3 Theories and Methods for Ecosystem Services Assessment in Landscape Planning

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Abstract
This chapter introduces the key theoretical and methodological concepts for landscape planning in Europe. A short portrait of landscape planning and its contribution to supporting sustainable landscape development provides insights into the capabilities of an integrative environmental planning tool that cuts across different sectors and levels of decision-making. The chapter then presents landscape planning procedures following the so-called DPSIR framework – Driving forces, Pressures, the State of the landscape, Impacts, and potential Response options. A subsequent discussion outlines how the concept of ecosystem services can be adapted to best integrate with the practice-oriented focus of landscape planning. Finally, the chapter provides some guidance on methodological aspects of landscape planning for ecosystem services, acknowledging the multiple types of values, scale issues, and the need for comparability of results, communication of uncertainties and transparency in the derivation of responses.

Keywords
Landscape planning · Ecosystem services · Methodology · DPSIR

The original version of this chapter was revised: The Fig. 3.3 has been updated now. The correction to this chapter is available at https://doi.org/10.1007/978-94-024-1681-7_32

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C. von Haaren et al. (eds.), *Landscape Planning with Ecosystem Services*,
Landscape Series 24, https://doi.org/10.1007/978-94-024-1681-7_3

3.1 Introduction

Biodiversity and ecosystem services are under pressure in Europe, as is particularly obvious at regional and local levels. Different land uses and conservation needs compete and there is a need to mitigate conflicts and to coordinate and optimize land use patterns in a sustainable way (cf. Chap. 7). Landscape planning can contribute to minimizing conflicts and delivering solutions if it is based on sound ecological data, a legitimized evaluation of the ES in the landscape and takes into account the preferences and knowledge of the local population. To be effective, landscape planning proposals need to be supported and implemented by decision makers, stakeholders and the public.

The choice of theories, concepts and methods to be applied in landscape planning is thus driven by consideration of the conditions for local and regional implementation of actions for the conservation and sustainable use of biodiversity and ecosystem services (for overview on planning theories see Hillier and Healey 2010; Allmendinger 2017; van den Brink et al. 2017). Landscape planning methods therefore need to provide results in a transparent and comparable way, and they need to provide assessments, valuation and proposals that integrate across the diverse and fragmented implementation contexts as reflected by various sectors and levels of decision-making (Leitão and Ahern 2002; Selman 2006; Albert et al. 2016a, b; BenDor et al. 2017). The aim of this chapter is to introduce key theoretical and methodological concepts with relevance for landscape planning in Europe. The chapter thus provides the theoretical background and describes the application context of all procedures and methods presented in the subsequent sections of this book.

3.2 Landscape Planning in a Nutshell

The definition of landscape planning applied in this book follows the European Landscape Convention (Council of Europe 2000: art. 1), characterizing it as “strong forward-looking action to enhance, restore and create landscapes” (see Chap. 1). Given this broad understanding, landscape planning arguably provides a proactive approach for bridging the fragmented efforts relating to the conservation and sustainable use of biodiversity and ecosystem services across different sectors and levels of decision making (cf. Selman 2010). In most European countries, there is a form of planning system comprising spatial, urban development and conservation planning activities that oversees, for example, the implementation of the Water Framework Directive or the Habitats Directive. Landscape planning can contribute to this process by either supplying a multifunctional, environmental perspective or by using the information available to provide an integrated multifunctional concept of landscape development. For this purpose, landscape planning must generate *a comprehensive, spatially-explicit information base* that supports the precautionary consideration and integration of biodiversity and ecosystem services into land use decision processes and fosters efficient implementation. The potential users of information generated by landscape planning are policy makers, stakeholders and the public. For application and implementation, landscape planning needs to provide place-based outcomes in the form of maps – particularly on local and regional scales (cf. Ogrin 1994; Gruehn and Kenneweg 1998; Reinke 2002; Nassauer and Opdam 2008).

Landscape planning plays an important role in combining *proactive* and *reactive* instruments with the overall objective of mainstreaming the consideration of biodiversity and ecosystem services in all spatially relevant decisions by public authorities or private project investors (Fig. 3.1). *Proactive* planning supports the implementation of conservation efforts by area protection and maintenance e.g. by adoption of agri-environmental measures (AEM) as well as restoration of impaired landscapes. Furthermore, it supplies an information base with data, evaluations and objectives relating to ecosystem services, which can support *reactive* instruments. *Reactive* planning is triggered by programme activities or projects and seeks to adapt resulting land use changes to the principles of environmentally-friendly development e.g. through the screening process in a Strategic Environmental Assessment (SEA) or Environmental Impact Assessment (EIA).

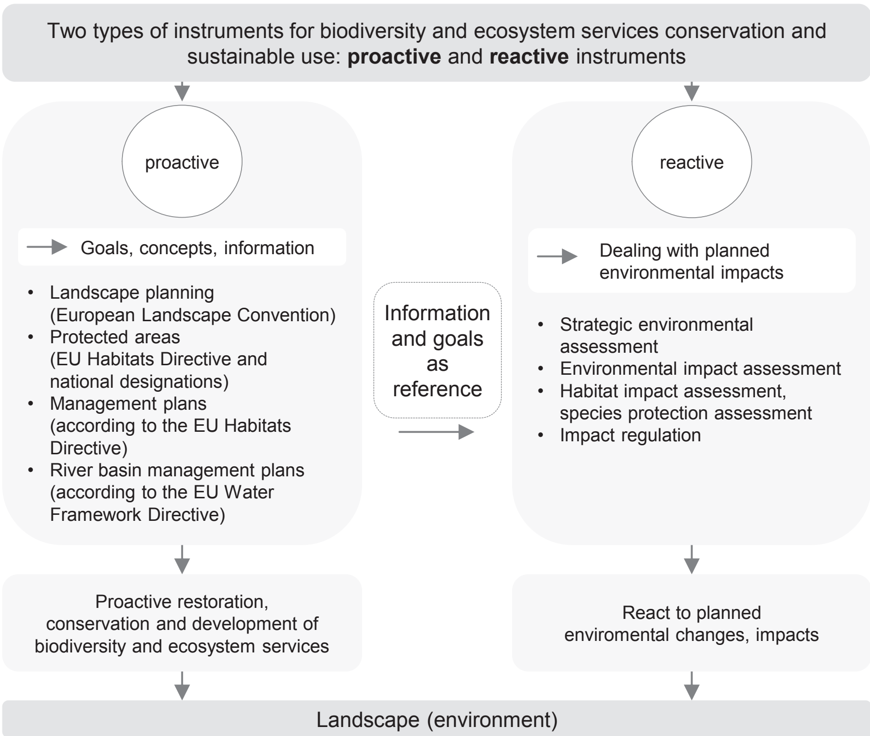

Fig. 3.1 Two types of instrument for considering ecosystem services in spatial decisions. Landscape planning is important for proactively pursuing environmental goals and as an information and evaluation basis for instruments which respond to planned interventions such as environmental impact assessments and offset mechanisms

Both types of instrument can use the methods presented in this book concerning the assessment of biodiversity and ecosystem services and for deriving appropriate response measures. The multifunctional scope of landscape planning is especially broad with regard to taking into account all ecosystem services that are relevant as public resources and in striving for multifunctional measures where efficient (Termorshuizen et al. 2007; Galler et al. 2015). Landscape planning includes: (i) identifying synergies and conflicts between different ES as well as with land uses; (ii) proposing needs for change and possible solutions; (iii) and considering the preferences and needs of those impacted by decisions. Thus, landscape planning supports political and regulatory decisions, public participation and social learning as well as the valorisation of ES in commercial markets (Fig. 3.2). Cooperation of the different sector administrations is fostered by identifying synergetic interests and multifunctional measures (Chap. 19), which is important in terms of efficiently spending public money.

