a weighing up process of the different values to the human being and on their own. They are just expressions of the surveyed and analysed changes by neobiota, but do not imply a (normative) value itself. Therefore, the framework of condensed criteria must be applied according to the different values to evaluate these impacts of neobiota, which will be carried out in the next section.

4.3.2 Values of neobiota based on criteria

The last section has revealed, which severe changes neobiota can have on our elements, structures, and functions of nature and landscapes. Therefore, neobiota are mostly seen as a problem (Körner and Eisel, 2003; cf. Weber, 2003). However, it does not tell us, if these changes are positive or negative to the different values of nature and landscapes to the human being and on their own. The next section shall discuss if this general negative assumption of neobiota can be verified by applying the proposed framework of criteria to the superordinated different values of neobiota of this research.

4.3.2.1 Economic values

Our whole nutrition supply is more or less based on cultivated neophytes and domesticated neozoa. Neobiota have become typical goods for trades and productions on different levels. There are profit hopes in billions of US$ in biotechnology of new agricultural neobiota, medicines, and costs reducing ecological processes.

On the other hand, there are also estimated costs in billions of US$, which have been caused by neobiota for changed ecological functions und reduced human uses of typical and natural parts of nature and landscapes (Table 4.3-8; cf. Schrader, 2002b; Reinhardt et al., 2003).

Table 4.3-8. Examples of estimated economic costs by neobiota (CBD, 2000, modified)

Economic costs caused by certain neobiota		
Neobiota	Economic effects	Costs in US$
Introduced disease organisms	• annual cost to the health of humans, plants, and animals in the USA	• 41 billion per year
A sample of neophytes and neozoa	• economic costs of damages in the USA	• 137 billion per year
Salt Cedar (*Tamarix spp.*)	• value of ecosystems lost in western parts of the USA	• 7-16 billion over 55 years
Knapweed (*Centaurea spp.*) and Leafy spurge (*Euphorbia esula*)	• impact on economy in three US states	• 40.5 million and 89 million per year direct and indirect costs, respectively
Zebra Mussel (*Dreissena polymorpha*)	• damages to US and European industrial plants	• cumulative costs of 750 million to 1 billion between 1988-2000

Most serious invasive alien plant species	• costs of herbicide control in Britain between 1983-92	• 344 million per year for 12 species
Six wild plant species	• costs in Australia's agroecosystems	• 105 million per year
Pines (*Pinus spp.*), Hakeas (*Hakeas spp.*), and Acacias (*Acacia spp.*)	• costs on South African Floral Kingdom to restore to pristine state	• 2 billion
Water Hyacinth (*Eichhornia crassipes*)	• costs in seven African countries	• 20-50 million per year
Rabbits	• costs in Australia	• 373 million per year of agricultural losses
Varroe Mite (*Varroa destructor*)	• economic costs to beekeeping in New Zealand	• 267-602 million

Natural direct and indirect human changes of nature and landscapes can support biological invasions of different economic values. Economic profits are especially vulnerable to neobiota, when there are no sufficient ways found to limit their impacts.

For example, the Lake Victoria in Africa is the largest tropical lake in the world, shared between Kenya, Uganda and Tanzania. Lake Victoria Basin is of great importance to its human population, which was estimated to be around 30 million in 1996, and growing at the rate of 3-4 % annually. The original fish diversity of the lake was very high, including more than 300 species of haplochromine cichlids, 99 % of them endemic. Haplochromines were the most abundant species until the 1980s. While they were too small to be of significance in a fishery, they obviously played a key role in the lake ecosystem and they were of value as a study material for evolutionary processes, such as adaptive radiation[44] (CBD, 2001b). The Nile Perch (*Lates niloticus*) was introduced by the human species into the Lake Victoria to add a profitable new fish species in 1954 (Figure 4.3-2; Geiter et al., 2002; Lowe et al., 2003?).

[44] Development of a sib due to adaptation to ecological conditions (Sedlag et al., 1987).

Figure 4.3-2. The neozoe Nile Perch (*Lates niloticus*), which was introduced at the Lake Victoria in Africa in 1954 (Lowe et al., 2003?) reproduced by kind permission of Jens Bursell (http://www.bursell.dk)

However, the Nile Perch (*Lates niloticus*) reduced severely populations of other harvested fish species by feeding on them, which changed the evolutionary unique biocoenosis of Cichlids (Geiter et al., 2002). Rare endemic fish species became endangered by the Nile Perch at the Lake Victoria and some even died out (CBD, 2000). Many of the native fish feed on algae and benefit from the frequent algal blooms that occur in the lake. A reduction in the number of algae-eating fish, together with progressive eutrophication of the water due to increasing human activity around the lake, increased the frequency of algal blooms and decreased the oxygen levels in deep water. This may have caused further declines in deep-water Cichlids (Pullin, 2002).

The increase in numbers of perch was accompanied by a drastic decrease of fish diversity, the haplochromines declining from 83 % of the biomass to less than 1 %. It is now estimated that about 60 % of the haplochromines have become extinct. The haplochromine fishes were extremely diverse and occupied nearly all the trophic levels including planktivores, herbivores, detritivores, molluscivores, insectivores, and piscivores (CBD, 2001b). In total, the Nile Perch has contributed to the extinction of more than 200 endemic fish species through predation and competition for food (Lowe et al., 2003?). The shrimp *Cardinia nilotica* has substituted the Cichlids as a food resource. In addition, the Nile Perch feeds to 30 % on the mosquito larvae of the *Chaoborus spp.* (WBGU, 1999a).

Moreover, the flesh of the Nile Perch is oilier than that of the local fish, so more trees were felled to fuel fires to dry the catch. The subsequent erosion and run-off contributed to increased nutrient levels, opening the lake up to invasions by algae and the Water Hyacinth (*Eichhornia crassipes*). The Water Hyacinth is a very fast growing plant with populations known to double in as little as 12 days (Figure 4.3-3; Lowe et al., 2003?).

Figure 4.3-3. The neophyte Water Hyacinth (*Eichhornia crassipes*) at the Lake Victoria in Africa (Lowe et al., 2003?) reproduced by kind permission of Aquarius Systems, USA

These invasions in turn led to oxygen depletion in the lake, which resulted in the death of more fish. Commercial exploitation of the Nile Perch has displaced local men and women from their traditional fishing and processing work. The far-reaching impacts of this introduction have been devastating for nature and landscapes, as well as, for communities that depend on the lake (Lowe et al., 2003?).

Moreover, native species, which can hybridize with neobiota, are more vulnerable to outbreeding depression and genetic drift than others, which can lead to economic costs of used species due to lower fitness in the environment or lower use qualities. Furthermore, neobiota can cause serious economic health costs as diseases. For example, the rinderpest, a viral disease, was introduced into Africa in the 1890s via infected cattle. It subsequently spread into both domesticated and wild herds of bovids throughout the savannah regions of Africa, changing the mammalian composition of much of the continent. Up to 25 % of the cattle-dependent pastoralists may have starved to death in the early 20th century, because rinderpest wiped out their cattle populations (CBD, 2000).

When we consider, that genetically modified organisms have undergone even much faster evolutionary changes than neobiota that come from other nature regions or even continents, and that they can hybridize with native species, it is rather questionable, if economic benefits of genetically modified neobiota can make up for the incalculable economic risks for the society connected with them. On company interest's level however, it might be a very profitable investment, if the public has to face the global economic costs of the changing influences on the public good nature and landscapes.

For example, one common modification to crops is to insert a gene taken from the bacterium *Bacillus thuringiensis* that enables the plant to produce a substance toxic to insect herbivores that damage the crop. This has enabled farmers to reduce the amount of pesticides applied to cotton in the USA by around one million kilograms in 1999 compared with the previous year. However, the potential problem is that this toxin is effective against many different insects. A recent study showed that the toxin is expressed in the pollen of genetically modified maize and reduces survival of the Monarch butterfly (*Danaus plexippus*) when larvae feed on its milkweed food plant that has pollen from the maize on its surface. Pollen from genetically modified crops could travel large distances and therefore be toxic to insects far removed from the targets (Pullin, 2002).

Conventional methods to create neobiota however are necessary, including incrossing of non-native species, to reduce economic costs for our human food supply, medical drugs, and ecological processes. It is just the difference that economic risks are sufficiently calculable in comparison to genetic modifications of species.

For production cycles, additional costs by neobiota can only be compensated by higher prices, if there are no cheaper economic competitors of the same product quality on the market. The re-establishment ability of economic profits depends on how successful former conditions can redevelop, to which extend alternative uses are possible, or other incomes can be found. However, neobiota can become a rare and endangered economic good itself, if they are overharvested or other reasons have lead to a non-profitable decrease of their (meta-)populations.

4.3.2.2 Ethical values

When we consider the holistic approach to respect that each organism on earth makes an effort to survive and we also take into account that non-living parts of nature and landscapes have a value on their own, we need to protect rare and endangered biodiversity and non-living parts nature and landscapes on each level against biological invasions. On the other hand, we need to allow natural and human influenced developments of new biodiversity and non-living components of nature and landscapes, including creative and innovative developments of new cultural heritage in the future.

Practically, it is impossible to estimate in detail current and future impacts of neobiota (cf. CBD, 1999). It is just possible to monitor their effects on nature and landscapes (Kinzelbach et al., 2003) and to model Neobiotic Risk and Benefit Analysis (NRBA) by using methods of PVAs, MVMs, and Exotic Species Models for each neobiotic species. There has been a specific risk analysis established according to the International Plant Protection Convention (IPPC) (cf. Unger, 2002; Schrader, 2002b, 2003).

However, in one case the human species radically intervenes in evolutionary processes by genetically modifying species to neobiota at incalculable risks, which would naturally take thousands of years. When we consider the poor successes of efforts to eradicate other neobiota in the wild in the past, then re-establishment abilities are rather unlikely of former conditions of nature and landscapes after genetically modified organisms have been released or exposed. The risks of genetically modified organisms cannot be accepted by any of the ethical approaches. Therefore, biotechnology should be reduced to laboratory modifications of species for urgent medical demands under high controls to prevent exposures to nature and landscapes.

A compromise between the contradictory moral attitudes of preserving nature and landscapes and allowing new developments could be to allow natural appearances of neobiota to an extend on practical level, that passive introductions and own immigrations or developments are generally permitted, but active releases of new species should be prohibited. This is currently already the case according to § 41 paragraph 2 of the Germany's Federal Nature Conservation Act (Bundesministerium der Justiz, 2002). However, several international regulations theoretically attempt to prevent also unintentional introductions of neobiota (WBGU, 1999a; CBD, 2001d), but have significant problems in practical implementations (CBD, 2001d). Moreover, there are international and national phytosanitary regulations within the European Union to limit and to monitor introductions of neobiota that can affect commercial uses in agriculture and forestry (cf. Billen, 2003; Feldmann, 2003; Gärtig and Kehlenbeck, 2003; Maixner and Holz, 2003; Pfeilstetter, 2003; Schorn, 2003; Schliephake and Thieme, 2003).

On the other hand, measures are taken to eradicate neobiota, but with rather low success (cf. Sukopp and Sukopp, 1994; CBD, 2001c; Wittenberg and Cock, 2001; Schepker and Kowarik, 2002). While large mammals can be reduced in numbers and even exterminated on small islands or in restricted areas, smaller animals and neophytes are almost impossible to be eradicated in any situation (CBD, 1999). For instance, the Canadian Waterweed (*Elodea canadensis*), the Musquash (*Ondatra zibethica*), and the Raccoon (*Procyon lotor*) have been systematically combated or hunted with high efforts and little success in Germany (Kowarik, 2003; for the Musquash Lauenstein, 2003; for the Raccoon Stier et al., 2003). Apparently, when neobiota have reached a certain disposal range, it seems generally to be impossible to take them out again of ecosystems.

Furthermore, costs for combating measures are often out of relation to achieved successes or hopes on them. For instance, more than 10,000 Euro have been invested for the fighting against the Black Cherry (*Prunus serotina*) on 750 ha forests at former Western Berlin since 1980, while it cannot be prevented that new individuals invade again from adjacent forests and roads. Therefore, this eradication effort has more a character of a permanent management scheme (Kowarik, 2003). The Black Cherry (*Prunus serotina*) was also combated mechanically, chemically, and biologically in the Netherlands for decades without significant success. Moreover, the use of chemicals against it has even caused damages of the soil fauna in the Netherlands (Sukopp and Sukopp, 1994). Therefore, attempts to eradicate neobiota are often a waste of money and personal resources, which could be spent on other urgently needed measures for nature conservation for ethical and other reasons. Furthermore, they can be a deterioration of nature and landscapes themselves.

For example, there have been efforts to cut down the early-introduced neophyte Sycamore (*Acer pseudoplatanus*), which has become a typical species at naturally grown secondary woodlands in the UK, despite evidence of ecological functions for other insects and in the food-chain. There are severe damages accepted of the natural structure and its depending species of these woodland ecosystems, apart from losses of other ecological functions of Sycamore trees for the public. For instance, Sycamore individuals reduce wind speed and noise, produce oxygen, deposit dust, and achieve climatic benefits (cf. Zisenis, 1993, 1996).

Moreover, in both exemplary cases of the Black Cherry (*Prunus serotina*) in Germany and the Sycamore (*Acer pseudoplatanus*) in the UK, these primarily dominant species become suppressed by other more competitive tree species during natural succession (cf. Kowarik, 2003 for the Black Cherry, and Gilbert, 1991 for the Sycamore, respectively). Therefore, it might be only reasonable from the ethical point of view in certain cases to restrict biological invasions by neobiota at particular areas for preferring other features, for example, to protect rare and endangered species at nature reserves. Those nature reserves are then kept like open museums in the traditional conserving approach of nature conservation.

However, some companion neobiota of fields have already become rare and endangered themselves during intensification of agriculture in Central Europe (cf. Blab, 1993; Korneck et al., 1998; Kowarik, 2003). Therefore, further decreases of these neobiota would be against the ethical approach to protect these typical species from extinction. In addition, their ecological functions are also part of their ethical value considering the whole ecosystem, as well as, each individual. Re-establishment abilities of neobiota themselves depend on similar conditions like for native species, but also on direct and indirect supporting human influences to allow similar biological invasions.

Furthermore, attacks against particular organisms of neobiota are cruel from the individual point of view and should be stopped, when they cannot prevent other more severe deteriorations of more important values of nature and landscapes in the long-term, including the non-living heritage. This refers especially to vertebrates, which can suffer similar pain to the human species due to their similar nerve system. All alternative measures to attacks must be proved from the ethical point of view. In addition, impacts of measures against neobiota on the rest of nature and landscapes need to be carefully assessed. The poor successes of measures against neobiota have empirically proved, how unlikely it is to provide re-establishment conditions of the former situation of nature and landscapes.

For instance, the regulating influences of hunters of the Musquash (*Ondatra zibethica*) are rather questionable, taking into account that one not killed Musquash pair reproduces about 25 offspring per year on average and annual hunting of 25,000 individuals have not been enough to eliminate this species in the Federal State of Germany Baden-Württemberg (cf. Diemer, 1996).

4.3.2.3 Psychological values

Neobiota can enhance or reduce the aesthetic quality of our nature and landscapes. Many neophytes are used for their flowering beauty in parks and gardens, for instance, Rhododendron (*Rhododendron ponticum*) in Great Britain (cf. Rose, 1981; Gilbert, 1991). They have become a typical part of parks and gardens for recreational and inspiring reasons. However, there are also neophytes, which can reduce the recreational value of nature and landscapes, for example, the Giant Hogweed (*Heracleum mantegazzianum*). Its sap contains Furanocumarines, which can cause heavy burnings and blistering under the influence of sunrays, when it is touched (cf. Bundesregierung, 2001?; European Commission, 2002b; Kowarik, 2003).

In general, neobiota can be assessed as a danger or alternatively as a contribution to nature and landscapes by the public (cognitive level of perception), depending on personal education and public consciousness. Many ruderal plant species are neophytes on unmanaged grounds that can be seen as wastelands or enjoyed due to its naturalness and typicalness of wild flowering plants, respectively (sensory, as well as, cognitive level). Furthermore, the unmanaged wildness of neophytes can be assessed as an expression of freedom and self-realization (symbolic level).

Ecological functions of neobiota are important, if they can be positively related to other parts of nature and landscapes for the psychological benefit of the human species, either physically or mentally, directly or indirectly, including other species. For example, the Five-leaved Ivy (*Parthenocissus quinquefolia agg.*) changes beautifully its colour from green to red in autumn, but provides also nesting and resting habitats for native bird species during spring and summer times. The latter ecological function contributes indirectly to psychological relaxation and inspiration opportunities of the human species in nature and landscapes. In addition, wall greening of the Five-leaved Ivy (*Parthenocissus quinquefolia agg.*) results in a better climatic feeling by reducing sultriness, providing oxygen, and buffering dust and noise (cf. Köhler and Schmidt, 1997).

In addition, certain rare and endangered neobiota and their features might be of higher psychological value than others due to their subjective sensory, cognitive, or symbolic perception by the human species. Moreover, the usability of neobiota for psychological benefits depends also on access and flexibility to different user demands. For example, the Broad-leaved Everlasting-pea (*Lathyrus latifolius*) flowers beautifully, but its climbing behaviour is also typically used for decorations at pergolas or other places in gardens (cf. Markstein et. al, 1985). Re-establishment abilities of psychological values again depend on natural and human redevelopment conditions, or alternative resources.

Furthermore, psychological values of neobiota are vulnerable to other disturbing influences either human or natural, and the right moments and places to get in touch with them. For example, there are contemplative moments necessary to able to perceive neobiota in more detail, but these can be difficult to find, if other influences are overlapping, or neobiota or their features are rare and endangered. PVAs, MVMs, and Exotic Species Models can be used to project the survival of neobiota, but it depends especially on the right moments and places in life to benefit of the beauty and peculiarity of neobiota, for example, when they are visible, or flowering, or active in a different way, and there is no disturbing noise, time pressure, or other influences, which may reduce the psychological values. Therefore, it depends very much also on our own attitude, but also on our own creativity to get in touch with neobiota in a benefiting psychological way.

4.3.2.4 Culture-historical values

Neobiota are closely connected to our culture-historical development. They can be typically found at urban areas, where human influences have created a variety of habitats (Sukopp, 1990; Gilbert, 1991; Wittig, 1991, 2002; Blab, 1993; Klausnitzer, 1993; Kowarik, 1998b; Sukopp and Wittig, 1998; WBGU, 1999a). Nevertheless, they are also typical culture-historical followers of agricultural harvests at the countryside (cf. Blab, 1993; Kowarik, 2003). Unnaturally domesticated and planted neobiota, respectively, are part of our culture-historical heritage and identity (Bremond, 2002). This concerns also cultivated plants at allotments (cf. Gladis, 2003), for example, of human immigrants (cf. Gladis and Hammer, 2002). Moreover, neobiota are culture-historically of great use for our supply of resources and for fulfilling ecological functions. Neobiota can be considered culture-historically of natural origin, when they have immigrated and dispersed themselves at these habitats of different hemeroby classes, or when they have developed out of those species.

However, many neobiota have become rare and endangered during culture-historical changes of land uses in cities and at the countryside. These changes in Central Europe are often not of equal value to benefits of higher food production or living qualities on concreted grounds. Therefore, we need also for culture-historical reasons to integrate neobiota, as well as, native species better in our land uses.

