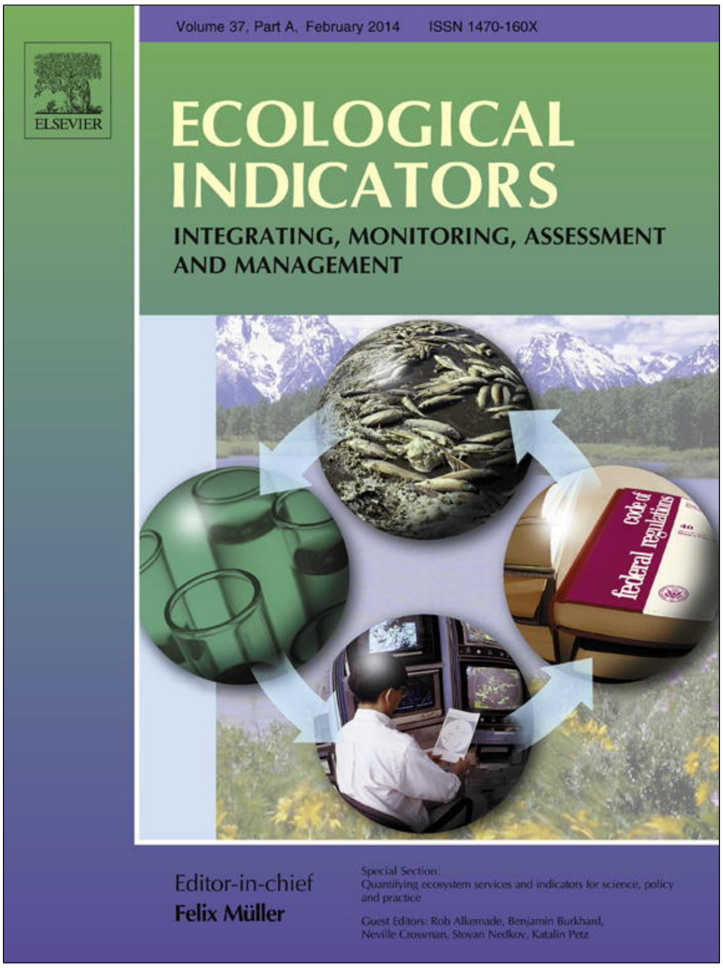
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Landscape management accounting as a tool for indicating the need of action for ecosystem maintenance and restoration – Exemplified for Saxony

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ABSTRACT

A politically fixed und broadly concerted social consensus for the permanent preservation of wildlife and of their habitats reflects the demand for biodiversity and intact cultural landscapes. But wherever human beings have to intervene in nature in order to secure their own existence, targeted landscape management becomes necessary for the preservation of the values and performances of ecosystems.

This paper explains the methodological framework of a landscape management accounting system as exemplified by the German Free State of Saxony. Management tasks are defined and the method of cost calculation is explained. The calculation of management costs comprises, first, the determination of care-dependent habitats; second, an allocation of necessary measures; and third, the estimation of the related costs per year. The total financial requirement is composed of costs for maintaining, developing and investing measures per habitat type. Based on different inventories of landscape structures showing the losses of the last decades, and considering the habitat needs of key species, a demand for restructuring measures was determined.

A total requirement for habitat management was quantified for almost 10% of the land area. Regarding the restructuring needs, analyses and assessments were made for running waters and accompanying structural elements demanding the opening of 300 km of closed rivulets from their pipes, the planting of copses along 680 km of bare streams, and the abandonment of 21,300 ha of arable fields in floodplains. Furthermore, 2500 km of tree lines, hedgerows and field margins are necessary to plant in the agricultural landscape.

1. Introduction

There exists a broad social consensus for the permanent preservation and development of our cultural landscapes with their habitats, which expresses itself in a growing demand for biodiversity and intact cultural landscapes, as well as in the willingness to provide the financial means to do this (e.g. Gibbons et al., 2011; Spangenberg and Settele, 2010). However, in order to secure their own existence, human beings have to intervene in nature, altering it through various forms of land use. In addition to provisioning services (e.g. generation of foodstuffs and raw materials through agriculture and forestry), cultural landscapes and their ecosystems also furnish many regulatory and socio-cultural services. In order to make the broad range of ecosystem services permanently available, i.e. to ensure that the biodiversity and productivity of the ecosystems are preserved, targeted landscape management is necessary, something which entails financial expenditure for society.