As a consequence of landscape planning's orientation towards decision support, the *spatial extent and delineation of the planning areas* is identical to the areas of jurisdiction on the different administrative levels (Albert et al. 2017). This implies

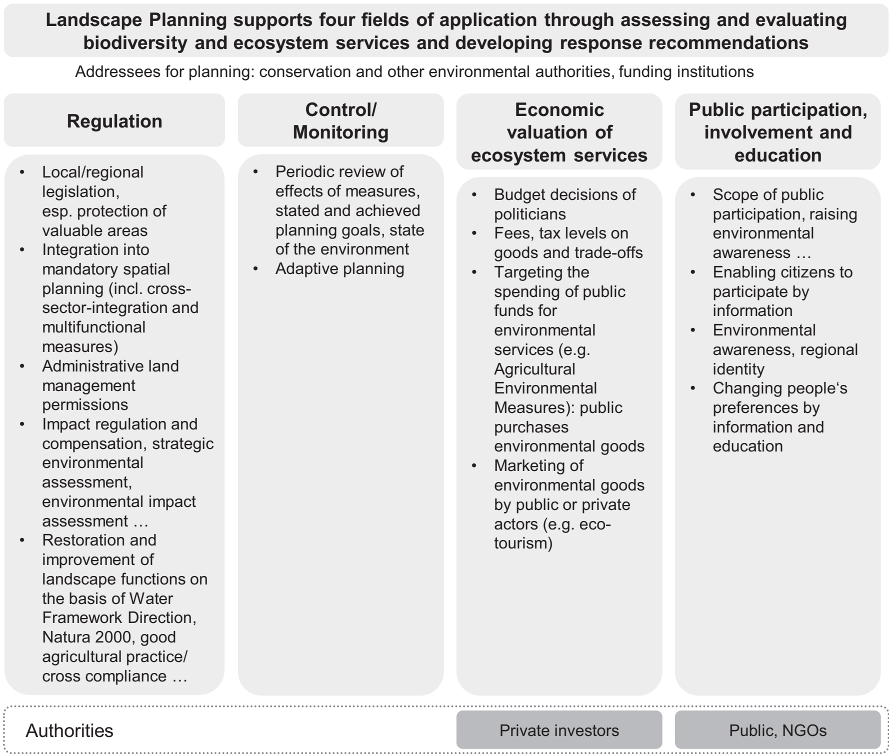

Fig. 3.2 Practical applications of landscape planning. The environmental information system, the objectives and management measures can be used by different stakeholders and in diverse contexts

that those aspects which are relevant (e.g. for a whole river catchment) should be addressed on a political decision level high enough to regulate upstream as well as downstream effects and actors (Fig. 3.3). Additionally, scarce natural resources (e.g. water provision, rareness of species) have to be assessed and considered on every decision level in order to prevent the destruction of resources by the tyranny of the small decisions (Odum 1982).

Planning at regional and local levels should consider and adhere to the framework conditions and objectives passed down from higher political (and planning) levels. Examples of such supra-local objectives are habitats or species protected in the European network of Natura 2000 sites, or the objectives laid down in plans to implement the Water Framework Directive. These supra-local objectives may not be open for local discussions or amendment, which is especially important to note during participation processes. Regional and local landscape planners should, in turn, highlight the issues for which they are responsible and be accountable for the implications of their decisions. Typical examples of such issues are spatial frameworks for urban development and zoning, regionally endangered species, local recreation amenities, and measures to operationalise higher level objectives (cf. Albert et al. 2017).

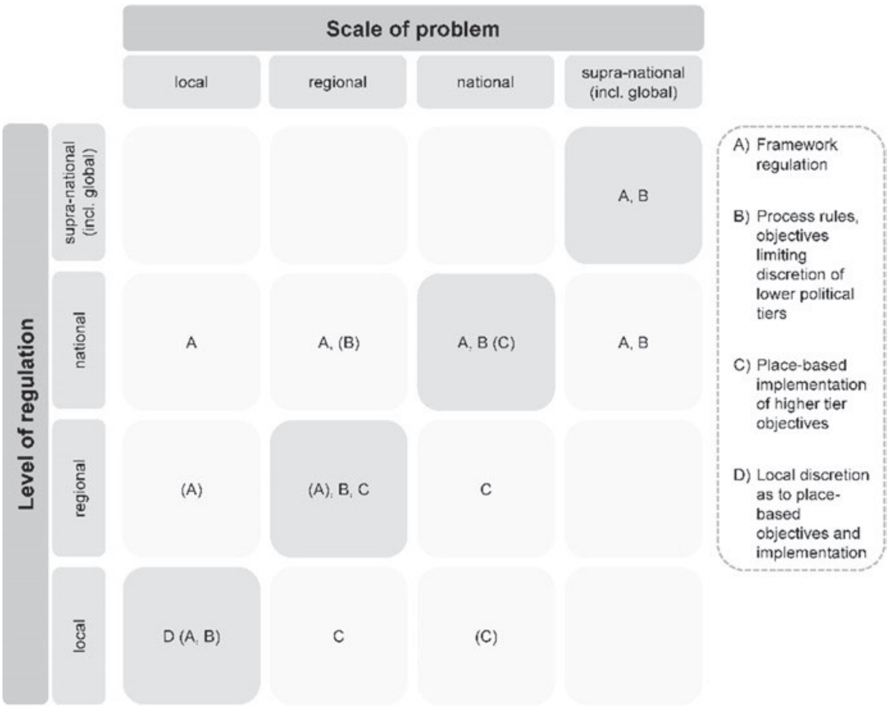

Fig. 3.3 Defining the decision space of landscape planning. Tasks on different planning tiers are determined by the scale of the problem and associated responsibilities. Projects with cross-boundary impacts or trans-boundary ecosystems (such as river catchments) need to be considered at higher planning tiers with authority that covers the whole relevant area. (von Haaren 2016: 171, amended)

A consequence of adopting a proactive approach and of matching the territories of political administrations is that landscape planning has blanket coverage and includes all types of landscapes whether obviously at risk or not, a feature which is specifically highlighted by the European Landscape Convention. This broad scope enables landscape planning to function as an environmental 'health check' for municipalities and regions.

3.3 DPSIR: A Framework for Assessment and Identification of Responses in Landscape Planning

The methods adopted in a particular landscape planning exercise should be selected and designed according to the purpose, possible responses and resources for implementation. A suitable framework which reflects this implementation-driven approach for determining the content of a plan is the widely used Driving forces, Pressures, State, Impacts and Responses (DPSIR) model (originally proposed by Smeets and Weterings (1999) in a report to the EEA, published 1997) (Fig. 3.4).