Furthermore, neobiota are part of our culture-historical heritage of gardening, for example, at allotments, parks, public squares, and cemeteries. Neobiota are parts of garden monuments that have been culture-historically used, for instance, for the outdoor design of their adjacent buildings (cf. Kowarik, 1998a). Re-establishment of culture-historically important neobiota is of similar difficulty to native species, depending on development conditions and human support. Moreover, in certain cases there might be neither the human skill nor financial resources nor culture-historical documents available any more to reconstruct garden monuments by using typical neobiota.

Also culture-historically important neobiotic species are vulnerable, when they occur just above their MVMs. Generalists of them are generally less vulnerable to habitat changes than specialists. Neobiota on the top of food-chains and mutualists are more vulnerable to habitat fragmentations. Low dispersal abilities contribute also to the vulnerability of culture-historically important neobiota.

4.3.2.5 Social values

Neobiota contribute as typical and natural parts to social meeting points, for example, at parks, gardens, or at the countryside. The quality of our nature and landscapes and thereby the quality and quantity of our social contacts depends also on the ecological functions of neobiota either by directly benefiting or indirectly by communicating about them. For example, neobiota are used as presents, and kept as domestic species for social contacts. All criteria of evaluations can contribute to the social value of particular neobiota by enhancing or reducing, respectively, the social position or communication abilities of the user. Furthermore, personal communications with neobiota can function as substitutes of social human contacts.

However, our personal attitude towards neobiota depends highly on social norms and values. Typically and naturally living neobiota at unmanaged grounds might be critically seen by certain people, whereas other assess them as positive parts of nature and landscapes. It is a question of education, research, personal experience, and public relations to change the public attitude towards a more precise evaluation of neobiota. Re-establishment abilities of socially important neobiota depend on quantitative and qualitative resources and possible alternative meeting points or other social features, but also on particular re-establishment conditions of each neobiota.

Furthermore, social functions of neobiota become as more vulnerable as more they are limited quantitatively to serve as meeting points or other uses for certain amounts of people depending on them, and qualitatively if neobiota or their characteristics become too rare and endangered to fulfil the necessary quality requirements of nature and landscapes for social contacts. As better there is possible access and use of neobiota, as higher can be the social benefits of them, also depending on the price.

4.3.2.6 Educational values

The use of neobiota as an educational resource depends on their availability, i.e. rarity and endangerment, as well as, on their ecological functions to explain and to demonstrate them to specific target groups of people for education. As more vulnerable neobiota and their habitats are, as more it is difficult to teach them in direct contacts on the ground. Moreover, the use of neobiota for educational purposes is also determined by access and perception ability of all senses.

Neobiota are typical examples to teach changes of ecological functions by them and to allow own experience, respectively, depending on their degree of naturalization and the influences of human beings (hemeroby). For example, natural ruderal areas of typical neobiota can function as playgrounds for children and as important free places of own experience for their individual educational developments.

The rarity and endangerment of characteristic features of each neobiota and its educationally important features depend also on alternative resources of educational objects, as well as, the re-establishment ability on their complexity. However, there are also the scientific knowledge and didactic skills itself, which determine the educational values of neobiota.

4.3.2.7 Scientific values

Typical neobiota can be systematically classified regarding specific features of them and conditions of their development. The naturalness and the degree of human impacts on neobiota provide research fields themselves. Rarity and endangerment of neobiota is combined with these human influences, as well as, the ability to naturalize within and to compete with native species also in reproduction and dispersal. Scientific research can reveal the ecological functions of neobiota.

Furthermore, neobiota are used to develop scientific models of the ecological functions or impacts, respectively, of genetically modified organisms and the vulnerability of nature and landscapes to them. Neobiota serve as research objects and resources to develop new species for human uses. Moreover, scientific research intends to improve growing and harvesting techniques of neobiota as cultivated plants and domesticated animals.

Re-establishment abilities of neobiota for scientific values depend on particular scientific questions and available alternative research objects. For example, if there is a long-term orientated monitoring scheme necessary for scientific questions of the succession of neobiota at specific areas, it might be only possible to find comparable research grounds, but not of the same conditions, e.g. the same species composition, any more.

4.3.2.8 Conclusive summary

Our whole nutrition supply is more or less based on cultivated neophytes and domesticated neozoa. Neobiota have become typical goods for trades and productions on different levels. There are profit hopes in billions of US$ in biotechnology for new agricultural neobiota, medicines, and costs reducing ecological processes. On the other hand, there are also estimated costs in billions of US$, which have been caused by neobiota for changed ecological functions und reduced human uses of typical and natural parts of nature and landscapes.

Moreover, native species, which can hybridize with neobiota, are more vulnerable to outbreeding depression and genetic drift than others, which can lead to economic costs of used species due to lower fitness in the environment or lower use qualities. Furthermore, neobiota can cause serious economic health costs as diseases.

For production cycles, additional costs by neobiota can only be compensated by higher prices, if there are no cheaper economic competitors of the same product quality on the market. The re-establishment ability of economic profits depends on how successful former conditions can redevelop, to which extend alternative uses are possible, or other incomes can be found. However, neobiota can become rare and endangered economic goods itself, if they are overharvested or other reasons have lead to a non-profitable decrease of their (meta-)populations.

When we consider the holistic approach to respect that each organism on earth makes an effort to survive and we also take into account that non-living parts of nature and landscapes have a value on their own, we need to protect rare and endangered biodiversity and non-living parts nature and landscapes on each level against biological invasions. On the other hand, we need to allow natural and human influenced developments of new biodiversity and non-living components of nature and landscapes, including creative and innovative developments of new cultural heritage in the future.

However, in one case the human species radically intervenes in evolutionary processes, which would naturally take thousands of years, by genetically modifying species to neobiota at incalculable risks. When we consider the poor successes of efforts to eradicate other neobiota in the wild in the past, then re-establishment abilities are rather unlikely of former conditions of nature and landscapes after genetically modified organisms have been released or exposed. The risks of genetically modified organisms cannot be accepted by any of the ethical approaches. Therefore, biotechnology should be reduced to laboratory modifications of species for urgent medical demands under high controls to prevent exposures to nature and landscapes.

In addition, a compromise between the contradictory moral attitudes of preserving nature and landscapes and allowing new developments could be to allow natural appearances of neobiota to an extend on practical level, that passive introductions and own immigrations or developments are generally permitted, but active releases of new species should be prohibited. On the other hand, measures are taken to eradicate neobiota, but with rather low success. Furthermore, costs for combating measures are often out of relation to achieved successes or hopes on them.

Moreover, primarily dominant neobiota species can become suppressed by other more competitive species during natural succession. Therefore, it might be only reasonable from the ethical point of view in certain cases to restrict biological invasions of neobiota at particular areas for preferring other features, for example, to protect rare and endangered species at nature reserves. Those nature reserves are then kept like open museums in the traditional conserving approach of nature conservation.

However, some companion neobiota of fields have already become rare and endangered themselves during intensification of agriculture in Central Europe. Therefore, further decreases of these neobiota would be against the ethical approach to protect these typical species from extinction. In addition, their ecological functions are also part of their ethical value considering the whole ecosystem and each individual. Re-establishment abilities of neobiota themselves depend on similar conditions like for native species, but also on direct and indirect supporting human influences to allow similar biological invasions. Furthermore, attacks against particular organisms of neobiota are cruel from the individual point of view and should be stopped, when they cannot prevent other more severe deteriorations of more important values of nature and landscapes in the long-term, including the non-living heritage.

Neobiota can enhance or reduce the aesthetic quality of our nature and landscapes. Many neophytes are used for their flowering beauty in parks and gardens. They have become a typical part of parks and gardens for recreational and inspiring reasons. However, there are also neophytes, which can reduce the recreational value of nature and landscapes.

In general, neobiota can be assessed as a danger or alternatively as a contribution to nature and landscapes by the public (cognitive level of perception), depending on personal education and public consciousness. Ecological functions of neobiota are important, if they can be positively related to other parts of nature and landscapes for the psychological benefit of the human species, either physically or mentally, directly or indirectly, including other species.

In addition, certain rare and endangered neobiota and their features might be of higher psychological value than others due to their subjective sensory, cognitive, or symbolic perception by the human species. Moreover, the usability of neobiota for psychological benefits depends also on access and flexibility to different user demands. Furthermore, psychological values of neobiota are vulnerable to other disturbing influences either human or natural, and the right moments and places to get in touch with them.

Neobiota are closely connected to our culture-historical development. They can be typically found at urban areas, where human influences have created a variety of habitats. Nevertheless, they are also typical culture-historical followers of agricultural harvests at the countryside. Unnaturally domesticated and planted neobiota, respectively, are part of our culture-historical heritage and identity. Moreover, neobiota are culture-historically of great use for our supply of resources and for fulfilling ecological functions.

However, many neobiota have become rare and endangered during culture-historical changes of land uses in cities and at the countryside. Furthermore, neobiota are part of our culture-historical heritage of gardening. Re-establishment of culture-historically important neobiota is of similar difficulty to native species, depending on development conditions and human support. Moreover, in certain cases there might be neither the human skill nor financial resources nor culture-historical documents available any more to reconstruct garden monuments by using typical neobiota.

Neobiota contribute as typical and natural parts to social meeting points. The quality of our nature and landscapes and thereby the quality and quantity of our social contacts depends also on the ecological functions of neobiota either by directly benefiting or indirectly by communicating about them. All criteria of evaluations can contribute to the social value of particular neobiota by enhancing or reducing, respectively, the social position or communication abilities of the user.

However, our personal attitude towards typically and naturally living neobiota depends highly on social norms and values. It is a question of education, research, personal experience, and public relations to change the public attitude towards a more precise evaluation of neobiota. Re-establishment abilities of socially important neobiota depend on quantitative and qualitative resources and possible alternative meeting points or other social features, but also on particular re-establishment conditions of each neobiota.

Furthermore, social functions of neobiota become as more vulnerable as more they are limited quantitatively to serve as meeting points or other uses for certain amounts of people depending on them, and qualitatively if neobiota or their characteristics become too rare and endangered to fulfil the necessary quality of nature and landscapes for social contacts.

The use of neobiota as an educational resource depends on their availability, i.e. rarity and endangerment, as well as, on their ecological functions to explain and to demonstrate them to specific target groups of people for education. As more vulnerable neobiota and their habitats are, as more it is difficult to teach them in direct contacts on the ground. Moreover, the use of neobiota for educational purposes is also determined by access and perception ability of all senses.

Neobiota are typical examples to teach changes of ecological functions by them and to allow own experience, respectively, depending on their degree of naturalization and the influences of human beings (hemeroby). The rarity and endangerment of characteristic features of each neobiota and its educationally important features depends also on alternative resources of educational objects, as well as, the re-establishment ability on their complexity.

Typical neobiota can be systematically classified regarding specific features of them and conditions of their development. The naturalness and the degree of human impacts (hemeroby) on neobiota provide research fields themselves. Rarity and endangerment of neobiota is combined with these human influences, as well as, the ability to naturalize within and to compete with native species also in reproduction and dispersal. Scientific research can reveal the ecological functions of neobiota.

Furthermore, neobiota are used to develop scientific models of the ecological functions or impacts, respectively, of genetically modified organisms and the vulnerability of nature and landscapes to them. Neobiota serve as research objects and resources to develop new species for human uses. Re-establishment abilities of neobiota for scientific values depend on particular scientific questions and available alternative research objects.

The last two sections have revealed that there can be several complex advantages and disadvantages of neobiota for the human species and the value of nature and landscapes on their own, depending on the particular neobiota evaluation case within a certain spatial area and time period. Therefore, the changes of elements, structures, and functions of nature and landscapes by neobiota can neither be valued negatively nor positively on general level. Evaluations of neobiota are too short orientated, which are not combined with information about negative and positive effects of species at particular cases (Kowarik, 2003). Each case of neobiota requires particular risks (cf. Bundesregierung, 2001?) and benefits assessments for a certain area and period.

There is still a huge research deficit of methods for risk analysis of neobiota and their influencing factors, as well as, to investigate relevant criteria for evaluations of their characteristics (Unger and Schrader, 2003). Nevertheless, this research shall provide, *inter alia*, a flexible, transparent, and universal applicable framework of condensed criteria and comprehensive values for interdisciplinary evaluations of nature and landscapes, which has been already successfully applied on a general level of neobiota. The next section shall prove if this interdisciplinary evaluation framework works also for a practical evaluation example of neobiota.

4.3.3 Practical example of the London Plane-tree (*Platanus x hybrida*)

Evaluations of neobiota cannot be generalized. It depends on the particular neobiota case at a specific surrounding and time-scale, which values can be determined in application of the mentioned criteria of the interdisciplinary evaluation framework. Therefore, this section shall focus on a practical evaluation case of a widespread neophyte in Central Europe at current times.

The London Plane-tree (*Platanus x hybrida = P. x acerifolia = P. x hispanica*)[45] is an example of a neophyte, which probably arose in Southern Europe around 1650 and was firstly planted in England about 1750. It is also widespread at the continent. It has a characteristic crown; the branches are somewhat tortuous and the perimeter is intricately branched giving a surprisingly delicate winter silhouette (Gilbert, 1991). Culture-historically, it has been widely used for plantings for promenades along avenues and at parks at cities in Central Europe, because of its low vulnerability to salt (the contrary of being unusually sensitive to de-icing salt cf. Gilbert, 1991), dust, and dry air (cf. Markstein et al., 1985), as well as, high beauty for landscape scenery (Figure 4.3-4).

Figure 4.3-4. The London Plane-tree (*Platanus x hybrida*) at Kaiser-Wilhelm-Platz in Berlin, Germany, during early 2004

Its low vulnerability includes also insufficient water supply and wounding of the trunk. Moreover, the London Plane-tree is deep-rooted, and therefore also less vulnerable to soil compressions. On the other hand, the London Plane-tree grows rapidly, has a stable trunk and reaches a high age. These advantages reduce costs as an economic value. Therefore, the London Plane-tree is neither rare nor endangered at many cities on central European level (cf. Markstein et

[45] The London Plane-tree (*Platanus x hybrida = x acerifolia = x hispanica*) is a hybrid of the American Sycamore (*Platanus occidentalis*) from Northern America and the Oriental Plane-tree (*Platanus orientalis*) from Eastern Mediterranean regions (Kowarik et al., 1987; Rothmaler et al., 1988).

al., 1985). However, it is vulnerable to shadow and to narrow standing positions, which influence also the characteristic wide crown (Kowarik et al., 1987). Re-establishment of planted London Plane-trees takes a certain period of time to reach the same size and to achieve similar functions for the mentioned values, depending on development conditions and resources.

Furthermore, its use for pleasure and decoration are the basis for important psychological values. It is a typical recreational part of high ecological functions within urban landscapes in Central Europe. The London Plane-tree contributes to the greatness of urban architecture. It can typically symbolize the beauty and power of urban trees depending on open spaces between surrounding buildings. Thereby, it enhances the living and working quality of adjacent real estates as an economic and psychological value, respectively.

Moreover, the London Plane-tree has an ethical value to improve favourable living conditions for human inhabitants, as well as, plants, animals, and other organisms on species and individual levels of surrounding areas. Ecological functions of the London Plane-tree provide shadow, oxygen, and reduce dust and noise for neighbouring real estates in contributing to public health. However in early summer, it sheds clouds of downy hairs to which certain people are allergic (Gilbert, 1991), which thereby can reduce also the economical value by decreased working ability and life quality.

Furthermore from the ethical point of view, the London Plane-tree has a low ecological function as a habitat for bird species. Only 10 nests of mostly the Magpie (*Pica pica*) could be found at 1134 London Plane-trees at the neighbourhood "Märkisches Viertel" of Berlin (Kowarik et al., 1987). Nevertheless, the Goldfinsh (*Carduelis carduelis*) uses the seeds as nutrition (Kowarik, 2003).

Moreover, there are a lot of insect species overwintering below the bark of the London Plane-tree, which gets off in more or less big pieces (Table 4.3-9; Klausnitzer, 1993). Unfortunately, again the latter research does not tell us, if these insect species are rare or endangered, or if they are stenotic or euryotic, or which ecological functions they have, for instance, within the food-chain. However, the London Plane-tree supports a comparable number of habitats for insect species in relation to other native tree species (cf. Table 4.3-7 on page 258). Further research is necessary to be able to assess this aspect more accurately.

Table 4.3-9. Number of bug species (*Heteroptera*) and beetle species (*Coleoptera*) overwintering below the bark of the London Plane-tree (*Platanus x hybrida*) at selected cities in Germany (Klausnitzer, 1993, modified)

Selected insect groups found below the bark of the London Plane-tree (*Platanus x hybrida*) in winter

Species	Bautzen	Berlin	Dresden	Leipzig	Totals:
Deraecoris lutescens	28	135	58	117	338
Anthocoridae	26	42	38	37	134
Other bugs (*Heteroptera*)	16	2	6	7	31
Ladybirds (*Coccinellidae*)	18	14	15	8	55
Other beetles (*Coleoptera*)	6	17	5	11	39
Totals:	94	210	122	180	606

In addition, the Mediterranean butterfly *Phyllonorycter platani* lives as a leaf-miner on the London Plane-tree, but does not seriously affect the health of it; in contrast to the two fungi species, the *Gnomonia platani* as the main fruit form, and the *Gloesporium platani* as the secondary fruit form, respectively, which cause anthracnose. There is also the fungus *Ceratocystis fimbriata*, which probably comes from North America and causes tracheomycose on the London Plane-tree. Moreover, the Sycamore Lace Bug (*Corythuca ciliata*) from North America affects the leaves and can cause completely drying out of them at full befall (Figure 4.3-5; Kowarik et al., 1987).

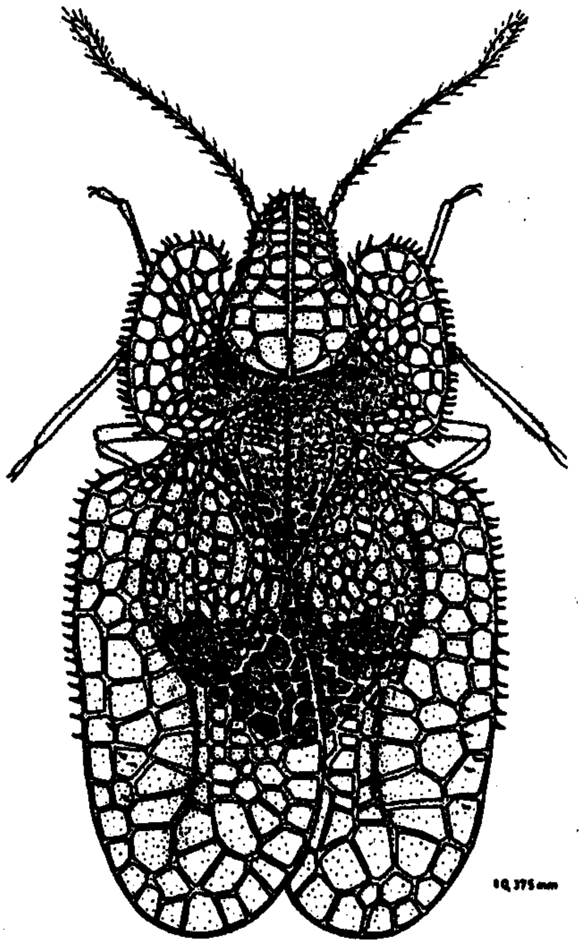

Figure 4.3-5. The Sycamore Lace Bug (*Corythuca ciliata*), which lives on the London Plane-tree (*Platanus x hybrida*) (Kowarik et al., 1987)

In addition, the London Plane-tree serves as a habitat for bacteria species (Table 4.3-10).