If we take account of the politically specified need for the preservation of species and habitats as contained in treaties, guidelines, laws and regulations (e.g. Convention on Biological Diversity, EU-Natura 2000 Guidelines, EU Biodiversity Strategy, Measures Program for Biological Diversity, Habitat Directive, Water Framework Directive), then suitable measures have to be taken in accordance with the technically derived requirements. The social expenditures and costs for landscape management therefore represent an indicator of the economic valuation of ecosystems, since the existence of some cultural landscape ecosystems is not secure without these performances. Apart from ethical, esthetic and informational values, which are very difficult to determine in monetary terms, landscape management accounting is a tool for indicating the need of action to maintain ecosystems and can help to negotiate the level of socially agreed demand for nature as well as the willingness to pay for nature protection. The ecosystem services approach addresses calls for incorporation of such economic valuations in ecological management decisions (Carpenter and Turner, 2000; Farber et al., 2006; Grunewald and Bastian, 2013).

We owe a large part of the biological diversity in Germany to traditional or less intensive forms of agricultural management,

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which are no longer economically competitive in the world market. These forms of agricultural management frequently result in newly created habitats such as dry and semi-dry grassland, dwarf shrub heathland and mat grassland, mountain meadows and wetland meadows, as well as clearance cairns and vineyard walls. In order to preserve these forms of use or to guarantee adequate management, financial support is imperative. In EU countries, funding is principally carried out using the agricultural development funds, and, secondly, using nature conservation funds. Usually these funds are co-financed by the individual countries.

The above-mentioned ecosystems (habitats) are only partially rooted in protected areas, and are also found in broad swathes of the "normal landscape". Efforts to preserve biodiversity should therefore not restrict themselves solely to protected areas but must also include the more or less intensively used "normal landscape" (Polasky et al. (2008) use the term "working landscape"). In the last decade especially, field margin structures along paths and along the edges of woods and fields have disappeared, thereby leading to discernible species impoverishment (e.g. Ringler et al., 1997; Wolff, 2004; Steffens, 2009). Today, intensively used agricultural landscapes in the most fertile locations lack natural landscape elements over broad areas, on which the animals and plants of the agricultural ecosystems are dependent for survival and which provide important ecosystem services. Exactly in such areas it is important to integrate landscape management and land use in a more intensive way to evaluate trade-offs between ecosystem services.

Landscape management is defined as the totality of all measures for the safeguarding, maintenance and development of natural habitats for indigenous species of plants and animals, and for the maintenance and renaturalization of ecosystems and landscapes in the event of damage (Jedicke, 1996). In this context, one important task is the preservation and development of the diversity of habitats and species as well as landscape elements. Landscape management is particularly concerned with the safeguarding and provision of general interest services for society (particularly regulation services and socio-cultural ecosystem services).

According to the Millennium Ecosystem Assessment (MEA, 2005), a landscape is typically composed of a number of different ecosystems, which then generate a whole cluster of different ecosystem services. Many ecosystem services are influenced by landscape structure and geographical context and therefore by the arrangement of landscape elements or land use units. After Willemen et al. (2012) the pattern of multifunctional landscapes is the basis for interactions, synergies or conflicts that may occur between landscape functions. Also the provision of services does not depend so much on the properties of the individual, small ecosystem patches, but rather on the spatial interaction, flows and fluxes between these patches and between patches and human elements (Termorshuizen and Opdam, 2009).

The agricultural landscape offers various points of approach with regard to restructuring (Syrbe and Grunewald, 2013). Firstly, the watercourses, including their accompanying structures, should be in a good ecological condition, so as to fulfill habitat functions and to contribute to a steady water and mass balance. Secondly, apart from the bodies of water, agricultural areas with low amounts of forest and water also need field trees, lines of trees, hedges and various sorts of linear or field margin structures (Ringler et al., 1997), in order to be able to provide cover, food and nesting opportunities to the organisms of our agricultural ecosystems, to enhance the landscape diversity, and to avert the dangers of erosion. The objectives of landscape management demonstrate that, among other tasks, the edges of forests are to be upgraded by means of staged boundary structures, a minimum proportion of wetland habitats are to be preserved in meadows, and terraces and clearance cairns/stone walls are to be secured or reconstructed in the mountains.