DPSIR represents a framework for studying casual relationships between socio-economic activities and the environment (Tscherning et al. 2012). Environmental indicators are required for all elements of this causal chain in order to meet the information needs of policy makers (Smeets and Weterings 1999). A range of different frameworks for landscape planning exist (e.g. Steinitz 1993; Steiner 2000; Kato and Ahern 2008; von Haaren et al. 2008) but all relate, more or less obviously, to the general DPSIR model. Slightly adapted, DPSIR is a suitable framework for landscape analysis, ES evaluation and deducing responses for landscape planning (Schößer et al. 2010; Müller and Burkhard 2012; van Oudenhoven et al. 2012; Albert et al. 2016a, b). Figure 3.5 gives an overview over the methodological approaches used for describing the different components of the DPSIR framework, as applied in landscape planning.

Concerning the methods used to identify and assess *pressures,* landscape planners can refer to the experience gathered in decades of environmental impact analyses. Pressures such as noise emissions and pollutants can be evaluated as a first step using legal emission standards (thresholds). However, when it comes to considering their impact in the landscape context, the sensitivity of the potentially impaired ecosystem services as well as their value need to be taken into account. Less regulated pressures such as hydrological changes can be assessed only in combination with such *state* information. Therefore – more explicitly than in the original DPSIR-concept – landscape planning needs to assess the *value* of existing ecosystem services and the pressure-specific *sensitivity*. State value and sensitivity are analysed by (indicator-based) models based on existing geodata, mapping the terrain, and evaluation models, which include legal standards as well as default values (e.g. federal/regional averages). Due to this approach and differing slightly from the original DPSIR-model, in landscape planning *impact* is conceptualized as part of *state,* which may include impairments from past activities. These are identified by the presence of pressures and a landscape state which contradicts societal objectives

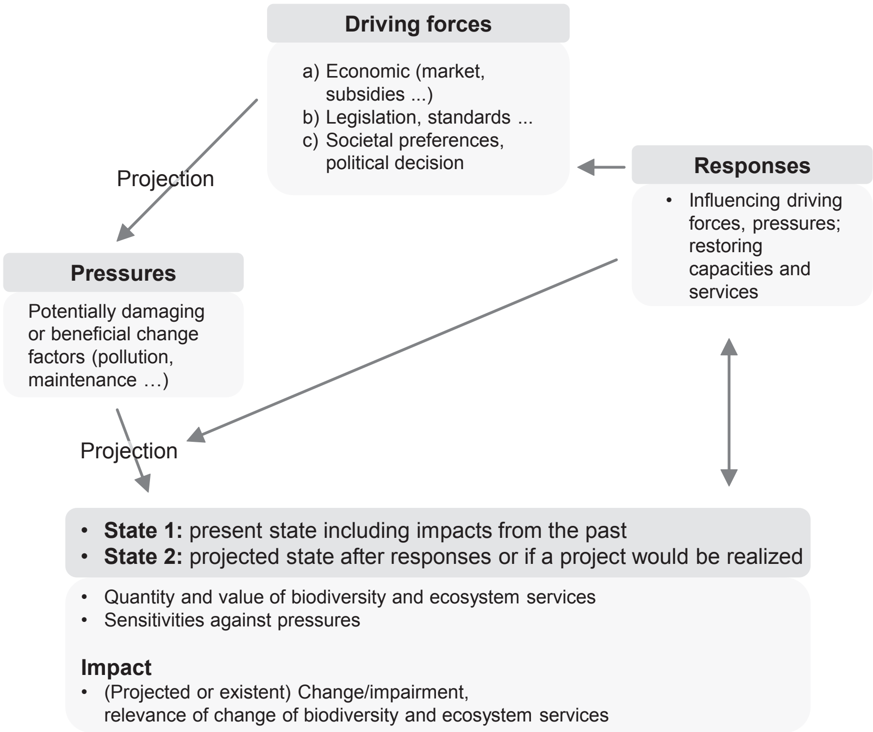

Fig. 3.4 Concept for modelling and assessing the state of ES, the need for action and possible responses in landscape planning. (Based on EEA 2011, adapted for landscape planning, cf. Albert et al. 2016a, b)

and thresholds for ecosystem services conservation. Reversible harmful impacts can be handled as triggers for rehabilitation. For example, the rapid eutrophication of a lake is highlighted by an abundance of algae which results in a low rating of the state of the lake. This should trigger the search for potential polluters (pressures) und suitable responses. Standardized impact analyses also offer the possibility to change the input data relating to pressure and thus generate state-scenarios about the impacts of different land use options.

The DPSIR concept involves deducing *responses* or implementation measures from knowledge about D, P, S, I and to use these insights as starting points to improve the delivery of ecosystem services. Possible responses can be found in Part IV of this book. For example, such recommendations may include changing local taxes (drivers), reducing commuting or private car use (pressures) or building amphibian tunnels which limit animal loss (state and impact). Methods include drawing from an information base about measures and their effect on preserving, maintaining, rehabilitating or developing biodiversity and ecosystem services. Assessing the effect of multifunctional measures and their optimized allocation is an important aspect of generating space-efficient and cost-saving planning

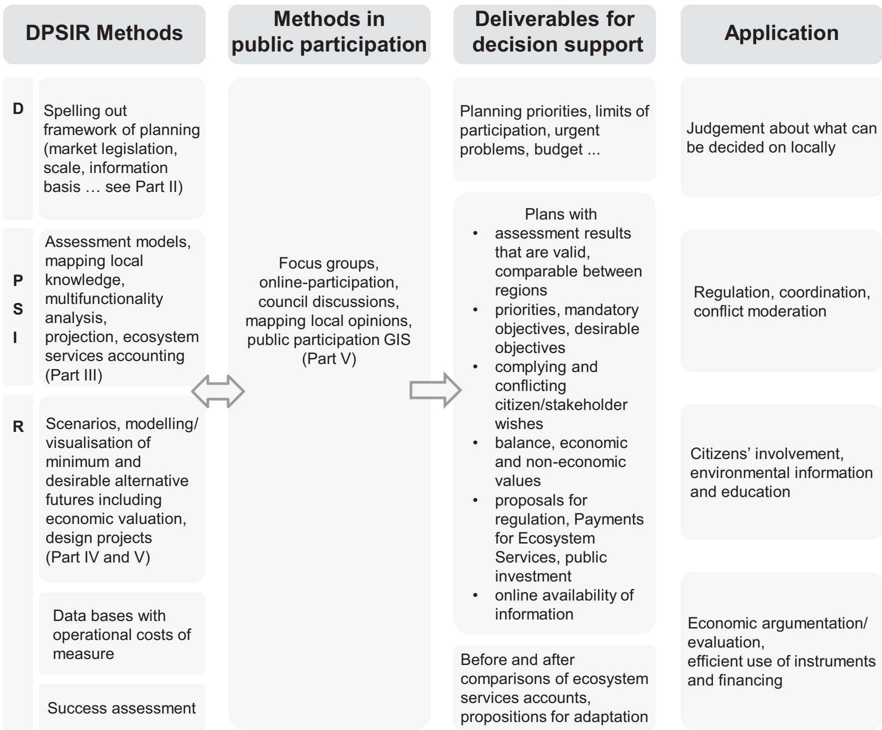

Fig. 3.5 Methods and the resulting deliverables for decision support and implementation. Parts II–V refer to sections of this book

solutions. Prioritizing objectives and measures draws on both the evaluation of the ecosystem services and the urgency of action due to projected impacts. Finally, the evaluation of the success of response measures may be reflected in a change of state (from condition 1 to condition 2, etc.).