Table 4.3-10. Bacteria and fungi species found on the London Plane-tree (*Platanus x hybrida*) (Kowarik et al., 1987, modified)

Bacteria and fungi species, respectively, which use the London Plane-tree (*Platanus x hybrida*) as habitats

Bacteria	Effects on the London Plane-tree
Pseudomonas saliciperda	• vessel changes
Agrobacterium tumefaciens	• tumors
Fungi	
Gnomonia platani	• anthracnose

Ceratocystis fimbriata	• tracheomycose
Polystictus versicolor	• decomposing of woody parts
Microsphaera aini	• mildew
Stigmina platani	• leaf changes
Phytophtora cinnamoni	• root decomposition

These species might be of favourable ethical values as being rare and endangered in Central Europe, but negatively assessed due to its deteriorating impacts on psychological, and economical values of the London Plane-tree, respectively. However, they can be considered as typical and natural examples as teaching and research objects for educational and scientific values, respectively.

Moreover, the London Plane-tree attracts people for social contacts due to its ecological functions and individual beauty for landscape scenery. In addition, the London Plane-tree is a scientific research object, for example, to discover to which extend it fits in the ecological system of other flora and fauna as a neophyte. Furthermore, it can serve as an educational object, for instance, for school classes of different aspects of trees, and for universities as a typical tree species of parks and avenues in Central Europe. The wide occurrence and good access to the London Plane-tree enhance its educational and scientific values.

Re-establishment abilities of the London Plane-tree are basically good, because planting material is relatively easy and cheap available. Planting and growing skills, as well as, knowledge are well developed. However, growing up to a certain size takes a long time, which depends, *inter alia*, on the planting material and on the particular growth conditions at a certain location during a particular period. An empirical study on London Plane-trees has revealed a non-linear growth curve of a maximum reachable height of 33 m, which was calculated based on the relation of age to height of 166 individuals at former Western Berlin (Kowarik et al., 1987; Figure 4.3-6). There is a relatively fast growing period at the beginning of doubling the size between 5 and 10 years, but it decreases during the years. Moreover, it depends, *inter alia*, on isolation distances, and dispersal ranges of the mentioned insects to be able to recolonize the London Plane-tree for re-establishing similar species compositions.

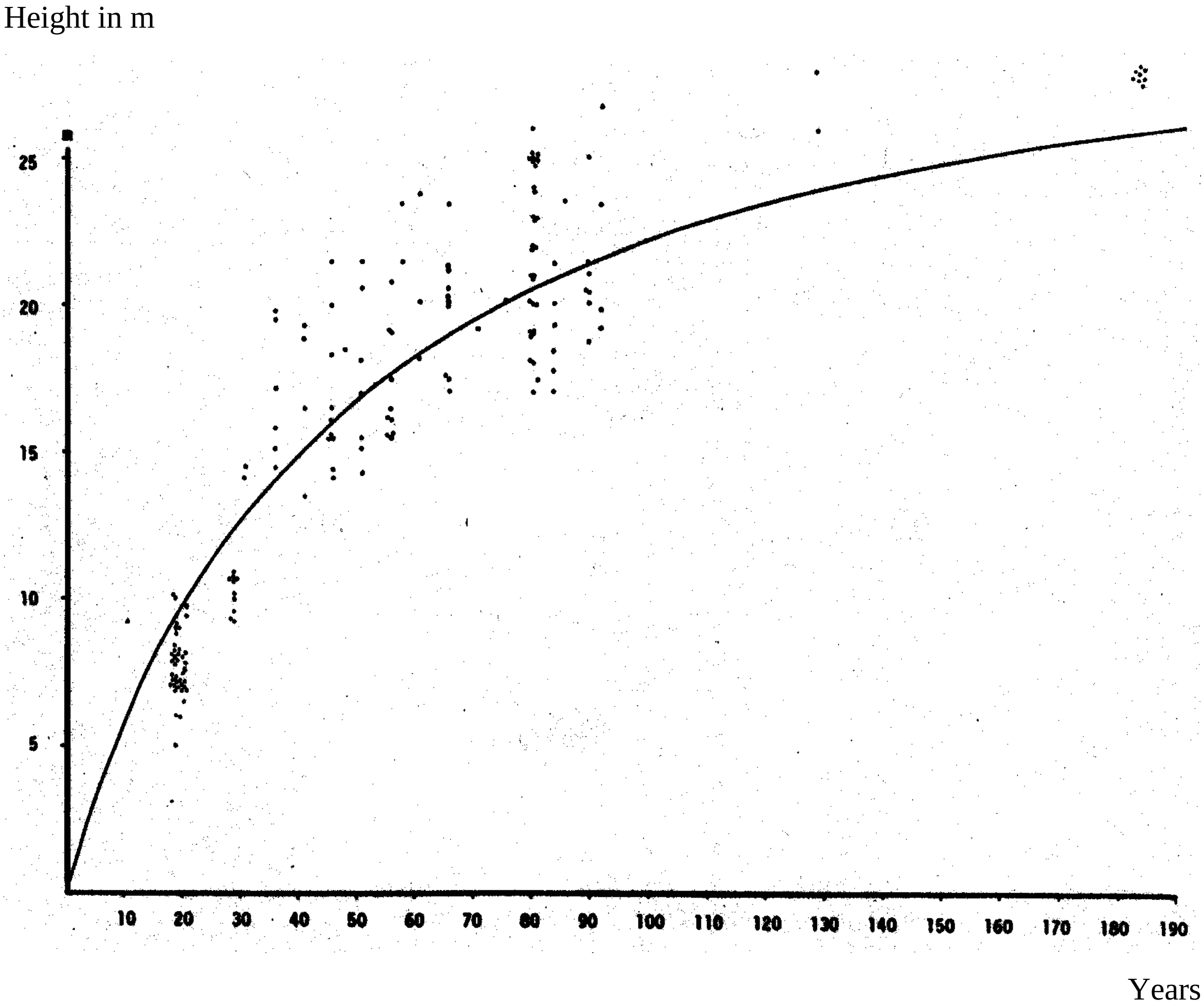

Figure 4.3-6. Non-linear growth curve of the London Plane-tree (*Platanus x hybrida*) based on the relation of age to height of an empirical study of 166 individuals at former Western Berlin, Germany (Kowarik et al., 1987)

Therefore, cutting down of old London Plane-trees cannot be substituted by new plantings for the time being, which need time to regrow to a certain height. Moreover, natural reproduction is rare in Central Europe and limited to few habitats: artificially stabilized embankments of rivers and canals, and particular urban habitats (Kowarik et al., 1987).

Furthermore, practical evaluations of nature and landscapes depend on specific priorities of values, which need to be weighed up against each other. For example, plantings of the London Plane-tree should be preferred along avenues or at parks, if the economic value to select a less vulnerable species weighs more than the ethical value to plant a native tree species. A certain native tree species might support more endangered and rare species.

However in particular cases, the culture-historical value can demand a more typical tree species at a specific place, or the psychological value a tree species of higher ecological functions. The use for social values could be higher of a different tree species, which attracts more people to come together for discussions due to its rarity and endangerment. Moreover, it might be necessary to unnaturally plant these tree species for educational purposes, but re-establishment by natural succession could be needed for a scientific project.

Therefore, there needs to be more research and information on particular cases for more accurate evaluations of the London Plane-tree on type and object levels, respectively.

4.4 Conclusions

The theoretical assessment of neobiota in general and the practical evaluation of the neophyte London Plane-tree (*Platanus x hybrida*) in particular have revealed that neobiota have several positive and negative impacts on the different values of nature and landscapes to the human species and on their own. However, even the practical example of the London Plane-tree (*Platanus x hybrida*) does not allow statements of its different values in more detail, because it is not related to a specific location and time-scale. Furthermore, it is not possible to integrate the public into the evaluation process for particular planning processes and project decisions to gather a subjective weighing up process of neobiota for the different values of nature and landscapes to the human species and on their own without this information.

Nevertheless, these theoretical and practical evaluation examples of neobiota have proven the flexibility and universal applicability of the proposed framework of condensed criteria and comprehensive values for interdisciplinary evaluations of nature and landscapes. The evaluation has also been transparent, because the different evaluation criteria and values are clearly separated. The objectivity is based on using always the same framework of criteria by the different value disciplines for each neobiota evaluation case. They can be repeatedly applied, independently of the particular scientist. The theoretical and practical evaluation example of neobiota have also confirmed that the proposed interdisciplinary evaluation framework is comprehensive, because it allows systematically covering all values of neobiota while integrating natural sciences, as well as, humanities. Furthermore, the condensed criteria allow reliable and validate to determine the different values of neobiota based on appropriate, i.e. additionally efficient and sensitive survey and analysis methods by the different value disciplines. Nevertheless, the particular criteria and values are more or less relevant depending on the certain neobiota evaluation case.

Despite the proposed interdisciplinary evaluations framework can contribute to remove the severe deficits of current evaluation frameworks of nature and landscapes (cf. chapter 1.2 Deficits of current evaluation methods on page 12), there is still the fifth question of this research unsolved, to which extend the proposed values and criteria of the comprehensive framework are already applied in practice for evaluations of nature and landscapes in Germany, i.e. if there is a need of the proposed interdisciplinary evaluation framework in practice (cf. chapter 1.4 Questions of the research on page 17)?

5. **Empirical study of Environmental Impact Assessments (EIA)**

After the author has provided an interdisciplinary framework of comprehensive values and condensed criteria for evaluations of nature and landscapes and discussed their theoretical and practical applications in detail, it is now interesting, to which extend evaluations consider these components already in practice. Representative Environmental Impact Assessments (EIA) in Germany shall serve as an empirical example.

5.1 Methods

5.1.1 Surveyed database

51 Environmental Impact Studies (EIS) (Figures 5.1-1 to 5.1-3) have been taken by chance out of a representative sample of 145 Environmental Impact Assessments from different Federal States in Germany dating from the 1990s (Wende, 2001, 2002). Some of the Environmental Impact Studies were not available, and mostly the authors' professions were not clarified. Therefore, these non-available Environmental Impact Studies are indicated in italics and put into brackets, as well as, the particular components left as an empty space (cf. chapter 14.1 List of case studies on page 443).

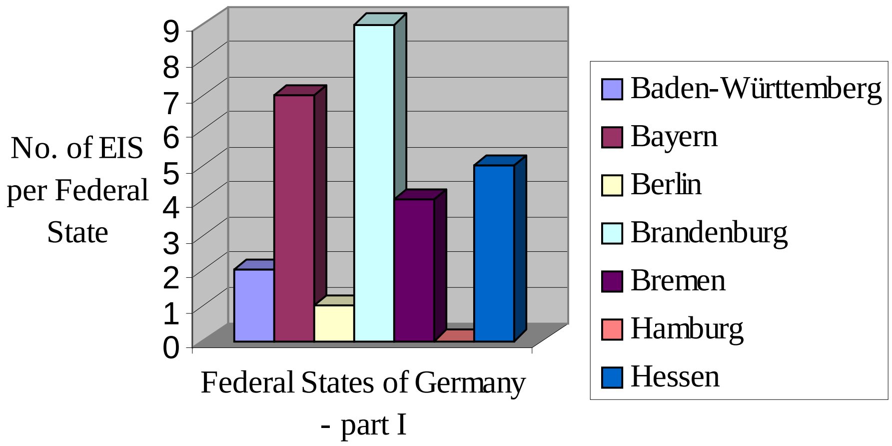

Figure 5.1-1. Number of Environmental Impact Studies by Federal State of Germany – part I

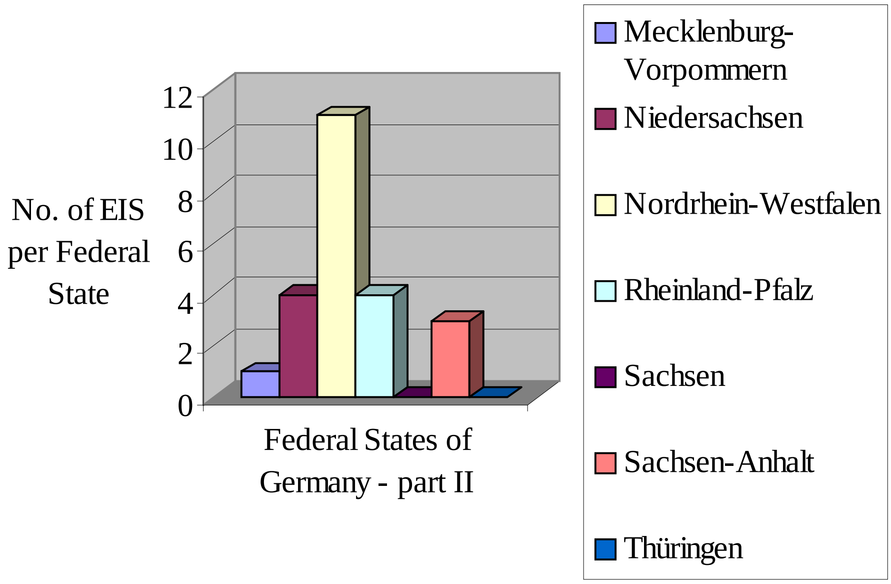

Figure 5.1-2. Number of Environmental Impact Studies by Federal State of Germany – part II

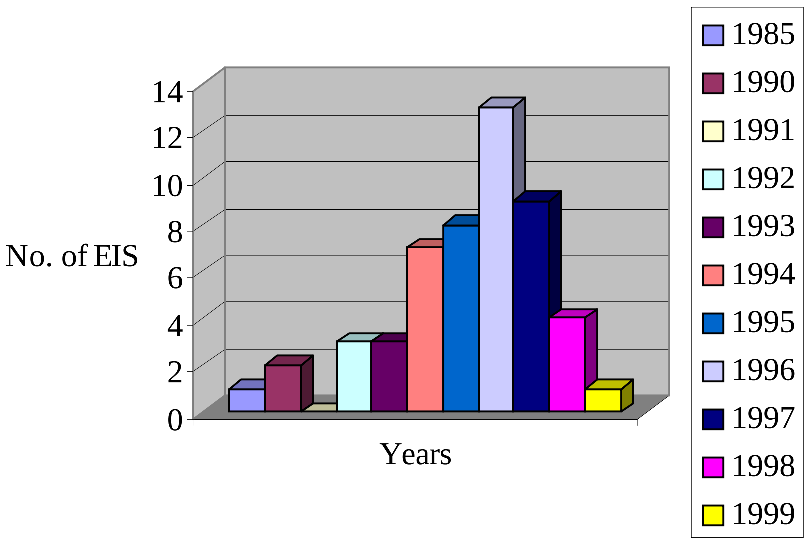

Figure 5.1-3. Number of Environmental Impact Studies by year of completion

This smaller sample of 51 Environmental Impact Studies has been surveyed to provide a tendency to which extend the mentioned criteria and values of nature and landscapes are applied in practice in Germany in the 1990s.

5.1.2 Surveyed data

In addition to the proposed values and criteria of this research, the following selected methodical components have been surveyed of the evaluations of nature and landscapes (Table 5.1-1).

Table 5.1-1. Selection of surveyed methodical components of the evaluations of nature and landscapes

Selected methodical components for evaluation analysis	
General components	Ecological components
• verbal-argumentative	• (meta-) population sizes
• mathematical	• (meta-) population fluctuations
• participative	• minimum areas
• separated parts of survey, analysis, and evaluation	• development times
• pre-studies	• dynamic processes
• reference scales	• keystone species
• model guidelines	• indicator species
• functional relations	• habitat structures and qualities
• visualizations	• trophic levels and interactions
• alternatives	• genetic base
• future projections	• monitoring data
• public relations	• abiotic resources
• encouraged actions	• current land use
• different professions	

The following ordinal classes have been applied to classify the degree of applications of values, criteria, and selected methodical components, respectively (Table 5.1-2).

Table 5.1-2. Ordinal classification classes of the selected evaluations of nature and landscapes

Ordinal classifications of the selected evaluations	
Degree of application	Classification marks
Extensively	5
A lot	4
Moderate	3
Low	2
Very little	1
Invaluable	

After an exemplary pre-study, 51 Environmental Impact Studies were surveyed according to their qualitative and quantitative extend of application of the mentioned 41 values, criteria, ecological and general components of evaluations of nature and landscapes, i.e. the empirical data is based on 2091 single classifications in total. There was about one hour necessary at an average to survey each of the 51 Environmental Impact Studies of different project types (Table 5.1-3) according to the 41 different aspects.

Table 5.1-3. Absolute and relative amount of different project types of the 51 Environmental Impact Studies of Federal States in Germany

Project type	Number	Relative amount
Military facilities	0	(0 %)
„Ambient environmental quality projects“[46]	2	(3.9 %)
Nuclear power facilities	0	(0 %)
Facilities for the deposition of nuclear wastes	0	(0 %)
„Waste disposal“	1	(2.0 %)
Sewage treatment facilities	0	(0 %)
“Waterways, expansion of waterways, dikes, etc.”	10	(19.6 %)
„Open cast mining“	5	(9.8 %)
„Road construction“	13	(25.5 %)
„Railroad installations“	1	(2.0 %)
Research facilities (also traffic)	0	(0 %)

[46] Classification names in inverted commas according to the definition and English translation by Wende (Wende, 2002).

„Tramways, subways“	3	(5.9 %)
Airports	0	(0 %)
„Facilities defined in the Land Consolidation Directive“	4	(7.8 %)
„Holiday villages, hotels, recreational facilities“	6	(11.8 %)
„Pipelines“	1	(2.0 %)
Magnetic railways	0	(0 %)
„Power supply lines“	3	(5.9 %)
„Industrial, shopping, and service centres“	2	(3.9 %)
Construction and land use planning	0	(0 %)
Others	0	(0 %)
Totals:	51	(100 %)

Only the survey of applied criteria was based on the authors’ theoretical intention to get a more distinguished result, but not on their practical qualitative and quantitative application, i.e. the practical application of the criteria was not of sufficient quality and quantity in the investigated Environmental Impact Studies to get a distinguished result.

5.2 Analysis of case studies

The median has been calculated for the analysis to eliminate exceptionally extreme figures in either direction that would in comparison strongly influence the arithmetic mean[47]. In particular, there are the following results of the empirical analysis.

5.2.1 Ecological components

The resulting median of the classified application degree of ecological components in 51 Environmental Impact Studies of Federal States in Germany reveals as following (Figures 5.2-1 and 5.2-2).

[47] The median is defined as the average of 50 % figures above and below in order, whereas the arithmetic mean is calculated as the sum of all figures divided by their total amount (Köhler et al., 2002).