Measure programs for the EU Water Framework Directive (WFD), which are implemented by the river basin associations (Bastian et al., 2012b; Albrecht, 2013) exist in EU countries for water bodies with catchment areas (EoA) larger than 10 km^2. In this respect, water bodies with EoA < 10 km^2 without their own WFD measures are particularly relevant for the landscape management accounting system.

The focal points for the restructuring of these small running waters and bodies of standing water are (Syrbe and Grunewald, 2013):

1. During the period of the socialist collectivization of agriculture (predominantly after 1960), many small running waters and ditches were straightened or installed with pipes as a result of state-run improvement measures, thereby destroying habitats, habitat networks, and sometimes greatly impairing ecosystem services. Many pipe installations from the period before 1990 today display functional restrictions in wellsprings, wet spots or flooding. For cost reasons also, dismantling of the pipe installations with the restitution of an above-ground water course would often be very practical.
2. The planting of trees along the watercourses is intended to contribute to an increase in the quality of the habitat and water, using factors such as shade and diversity of riverbank structure.
3. As a result of an expansion of uses and restructurings in the environment of the water body, space is created for shelter habitats and stepping stones for the habitat network in the area of meadows, e.g. small/temporary bodies of standing water.

This paper presents a methodology developed for the elaboration of a regional landscape management accounting on the basis of the example of Saxony (Germany). Accordingly, those performances which display a specific relationship to the landscape can therefore be understood as landscape services (Termorshuizen and Opdam, 2009; Grunewald and Bastian, 2010; Hermann et al., 2011; Bastian et al., 2012a).

This type of landscape management accounting system is an aid to political decision makers in regard where to invest public money to maintain landscapes and protect biodiversity. The methodology as developed permits an estimation of the total extent of landscape management tasks for the coming years – in this example, for a German federal state, the Free State of Saxony – as well as harmonization of the multiplicity of requirements and measures. Complex methodological principles as well as differentiated cost-benefit analyses were necessary for this study "Landscape Management Assessment Saxony". Even with the gradual improvement of relevant data sources, comprehensible calculation models with regard to the evaluation of landscape management performances are not yet very useable. However, a knowledge of the dimensions of the required financial resources is necessary in order to support agricultural land development which is in conformity with nature conservation, and to plan and guarantee additional expenditure for the use, maintenance and development of habitats and certain species of plants and animals.

The concern of the paper is to present, in addition to measures regarding the management and development of habitats, indicators and methodological approaches for the restructuring planning of the landscape. On the basis of the available specialist data, an explanation will be given as to how the current inventory of water, field margins and wooded structures in farmland can be determined and the need for measures for the creation or upgrading of natural landscape elements within intensively used areas can be derived.

2. Methodological framework

2.1. Overview

The objective fields of practical action of a landscape management accounting include, above all, open-land areas, structures of watercourses, woods, as well as measures for species protection relating to object and habitat. In this context, reference must be made to the funding practices of individual countries and of the EU in regard to nature conservation and landscape management.

Any investigation of the requirements for landscape management includes a comprehensive recording of the landscape management objects or tasks (habitats, structures, species, as well as any existing deficits) and an estimation of the management costs (related to year, type and object). The total financial requirements consist of the costs for the management, developmental and investment measures for each type of habitat, as well as of special expenditures for the protection of particular species. Fig. 1 illustrates the contents and the focal points of a landscape management accounting system containing the possibility of regional differentiation on the administrative level and on the level of the physical region, as it was compiled in an exemplary manner for the Free State of Saxony (ca. 18,420 km^2) in Germany (Grunewald and Syrbe, 2013).

The overall stepwise approach can be characterized as follows:

(1) identifying/mapping land that needs management measures,
(2) identifying necessary measures and their cost,
(3) applying measures and costs to the mapped ecosystems.