Participation of stakeholders and the public should be part of the entire planning process and across all steps of the DPSIR model. Suitable participation methods must promote the elicitation and integration of local knowledge as well as active involvement within the assessment and planning process. Methods for facilitating participation include face-to-face events (e.g. town hall meetings) and online consultation through tools such as interactive maps and citizen mapping. Different techniques of visualizing scenarios or alternative futures support communication and a common understanding of the planning proposals (e.g. Albert et al. 2012; Steinitz 2012). In addition, desired alternative response options can be combined with design approaches and thus may be part of bottom-up participation (von Haaren et al. 2014b). More detail on participation techniques can be found in Part V of this book.

3.4 The Process of Landscape Planning and the Role of Participation

Landscape planners not only produce the content of a landscape plan but also organize and facilitate participation and decision processes. In principle, the different planning processes involved can be structured along the components of the DPSIR framework, accompanied by many feed-back loops and systematic public participation throughout the entire process (Fig. 3.6).

3.4.1 Scoping

The first phase of proactive environmental planning is characterised by a scoping process. City or regional officials, stakeholders and planners come together to identify urgent problems in the area, goals for future development of the region and the possible contribution of landscape planning, as well as drivers from higher policy levels. Such drivers cannot be changed in local landscape planning but may be addressed in strategy building for implementation or for defining the limits of

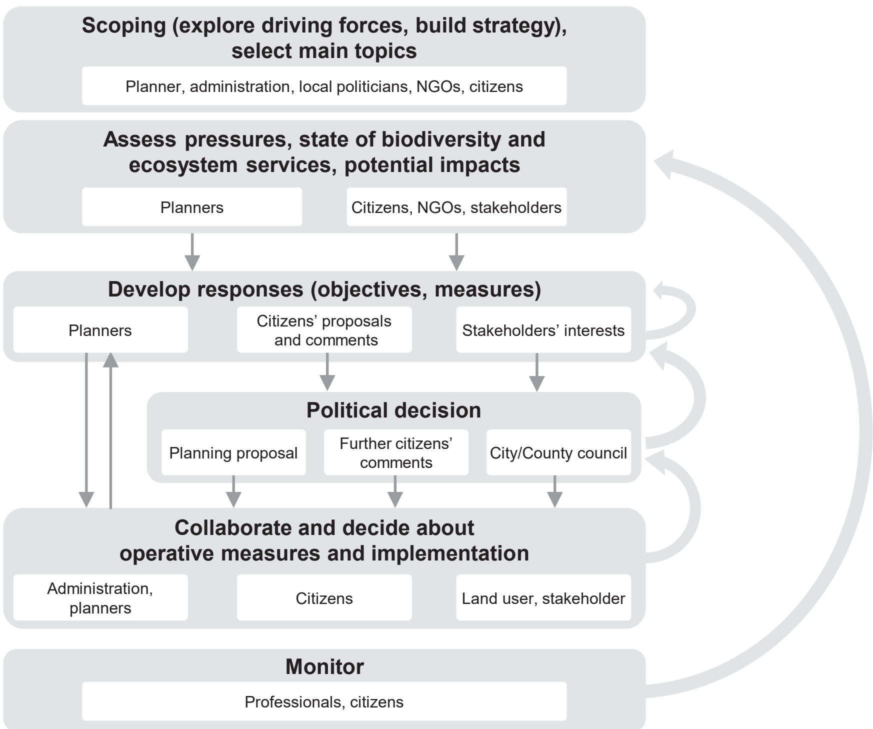

Fig. 3.6 The landscape planning process includes many feedback loops. The planner has to organize and facilitate this process. The whole process is accompanied by public participation

participation. Drivers include governmental regulations and standards which are both a basis of assessment and a driving force for changing pressures, for example if law enforcement is activated. Other drivers are market forces, such as product prices, which will influence the actions of land users. Financial incentives e.g. through EU programmes or purchaser preferences also fall in this category (see Part II of this book). In addition, the national planning system will be relevant. It defines the content of landscape and other land use planning and whether an integrated approach, covering all ecosystem services instead of only biodiversity or landscape aesthetics, can be pursued.

In this early phase of the planning process, some implementation activities should be started to motivate citizens to participate and to maintain the impetus during the planning process. The best way to do this is to initiate small projects which will show quick results. The restoration of a creek to a more natural state is an example which gives landowners and citizens the opportunity to discuss and decide about locations and design.

3.4.2 Assessment

The next phase of the planning process is the inventory and evaluation of the state and prospects for the landscape, biodiversity, and ecosystem services. This comprises an assessment of existing and foreseen pressures and their impacts. The inclusion of the public and stakeholders is crucial for the acceptability of the whole plan. The objective is to avoid doubts about correctness and bias in the approach, to acquaint the public with the new information base, to include as much local knowledge as possible, and to account for multiple values (as now also acknowledged in major assessments, cf. TEEB 2010; Maes et al. 2012; Pascual et al. 2017). Landowners and farmers can be a particularly sensitive stakeholder group. It is mandatory that those stakeholders get very area-specific information and the opportunity to comment on the landscape planning inventory, for example, as to the designation of their land as grassland or arable fields. Mistakes can result in legal or financial consequences, for example if an area should be legally protected, or if a cross-check with the direct payment system of the EU's Common Agricultural Policy is performed.

3.4.3 Develop Responses

The inventory and evaluation of the landscape and ES are the basis for the response measures proposed to decision makers and the public. These measures indicate where and which pressures should be reduced, which sites should be maintained and possibly protected, and which impacted areas should be rehabilitated. Each response should also have a level of priority for action. Prioritising responses and arguing about the basic needs for protection or rehabilitation, must draw on a sound inventory and evaluation of the present and projected states of the ES. The response objectives and measures should be framed and presented according to the needs of different interested parties and possible means of implementation. For example, spatial planners will adopt propositions better if the ES objectives have been translated into the planning categories of the regional plan. Citizens are likely to welcome 3D visualisations portraying the visual consequences of a neighbourhood development or renewable energy developments in the landscape; the nature conservation authority needs information about habitat and species rareness combined with a proposal for protection priorities or recommendations on where to allocate incentives for landscape maintenance. Again, participation is crucial in this phase.