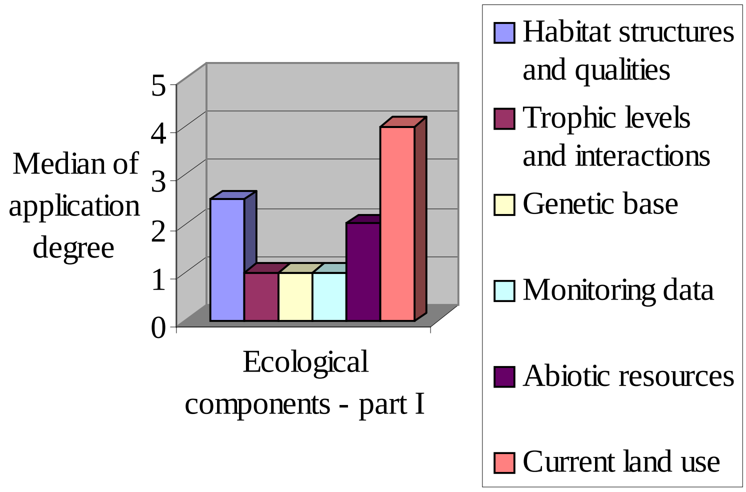

Figure 5.2-1. Median of the classified application degree of ecological components in 51 Environmental Impact Studies of Federal States in Germany – part I

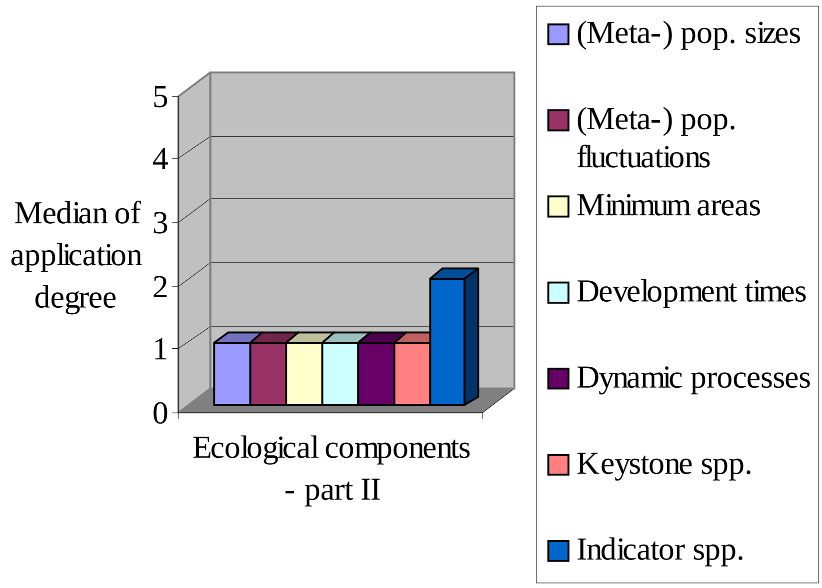

Figure 5.2-2. Median of the classified application degree of ecological components in 51 Environmental Impact Studies of Federal States in Germany – part II

Habitat structures and qualities

Habitat structures and their qualities have been taken into account at a low to moderate extend. Mostly habitat type mappings have been undertaken added by general descriptions of habitat demands of vascular plant and animal species. However, specified research has generally not been done of particular habitat qualities of the concerned study area that reveals to which extent and for whom these habitats might be of value.

Trophic levels and interactions

Trophic levels and interactions have played a very little role in the Environmental Impact Studies; especially trophic interactions have not been analysed and evaluated.

Genetic base

Genetic aspects have not yet been part of the Environmental Impact Studies.

Monitoring data

Very little monitoring data has been applied in the Environmental Impact Studies, if so, just for abiotic resources.

Abiotic resources

The Environmental Impact Studies have considered abiotic resources to a low extend, mostly in the survey part, but less in the analysis and the evaluation parts, respectively.

Current land use

Current land use has been surveyed, analysed, and evaluated a lot; however, just quantitatively by mapping, not qualitatively by sociological methods.

(Meta-) population sizes

(Meta-) population sizes of species have been very little applied, almost exclusively in the survey part of flora and vegetation densities to determine plant communities.

(Meta-) population fluctuations

(Meta-) population fluctuations have not been applied to the Environmental Impact Studies.

Minimum areas

Minimum areas have been of almost no importance for the Environmental Impact Studies. This refers to all abiotic, as well as, biotic components.

Development times

Development times of abiotic and biotic components have been applied to a very little extend, almost only for habitat types without clarifying their values.

Dynamic processes

Very little dynamic processes have been considered of abiotic and biotic components.

Keystone species

The concept of keystone species has not been applied in the Environmental Impact Studies.

Indicator species

Indicator species have been applied to a low extend, mostly in the survey part, but less in the analysis, and evaluation parts, respectively. It has been generally unclear for which indicating conditions the species have been selected in the Environmental Impact Studies.

5.2.2 General components

The median has been also calculated for the classified application degree of general components in 51 Environmental Impact Studies of Federal States in Germany (Figure 5.2-3 and 5.2-4).

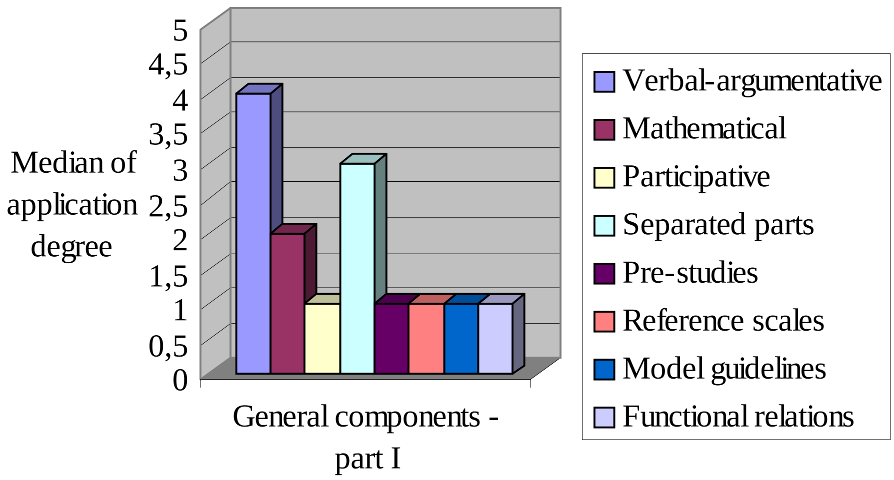

Figure 5.2-3. Median of the classified application degree of general components in 51 Environmental Impact Studies of Federal States in Germany – part I

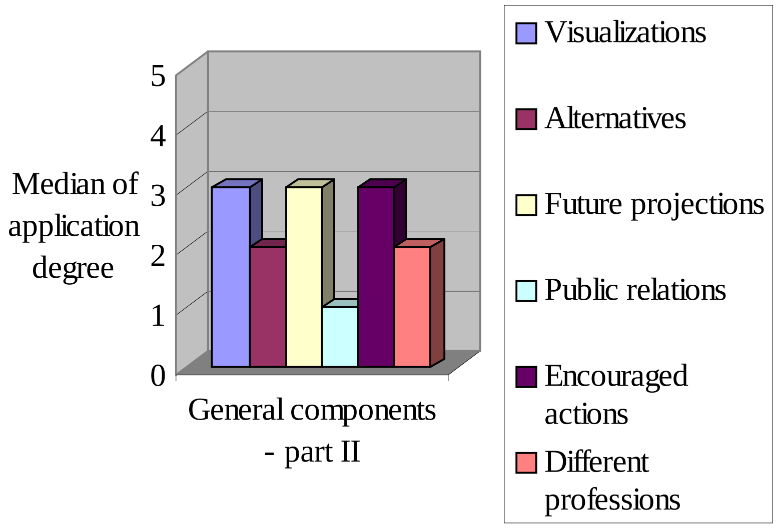

Figure 5.2-4. Median of the classified application degree of general components in 51 Environmental Impact Studies of Federal States in Germany – part II

<u>Verbal-argumentative</u>

The Environmental Impact Studies have been a lot verbal-argumentative, mainly combined with diagram simplifications and presentations.

Mathematical

Mathematical methods have been applied to a low extend, but then summarizing different criteria and values.

Participative

Participation has been very little applied in all three parts of survey, analysis, and evaluation of the Environmental Impact Studies, if so, just for the institutional public, i.e. other administrations and selective private interest groups.

Separated parts of survey, analysis, and evaluation

Survey, analysis, and evaluation parts have been moderately separated. The survey part has mostly been much more extensive than the analysis part and even less the evaluation part. The survey part has had low connection with the analysis part that was a lot mixed together with the evaluation part.

Pre-studies

Pre-studies have been very little undertaken for abiotic or biotic components of the Environmental Impact Studies.

Reference scales

Reference scales have been very little applied, if so, almost only for abiotic resources according to technical standards of German environmental laws for the human species.

Model guidelines

The Environmental Impact Studies have been very little orientated to model guidelines, just legal planning guidelines have been mainly mentioned in the survey part.

Functional relations

Functional relations of the different aspects of the Environmental Impact Studies have been very little considered.

Visualizations

The Environmental Impact Studies have visualized a lot, but almost only by maps and tables. Other multimedia sources have nearly not been applied.

Alternatives

Alternatives have been considered to a low extend in the Environmental Impact Studies. Especially the rejection of the project has been almost no alternative consideration. Just different alternatives of the undertaken project have been analysed and evaluated.

Future projections

Future projections have been moderately part of the Environmental Impact Studies.

Public relations

Public relations have almost not been applied in the Environmental Impact Studies.

Encouraged actions

The Environmental Impact Studies have moderately encouraged actions, exclusively according to the demands of the German impact regulations.

Different professions

Just 26 of the 51 Environmental Impact Studies have indicated the profession of the authors. These 26 Environmental Impact Studies reveal different professions at a low extend, almost exclusively of natural sciences.

5.2.3 Criteria

There is also the median of the classified intended application degree of criteria in 51 Environmental Impact Studies of Federal States in Germany (Figure 5.2-5).

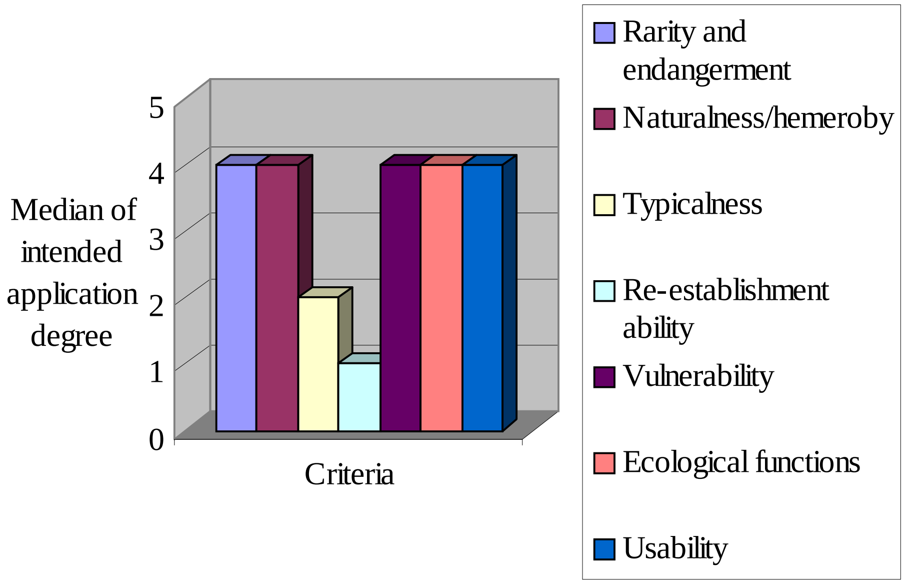

Figure 5.2-5. Median of the classified intended application degree of criteria in 51 Environmental Impact Studies of Federal States in Germany

Rarity and endangerment

There has been the intention to apply the criterion rarity and endangerment a lot in the Environmental Impact Studies, but almost only regarding Red Data lists of species and habitats.

Naturalness/degree of human impacts

Naturalness/degree of human impacts have been intended to play a lot of importance in the Environmental Impact Studies concerning biotic, as well as, abiotic components, but current natural occurrence of species, including neozoa, neophytes, and other neobiota after 1492 (cf. section 4.3.1.2 Naturalness/degree of human impacts on page 245), has nearly not been aimed to be applied as a criterion.

Typicalness

Typicalness has been intended to be applied to a low extend for abiotic, as well as, biotic components in the Environmental Impact Studies.

Re-establishment ability

There has been very little intention to consider re-establishment abilities in the Environmental Impact Studies, almost only for habitat types without clarifying their particular values.

Vulnerability

The Environmental Impact Studies have intended to apply the criterion vulnerability a lot, sometimes to an extend that it has been used as a value itself, while low analysing and evaluating the particular impacts of the project.

Ecological functions

Ecological functions have been aimed to be a lot of importance for the Environmental Impact Studies concerning biotic, as well as, abiotic components, but mostly just in general qualitative descriptions.

Usability

The criterion usability has been intended to be applied a lot in the Environmental Impact Studies, but very low quantified, mainly by rough estimations of area sizes of different land uses.

5.2.4 Values

Finally, there is the median of the classified application degree of values in 51 Environmental Impact Studies of Federal States in Germany (Figure 5.2-6).

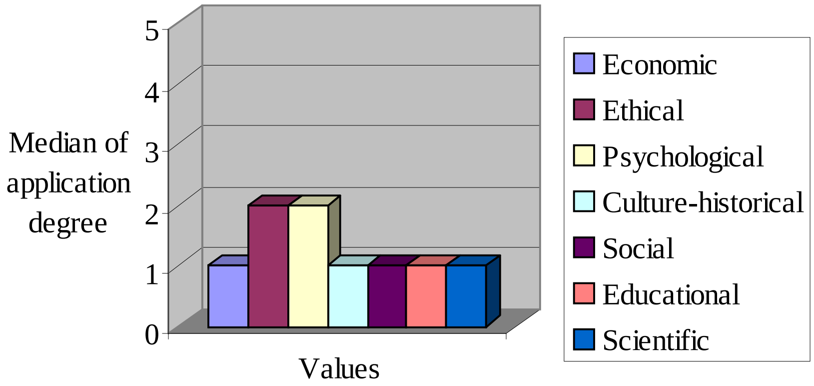

Figure 5.2-6. Median of the classified application degree of values in 51 Environmental Impact Studies of Federal States in Germany

Economic values

Economic values are very little applied, just to a rough estimation of the economic profitability of the project mainly for the owner.

Ethical values

Ethical values have almost not been particularly mentioned in the Environmental Impact Studies, but they can be assumed to have been of importance to a low extend for the value of nature and landscapes on their own and the human benefits of them.

Psychological values

Psychological values are very little considered and mainly limited to landscape scenery and recreational uses.

Culture-historical values

Culture-historical values have been of very little importance in the Environmental Impact Studies, almost exclusively concerning historical monuments protected by the German law, but not culture-historical land uses.

Social values

Social values are not considered in the Environmental Impact Studies, except of very little studies that briefly mention the benefits for the employment market of the particular project.

Educational values

Educational values have been not of importance for the Environmental Impact Studies.

Scientific values

Scientific values do not play a role in Environmental Impact Studies.

5.3 Conclusive evaluation of case studies

5.3.1 Ecological components

The 51 Environmental Impact Studies in Germany of the 1990s reveal that biological aspects are nearly unconsidered for evaluations of nature and landscapes. There are mainly general assumptions of habitat values based on flora and vegetation surveys and habitat type mappings.

A study of the quality of habitat type mappings of 62 compensation areas for impact assessments at the German Federal State Schleswig-Holstein confirms similar deficits in 1995. The form sheets for habitat type mapping mainly content of rough and unsystematic information on dominant habitat types at the surveyed areas, but few information about flora generally in form of an incomplete list, and commonly fragmentary information on fauna (Dierßen and Reck, 1998a).

Therefore, the 51 Environmental Impact Studies do not allow statements of the living conditions, structures, and developments of animal species and their (meta-) populations, because they generally lack of quantitative, as well as, monitoring data for reference scales. Flora and vegetation surveys include quantitative data by density, but there is no analysis and evaluation on (meta-) population level.

The trophic levels and interactions of fauna and flora stay unclear, as well as, mostly their relations to the human species stay unrevealed. In general, the different biodiversity levels are indistinct and not examined. There are also rather limited conclusions possible of the abiotic components due to the same deficits. Interactions between biotic components and abiotic resources, as well as, the human species have not particularly been investigated. Dynamic processes and development times are nearly out of consideration.

The concept of keystone species is not applied. Indicator species appear especially in the survey part, but it is generally unclear for which particular condition of the area concerned they might indicate a certain qualitative and quantitative value of nature and landscapes.

5.3.2 General components

Verbal-argumentative parts of the Environmental Impact Studies dominate mathematical calculations, but they do not allow concluding concrete measures, because they are too general and schematic. The applied visualizations are not sufficient to experience and to understand the conditions of nature and landscapes of the particular area, and to imagine future changes, because they are mainly limited to maps and diagrams, instead of using all media and public relations technologies.

A high content of descriptions in the survey part is not equally reflected in the analysis and even less in the evaluation part. Pre-studies have almost not been carried out to determine the necessary qualitative and quantitative survey efforts. Survey, analysis, and evaluation parts are biased due to a lack of participation processes of the public to gather information and to contribute to the evaluation results, as well as, a missing interdisciplinary team of scientists also involving the humanities. Analysis and evaluation parts are mixed together as a signal for the unclear evaluation guidelines.

Alternatives to reject the project for other higher values do not play a role in nearly all cases. The Environmental Impact Studies are almost entirely missing model guidelines as a basis, which are developed in co-operation with the public. Functional relations of biotic and abiotic components are just superficially explored. A very few reference scales have been used for some abiotic impacts on human health.

Future projections and encouraged actions are also rather limited to the established insufficient legal standards of German environmental impact laws. They seem to be only cosmetics of the impacts of the undertaken projects due to their superficial scientific and participatory basis. Therefore, project implementation deficits and resistances of the public indirectly and directly concerned become very likely.

5.3.3 Applied criteria

The Environmental Impact Studies have the intention to apply mostly the criteria rarity and endangerment, naturalness/degree of human impacts, vulnerability, ecological functions, and usability. Their authors have much less intended to consider typicalness and even more re-establishment ability.

However in practice, the criteria are very limited applied to analyse and to evaluate certain circumstances and relations of nature and landscapes. There is above all a connection missing with the values, but also with reference scales, model guidelines, functional relations, and dynamic processes. Each author seems to select and to apply the criteria more or less how he/she wants, apart from some rather limited requirements according to § 1 of Germany's Federal Nature Conservation Act (Bundesministerium der Justiz, 2002).

Rarity and endangerment mainly use Red Data lists of species, just one aspect of nature and landscapes. Naturalness/degree of human impacts are mostly focused on historical naturalness without a clear concept of spatial and time related model guidelines. Vulnerability is mostly applied in the Environmental Impact Studies without clarifying its qualitative and quantitative consequences for nature and landscapes of the particular project. Re-establishment ability is just schematically applied to some habitat developments, but it does not tell us, if it would be possible and how long it would take to get similar specified conditions of nature and landscapes in the particular case.

The applied ecological functions are mainly limited to descriptions of productions of abiotic resources without quantifying them and only very briefly considering their interactions qualitatively. Applications of the criterion usability should cover much more than the considered area sizes of quantitative land use in these Environmental Impact Studies. Also typicalness is just superficially and often unrelated applied to some abiotic and biotic components, but it does not provide us with information on a sufficient scale for evaluations.

Neobiota after 1492 are generally considered of low value in these Environmental Impact Studies due to their historically unnatural origin, without applying the different criteria as revealed in the theoretical evaluation example of this research. Moreover, the criteria are commonly applied as values themselves. It becomes obvious that is necessary to establish a comprehensive evaluation framework that relates these criteria with the different survey parts in accordance with the leading different values.