In the following, we explain the procedure, indicators and data of the tasks 'habitat management' and 'restructuring requirements for landscape elements and habitat structures' in detail. An estimate was made of the expenditure required for specific measures for species protection using funds from state agencies (third pillar of the calculation, see Fig. 1) on the basis of a survey. However, this aspect of landscape management accounting was not subject to detailed methodological investigation, since the species protection strategy of Saxony is still being developed.

2.2. Landscape management measures

2.2.1. Habitat management

First step is the mapping of management-relevant habitat types of a region or of a country as "regional backdrop of habitat types, which are relevant for the landscape management" (groups of habitat types, see Table 1):

– Determination of the habitat areas on the basis of existing habitat mappings: selective mapping of the habitats (biotopes) in Saxony (SBK; German: Selektive Biotop-Kartierung), which are important for nature conservation.
– Expansion in accordance with the habitat types mapped within the Natura 2000 areas of the EU (Habitat Directive, 1992), in as far as these surpass the SBK-habitat mappings.
– Integration of the so far quite neglected category "arable land which is to be used less intensively", which (still) does not comply with the criteria of the habitat type "extensively used fields rich in wild herbs", but which could contribute to the preservation of important species of our cultural landscapes by means of careful agricultural management: estimation of a realistic area using the HNV (High Nature Value) farmland indicator of the German Federal Agency for Nature Conservation (http://www.bfn.de/0315_hnv.html).

Subsequently, the maintenance status of the habitats is to be estimated, subdivided into regular and episodic measures. "Regular management" refers to management of 100% of the habitat areas at least twice or more often per decade. "Episodic management" (investment costs) refers to either so-called once-off measures, e.g. land clearance or treetop pruning in the case of old fruit trees, or to cases where the management interval is so large that the relevant habitat type is "affected" by a measure at most once within the usual period of 10 years, e.g. in the case of hedge/copse maintenance.

2.2.2. Determining restructuring requirements using trees, hedges and field margin structures

With regard to elements in the agricultural landscape which are valuable from the point of view of nature conservation, investigations were carried out as to where an increase of their proportion is desirable. Groves were identified in the habitat (biotope) and land use mapping (BTLNK; German: Biotop-Typen- und Land-Nutzungs-Kartierung) and overlaid with the search spaces of the habitat network. Special requirements are to be identified wherever wooded areas are lacking within the habitat network areas.

Linear elements were investigated in more detail, in order to be able to also determine restructuring requirements quantitatively from the comparison of target and actual density values. The best data basis for the actual analysis proved to be the linear elements of the BTLNK from 2005 outside the settlements:

- Meadow and field margins,
- Lines of trees without contact to water bodies,
- Hedges of all types.

The structural elements lying within settlement areas were firstly hidden using a settlement mask and the lengths per physical region were totaled up outside the mask. The density values form the quotient of the sum of the lengths divided by the area of agricultural grassland (without ruderal and herbaceous meadows) and arable land including permanent cultures (wine, plantations, etc.) in the habitat mapping.

The determination of target values is based on comparable historical data. In this case, use was made of mappings of landscape structures on the basis of aerial photos from the years 1953–1960 (that is to say, before the beginning of the collectivization of agriculture). The historical status was chosen as a basis for target definition because we assume that at that time the conditions were optimal for biodiversity and no better indications were available. On the basis of three large-size reference areas in Saxony, both the field margins, hedges and lines of trees digitalized at that time, as well as current structural elements were statistically evaluated. In addition, wood density analyses by Schmidt and Richter (2009) on the basis of topographic map analyses from five test areas were used. The target values were defined under consideration of the regional genesis and structures as follows: 2.0 km/km^2 in the glacial lowland, in the heathlands of the lowland up to 3.0; in the loess-covered hill regions 2.5–2.6 km/km^2, in the mountainous regions 3.0–3.5 km/km^2.

2.2.3. Determining the restructuring requirements of surface waters and accompanying habitats

Additional measures, such as the removal of waterside and water-crossing obstructions, the reduction of straightening measures, or the establishment of riparian stripes, are to be specified in harmony with the maintenance of the water bodies and are dependent on the availability of area in the environment. Priority should be given to the dismantling of dikes and construction features, as well as to provide space for natural processes before technical measures are carried out on the water body itself.