3.4.4 Implementation

Implementation can be initiated by a political decision of the regional or municipal council. An operational plan will include timelines, financing and priorities. Authorities can use landscape planning as basis for quick decision making about activities and projects with possible impact on the environment. For farmers, landscape planning outcomes can provide a basis for locating agri-environmental measures on their farm. Private sector developers or investors may draw on mitigation measures proposed in the landscape plan and demonstrate the success of their investment in nature to the public. Finally, environmental agencies can update the digital data base to include recent changes. This process can be regarded as ongoing *adaptive planning*, in which measures are altered according to landscape changes, unforeseen conditions or the outcome of evaluations.

A similar approach to that sketched out here is the framework proposed by Steinitz (1990) that structures landscape planning along key questions to be answered in each phase of the work. This framework also follows the steps of inventory, evaluation, prognosis and determination of advice. It is influenced by a design approach and particularly emphasises feedback loops which are necessary to refine the study question, choose appropriate methods, and finally implement the study. The process flow may go back to any previous phase if evidence in the current phase indicates the need for corrections or modifications. Feedback from stakeholders and officials plays a particularly important role in this iterative process. Such enhanced flexibility is particularly important if the planning process must be performed quickly and with a limited supporting evidence base.

3.5 Incorporating Ecosystem Services Concepts Into Landscape Planning

As outlined in Chap. 1, the concept of 'ecosystem services' is defined in various ways in the literature. This book draws upon many of the existing definitions and concepts, but adapts them to the specific requirements of landscape planning implementation (de Groot et al. 2010; von Haaren et al. 2014a; Spangenberg et al. 2014; Albert et al. 2016a, b).

Landscape planning concentrates on the elements and processes of an ecosystem which are relevant for human needs. Thus, ecosystem services in landscape planning represent a selection of the properties of the real world, driven by our abilities to understand and survey, and by our preferences and needs. This approach is different from basic ecological science, which strives to understand the processes and structure of ecosystems. Given this specific perspective, the understanding of ecosystem services applied in this book (Fig. 3.7) includes both the currently delivered but unused provisions by nature (final ES in UK NEA 2011) as well as ecosystem services which are actually utilized (termed goods by UK NEA 2011). The delivered ecosystem services represent the totality of ecosystem contributions that may provide benefits to humans today or in the future, but need not necessarily be used today. In other studies, these types of service are referred to as capacities or functions (Haines-Young and Potschin 2010; Potschin and Haines-Young 2016; cf. TEEB 2010). However, these terms seem to be more difficult to communicate to politicians as they are more abstract and refer to a 'potential' rather than an existing and already valuable resource. The provision of delivered services is dependent on appropriate underlying ecosystem elements (hereafter termed *natural capital*), including processes and structures as well as geo-and biodiversity. The utilized ecosystem services are those that are actually turned into goods or directly consumed by humans. This transformation often requires human input (UK NEA 2011), with examples being fertilizer, energy, pesticide, labour, infrastructure or knowledge (cf. Burkhard et al. 2014). The resulting benefits are impacts on actual human wellbeing, individual or collective, stemming from the direct or indirect contributions of delivered and/or utilized ES. Examples for the different categories included in Fig. 3.7 are as follows:

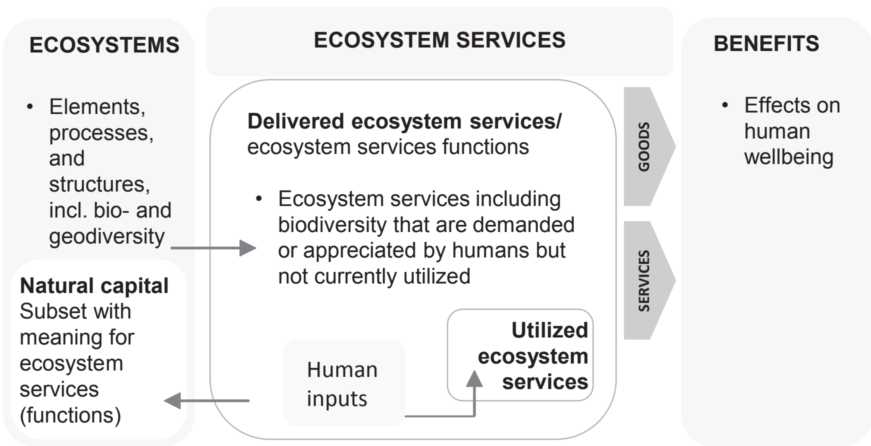

Fig. 3.7 Proposed ecosystem service concepts and terminology for landscape planning

- *Ecosystem Elements and Processes (also termed natural capital here, including ecosystem assets)* – primary production, water cycling, nutrient cycling, soil formation, weathering, ecological interaction, evolutionary processes
- *Delivered Ecosystem Services* – production capacity for food, renewable energies, pollination, water retention, clean water supply, GHG sequestration
- *Utilized Ecosystem Services* – food, drinking water, energy supply, flood control, air pollution mitigation, climate regulation, recreation amenities
- *Benefits* – health, good nutritional status, security, education, enjoyment, happiness

Protection of delivered ecosystem services is governed primarily through objectives and standards as described in legislation (representing shared societal values) and then interpreted and made more specific by planners (Fig. 3.8). This legal basis is essential for applications in planning and decision-processes to ensure the legitimacy of objectives classified as mandatory, their transparency and a fair balancing of public and private/individual interests. In contrast, utilized ecosystem services tend to be assessed from an individual perspective and are represented by other economic measures (e.g. crop yields or sale values) or preferences which can be captured through socio-economic valuation methods. These different forms of evaluation are further discussed in Chap. 4.

Analysis of both delivered and utilized ecosystem services allows for presentation of different and complementary perspectives to inform planning and decision-making processes, enabling consideration of the public, legal perspective alongside the economic and individual perspective. Evaluation is therefore based on a range

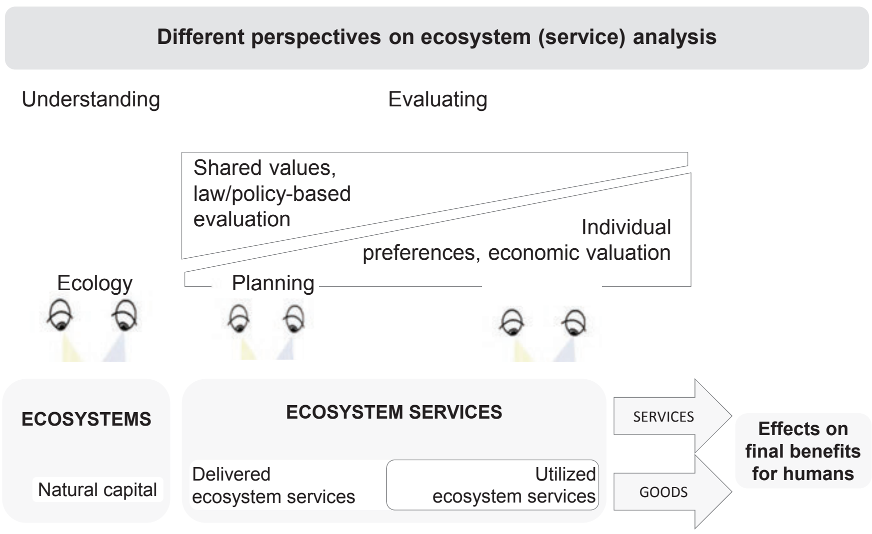

Fig. 3.8 Different values underpinning the assessment of ecosystem services. (cf. von Haaren et al. 2014a)

of values. This helps to reduce the risk of the economic valuation (and thus of commodification of nature) becoming the priority, which is feared by many scientists and practitioners (Albert et al. 2014; Schröter et al. 2014). Valuable delivered ecosystem services should be protected even if the benefits only accrue to future generations. However, including both the individual (economic) perspective is valuable for the participation process, as well as for deciding when market instruments are the right choice for policy responses.