5.3.4 Applied values

Economic values are just of importance for rough estimations of the economic benefit of the particular project of the investor. Ethical values seem to be of importance for the rest, apart from some psychological values reduced to landscape scenery and recreational uses. Culture-historical, social, educational, and scientific values, respectively, are almost not represented. It becomes apparent that humanities do not sufficiently participate in the evaluation process. This is no wonder, because the reporting authors originate from natural sciences, and they are directly entrusted and paid by the investors, who are interested to limit impeding and cost-intensive influences of the Environmental Impact Studies.

It is especially unclear, how the different values are weighed up against each other, which should be a normal and necessary process of evaluations of nature and landscapes. There is also rarely pointed out a relation between specific values and criteria for their assessments. The red line between measurements, determining criteria, and their leading values has not been drawn. Moreover, the decision process about relevant values and their results of applications seems to be mainly in the hands of the authors, who depend on their financing clients of the particular projects.

5.4 Conclusions

The empirical study of 51 Environmental Impact Studies (EIS) in Germany of the 1990s has clearly revealed that there is an urgent need of an interdisciplinary evaluation framework of comprehensive values and condensed criteria to consider all different values of nature and landscapes to the society, to particular people, and on their own. Moreover, this random sample of Environmental Impact Studies (EIS) confirms the severe deficits of current evaluation frameworks of nature and landscapes (cf. 1.2 Deficits of current evaluation methods on page 12). It makes it also obvious that there are some general remarks necessary on the methods of evaluation systems of nature and landscapes. Therefore, the next chapter shall discuss different methodical concerns about evaluation systems of nature and landscapes as a result of the empirical study.

6. Discussion of general methodical concerns

This research provides a framework of comprehensive values and condensed criteria for interdisciplinary evolutions of nature and landscapes, common methods of the different scientific value disciplines, and mainly species and population ecological survey and analysis methods, as well as, concepts within an ecosystem context arranged to the particular evaluation criteria for practical planning processes and project decisions. However, the empirical study of 51 Environmental Impact Studies (EIS) in Germany of the 1990s has revealed that there is an additional need to discuss general methodical concerns of evaluation systems of nature and landscapes that shall also serve to apply the proposed interdisciplinary evaluation framework, which will be carried out in this chapter.

6.1 Mathematical and descriptive methods

There is a tendency to simplify evaluations of nature and landscapes by points or numbers and even to summarize different values and criteria for comparisons or Environmental Impact Assessments (EIA) (e.g. Auhagen, 1994; Deiwick et al., 2004, 2005). 68.4 % of all quantified evaluation methods of nature and landscapes are based on points in Germany, 30.0 % on compensative area factors, 5.3 % on restoration costs, and 4.2 % others (multiple answers possible) of in total 190 evaluation schemes (Böhme et al., 2005). Aggregations of mathematical evaluation results can cause information losses and suggest the possibility to add or to multiply different aspects of nature and landscapes together (Knospe, 2001). This is contradictory to more transparency, because different values and criteria cannot be mixed together, which are based on different features. For example, the bird Skylark (*Alauda arvensis*) is a predator of thousands of insects in his life as an ecological function for the economic value to safe pesticides in agriculture, which can be estimated in money. However, the Skylark is also a typical species of agricultural fields to feel home and to relax at the countryside as a culture-historical value and as a psychological value, respectively. It is already difficult to calculate the ecological functions of the Skylark in amounts of money. However, it is impossible to estimate the culture-historical and psychological values, respectively, of this bird in numbers or points or to mix them together with the economic value.

Other authors criticize also that assessments of nature and landscapes often just pretend to be objective by using computerized quantifications of qualitative and semi-qualitative circumstances. Ecological components are often underestimated and assessment methods are too complex for being transparent. Therefore, verbal argumentations should be preferred in many cases to formalized quantified evaluations, especially to assess non-quantifiable aspects, such as the beauty of nature and landscapes or the total value of a bird. However, verbal argumentative assessment methods can be less clear and comparable, less usable for computer-supported analysis, and less checkable. Therefore, it might be the best solution to combine both approaches (Haber et al., 1988). 84.8 % of all evaluation methods of nature and landscapes are quantified in Germany, but just 15.6 % verbal-argumentative, and 14.3 % combined methods (multiple answers possible) of in total 190 evaluation schemes (Böhme et al., 2005). Furthermore, different aspects of nature and landscapes, even different ecological circumstances, should never be put together to one evaluative conclusion (cf. Bastian, 1997; Bastian and Schreiber, 1999), but they need to be presented in a comparable way according to the same text, table, and figure structure (cf. Haber et al., 1993).

Descriptive evaluation methods have the advantage to formalized quantified evaluations to be able to focus on specific conditions of particular cases and to evaluate better functional relationships. In addition, descriptive evaluation methods can integrate aspects of nature and landscapes, which are difficult to quantify, for example, landscape scenery or isolation effects. However, it can be also difficult to visualize certain values of nature and landscapes by descriptive evaluation methods for comparisons (cf. Runge et al., 1999). Therefore, verbal-argumentative evaluations can be completed and clarified by numerical descriptions. Pure verbal-argumentative evaluations have often the disadvantage of being less comparable due to their lack of formalization (cf. Bernotat et al., 2002c; Gerhards, 2002).

Current evaluations of nature and landscapes reveal significant methodical deficits (Table 6.1-1).

Table 6.1-1. Overview of current methodical deficits of evaluations of nature and landscapes (Theobald, 1998, modified)

<u>Overvaluation of data collections and natural scientific parts</u>

- data collections and natural scientific parts are often overstressed
- analysis and evaluation parts are often underrepresented

<u>Overstressing of indicators and few inefficient justifications of indicator methods</u>

- relations of indicators and measured features are often not efficiently examined
- used indicators are often not representative and not enough considered in their current context

<u>Increased mathematical applications of evaluation methods and results</u>

- incomparable criteria are often scaled on an unrealistic exactness of numbers and limits in relation to available data

Deficient considerations and transparency of normative values

- there is often only a formal analysis and evaluation of natural scientific data combined with subjective evaluation systems of the current researcher

Deficient transparency of evaluation methods

- particular parts of evaluations are often not sufficiently separated
- validities of evaluations are often not specified on spatial and thematic levels

Moreover, single steps of evaluations are often not sufficiently distinguished from each other, as well as, scientific facts are incorrectly used as criteria itself for evaluations, for instance, species numbers, area and population sizes. Furthermore, results of evaluations are often based on vague evaluation criteria combined with the specific competence of the researcher, but not on clear value relations. In addition, analogical conclusions are incorrectly used to allow evaluations of specific spatial areas (Placke and Scherfose, 1998).

Simplified mathematical evaluations of nature and landscapes have been especially criticized for impact assessments (cf. Rassmus et al., 2002). Nevertheless, measurements of criteria can be categorized in different scales for statistical analysis (Table 6.1-2; cf. Preißner, 1994).

Table 6.1-2. Different measurement scales of criteria for assessments of nature and landscapes (Plachter, 1991a, 1994, modified)

Types of scales		
Nominal	Cardinal	Ordinal
• alternative features	• steady decreasing or increasing characteristics	• classified marks

For example, the Skylark does or does not occur in certain areas of nature and landscapes (nominal scale). When it occurs, than in certain numbers (cardinal scale), which can be classified into, for example, rare, occasional, frequent, abundant, and dominant (ordinal scales). In general, more detailed information can be converted into more simplified presentations for assessments and comparisons, i.e. cardinal scales can be converted into ordinal scales and those into nominal scales, but not vice versa. For instance, if we know the cardinal number of Skylarks at certain areas of nature and landscapes, we can categorize it in ordinal classes for comparisons with other areas. We can also state nominally that the Skylark occurs or does not occur in certain areas, respectively, to allow simplified presentations of its dispersal. However, if we just have the nominal information of the occurrence of the Skylark, we do not know in which ordinal class, nor in which cardinal amount it can be found.

In general, there ought to be a reasonably limited number of evaluation classes to prevent that exactness is assumed, which does not correspond to the collected data. In addition, odd numbers should be preferred to allow marking also the middle class (Placke and Scherfose, 1998; Bernotat et al., 2002c). Therefore, in general scales of three to five value classes have been proven as appropriate (Kiemstedt et al., 1996b).

Mathematical calculations are not possible of ordinal measurement classes of different areas of certain cardinal sizes, because they do not sufficiently take into account qualitative and functional aspects. In addition, ordinal classes do not provide information on classification distances. For example, a bigger area of a lower ordinal measurement class cannot be evaluated as equal as a smaller area of a higher ordinal measurement class (cf. Dierßen and Reck, 1998b). Moreover, different ordinal measurements can neither be added up nor multiplied (cf. Haber et al., 1993; Kiemstedt et al., 1996b; Reck, 1996; Schweppe-Kraft, 1997; Runge et al., 1999; Rassmus et al, 2003). For example, ordinal classified occurrences of Skylarks cannot be mixed together with scales of their vulnerability to evaluate certain habitats on object levels, because their classification distances are not exactly measured, i.e. they are not on cardinal scales.

In addition, correlations of parts of nature and landscapes are often not linear, but logarithmic, exponential, sigmoid, or even more complex (Fränzle, 1998; Haber et. al., 1988; Placke and Scherfose, 1998; Bastian and Schreiber, 1999). Moreover, complex systems like nature and landscapes can suddenly have system bounds and breaks, respectively (cf. Bendoricchio, 2000). They are called bifurcations according to the chaos theory (cf. Fränzle, 1998; J∅rgensen, 2000), which can also make prognosis of future developments impossible. This is not a question of enough knowledge, but also a characteristic feature of the system itself (cf. sections 3.2.3 Naturalness/degree of human impacts on page 149 and 3.2.5 Re-establishment ability on page 177, respectively). Therefore, data collections for predictions of developments of nature and landscapes should be concentrated on the most important influencing features of the system (Table 6.1-3; Jessel and Tobias, 2002) according to the mentioned criteria and values. However, most interactions between living organisms and their environment do not allow determining certain occurrence probabilities. Therefore, scenarios can be used as one form of prognosis to reveal plausible developments and trends (Jessel, 1998; Jessel and Reck, 1999; Hoisl et al., 2000).

Table 6.1-3. Different sources of prognosis (Jessel and Tobias, 2002)

Prognosis methods	
• causally derived data • statistically derived data • use of classified information	• analogous conclusions • trend extrapolations and regression analysis, respectively • validated expert knowledge

6.2 Model guidelines

Moreover, there have been attempts to develop Environmental Quality Goals and Standards for certain areas of nature and landscapes, as well as, model guidelines for their development (cf. Marzelli, 1994; Heinig, 1997; Kratochwil and Schwabe, 1997; Poschmann et al., 1998; Jessel, 1998; Knospe, 2001; Kratochwil and Schwabe, 2001; von Haaren and Horlitz, 2002; Jessel and Tobias, 2002; Plachter et al., 2003; Schröder, 2003; von Haaren, 2004b). Sectorial model guidelines can help to transfer different values of nature and landscapes into concrete terms (Table 6.2-1).

Table 6.2-1. Examples of sectorial model guidelines for different values of nature and landscapes in Germany (Dierßen and Roweck, 1998, modified)

Sectorial model guidelines	Relations to nature and landscapes	Evaluation sources
Culture-historical model guidelines	• cultural landscapes	• historical maps and photos
Aesthetic model guidelines	• psychological needs of people	• opinion surveys
Habitat and species model guidelines	• habitat requirements of species	• habitat and species surveys
Abiotic model guidelines	• abiotic conditions	• environmental surveys
Land use model guidelines	• land demands of users	• land use surveys

Model guidelines are simplified instruments for human consciousness to visualize the complexity and the complicatedness of the environment. All model guidelines are dynamically influenced by individual developments and changes of the society. Town planning model guidelines have nearly always consisted of constructive architectural, spatial, and aesthetic model guidelines, as well as, also of abstract social, economic, and ecological aims (Bote and Krautzberger, 1999). There are different methods to develop model guidelines (overview in von Haaren and Freytag, 2002).

Furthermore, there are models of benefit analysis of values (cf. Bechmann, 1988b; Haber et al., 1988; Jacoby and Kistenmacher, 1998; Knospe, 2001), which should include different options (cf. Sutherland, 2000). In addition, ecological risk analyses of impacts are applied as theoretical estimations for evaluations of Environmental Impact Assessments (EIA) (cf. Haber et al., 1988; Runge, 1988; Scholles, 1997; Jacoby and Kistenmacher, 1998; Poschmann et al., 1998; Waldmüller, 2000; Knospe, 2001; Jessel and Tobias, 2002). There are also recommendations of establishing a risk assessment panel for general global environmental risks on United Nations' level (WBGU, 1998).

Moreover, evaluations of nature and landscapes must be related to regions of different levels. Values and criteria for evaluations are related to local, regional, national, supranational, and international levels (cf. Plachter, 1991a, 1991b; Kiemstedt et al., 1996b; Reck, 1996). Therefore, evaluations require comparable data on each of these levels. Monitoring programmes allow gathering this data (cf. Schröder et al., 1998; SRU, 2002). Monitoring schemes are necessary to detect changes of the society and their attitudes to nature and landscapes as part of the humanities, as well as, to monitor issues of natural sciences. Furthermore, it must be possible to spatially locate the monitoring results (Meier and Erdmann, 2003).

6.3 Monitoring

Monitoring has the task to repeatedly survey conditions of nature and landscapes and its components, influences of human activities on them, and to detect changes. Monitoring schemes are decisive for gathering comparative data material related to different spatial levels for evaluations of nature and landscapes.

For Germany, a Random Spatial Ecological Sample Monitoring has been developed. It allows a countrywide standardized long time monitoring of 800 random samples of 1 km², which covered 90 % of the German landscape in 1997: 54 % agricultural fields, 29 % forests, 6 % buildings and free spaces, 5 % traffic areas, 2 % waters, 2 % other uses, 1 % firm areas, and 1 % recreational areas (cf. Hoffmann-Kroll et al., 1998; Hoffmann-Kroll et al., 1999; Der Landesbeauftrage für Naturschutz und Landschaftspflege Berlin, 1999; Statistisches Bundesamt and Bundesamt für Naturschutz, 2000). There are also recommendations for an ecosystem monitoring (cf. Schönthaler et al., 2003) combined with a socio-economic monitoring (cf. Petermann, 2002). Monitoring of permanent plots is especially important for evaluations of nature and landscapes to gather comparable data and to detect developments (Nietfeld, 1994; cf. Zierdt, 1997; Dierßen, 1999). Therefore, there are attempts to establish an environmental specimen banking to gather samples for reference scales in Germany (Wagner et al., 1998).

For Berlin, a detailed representative spatial monitoring programme of permanent plots has been developed (cf. Janotta et al., 1987) that was unfortunately reduced to nature reserves due to political reasons (cf. Böcker et al., 1991). Nevertheless, there are monitoring programmes throughout Europe (overview in Goldsmith, 1991; Traxler, 1998; Bischoff, 2000; Stickroth et al., 2003). The European Union has initiated a European wide coherent net of nature reserves "Natura 2000" that includes regularly monitoring surveys of its management success (cf. Rückriem et al., 1999). There are also ecological monitoring schemes on earth level, and proposals for social monitoring schemes that use their own indicators (overview in Hartmuth, 1998). Furthermore, genetic variability is also monitored (cf. Günther and Assmann, 2000). In general, monitoring schemes must fulfil the following requirements (Table 6.3-1).

Table 6.3-1. Requirements of monitoring schemes (Maas, 2000, modified)

Monitoring schemes
• to distinguish between caused trends and random noise • to reveal correctly scientific and logic data by applying reproducible methods • to allow representative statements about the state of nature and landscapes and its potential future changes • to describe achievements of predefined standards or its deviations, respectively • to allow comparisons with starting conditions of the monitoring period • to allow formulating at least hypotheses of development reasons and influencing factors

Moreover, there are methods to find out historical ecological processes of nature and landscapes, so-called Historical Range of Variability (HRV) methods (Table 6.3-2; cf. Dierschke, 1994; Ecker, 1998; Kratochwil and Schwabe, 2001).

Table 6.3-2. Characteristics of Historical Range of Variability (HRV) methods (Humphries and Bourgeron, 2001, modified)

Method	Temporal resolution	Techniques often used in concert	Limitations
Dendroecological: fire scar	• seasonal to annual	• charcoal analysis, repeat photography	• tree-based, lack of spatial precision
Dendroecological: stand age	• decades	• repeat photography	• tree-based
Pollen analysis	• annual to hundred of years	• plant macrofossils, charcoal analysis	• coarse taxonomic resolution, lack of spatial precision
Plant macrofossils from sediments	• points, associated with pollen chronologies	• pollen analysis, charcoal analysis	• heterogeneous distribution in sediments
Plant macrofossils from middens	• points	• pollen analysis	• restricted locations and numbers of samples
Charcoal analysis	• annual to hundreds of years	• dendroecological pollen analysis, plant macrofossils	• lack of spatial precision, heterogeneity in charcoal deposition
Land survey records	• points	• repeat photography, historical maps	• availability of records, surveyor bias, limited temporal extent
Repeat photography: ground	• points	• dendroecological methods	• photographer bias, limited temporal and spatial extent
Repeat photography: aerial	• points, may constitute time series	• dendroecological, land survey, historical maps	• limited temporal extend

Maps from historical data	• points	• land survey, repeat photography	• limited temporal extent
Simulation models	• annual to hundred of years	• dendroecological, pollen analysis, repeat photography, historical maps	• predicted HRV
Biophysical environment characterization	• not applicable	• dendroecological, repeat photography	• predicted HRV

6.4 Visualizations

Maps, drawings, diagrams, tables, videos, computer animations, and other multimedia methods visualize features of nature and landscapes on different scales (cf. Demuth and Fünkner, 1997, 2000; Stocks and Kramer, 2000; Kunze, 2004). The Geographic Information System (GIS) is another useful opportunity to visualize different aspects of nature and landscapes (Table 6.4-1; cf. Scholles, 1997; Reiter and Fussenegger, 1998; Runge, 1998a; Amler et al., 1999; Duttmann, 1999a, 1999b; Koch, 2000; Schneider et al., 2000; Weidenbach, 1999, 2000; Blaschke and Lang, 2000; Braun et al., 2001; Franklin, 2001; May, 2001; Golledge, 2002; Jessel et al., 2003; Redslob, 2004).

Table 6.4-1. Applications of the Geographic Information System (GIS) linked with models for evaluations of nature and landscapes (Wenkel, 1999, modified)

Model systems	Linkages with Geographical Information System (GIS)
Ecosystem models	• development of sectorial ecosystem models and usage of GIS for analysis
Statistical evaluation models	• linking of GIS with statistical evaluation models
Sectorial dynamic process models	• linking of GIS with space and time related evaluations
Partially automatically sectorial dynamic process models	• data base supported automatic linkages and mutual information exchanges between GIS and sectorial dynamic process models
Fully automatically sectorial dynamic process models	• data base supported automatic linkages and mutual information exchanges between GIS and

	sectorial dynamic process models, as well as, interactive operations

6.5 Classifications

Furthermore, assessments of nature and landscapes distinguish between type and object levels, respectively (cf. Plachter and Foeckler, 1991; Plachter, 1994; Kirsch-Stracke et al., 2004). For example, there are different ecosystem types, landscape types, and habitat types, as well as, species, and subspecies at certain regions. On object levels of these types, we can distinguish between different expressions of features of certain types. For instance, the Skylark (*Alauda arvensis*) is a typical species of the habitat type open fields (cf. Ferguson-Lees et al., 1983). However, we can map certain amounts of occurring individual Skylarks at a particular open field as an object (Table 6.5-1). For statistical reasons and due to the different values as discussed in chapter 6.1 Mathematical and descriptive methods on page 299, it is forbidden to mix type and object levels, as well as, to aggregate ordinal and nominal/cardinal evaluation classes (cf. Kiemstedt et al., 1996a; Bernotat et al., 2002c).