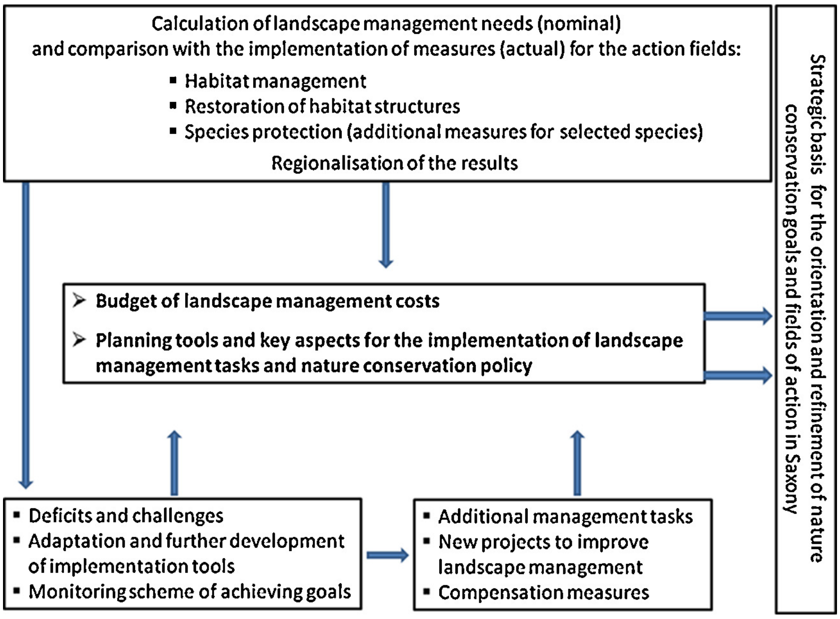

Fig. 1. Scheme of the key aspects of a landscape management accounting system (according to Grunewald and Syrbe, 2013), slightly modified.

The three measures outlined in chapter 1 are explained in more detail in the following:

1. Identification of piped water bodies

   The analysis is based on the comparison of the whole waterway network with the identifiable above-ground running bodies of water, supplemented by an evaluation of specialist data. The waterway network in the Official Topographical-Cartographical information system (ATKIS-DLM 1:25,000) forms the underlying data. It includes both above-ground and underground watercourses as well as hydrological connecting lines. For the preliminary selection, the WFD bodies of water with an

Table 1
Cost rates of habitat management, determined within the framework of the Landscape Management Assessment Saxony (Grunewald and Syrbe, 2013).

Habitats/habitat group	Regular costs [€ ha^{-1} a^{-1}]	Episodic costs [€ ha^{-1} a^{-1}]
Relevant forest habitats		
Floodplain forests; marsh forests; softwood alluvial forests; slope/gorge and talus forests; mesophilous and acidophilous beech (mixed) forests; deciduous forests in warm, dry environments; natural pine forests and spruce forests; richly structured forest stands; old wooded areas rich in hallow trees	0	10
Hardwood alluvial forests; oak-hornbeam forest; acidophilous oak (mixed) forests	0	220
Moor forests	0	230
Field hedges	0	1925
Field trees	0	965
Orchard meadows	545	55
Near natural running waters (ditches/canals)	625	0
Standing waters		
Near natural small/standing waters	0	130
Near natural lakes/ponds	360	130
Moors and marshes		
High and transition moors	0	155
Fens and marshes	435	55
Small/large sedges and reeds	635	0
Grassland	355–735	6–9
Herbaceous meadows and field margins		
Herbaceous meadows in wet environments	500	0
Ruderal meadows	0	55
Heathland and mat grassland		
Broom heathland	0	55
Dwarf shrub heathland; mat grassland; sandy and silicate mat grassland; dry and semi-dry grassland	520–765	0–8
Open natural and natural rock formations, open inland dunes	0	3–6
Clearance cairns	0	1925
Natural stone walls	0	8250
Vineyard, extensively used	0	7875
Arable land to be used more extensively	525	0

above-ground catchment area (EoA) > 10 km^2 were excluded as well as non-relevant routes, e.g. mining tunnels. The analysis concentrated on areas of arable land, since the probability of piping and the recognizability of bodies of water in aerial photographs are greatest there. Water routes were chosen which run approximately along the depth contours of the landform configuration and are not recognized terrestrially (in the terrain itself) in the selective habitat (biotope) mapping (SBK, 1:25,000) or in the aerial photo analysis of the comprehensive habitat (biotope) types and land use mapping (BTLNK, 1:10,000). In order to reduce false selections as a result of mapping inaccuracies, nearby water routes at a distance of less than 50 m and segments with a total length of less than 50 m were removed.