3.6 Methodological Issues in Landscape Planning

Based on our experience there are a number of issues that need attention in almost any landscape planning exercise. These include transparency in the methods adopted and the normative judgments made, ensuring comparability of assessment results, considering the applicability of methods at different spatial scales, communicating uncertainty in findings and justifying choices of response measures (cf. von Haaren and Albert 2011; Selman 2006; von Haaren et al. 2008). These requirements are elaborated on below and can be considered as the checklist for landscape planning exercises.

3.6.1 Distinguishing Scientific and Normative Components

Planning and decision support methods almost always consist of both scientific and normative components. These two components need to be distinguished from each other in order to give policy makers and citizens the opportunity to understand and discuss them, particularly the normative aspects of setting local priorities. The initial framing of both problems and questions to be answered is influenced by the normative basis of a society, as is the selection of ecosystem aspects to be mapped and assessed. The methods used for inventory compilation are invariably scientific, while the evaluation of outcomes and choice of responses is driven by normative standards. Actual implementation is mainly driven by scientific and practical knowledge. This mixture should be reflected in planning practice by clearly separating the inventory and evaluation phases, and by making any subjective planning decisions transparent within the methodological workflow.

3.6.2 Selecting and Implementing Methods

The methods to be used, whether bespoke (i.e. tailor-made) or standardised must be selected according to the intended application of the results (Merry 2011: 89; Fukuda-Parr 2014) (Fig. 3.9). In reality, a combination of both standardized and tailor-made methods will often be the best solution. For example, evaluating the visual quality of a landscape by first using a nationwide calibrated/normalized scale provides citizens with information about the value of different areas compared to

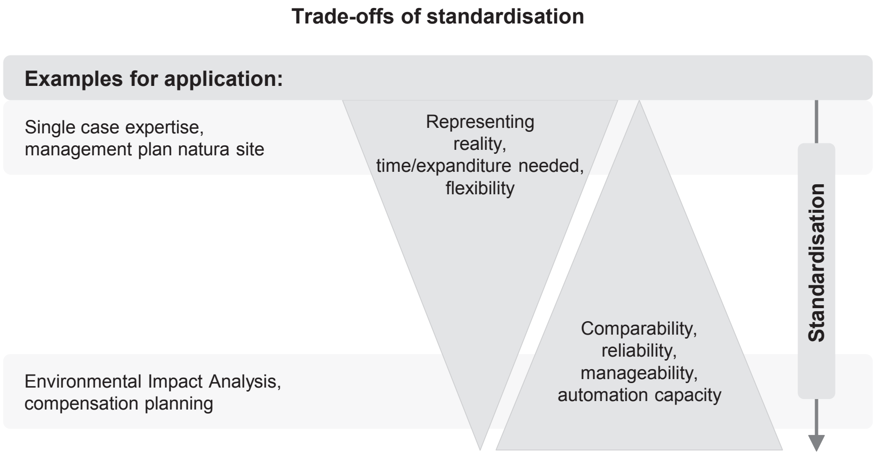

Fig. 3.9 Trade-offs between bespoke and standardised methods

the national mean. Such information could be relevant to assessing the potential to attract nature-based tourism. If national level data is then amended with more local information, e.g. from citizen surveys of preferred places or the application of an adapted, local preference scale, it can provide a valuable contribution to place-specific recreation planning.

Whether a method is bespoke or standardised it is important that the workflow of steps is thoroughly documented. Fig. 3.10 shows an example of the type of approach that should be followed. In this case the objective is sustainable use of groundwater and the first stage is to create an inventory of the existing state across a region. Since the groundwater recharge rate cannot be directly measured it needs to be modelled based on soil type, slope and precipitation. The results in terms of estimated recharge rate are then compared to standards in order to evaluate differences in state and determine priorities for action.

Bespoke evaluation methods, often including the elicitation of local preferences, allow for flexibility, adapting planning to local needs and including specific local parameters and indicators. In general, one advantage of a tailor-made approach over a standardised method is the higher accuracy of the results, especially with respect to quantification of ecosystem services. In addition, tailor-made methods allow for eliciting individual values or interests of local citizens and facilitate engagement in the participation process.

In contrast, standardised methods rely on consistent evaluation factors and their application follows a strict, pre-defined procedure and data format. One advantage of standardised methods is the comparability of the results across different regions and users. However, there is no ‘one fits all’ solution and the trade-off between flexibility and standardisation (Adams et al. 2016: 143) must be considered. Wherever possible, landscape planners should prefer standardised over bespoke methods because they allow for inter-area comparisons. Planners usually need to prioritise some areas in comparison with others – be that on regional, national or global scale.

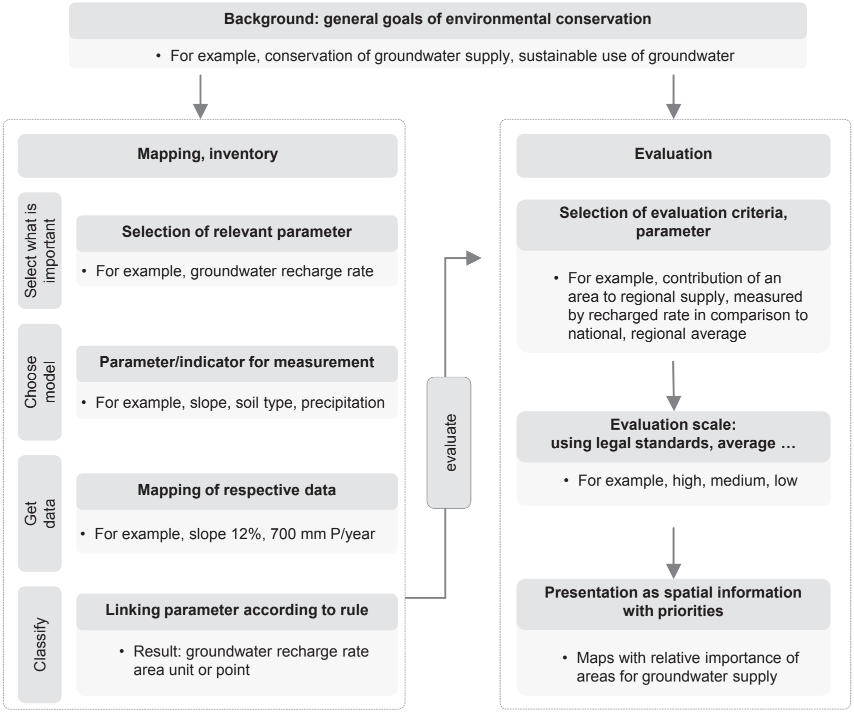

Fig. 3.10 Workflow example to assess the state of ecosystem services

In such decisions about priorities, standardised methods allow for comparison and any lower level of accuracy in the assessment of individual sites is often acceptable. In other words, achieving high quantitative accuracy in ecosystem services assessment is less relevant in landscape planning if prioritising areas or actions is the main purpose and all results have a similar level of accuracy. Similarly, if payments are connected to the quantitative outcomes, using less exact results may be inconsequential so long as every individual or organisation is treated equally in resulting implementation processes. The planner should also recognize if some implementation options require exact quantitative assessment outcomes. Examples would be whether there is an exceedance of a pollution threshold, or how much a polluter should pay if their land use related greenhouse gas (GHG) emissions are included in a greenhouse gas trading system. In these cases, calculations must be as exact as possible to treat polluters equally.