Table 6.5-1. Examples of the Skylark's (*Alauda arvensis*) occurrence on type and object levels, respectively

Skylark (*Alauda arvensis*)	
<u>Habitat type level</u>	<u>Object level</u>
• open field	• specific open field of a certain region • nominal/cardinal occurrence of individuals • ordinal classified occurrence, for example, rare, occasional, frequent, abundant, or dominant

6.6 Habitat-mapping

Habitat-mapping allows to structure nature and landscapes completely in different habitat[48] types (cf. Sukopp et al., 1984; Schulte et. al., 1993; Bastian and Schreiber, 1999; Schulte and Sukopp, 2000; Bundesamt für Naturschutz, 2002; Davies and Moss, 2002; Kirsch-Stracke et al., 2004). Depending on available resources, there are overall and representative habitat-mapping methods, respectively. Overall habitat-mapping covers all individual habitats of certain regions of nature and landscapes, whereas representative habitat-mapping just surveys in more detail a few representative examples of each habitat type with in a region. In general, habitat-mappings start with using different information sources, for example, topographical, thematic (geological, soil, climatic, and vegetation maps), and historical maps, as well as, aerial photographs (Table 6.6-1; cf. Hausherr, 1998; Grabski-Kieron, 1999; Haefner, 1999; Linder et al., 1999; Förster et al., 2000a, 2000b; Glaser, 2000; Wezyk, 2000; Zihlavnik, 2000; Arweiler et al., 2002; Jessel and Tobias, 2002; von Haaren, 2004d; Redslob, 2004), satellite images (cf. Hausherr, 1998; Kenneweg et al., 2000; Löffl, 2000; Wirthmann, 2000; Bergstedt, 2001; Werner, 2002; Redslob, 2004), planning sources, literature, and expert knowledge (overview in Ermer et al., 1994; Sukopp and Wittig, 1998; Bastian and Schreiber, 1999).

Table 6.6-1. Indications for habitat-mappings by aerial photographs (Grabski-Kieron, 1999, modified)

Habitat-mapping by aerial photographs
• spatial location of habitat types • form and expression of habitat types • spatial order within user structures • dominant vegetation and structuring plant species • age and vitality of vegetation

The mentioned habitat type mapping methods can be especially applied to Central Europe and urban areas worldwide. In Central Europe, different landscape uses over centuries have revealed sharp borders of different habitat types at the countryside. Whereas, there are very large areas of transitional habitat changes outside cities at other continents, such as the wide countryside of America, Asia, Africa, and Australia (cf. Volg, 2003). Therefore, sharp habitat type borders on smaller scales cannot be found at rural areas in these regions to apply representative plant mapping methods, for example, Braun-

[48] In the German language, the term “biotope” is instead used in this context, which defines a living space of a community of species (“biocoenosis”), whereas the term “habitat” refers to the living space of one species (cf. Martin, 2002).

Blanquet’s (cf. Ellenberg, 1955; Dierßen, 1990; Dierschke, 1994; Glavac, 1996; Taxler, 1998; Glawion and Klink, 1999). Instead statistical sampling methods must be used, such as random plots or systematic sampling on the ground (Table 6.6-2).

Table 6.6-2. Different statistical sampling methods (Kratochwil and Schwabe, 2001, modified)

Different statistical sampling methods	
Method	Application difficulties
Random sampling	• can result in concentration of plots, i.e. unequal survey of areas; especially rare types can be underrepresented
Systematic random sampling	• combines random sampling with using a certain structure of locations of plots, such as a grid or transects to provide a more equal distribution of random sampling plots
Stratified systematic random sampling	• additional rare types are included

Nevertheless, habitat type mappings have been carried out worldwide in Austria, Brazil, China, Croatia, the Czech Republic, Germany, Hungary, Italy, Japan, Korea, Mexico, the Netherlands, Poland, South Africa, Switzerland, Turkey, the UK, and the USA (overview in Schulte and Sukopp, 2000; for the European Communities in Davies and Moss, 2002; European Commission, 2003).

Most habitat-mappings and resulting classifications of habitat types are based on flora and vegetation. However, animals and animal metapopulations are not fixed to the same spatial habitat structures as flora and vegetation. Animal species react differently to certain conditions of the area (cf. section 3.2.4.1 Indicator species on page 159). Furthermore, fauna is generally not related to specific plant communities, i.e. habitats of flora and vegetation are not necessarily corresponding to animal habitats. In addition, animals often react more sensitive and faster to changes of their habitats than plant communities. Therefore, it is as crucial for habitat type mappings to survey flora and vegetation, as well as, occurring fauna (cf. Spang, 1995; Schweppe-Kraft, 1997; Riecken, 2000b).

Furthermore, nature and landscapes practically do not have exact and sharp borders of ecosystems that are necessary for cartographic presentations. Habitats can change in sizes, such as natural displacements of riverbeds. In addition, habitats are often interconnected in mosaics. There are various abiotic gradients within them, which cannot be presented cartographically. In general, fauna needs complex structures of different interconnected habitat types (Ott, 1998).

In addition, there are geoecological spatial mappings of nature and landscapes, which include apart from flora and vegetation also water, material, soil, and energy households. However, also so called "geochores" and "geotopes" are graphic models that do not exist in these simplified sharp borders and uniform conditions in nature and landscapes, but they can be well used for presentations in Geographic Information Systems (GIS) (cf. Syrbe, 1999; Zepp, 1999; von Haaren, 2004e).

6.7 Conclusive summary

Mathematical methods for evaluations of nature and landscapes reveal a tendency to simplify by using points or numbers and even to summarize different values and criteria. However, aggregations of mathematical evaluation results can cause information losses and suggest the possibility to add or to multiply different aspects of nature and landscapes together. This is contradictory to more transparency, because different values and criteria cannot be mixed together, which are based on different features.

Other authors criticize also that assessments of nature and landscapes often just pretend to be objective by using computerized quantifications of qualitative and semi-qualitative circumstances. Ecological components are often underestimated and assessment methods are too complex for being transparent. Therefore, verbal argumentations should be preferred in many cases to formalized quantified evaluations, especially to assess non-quantifiable aspects, such as beauty of nature and landscapes or the total value of a bird. However, verbal argumentative assessment methods can be less clear and comparable, less usable for computer-supported analysis, and less checkable. Therefore, it might be the best solution to combine both approaches.

Nevertheless, measurements of criteria can be categorized in nominal, cardinal, and ordinal scales for statistical analysis. In general, there ought to be a reasonably limited number of evaluation classes to prevent that exactness is assumed, which does not correspond to the collected data. Mathematical calculations are not possible of ordinal measurement classes of different areas of certain cardinal sizes, because they do not sufficiently take into account qualitative and functional aspects. In addition, ordinal classes do not provide information on classification distances.

Correlations of parts of nature and landscapes are often not linear, but logarithmic, exponential, sigmoid, or even more complex. Complex systems like nature and landscapes can suddenly have system bounds and breaks, respectively, which can also make prognosis of future developments impossible. Therefore, data collections for predictions of developments of nature and landscapes should be concentrated on the most important influencing features of the system. Scenarios can be used as one prognosis form to reveal plausible developments and trends.

Moreover, there have been attempts to develop Environmental Quality Goals and Standards for certain areas of nature and landscapes, as well as, model guidelines for their development. Sectorial model guidelines can help to transfer different values of nature and landscapes into concrete terms. All model guidelines are dynamically influenced by individual developments and changes of the society. Furthermore, there are models of benefit analysis of values and ecological risk analyses of impacts on nature and landscapes.

In addition, evaluations of nature and landscapes must be related to local, regional, national, supranational, and international levels. Monitoring programmes allow gathering comparable data on each of these levels. Monitoring has the task to repeatedly survey conditions of nature and landscapes and its components, influences of human activities on them, and to detect changes.

For Germany, a Random Spatial Ecological Sample Monitoring has been developed, and there are attempts to establish an environmental specimen banking to gather samples for reference scales. The European Union has initiated a European wide coherent net of nature reserves "Natura 2000" that includes regularly monitoring surveys of its success. There are also ecological monitoring schemes on earth level. Furthermore, there are methods to find out historical ecological processes of nature and landscapes, so-called Historical Range of Variability (HRV) methods.

Moreover, assessments of nature and landscapes distinguish between type and object levels, respectively. Habitat-mapping allows structuring nature and landscapes completely in different habitat types. Depending on available resources, there are overall and representative habitat-mapping methods, respectively. Overall habitat-mapping covers all individual habitats of regions of nature and landscapes, whereas representative habitat-mapping just surveys in more detail a few representative examples of each habitat type of certain regions.

Habitat type mapping methods can be especially applied to Central Europe and urban areas worldwide. However at other continents, where we hardly can find sharp borders, such as the wide countryside of America, Asia, Africa, and Australia, they must be substituted by statistical methods, for instance, random plots or systematic sampling on the ground. Most habitat-mappings and resulting classifications of habitat types are based on flora and vegetation. However, animals and animal metapopulations are not fixed to the same spatial habitat structures as flora and vegetation. Furthermore, nature and landscapes practically do not have exact and sharp borders of ecosystems that are necessary for cartographic presentations. In addition, there are geoecological spatial mappings of nature and landscapes, which include apart from flora and vegetation also water, material, soil, and energy households.

Multimedia methods are used to visualize features of nature and landscapes on different scales, for instance, using maps, drawings, diagrams, tables, videos, or computer animations. The Geographic Information System (GIS) is another useful opportunity to visualize different aspects of nature and landscapes in complex constellations.

There are different methodical approaches to apply evaluation systems of nature and landscapes as discussed in this chapter. However, there are no general methodical application guidelines possible in detail, because the appropriate survey and analysis methods must be chosen after pre-studies depending on the particular evaluation case (cf. chapter 3 Criteria for evaluations of nature and landscapes on page 105). Nevertheless this research can provide an interdisciplinary evaluation framework, which contents of a framework of comprehensive values and a condensed number of criteria to take into account all different values of nature and landscapes to the human being and on their own. Furthermore, it allows removing the severe deficits of current evaluation methods together with these basic methodical considerations (cf. chapter 1.2 Deficits of current evaluation methods on page 12).

7. Conclusions

Nature conservation in the modern sense is an integrated spatial planning process of all demands of our society (cf. first chapter Introduction on page 12; Vogtmann, 2003). Therefore, it needs an interdisciplinary evaluation framework of comprehensive values, which are applied to the same criteria by each discipline for evaluations of nature and landscapes according to their own survey and analysis methods (Figure 6.7-1).

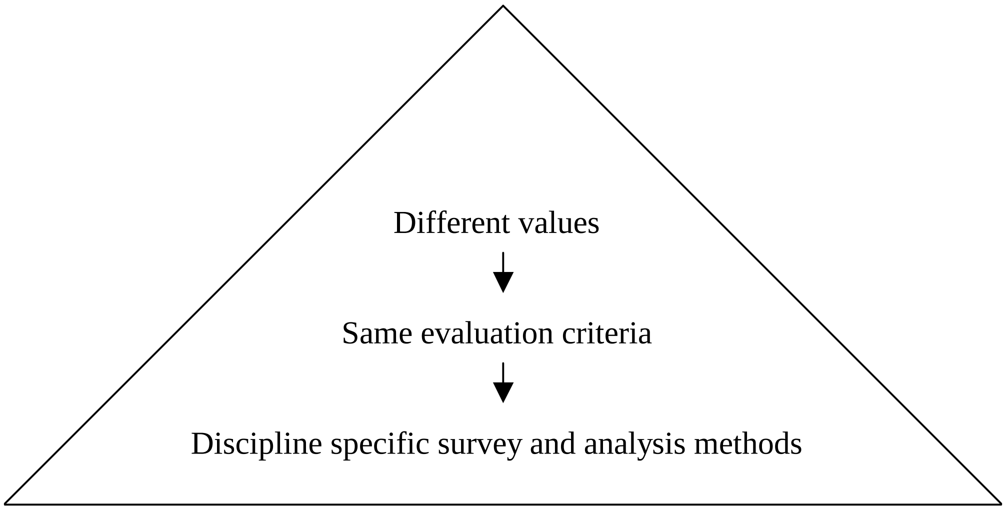

Figure 6.7-1. Levels of interdisciplinary evaluations of nature and landscapes

However, already this selection of comprehensive values and criteria for their measurement is subjectively determined (cf. Schröder, 1996; Schröder et al., 1998). In addition, socialization, personal experience, and education of the evaluator itself influence the evaluation (cf. Poschmann et al., 1998), as much as, economic and other dependences.

Objective evaluation results of the different values of certain elements, structures, and functions of nature and landscapes to the human being and on their own do not exist, just the results of subjectively selected survey and analysis methods must be theoretically the same under similar conditions, independently of the particular scientist. Practically, each particular evaluation case is different at a certain area and time span, as well as, the subjective perception, evaluation, and behaviour of people. However, it is the intention of this research to provide a comprehensive framework of values and applicable criteria to allow considering at least objectively all different values of nature and landscapes to the human species and on their own, including their interacting influences, for practical planning processes and project decisions in a participatory process of the public.

Therefore, the second chapter Different values of nature and landscapes on page 19 provides, after an introductory discussion of the general conditions of evaluations, an answer to the first question of this research by systematically structuring and discussing the background fields of the society that are directly or indirectly depending on the status and development of nature and landscapes, i.e. by revealing and discussing the human backgrounds, as well as, the interacting influences between nature and landscapes and the human being for each value within a comprehensive framework (Table 6.7-1).

Table 6.7-1. The different values of nature and landscapes (Zisenis 1993, 1998, 2005, modified)

Values of nature and landscapes	
• ethical	• economic • psychological • culture-historical • social • educational • scientific

In addition, the second chapter Different values of nature and landscapes on page 19 answers the second question of this research by discussing common survey and analysis methods of the different value disciplines in general that could serve to evaluate the different elements, functions, and structures of nature and landscapes for the society, each person, and the different components of nature and landscapes on their own. These survey and analysis methods of the different scientific disciplines partly overlap, such as socio-economic methods, as well as, their leading values for the same element of nature and landscapes. For example, there are socio-economic methods to determine the material economic and immaterial psychological recreational values of green spaces.

Nevertheless, each discipline must develop its own methods to measure their evaluation part of nature and landscapes according to the same framework of criteria. In an ideal case, there is a team of scientists of all disciplines to assess comprehensively the different values of nature and landscapes. Therefore, economists, philosopher, psychologists, social scientists, educationalists, culture-historians, and ecologists should come together to analyse and to evaluate nature and landscape according to the framework of this research. Irrespectively of their discipline, they ought to have the same framework of values and criteria to be comparable and comprehensive. This framework is applicable for urban, as well as, rural areas.

Furthermore, the second chapter Different values of nature and landscapes on page 19 of this research reveals also that our subjective perception, evaluation, and behaviour towards nature and landscapes and to other humans is an interactive dynamically changing process itself, i.e. the outcomes of evaluations of nature and landscapes are influenced by developing an ethical consciousness and emotional contact during education and socialization processes from early childhood on, which influences the condition and development of nature and landscapes themselves as a result of practical planning processes and project decisions with an impact on them. Assigned values of nature and landscapes by the human species depend, *inter alia*, on satisfying psychological human needs, providing social recognition, as well as, a positive economic feedback within a certain cultural-historical region and period. The different values of nature and landscapes are permanently more or less changing as much as the objects of evaluations vary themselves within a certain spatial and time context. They also more or less influence each other constantly in the dynamic interacting and developing process of nature and landscapes, our societies, and ourselves.

Therefore, human basic needs and behavioural mechanisms, as well as, personal experience and knowledge, communication barriers, social norms and structures, and motivating elements play a key role for assessments of the different values of nature and landscapes. Moreover, democratization and participation of evaluation processes are decisive to gather important knowledge of people, to motivate for own actions, and to reduce implementation barriers of the evaluation results. Without letting sufficiently participate the public at evaluations of nature and landscapes, they become arbitrary. For instance, the assessment of beauty as an expression of an aesthetic psychological value is highly subjective and cannot be evaluated by scientists on their own on a general level. Nevertheless, a personal emotional and aesthetic motivating contact is as much important as a logically based argumentation to get people involved in practical planning processes and project decisions, as well as, to develop political awareness and actions for a comprehensive interdisciplinary evaluation approach to nature and landscapes. These circumstances need to be considered in all evaluations of planning processes and for project decisions with an impact on nature and landscapes.

Natural sciences and humanities provide the necessary knowledge to apply the different superordinated values by the same evaluation criteria based on discipline specific survey and analysis methods. The common framework of the same evaluation criteria is necessary for each discipline to be able to get comparable results for a participative weighing up process of the society in practical planning processes and for project evaluations with an impact on nature and landscapes. Therefore, the third chapter Criteria for evaluations of nature and landscapes on page 105 gathers a condensed number of the same criteria to allow comparable results for democratic weighing up processes of evaluation results of the different scientific disciplines and their particular methods, i.e. it answers the third question of the research to provide a framework of condensed criteria that can be used to evaluate nature and landscapes according to the particular survey and analysis methods of each scientific discipline (Table 6.7-2).

Table 6.7-2. Condensed number of criteria for evaluations of nature and landscapes (Zisenis 1993, 1998, 2005, modified)

Criteria	
• rarity and endangerment • typicalness • vulnerability • usability	• naturalness/degree of human impacts • re-establishment ability • ecological functions

Moreover, the third chapter Criteria for evaluations of nature and landscapes on page 105 includes several application examples that relate the particular criteria to the different superordinated values for interdisciplinary evaluations of nature and landscapes. Thereby, it makes clear that criteria do not have a (normative) value on their own, because the same criteria can indicate a positive or negative value, respectively, of certain elements, structures, and functions of nature and landscapes to the human being and on their own depending on the particular evaluation case at a specific area and time period, i.e. the particular evaluation criteria must be always considered in a certain spatial and time related context of values determined in a participatory process by the society and personal judgements.

In addition, the third chapter Criteria for evaluations of nature and landscapes on page 105 provides a discussion of selected mainly species and population ecological survey and analysis methods, as well as, concepts within an ecosystem context, which are systematized and allocated to the particular criteria of the interdisciplinary evaluation framework. Nevertheless, it is not possible to relate particular criteria to the different values by general application schemes of certain survey and analysis methods in detail, because the appropriate methods and indicators must be selected by each discipline after pre-studies depending on the particular evaluation case at a certain spatial- and time-scale. However, nature and landscapes themselves cannot directly be asked for their opinion. Therefore, it is an ethical duty to consider their assumed interests as much as possible in the weighing up process of different contradictory values.