2. Upgrading of above-ground watercourses which are not subject to the WFD

   The water elements recorded in the comprehensive habitat and land use type mapping of the Free State of Saxony served as the data source for an analysis of possible ecological improvement measures. This GIS database supplies attributes such as the lining, reinforcement, treeing and use of banks. To this end, all small running water bodies (EoA < 10 km^2) which run through arable land or grassland and possess ruderal or grassy slopes/embankments (without wooded areas) and which are not recorded as valuable in the selective habitat mapping were selected. This yielded the restructuring requirements of tree planting on at least one riverbank. Accordingly, a selection of sections of the water body which are straightened but not reinforced was carried out, since a dismantling of reinforcements could lead to safety problems in the adjacent environment.

3. Restructuring in the environment of the water body

   The restructuring of extensive habitats and wooded areas in the environment of the water body cannot be funded solely with the financial resources of landscape management. In this case, steep slopes which are in particular danger of erosion and depth contours on arable land provide an area pool which cannot be intensively farmed on a permanent basis. These areas are to be regarded as potential areas for extending the environment of the water body.

2.3. *Estimating of costs*

Landscape management has associated costs which cover all that must be given up to implement conservation interventions. Costs can include in particular acquisition costs, transaction costs, opportunity costs, or management costs (e.g. Naidoo et al., 2006; Naidoo and Ricketts, 2006).

2.3.1. *Calculation of the costs of regular habitat management*

In addition to the total area requiring maintenance, the necessary frequency of the management or maintenance use is an important criterion. In this context, the relevant management intervals were derived after Döring (2005). The cost rates specific to regular management measures were determined on the basis of the currently valid funding rates for habitat management (EU funds, combined with co-financing by the country). In addition, the 5242 individual funding measures for the Saxon guidelines NE ("Natural Heritage" 2007) and AuW ("Agricultural Environmental Measures and Forestation" 2007) were evaluated in the year of reference 2009.

The records were first of all filtered according to habitat types requiring maintenance. Subsequently, the claimed area per measure and the corresponding funding area for each habitat type were determined.

The procedure as developed will be explained in the following on the basis of the habitat type "mountain meadow" (GB, acronym of the biotope classification for this habitat type) using the example of the funding measures G3a = nature conservation compatible use of meadows with elimination of fertilizers (Table 2). The funded area per measure (317.6 ha) is multiplied by 100% and divided by the funded area habitat type (1055.5 ha = sum of the measure area). The result then shows the percentage of the individual measure in the calculated total habitat funded area (30.1%). Multiplying this percentage by the funding rate (394.00 €) gives the costs of the measure for one hectare of maintained area (118.53 €). The other measures listed in Table 2 were treated similarly, so that annual management costs amount to 380.62 €. It means we first take the total amount of mountain meadows and see what kinds of measures are funded there and on what number of ha. Then we take the weighted average of funding rate and number of ha to calculate the costs for that habitat.

The possibility of adaptations of premiums on the basis of cost increases occurs regularly in the specified planning period of 10 years (at least once upon expiry of the funding period) as well as irregularly, according to special adaptation requirements. A total increase of the premium rates of 10% was assumed for the period under consideration (10 years), which gives a markup of 5% on the current calculation sum.

Furthermore, an estimation of 5% transaction costs was stipulated. Transaction costs are described as "expenses which arise in order to obtain information, to make decisions or conduct negotiations, to monitor agreements and rules, as well as implementing them or adapting them to modified framework conditions" (Masten, 2000). Therefore, within the framework of landscape management, expenses which arise in connection with information, consultation, conclusion and accompanying bureaucracy within the environmental programs should be apportioned at a general rate per hectare.