Standardisation and a detailed description of the methods also helps ensure that the results under the same condition will be repeatable and independent of who carries out the method. The results will not necessarily be objective in a strict sense (like the laws of physics), but they can be considered *neutral* as they (ideally) are independent of the specific preferences, biases or abilities of the person applying the method. Even evaluation standards and criteria for issues which are usually considered subjective, like landscape aesthetics, can be neutral in this sense. Nevertheless, in cases of forecasting, even if several individuals come to the same result, this may be fatally inaccurate. Therefore, in choosing the methods, it is important to strive for as much validity as the application purpose requires and communicate any uncertainties associated with the results.

3.6.3 Appreciating the Properties of Assessment Scales

Transforming the results of the inventory or evaluation to an assessment scale may require summation using quantitative or qualitative measurements. By measuring the properties of ecosystems, we summarise the vast complexity of nature and landscapes into classes, transforming them into statements that are meaningful for scientists, the public, or decision makers. Depending on the nature of the properties which we want to measure, and depending on the purpose intended, we can use four types of scales: nominal, ordinal, interval and ratio (Stevens 1946; Chrisman 1998) (Fig. 3.11).

Nominal scales are used when the categories of an inventory are of equal importance (without any order or hierarchy) or consist of only two classes (e.g. protected or not protected).

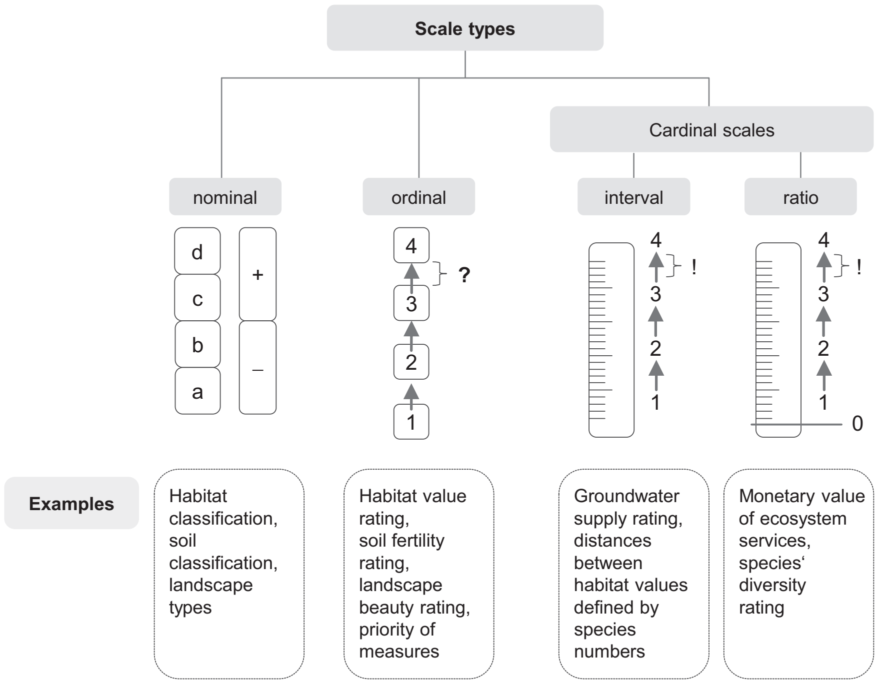

Fig. 3.11 Types of scales for ecosystem services assessments. (According to Stevens 1946; Chrisman 1998)

The *ordinal scale* implies an order or ranking amongst the different classes. Landscape planning frequently uses ordinal scales in evaluation, for example to assign values to habitat types from 'very rare' to 'very common'. However, it is important to note that on an ordinal scale the intervals (i.e. amounts of difference) between the classes are undefined. We cannot tell whether a habitat classed as 'very rare' is twice as important as one rated as 'rare'.

Interval and ratio scales are very similar and can be subsumed under the term *cardinal scale*. Both are characterised by the interval between points on a scale being known. The two types only differ in that the ratio scale has an absolute (natural) zero point. A classic interval scale would be for example the measurement of temperature in degrees Centigrade (°C). Here, the differences between degrees are defined and equal, but the zero point is arbitrary (i.e. 0 °C is a temperature and does not represent no heat). In contrast, a characteristic such as species richness can be measured on a ratio scale (no species at all being the zero point). Cardinal scales are used in planning if definite quantities are needed as an assessment outcome and the measurement system permits quantification (*compare Porter* 1994). An example is the calculation of the phosphorous loss from a sub-catchment into a river to assess its contribution to the total pollutant load of the water body.

The scale types allow different reclassifications and calculations to be performed. On nominal scales, it is possible to reclassify individual categories by summarising or grouping them into new classes (e.g. subsume habitat types into habitat groups). Ordinal scales do not allow any reclassification operations beyond the ones already possible for nominal scales. On an ordinal scale, each level stands for a relative quality or priority. Planners using ordinal scales therefore need to take care that the order of the scale is not disturbed by regrouping.

Interval scales permit linear transformations such as addition, subtraction and multiplication. However, the absence of a true zero means that ration calculations (i.e. division) are not meaningful (i.e. 20 °C is not twice as hot as 10 °C). A ratio scale does allow for such proportional transformations (see Chrisman 1998 for more about permissible statistics). In practice, awareness of these scale-specific transformation rules is particularly important when accounting or monetisation is the desired outcome.

The case of habitat value demonstrates how the barrier between ordinal and cardinal scales may be overcome in certain cases. Habitat value is often represented on an ordinal scale (e.g. low, medium, high). However, there may be a need to derive a numeric habitat value for a particular area. Examples include the calculation of the total habitat value for a farm with the aim of comparing it to other farms, or to a modelled prediction of the same area after improvement measures. One simple option, assuming spatial data are available, is to calculate the proportion of area occupied by different categories (e.g. the percentage of the farm rated as high habitat value). A more refined approach would be to match the ordinal categories with quantitative data (such as numbers of species present e.g. Bredemeier et al. 2015) and then use these to define the distances between the points on the scale. Another possibility is to set a standard where the ordinal levels are distributed evenly across the cardinal scale. If adopted, this approach must be agreed by the agencies or (political) authorities with responsibility for the application of the method and for the area where it will be used.