Moreover, the third chapter Criteria for evaluations of nature and landscapes on page 105 reveals that the different elements, structures, and functions of nature and landscapes are too complex to be ever completely understood by the human species. It is neither possible to simulate nor to create nature and landscapes completely in their complexity and unpredictable development. This is not only a question of enough knowledge, but also a characteristic feature of the system itself. Complex systems like nature and landscapes, including the diverse relations to the human being, can suddenly have system bounds and breaks, respectively, which can make prognosis of future developments impossible. The assumption that elements, structures, and functions of nature and landscapes could be generally reconstructed by the human being or even re-establish by themselves is misleading for evaluations of nature and landscapes, such as Environmental Impact Assessments (EIA) (cf. chapter 5 Empirical study of Environmental Impact Assessments (EIA) on page 282). It is rather an exception. In practice, the same part of nature and landscapes can hardly re-establish, just a similar one at the best.

Therefore, the precautionary principle should be much more considered in political decisions with an impact on nature and landscapes, especially for evaluations of certain planning and project decisions of unpredictable impacts of new technologies, such as genetically modified organisms. Investigations and evaluations of the background and practical reasons of deteriorations of the different values of nature and landscapes to the human species and on their own, including their interactions, by a comprehensive and participatory evaluation system are much more important than uncertain development prognosis for practical planning processes and project decisions. Moreover, the focus in nature conservation should be in general on providing large habitats that allow natural and human influenced dynamics, and to integrate species metapopulations and their habitat demands in human land use processes of ecosystems. Basically, we can distinguish between subjective perceptions and cognitive interpretations of elements, structures, and functions of nature and landscapes, active interventions of the human being, and self-development. There should be generally more space and time for self-developments ascribed to nature and landscapes in planning processes and project decisions to allow developing elements, structures, and functions of certain participatory weighed up values of nature and landscapes to the human being and on their own, which human beings cannot create themselves, for example, during natural succession processes.

After the third chapter Criteria for evaluations of nature and landscapes on page 105 has already briefly mentioned several interdisciplinary evaluation examples of nature and landscapes, the fourth chapter Evaluation example of neobiota (non-native species) on page 225 of the research proves in detail that the developed interdisciplinary evaluation framework can be sufficiently applied to a certain theoretical example of neobiota in general (cf. 4.3 Evaluation on page 237) and a practical evaluation example of the London Plane-tree (*Platanus x hybrida*) in particular (cf. section 4.3.3 Practical example of the London Plane-tree (Platanus *x hybrida)* on page 274).

Thus, these theoretical and practical evaluation examples of neobiota have proven the flexibility and universal applicability of the proposed framework of condensed criteria and comprehensive values for interdisciplinary evaluations of nature and landscapes (cf. 3.1 General conditions of evaluations on page 106). Their interdisciplinary evaluation is also transparent, because the different evaluation criteria and values are clearly separated. The objectivity is based on using always the same framework of criteria by the different value disciplines for each neobiota evaluation case. They can be repeatedly and comparably applied, independently of the particular scientist. The theoretical and practical evaluation example of neobiota have also confirmed that the proposed interdisciplinary evaluation framework is comprehensive, because it allows systematically covering all values of neobiota while integrating natural sciences, as well as, humanities. Furthermore, the condensed number of criteria allow reliable and validate to determine the different values of neobiota based on appropriate, i.e. additionally efficient and sensitive survey and analysis methods by the different value disciplines. Nevertheless, each particular criterion and value is more or less relevant for different neobiota evaluation cases, because each evaluation case is different.

Consequently, the proposed interdisciplinary evaluation framework can contribute to remove the severe scientific and practical deficits of current evaluation methods of nature and landscapes in Germany that apply several evaluation criteria and methods, but do not clarify sufficiently and comprehensively the determining values, which can cause different results of the same subject (cf. chapter 1.2 Deficits of current evaluation methods on page 12). The suggested interdisciplinary evaluation framework has made clear the background values and motivations that determine, for example, if the diversity or peculiarity are valued positively or negatively by people according to § 1 of Germany’s Federal Nature Conservation Act, respectively. The research has also clarified the reasons according to § 1 of Germany’s Federal Nature Conservation Act that make elements of nature and landscapes beautiful for us, and why nature and landscapes are of higher recreational value to someone.

Thereby, the presented interdisciplinary evaluation framework can contribute to overcome the mentioned grave implementation and acceptance problems, because it takes into account the different particular values of nature and landscapes in a participatory survey, analysis, and weighing up process of the public for practical planning processes and project decisions. The ethical weighing up principle of the different values of nature and landscapes to the human being and on their own is neither impracticable nor irrational. It is also based on a feeling of responsibility for nature and landscapes, which has psychological, culture-historical, educational, and social backgrounds. Due to the fact that nature and landscapes cannot express directly their vote for their intentions of existence and development, including non-living elements, the human being needs to respect and to consider also their value on their own for each planning process and project decision with an impact on them.

Moreover, the fifth chapter Empirical study of Environmental Impact Assessments (EIA) on page 282 confirms by a clear answer to the fifth question of the research that the proposed values and criteria of the comprehensive framework are barely applied in practice to evaluations of nature and landscapes in Germany, i.e. that there is a high practical demand of the suggested interdisciplinary evaluation framework. This empirical study of 51 Environmental Impact Studies (EIS) in Germany of the 1990s reveals the urgent need of an interdisciplinary evaluation framework of comprehensive values and condensed criteria to consider all different values of nature and landscapes to the society, to particular people, and on their own, but also to apply already developed survey and analysis methods of the different value disciplines by the same proposed framework of condensed criteria.

Therefore again, each planning and decision process with an impact on nature and landscapes needs to integrate experience and methods of different scientific disciplines as also urged in chapter 8 of the adopted Agenda 21 during the United Nations Conference on Environment and Development in Rio de Janeiro in 1992 (Quarry, 1992; BMU, 1997). Scientific considerations of planning issues need to combine knowledge and methods of different disciplines (Zehlius-Eckert, 2001). Each discipline needs to develop specific indicators for implementations of local Agendas 21 (cf. Heiland et al., 2003).

In legislation, the Convention on Biological Diversity points out in paragraph 1 of its preamble the intrinsic value of biological diversity and the ecological, genetic, social, economic, scientific, educational, cultural, recreational, and aesthetic values of biological diversity and its components (United Nations, 1992; BMU, ?). However, in practice there are very few examples of integrated interdisciplinary approaches to nature and landscapes, for instance, Biosphere Reserves designated by the Programme Man and the Biosphere (MAB Programme) of United Nations Educational, Scientific and Cultural Organization (UNESCO) (cf. Erdmann et al., 1995; Schröder, 1996; UNESCO, 1995, 1996, 2002; Erdmann, 1998, 1999, 2000; Schröder et al., 1998; Jardin et al., 2000; Gündling, 2002; Bridgewater and Bouamrane, 2003; Heinze et al., 2003). UNESCO's intention of Biosphere Reserves concerns different aspects (Table 6.7-3).

Table 6.7-3. UNESCO's intentions of Biosphere Reserves (Erdmann and Frommberger, 1999)

Functions of UNESCO's Biosphere Reserves	
Protection	• to contribute to the preservation of landscapes, ecosystems, species, and genetic diversity
Development	• to support economic and human developments, which are socio-culturally and ecologically sustainable
Logistic support	• to promote demonstration programmes, education and training of nature, as well as, research and environmental monitoring within the context of local, regional, national, and worldwide subjects of protection and sustainable development

However, administrations of Biosphere Reserves are frequently concentrated at nature conservation departments in Germany, which do not sufficiently integrate the interdisciplinary approach of Biosphere Reserves. In addition, participation of the public in establishing Biosphere Reserves often just takes part at relatively late obligatory legal stages (Brodda, 2001).

Furthermore, the empirical study of 51 Environmental Impact Studies (EIS) in Germany of the 1990s makes it also obvious that there are some general methodical remarks necessary on the methods of evaluation systems of nature and landscapes as a result of the severe deficits of current evaluation approaches that are also criticized by different authors, which are given in the sixth chapter. They concern comments to mathematical and descriptive evaluation methods, respectively, model guidelines of value targets, monitoring schemes of data on nature and landscapes, visualizations methods, classification types, and habitat-mapping methods.

The current evaluation methods of nature and landscapes have revealed grave deficits in underestimating public economic, social, psychological, culture-historical, educational, and scientific values to the human species, but also of ethical values of elements, structures, and functions of nature and landscapes on their own. The research provides a substantially underpinned and critically discussed framework of comprehensive values and condensed criteria, as well as, common discipline specific survey and analysis methods, which integrates humanities, as well as, natural sciences. This interdisciplinary evaluation approach allows integrating the different demands, life-situations, and backgrounds of people by systematically considering the different values of nature and landscapes to the human being and on their own.

It is the author's hope to contribute with the proposed interdisciplinary evaluation framework of comprehensive values and condensed criteria to fill the scientific gap of current deficits of evaluation systems of nature and landscapes, but also to rise the awareness and the weight of the often underestimated public values in practical participatory planning processes and project decisions.

8. **Outlook into future research**

This research provides an interdisciplinary evaluation framework of comprehensive values of nature and landscapes and condensed criteria for their measurement, as well as, a general discussion including their common methods. However, there is still an urgent need to refine these methods in all disciplines to a necessary transparent and practical extend (cf. chapter 3.1 General conditions of evaluations on page 106) in accordance with the public consciousness and in relation to the mentioned criteria.

There is also a lot of further research needed to which extend indicators of each discipline can be applied to survey and to analyse the conditions of nature and landscapes and what are their limits to reveal (cf. chapter 6.1 Mathematical and descriptive methods on page 299 and section 3.2.4.1 Indicator species on page 159, respectively). Moreover, there is an intensification necessary of the dialogue between basic research of sciences, applied sciences, and practical issues concerning nature and landscapes (Kals, 1996). Furthermore, intercultural research is necessary to sort out individual consciousness of nature and landscapes and practical behaviour towards them in different cultural and social groups, as well as, societies (cf. WBGU, 1999b; Renn, 2001).

Concerning ecological methods, there are still huge research deficits of evaluations of nature and landscapes on taxonomic, autecological, population dynamic, biocoenosis, ecosystem, and landscape levels (overview in Holz and Kaule, 1997; for ecosystems in Dierßen, 1999, 2000b). For instance, many youth life-stages of insects are not yet identified on species level in Central Europe. Furthermore, in the tropics many amphibian, “reptiles”, and small mammal species are not yet classified, as well as, even more insect species and other tropical invertebrates.

There are important evaluation measures unknown even for relatively abundant mammals and birds in Central Europe, as well as, for most invertebrates, such as minimum areas for survival. In addition, changes of spatial and time occurrences and valences are only known in some cases (Nagel, 1999). The Minimum Viable Metapopulation Concept (MVP) has not yet been developed to a stage of possible practical implementation depending on time and energy resources in practical planning and decision processes, despite there are some promising initiatives (cf. section 3.2.2.5 Population Vulnerability Analysis (PVA) on page 131). Concepts for keystone species need to be developed and to be applied to a much wider extend including dynamic processes in sciences and in the public.

In addition, there are further investigations necessary on material, energetic, and informative interactions on habitat and biocoenosis levels, as well as, on structures and dynamics of ecosystems (cf. Dierßen, 2000b; overview in Fränzle, 1998; von Haaren et al., 2003).

There is a general need of monitoring schemes concerning abiotic and biotic resources including their interactions, as well as, of human values and developments to provide reference scales for evaluations of nature and landscapes. Participatory and public agreed model guidelines need to be established for all development processes of nature and landscapes, including scientific research demands of benefits and interdisciplinary development perspectives of nature and landscapes on global level (cf. WBGU, 1996).

Furthermore, there is further research and practical implementation necessary to improve the public consciousness and behaviour as a correlating factor of the evaluation of nature and landscapes itself. Sciences and humanities need to come together for interdisciplinary research projects to provide practical application examples for the integrated framework of comprehensive values and criteria. Moreover, the coherent concept of the different values of nature and landscapes needs to be institutionalized by structures, persons, and mechanisms in all parts of our societies in research, law, and politics (cf. WBGU, 1999a, 2000).

Evaluation of nature and landscapes is a permanently dynamic process. Therefore, scientific research and public implementations are simultaneously and continuously necessary on intellectual and emotional levels. Nature conservation is a never-ending creative process of questioning and evaluating the relation to us, to other human beings, and nature and landscapes also for their own value.

9. Brief German summary („Zusammenfassung“)

Natur und Landschaft beinhalten alle Lebensfelder des Menschen sowie der Fauna und Flora in wechselseitiger Beziehung. Für Bewertungen von Natur und Landschaft ist es deshalb unerlässlich, diese einzelnen Lebensbereiche umfassend zu erfassen, zu analysieren und zu bewerten.

Die vorliegende Forschungsarbeit widmet sich deshalb einem Rahmen von umfassenden Werten und Kriterien für die interdisziplinäre Bewertung von Natur und Landschaft. Hierfür unterscheidet sie zwischen einer Wertebene der verschiedensten individuellen und gesellschaftlichen anthropozentrischen Ansprüche an Natur und Landschaft sowie ihrem nicht-anthropozentrischen Wert um ihrer selbst willen (vgl. Table 6.7-1).

Table 6.7-1. Die verschiedenen Werte von Natur und Landschaft (Zisenis 1993, 1998, 2005, verändert)

Werte von Natur und Landschaft	
• ethische	• ökonomische • psychologische • kulturhistorische • soziale • erzieherische • wissenschaftliche

Auf der Ebene der Anwendung dieser umfassenden Werte von Natur und Landschaft werden bereits entwickelte Bewertungskriterien für gemeinsame Bewertungen der verschiedenen Fachdisziplinen zusammengefasst, die jeweils nach ihren eigenen Erfassungs- und Analysemethoden arbeiten (vgl. Table 6.7-2).

Table 6.7-2. Zusammengefasste Bewertungskriterien von Natur und Landschaft (Zisenis 1993, 1998, 2005, verändert)

Bewertungskriterien von Natur und Landschaft

• Seltenheit und Gefährdung	• Natürlichkeit/Hemerobie[49]
• typische Eigenschaft	• Wiederentstehungsmöglichkeit
• Empfindlichkeit	• ökologische Funktion
• Nutzbarkeit	

Folglich führen im Idealfall Wissenschaftler der verschiedenen Fachdisziplinen unter Beteiligung der Öffentlichkeit eine Einzelfallbewertung mit räumlichem und zeitlichem Bezug nach den vorgestellten einheitlichen Bewertungskriterien durch. Für konkrete Handlungsempfehlungen und Entscheidungen müssen die daraus resultierenden konkurrierenden Werte gegeneinander abgewogen werden.

Vielfach sind Vollzugs- und Akzeptanzprobleme von Maßnahmen des Naturschutzes und der Landschaftspflege zu beklagen, die sich in Kommunikationsproblemen der einseitig auf naturwissenschaftliche Fachdisziplinen ausgerichteten Bewertungsverfahren und ihren nicht einheitlichen Bewertungskriterien und damit oftmals wenig nachvollziehbaren Bewertungsmethoden begründen. Die vorliegende Dissertation schließt diese Erkenntnislücke, indem sie den Ansatz eines umfassenden interdisziplinären Bewertungsrahmens und eine Diskussion der gängigen Erfassungs- und Analysemethoden der einzelnen Fachdisziplinen vorstellt.

Darüber hinaus erörtert die Forschungsarbeit die gesellschaftlichen und persönlichen Hintergründe der einzelnen Werte in einem interaktiven dynamischen Entwicklungsprozess gegenüber Natur und Landschaft und zieht daraus Schlüsse für die Anwendung eines interdisziplinären Bewertungsverfahrens.

Anhand eines theoretischen und praktischen Beispiels der Neobiota[50] sowie einer empirischen Untersuchung von 51 Umweltverträglichkeitsstudien aus der Bundesrepublik Deutschland aus den 90er Jahren wird die Anwendung des fachübergreifenden Bewertungsrahmens diskutiert und der hohe Bedarf aufgezeigt.

[49] Hemerobie drückt das Maß des menschlichen Einflusses aus (vgl. Kowarik, 1999, Klotz and Kühn, 2002).

[50] Neobiota sind nichteinheimische Arten, die nur mit direkter oder indirekter Unterstützung von Menschen in ein Gebiet gelangt oder aus solchen Arten entstanden sind (Kowarik, 2003).

Schließlich wird ein kurzer Überblick über einige Forschungsdefizite gegeben, insbesondere des Entwicklungsbedarfs geeigneter Indikatoren für den i.d.R. begrenzt zur Verfügung stehenden Erhebungs-, Analyse- und Bewertungszeitraum sowie –umfang.

Es bleibt zu hoffen, mit dem vorgestellten interdisziplinären Bewertungsrahmen zu einer umfassenden wissenschaftlichen Bewertung der individuellen und gesellschaftlichen Werte von Natur und Landschaft beizutragen, um nicht zuletzt aus ihrem Eigenwert heraus zu einer stärkeren Berücksichtigung in alltäglichen abwägenden Entscheidungsprozessen zwischen verschiedenen öffentlichen und privaten Belangen zu führen.

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11. Figures

12. **Tables**

13. **Index**

14. **Appendix**

14.1 List of case studies

The following 51 Environmental Impact Studies (EIS) (Table 14.1-1) have been taken by chance out of a representative sample of 145 Environmental Impact Assessments (EIA) from different Federal States in Germany dating from the 1990s (Wende, 2001, 2002). Non-available Environmental Impact Studies are put into brackets and indicated in italics, which were not investigated.

Table 14.1-1. 51 Environmental Impact Studies (EIS) of the empirical research from different Federal States in Germany dating from the 1990s

Federal State of Germany (sample no.) and project type[51]	**Reference of Environmental Impact Study (EIS)**
Baden-Württemberg (1) • „road construction“	Trautner, J.; Menz, N.; Leisner, B.; Haak, S.; Sombrutzki, A.; Bauer, H.-G.; Ley, H.-W.; Rietzke, J.; Löderbusch, W.; Banzhaf, R.; Hermann, G.; Buchweitz, M.; Bense, U.; Peissner, T.; Kappus, B. and N.N. (1994). *Umweltverträglichkeitsstudie B 30 Nordbogen Ravensburg, IV. Bauabschnitt Niederbiegen-Egelsee. Fachgutachten „Pflanzen, Tiere und ihre Lebensräume“*. Arbeitsgruppe für Tierökologie und Planung H. Reck und J. Trautner, Filderstadt, Germany. 122 pp. + appendix. Schettler, W.; Perstrup, S.; Bickel, I.; Trautner, J.; Aschauer, J.; Krüger, C.; Nagel, T.; Bösinger, R.; Schaechterle, K. and H. Siebrand (1995). *Umweltverträglichkeitsstudie zur B 30 Nordbogen Ravensburg, BA IV*. Entwicklung- und Freiraumplanung Prof. Dipl.-Ing K. Eberhard + Partner, Konstanz, Germany. 187 pp. + appendix.
Baden-Württemberg (43) • “waterways, expansion of waterways, dikes, etc.”	Böhler, U. and P. Frentzel (1996). *Neuerteilung der Wasserentscheidung vom 29.01.1969 für das Wasserwerk Hardtwald. Unterrichtung über den voraussichtlichen Untersuchungsrahmen der UVP (Scoping gem. § 5 UVPG)*. Mailänder Geo Consult GmbH, Karlsruhe, Germany. 7 pp. + appendix. Mailänder, T.; Böhler, U. and B. Mager (1996). *Umweltverträglichkeitsstudie zur Neuerteilung der wasserrechtlichen Bewilligung für das Wasserwerk Hardtwald der Stadtwerke Karlsruhe*. Mailänder Geo Consult GmbH, Karlsruhe, Germany. 74 pp. + appendix.
(Bayern (9) • *„road construction“*	*Straßenbauamt Kronach und Regierung von Oberfranken (1990?). Staatsstraße 2194 „Geroldsgrün-Helmbrechts-Müncheberg“. Verlegung südlich Meyerhof von Straßen-km 16,813-21,107. Straßenbauamt Kronach, Kronach, und Regierung von Oberfranken, Germany.)*
Bayern (2) • „road construction“	Baier (1990). *Bundesstraße 11. Deggendorf-Bayerisch Eisenstein. Verlegung bei Regen von km 64,5 (B 85) bis km 105,1 (B11). Ergänzendes Raumordnungsverfahren für eine Bundesfernstraßenmaßnahme.*

[51] Classification names in inverted commas according to the definition and English translation by Wende (Wende, 2002).