3.6.4 Considerations Regarding Spatial Scale

The realm in which a particular landscape planning process is carried out should be taken into account in two ways: in terms of the resolution of the available spatial data and the detail of the assessments required. In general, a method should only be applied at the spatial level for which it was originally developed. If a particular method is applied across a much larger region, the required quality of data may be difficult to find. Conversely, applications of a method in a smaller area than originally intended may generate results that are too generalised for robust planning purposes. However, as noted already, the best achievable detail is not always necessary. In some cases, the planning process may be overloaded with the amount of content or precision and, wherever possible, the amount of details should be adapted to the decision level. Also, as described earlier (in Sect. 3.2), many evaluation standards or objectives are adopted from higher decision levels. This is especially important if ecosystems such as rivers or national habitat networks cross the jurisdiction boundaries of planning authorities. In such cases, it can be difficult for local decision makers to judge the wider implications of their actions and there is again a case for adopting standardised evaluation methods to support consistency amongst relevant agencies.

3.6.5 Assessing and Communicating Uncertainties

The data bases used in landscape planning often have some limitations and this has implications for the confidence that can be placed in assessment results (Grêt-Regamey et al. 2013; Neuendorf et al. 2018). Nevertheless, decisions about actions and future developments will need to be made despite possible gaps in information. Using imperfect data for analyses in landscape planning is invariably better than taking no action at all. However, it does mean that it is important to assess and communicate the levels of uncertainty in inventories, evaluations and projections.

Considering possible future conditions introduces further uncertainty. Such assessments can be undertaken in landscape planning in several different ways. These include:

- *Predictions* over short time spans are generally based on sound scientific knowledge of what will happen and have relatively high certainty. The probability of a particular event occurring (e.g. a flood of particular magnitude) can often be calculated.
- *Deductive forecasting* is based on well-established and verified hypotheses. Again, the probability of a particular outcome can be calculated.

- *Projections* and *scenarios* are least certain and based on assumptions regarding plausible development pathways. The probability of events cannot be calculated. The methods applied in this type of approach are trend-extrapolation (using data from the past to estimate the future), analogy-projection (results from other cases are transferred to new situations) and expert interviews (e.g. opinions on how the future will unfold). Scenarios may also be based on goals for the future.

Uncertainties in assessments and projections can be calculated in various ways (see Chap. 6, Neuendorf et al. 2018). Many different forms of media have been used to communicate uncertainties including text, images, and dynamic visualisations (Appleton et al. 2004; Janssen et al. 2005). Another common way to express uncertainty is the use of scenarios to illustrate different plausible trajectories (Schenk and Lensink 2007). In addition, uncertainties can be considered by monitoring and adaptation of objectives as an on-going process accompanying implementation (see also Steinitz 2012: 119).

3.6.6 Deriving Response Options in a Transparent Manner

Transparency in aggregating and interpreting evaluation results should be the leading principle in the phase of deciding upon response options. As illustrated in Fig. 3.12 several 'rules' can be used to interpret the state and impact information, helping to achieve clarity in the derivation of priorities. An initial step is to evaluate the state conditions and, as discussed already, this will draw upon both scientific expertise and normative judgements. Once such evaluations and ratings have been made the key next step is to distinguish between those phenomena where mandatory objectives apply (e.g. those set by EU objectives or national laws) and those where improvements are desirable (or even not required at all). Where mandatory obligations exist the priority is usually to maintain and protect very valuable assets or to restore impaired systems, since otherwise there may be consequences such as fines or other enforcement actions. With desirable objectives there is more discretion about whether and how they are achieved, though a common approach would be to protect areas of high value before contemplating restoration or development initiatives.

With discretionary objectives it is particularly important to undertake participatory activities and engage creativity to generate measures that are in accordance with people's needs, which create local and regional identity and can be communicated by collecting design ideas (see the change models of Steinitz 2012; von Haaren et al. 2014b).

Planners need to find appropriate ways to communicate the results of assessment exercises to decision makers, stakeholders, and the public. In this context, an ongoing discussion concerns the role of ecosystem services in communicating

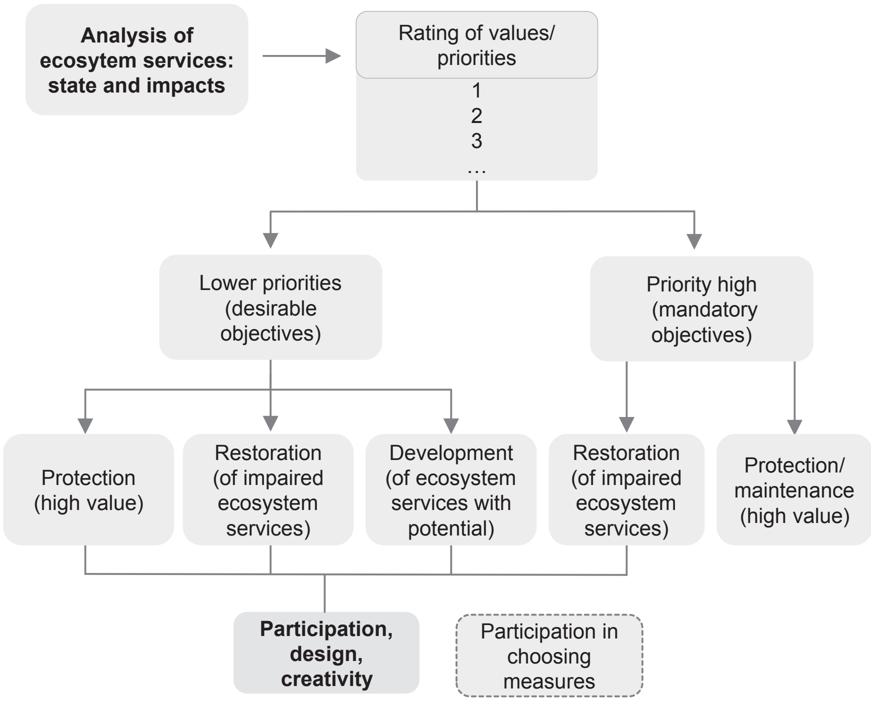

Fig. 3.12 General 'rules' for deducing response options

landscape planning outcomes. For example, it could be that politicians and citizens would better understand or accept particular measures or objectives if aggregated performance measures of ecosystem services delivery and use were provided. Examples of such situations would include the comparison of different variants of a new road corridor and the accounting of the total environmental performance of a region. Politicians usually ask for summary arguments that are easy to use. Performing such summations leads into a dilemma, as it usually implies 'comparing apples and pears'. The answer depends on the complexity of the original results and the purpose for which the information will be used. In particular the consequences an oversimplified result could generate must be carefully considered. Methodologically, multicriteria aggregation is a scaling problem because properties which are classified on different value scales have to be unified on one common scale. One example is the presentation of phenomena as monetary values and this is not without its challenges (see Chaps. 4 and 20). Another potentially problematic situation is the transformation of ordinal assessments to cardinal scales (see Sect. 3.6.3).

In order to express the scientific reservation which often accompany the aggregation process, it may help to present comparisons both using one or more overall scales and additional text, referring to individual ecosystem services, for an aggregate evaluation of state and changes in ecosystem services (compare Bateman et al. 2013).

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