Erläuterungsbericht. Straßenbauamt Deggendorf, Deggendorf, Germany. 60 pp. + appendix.

(Bayern (5)

- *„road construction“*

Regierung von Oberfranken, Nürnberg (1992?). Bundesautobahn A 93 ROV Hof-Weiden-Regensburg. Ortsumgehung Hof, A 72-Rehau.)

Bayern (130)

- „facilities defined in the Land Consolidation Directive“

Neukirchner (1993). *Ländliche Entwicklung in Dorf und Flur. Verfahren Flachslanden, Landkreis Ansbach. Erläuterungsbericht zum Plan über die gemeinschaftlichen und öffentlichen Anlagen (Plan nach § 41 FlurbG). Teil 2: Umweltverträglichkeitsstudie*. Stadt Ansbach, Ansbach, Germany.

Bayern (104)

- „railroad installations“

Igi Niedermeyer GmbH (1993). *Erläuterungsbericht zur landesplanerischen Abstimmung für die Ausbaustrecke Nürnberg-Ebensfeld. Beilage 3 Umweltverträglichkeitsstudie*. Igi Niedermeyer GmbH, Westheim, Germany. 295 pp. + appendix.

Bayern (3)

- „road construction“

Schanze, J.; Merz, W.; Kunze, P.; Meier, H. and C. Ottmann (1993). *Umweltverträglichkeitsstudie (UVS) zur Planfeststellung B 11. Verlegung bei Regen von Bau-km 0-208 bis Bau-km 2+200*. Planungsbüro Zimmermann, Straubing, Germany. 90 pp. + appendix.

Schanze, J.; Merz, W.; Karnath, H. and P. Kunze (1994). *Regen B 11. Verlegung bei Regen. Landschaftspflegerischer Begleitplan*. Planungsbüro Zimmermann, Straubing, Germany. 61 pp. + appendix.

Bayern (131)

- „facilities defined in the Land Consolidation Directive“

Pirkl, A.; Riedel, B. and R. Theurer (1994). *STUBLANG. Landschaftsplanung in der ländlichen Entwicklung. Stufe 1 mit UVS-Grobphase*. Landschaftsbüro Pirkel-Riedel-Theurer, Freising-Tüntenhausen, Germany. 66 pp. + appendix.

Pirkl, A.; Riedel, B. and R. Theurer (1997). *Umweltverträglichkeitsstudie (UVS)-Feinphase. Verfahren Stublang*. Landschaftsbüro Pirkel-Riedel-Theurer, Landshut, Germany. 24 pp.

Pirkl, A.; Riedel, B. and R. Theurer (1997). *Landschaftsplanung in der ländlichen Entwicklung. Stufe 2-Gestaltung. STUBLANG*. Landschaftsbüro Pirkel-Riedel-Theurer, Landshut, Germany. 35 pp.

Bayern (77)

- „holiday villages, hotels, recreational

Böhringer, R. and M. Schlichtiger (1996). *Raumordnungsverfahren „Lerchenhügel“ Markt Bad Steben. Antrag auf Landesplanerische Überprüfung eines Golfstandortes im Gebiet des Marktes Bad Steben.*

facilities“

Landschaftsarchitekt BDLA Dipl.-Ing. Raimund Böhringer, Bad Alexandersbad, Germany. 42 pp. + appendix.

<u>Bayern (78)</u>

- „holiday villages, hotels, recreational facilities“

Küstner, R. (1997). *Freizeitsee Küps/Oberlangenstadt. Landkreis Kronach, Regierungsbezirk Oberfranken. Erläuterungsbericht*. Rainer Küstner, Warmensteinach, Germany. 23 pp. + appendix.

<u>Berlin (141)</u>

- „tramways, subways“

VEPRO GmbH Berlin (1997). *Verkehrsanlagen Alexanderplatz. Neubau der Straßenbahnstrecke Mollknoten-Alexanderplatz-Hackescher Markt. 2. Baulos: Gontardstraße-Hackescher Markt. Umweltverträglichkeitsstudie*. VEPRO GmbH Berlin, Berlin, Germany. 37 pp. + appendix.

VEPRO GmbH Berlin (1998). *Verkehrsanlagen Alexanderplatz Straßenbahnneubau. Planfeststellung – 2. Planfeststellungsabschnitt – Landschaftspflegerischer Begleitplan*. VEPRO GmbH Berlin, Berlin, Germany. 36 pp. + appendix.

<u>Brandenburg (137)</u>

- „power supply lines“

Baader, P.; Günther, J.; Henkel, M.; Pfeiffer, M.; Engels, H. and D. Herold (1992). *110-kV-Bahnstromleitung Priort-Golm mit Unterwerk Golm. Untersuchungen zur Umweltverträglichkeit*. Igi Niedermeyer GmbH, Westheim, Germany. 134 pp. + appendix.

<u>(Brandenburg (80)</u>

- *„holiday villages, hotels, recreational facilities“*

Ministerium für Umwelt, Naturschutz und Raumordnung des Landes Brandenburg (1992). Raumordnungsverfahren mit integrierter Umweltverträglichkeitsprüfung „Sport- und Freizeitzentrum Potsdam-Land“ in Uetz-Paaren, Kreis Potsdam-Land)

<u>(Brandenburg (72)</u>

- *„industrial, shopping, and service centres“*

Magistrat Potsdam (1992?). ROV Sterncenter Potsdam-Drewitz. Nuthestraße. Gemeinsame Landesplanungsabteilung Berlin-Brandenburg, Berlin, Potsdam, Germany.)

<u>Brandenburg (18)</u>

- „road construction“

Froelich and Sporbeck (1992). *Umweltverträglichkeitsstudie zum Ausbau der A 10 Berliner Ring (AS Rüdersdorf – AD Spreeau)*. Froelich & Sporbeck, Bochum, Plauen, Germany i.V., Germany. 86 pp. + appendix.

Froelich and Sporbeck (1995). *Faunistische Untersuchungen im Rahmen der UVS und des LBP zum Ausbau der A 10 (Berliner Ring) zwischen Rüdersdorf und Dreieck Spreeau. Erläuterungsbericht*. Froelich &

	Sporbeck, Bochum, Plauen, Germany i.V., Germany. 60 pp. + appendix.
Brandenburg (107) • „open cast mining“	Ingenieurgesellschaft für Geologie Dr. Hultzsch GmbH (1996). *Rahmenbetriebsplan*. Ingenieurgesellschaft für Geologie Dr. Hultzsch GmbH, Stahnsdorf, Germany. 45 pp. + appendix.
Brandenburg (108) • „open cast mining“	Ingenieurgesellschaft für Geologie Dr. Hultzsch GmbH (1996). *Rahmenbetriebsplan Sandgewinnung Fohrder Berg. Teil 2. Umweltverträglichkeitsstudie*. Ingenieurgesellschaft für Geologie Dr. Hultzsch GmbH, Stahnsdorf, Germany. 90 pp. + appendix. AG Landschafts- und Ortsplanung Ingenieurbüro Petrick & Partner (1996). *Ökologische Studie zur Umweltverträglichkeitsprüfung Sandtagebau Fohrde*. AG Landschafts- und Ortsplanung Ingenieurbüro Petrick & Partner, Brandenburg, Germany. 34 pp. + appendix.
Brandenburg (45) • “waterways, expansion of waterways, dikes, etc.”	Schwalb, O.; Keller, T.; Wettstein, C. and M. Wichmann (1996). *Verkehrsprojekt „Deutsche Einheit“ Nr. 17. Ausbau der Wasserstraßenverbindung Hannover-Magdeburg-Berlin. Neubau der Straßenbrücke Paaren-Falkenrehde (B 273) über den Havelkanal, HvK-km 30,18. Planfeststellungsverfahren. Umweltverträglichkeitsstudie*. Institut für Umweltstudien Weisser & Ness GmbH, Potsdam, Germany. 100 pp. + appendix.
Brandenburg (46) • “waterways, expansion of waterways, dikes, etc.”	PAN Planungsgesellschaft ARSU-NWP mbH (1996). *Havel-Auen Werder. Anlage eines Stichkanals/Bootshafens. Umweltverträglichkeitsstudie mit integriertem Landschaftspflegerischen Begleitplan*. PAN Planungsgesellschaft ARSU-NWP mbH, Potsdam, Germany.
Brandenburg (81) • „holiday villages, hotels, recreational facilities“	Walther, K.; Kunze, G.; Kubat, R.; Zimmermann, G.; Wiedemann, B.; Reuter, C.; Reichel, F.; Schönheinz, D.; Schulz, K.-H.; Stiller, B.; Bertl, R. and W. Neumann (1997). *Umweltverträglichkeitsstudie (UVS) „Spreewaldpark Lübben“*. Günther & Partner Cottbus GmbH, Cottbus, Germany. 213 pp. + appendix.
Brandenburg (109) • „open cast mining“	Schüler, W. (1997). *Umweltverträglichkeitsstudie zum Vorhaben Kiessandabbau Koßdorf-West I*. Büro für Landschaftsplanung, -pflege und Naturschutz (BLLN) Dr. W. Schüler, Bernburg, Germany. 104 pp. + appendix.
Brandenburg (79)	GPLE GmbH (1998). *Sarcon Ferienpark Fürstenberg. Prüfungsunterlagen zum Raumordnungsverfahren*. GPLE

• „holiday villages, hotels, recreational facilities“	Grundstückspartner für Liegenschaftsentwicklung GmbH i.G., Berlin, Germany. 56 pp. + appendix.
	Gemeinsame Landesplanungsabteilung Berlin-Brandenburg (1998). *Landesplanerische Beurteilung Sarcon Ferienpark Fürstenberg*. Gemeinsame Landesplanungsabteilung Berlin-Brandenburg, Berlin, Potsdam, Germany. 26 pp.
Bremen (142) • „tramways, subways“	Kölling, A.; Storz, G.; Luft, S.; Weiler, D.; Handke, K.; Handke, P.; Behrens, A.; Dettmar, B.; Gerold, J. and G. Hahn (1994). *UVS und LBP. Verlängerung der Straßenbahnlinie Riensberg–Universität*. Planungsgruppe grün köhler, storz und partner, Bremen, Ovelgönne-Frieschenmoor, Germany. 85 pp. + appendix.
Bremen (20) • „road construction“	Warming, A.; Bolte, D.; Bonk, M.; Maire, W.; Hoppmann, G. and N.N: (1995). *Umweltverträglichkeitsstudie zum Ausbau des 4. Bauabschnitts der Hafenrandstraße in Bremen*. Büro Schreckenberg und Partner, Bremen, Berlin, Leipzig, Stralsund, Germany. 130 pp. + appendix.
Bremen (97) • „ambient environmental quality projects“	Heuwinkel, J.; von Glowczewski, R. K.; Korn, S.; Nguyen, T.; Schlichting, A.; Weidmann, P. and M. Zingk (1995). *Umweltverträglichkeitsuntersuchung zur geplanten Klärschlammmitverbrennung im Kraftwerk Farge*. Technischer Überwachungs-Verein Nord e.V., Hamburg, Germany.
Bremen (48) • “waterways, expansion of waterways, dikes, etc.”	AGL-Institut für Angewandte Gewässerkunde und Landschaftsökologie (1995). *Airport-Gewerbezentrum. Wasserrechtliches Verfahren. Landschaftspflegerischer Begleitplan*. AGL-Institut für Angewandte Gewässerkunde und Landschaftsökologie, Bremen, Germany. 69 pp. + appendix.
	Stiehler and Partner (1996). *Airport-Gewerbezentrum. Wasserrechtliches Verfahren. Zusammenstellung zur UVP nach & 6 UVPG*. Stiehler & Partner, Bremen, Germany. 34 pp. + appendix.
Hessen (52) • “waterways, expansion of waterways, dikes, etc.”	Wasserwirtschaftsamt Marburg (1985). *Durchführung der Umweltverträglichkeitsprüfung (UVP) im wasserrechtlichen Verfahren. Grundwassererschließung der Oberhessischen Versorgungsbetriebe AG (OVAG) in der Gemeinde Mücke (Ohmgebiet).* Wasserwirtschaftsamt Marburg, Marburg, Germany.

Hessen (132)

- „facilities defined in the Land Consolidation Directive“

Böger, K. and G. Rausch (1994). *Umweltverträglichkeitsuntersuchung für den Weg 353a im Flurbereinigungsverfahren Wächtersbach-Aufenau II*. Naturplan, Darmstadt, Germany. 27 pp. + appendix.

Hessen (127)

- „pipelines“

Kosack, L. and M. Löffler (1996). *Bau einer Erdgasfernleitung. Westdeutsche Anbindungsleitung, Wedal II, Werl-Aachen, Bauabschnitt 3: Wuppertal-Monheim. Raumordnungsverfahren*. INGE WEDAL II, NAFU, pro-mont, Schöneiche, Berlin, Germany. 132 pp. + appendix.

Hessen (138)

- „power supply lines“

Bechtold, B. and W. Riehm (1998). *Umweltverträglichkeitsuntersuchung für das Freileitungsbauvorhaben 380-kV-Hochspannungsfreileitung Dauersberg-Limburg-Kriftel. Abschnitt Landesgrenze Rheinland-Pfalz/Hessen-Limburg der RWE Energie Aktiengesellschaft. Fassung vom 25. Februar 1998*. Regioplan Ingenieure GmbH, Mannheim, Liegau-A., Germany. 86 pp.

Hessen (15)

- „holiday villages, hotels, recreational facilities“

Planungsgruppe Stadt + Land (1999). *Umweltverträglichkeitsuntersuchung zur Errichtung eines Freizeitcenters in der Stadt Bad Wildungen*. Planungsgruppe Stadt + Land, Kassel, Germany. 28 pp. + appendix.

Stübing, S. (1999). *Faunistische Untersuchungen im Bereich des geplanten „Freizeitcenters Bad Wildungen“*. Planungsgruppe Stadt + Land, Kassel, Germany. 20 pp.

Mecklenburg-Vorpommern (53)

- “waterways, expansion of waterways, dikes, etc.”

Tepper and Kinttof-Westphal (1995). *Rückbau Wehr Eickhof. Umweltverträglichkeitsstudie*. GfL Planungs- und Ingenieurgesellschaft GmbH, Güstrow, Germany. 17 pp.

Niedersachsen (27)

- „road construction“

Krämer, B.; Lohrberg, F. and K. Hanebeck (1993) *Ergänzung der Umweltverträglichkeitsstudie zur Autobahn 26 Stade-Horneburg (I. Bauabschnitt)*. Gruppe Freiraumplanung, Hannover, Germany. 174 pp. + appendix.

Krämer, B. and F. Lohrberg (1993). *Landschaftspflegerischer Begleitplan zur geplanten Autobahn 26 Stade-Horneberg (I. Bauabschnitt)*. Gruppe Freiraumplanung, Hannover, Germany. 73 pp. + appendix.

Niedersachsen (134)

- „facilities defined in the Land Consolidation Directive"

Borchers, Gerders (1995?). *Plan über die gemeinschaftlichen und öffentlichen Anlagen. Plan nach § 41 FlurbG. Vereinfachte FlurbereinigungOstervesede, Landkreis Rotenburg (Wümme)*. Erläuterungsbericht. Amt für Agrarstruktur, Verden, Germany. 46 pp. + appendix („*Ergänzende Erläuterungen zur Umweltverträglichkeitsprüfung (UVP*)").

Niedersachsen (143)

- „tramways, subways"

Zimmermann, T.; Poll, M.; Meininghaus, F.; Luft, S.; Nahrmann, A.; Bach, L. and T. Junge (1997). *Umweltverträglichkeitsstudie zur Verlängerung der Straßenbahnlinie 4 von Borgfeld bis zum Falkenberger Kreuz. Band II. Wirkungsanalyse*. BPR Beraten Planen Realisieren Dipl.-Ing. Bernd F. Kühne, Hannover, Germany. 43 pp. + appendix.

Niedersachsen (9)

- „road construction"

Zawadzki, R. (1998). *Allgemein verständliche Zusammenfassung gem. § 6 UVPG für den Neubau der Barumer Kreuzung im Zuge der B 4/K 11*. Dipl.-Ing. Rainer Zawadzki, Lüneburg, Germany. 36 pp. + appendix.

Nordrhein-Westfalen (120)

- „waste disposal"

Bühner (1991). *Ökologischer Fachbeitrag zur Umweltverträglichkeitsprüfung „Mülldeponie Coesfeld-Höven"*. Büro für Landschaftsplanung Bühner, Arnsberg, Germany. 45 pp.

Gallenkemper, B. and R. Eitner (1992). *Umweltverträglichkeitsuntersuchung zur Erweiterung der Deponie Coesfeld-Hoeven*. IWA Ingenieurgesellschaft für Wasser- und Abfallwirtschaft, Ennigerloh-Enniger, and Ingenieurbüro Schmelzer & Flick, Ibbenbüren, Germany. 233 pp.

Nordrhein-Westfalen (101)

- „ambient environmental quality projects"

Häring, S.; Beck, A.; Leindecker, T.; Kleiser, T.; Dröscher, F.; Mast, G.; Sommer, B.; Gommeringer, K. and B. Flex (1994). *Beschreibung der zu erwartenden erheblichen Auswirkungen des Vorhabens der Errichtung und des Betriebes einer Restmüllverbrennungsanlage auf die Umwelt (§ 4 e 9. BImSchV) unter Berücksichtigung des allgemeinen Kenntnisstandes und der allgemein anerkannten Prüfungsmethoden*. TÜV Energie und Umwelt GmbH, Filderstadt-Bonlanden, Germany. 135 pp.

Nordrhein-Westfalen (57)

- "waterways, expansion of waterways, dikes, etc."

Schleuter, M. (ed., 1994). *Umweltverträglichkeitsuntersuchung zum Ausbau des Dortmung-Ems-Kanals. DEK-km 59,200 – 62,000*. Bundesanstalt für Gewässerkunde, Koblenz, Germany. 192 pp. + appendix.

Nordrhein-Westfalen (30)

- „road construction“

Froelich and Sporbeck (1994). *Umweltverträglichkeitsuntersuchung zum Ausbau der BAB 2 – Hamm-Osttürmen bis Lippequerung. Erläuterungsbericht*. Froelich & Sporbeck, Bochum, Planen i.V., Greifswald, Potsdam, Germany. 59 pp. + appendix.

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