Adding the rate of increase and transaction costs (together 10%) to the calculated management funding rate and rounded up to the full Euro in steps of five gives the target funding requirements for the habitat type – in the sample case "mountain meadow" 420 €/ha (Table 2).

In the case of premium rates in the field of habitat use and management, we are dealing with fixed cost rates. Neither planning and management costs nor incentive components are contained in these. Calculation of an incentive component (actually held to be necessary) was not carried out as this has been excluded by the EU for the foreseeable future (period under consideration).

2.3.2. *Calculation of episodic (investment) costs of habitats*

Investment costs generally affect only one part of the mapped habitat area and the timeframe for the realization of the so-called investment costs was usually estimated at 10 years (without a kind of grow rate). Some measures in habitat types (e.g. hedges, clearance cairns/stone walls) are actually recurring habitat management measures which, however, on the basis of the selected period under consideration of 10 years, are treated as investment measures because of single implementation (organizational/administrative).

Depending on the evaluations in the framework of the Fauna–Flora–Habitat (FFH) monitoring activities within the framework of Natura 2000, the additional devolvement requirements were estimated for each habitat or habitat type.

In the case of habitat areas in a condition of preservation which can be rated as average to bad condition (C), regular management measures are not sufficient to restore an excellent (A) or a good (B) condition of preservation of the habitat type. In these cases, some once-off management measures with a greater expenditure of time and cost are necessary, such as land clearance and repeated mowing. Consequently, once-off management measures (=investment)

Table 2
Calculation example – management cost rate (needs) for the habitat type "mountain meadow" (GB; German: Grünland/Bergwiese).

Measure (due to the EU-/Saxonian support programs AuW and NE)	Funding rate [€ ha^{-1}]	Funding area measure [ha]	Share of the measure of the overall funding area [%]	Management cost rate [€ ha^{-1} a^{-1}]
Use of meadowland in accordance with nature conservation with elimination of fertilizers				
G2 – before first use	312	114.9	10.9	33.95
G3a – first use from 15th June	373	532.7	50.5	188.23
G3b – first use from 15th July	394	317.6	30.1	118.53
G4 – with impoverishment (nutrient removal) phase	352	19.6	1.9	6.52
G6 grazing in accordance with nature conservation with later first use	190	52.6	5.0	9.48
G9 establishment of fallow areas and fallow strips in the grassland	536	0.0	0.0	0.02
Mowing of habitat areas with specially adapted technology including clearance and removal				
NB1d – once annually – with medium difficulty	555	6.5	0.6	3.43
NB1f – once annually – with high difficulty	1557	6.8	0.7	10.08
NB2d – (single axle motor mower), once annually – with medium difficulty	840	0.2	0.0	0.16
NB2f – (single axle motor mower), once annually – with high difficulty	1848	2.6	0.3	4.59
NB3c – (using manual labor), once annually – with high difficulty	2930	2.0	0.2	5.64
Total		1055.5	100.0	380.62
Markup for cost increase and transaction costs (10%)				38.06
Rounded-up management cost rate "mountain meadow" (GB)				420

are designed for open land habitats such as grassland, heathland and neglected grassland, if these were rated only in preservation condition "C" (bad). In such cases the cost expenditure of approx. 1000 €/ha (plus rate of increase) is distributed over an implementation period of 10 years.

Not all habitat types are covered by measures and costs in FFH management planning. In such cases, plausible cost estimations were undertaken by means of comparisons. Among other factors, this concerns the habitat types YS (clearance cairns) and UR (vineyard extensively), whose management costs are taken as analogous to BH/BA (field hedge/field trees) or YM (natural stone walls).

The requirements of investment measures for the preservation of forest habitat types were thereafter classified on the basis of whether a habitat type can preserve itself without human assistance in the cycle of natural regeneration, or whether guided intervention and therefore investments are necessary. Particularly with oak-hornbeam forests (WE), hardwood alluvial forests (WH) and oak forests of acidic soil (WQ), sufficient regeneration of the oaks does not occur in most cases in Saxony without planting and fencing.

To a lesser extent, the same applies to alder/ash stream forests, for which reason planting and fencing activities were also calculated proportionately for them. A comprehensive artificial regeneration of the natural alder/ash stream forests identified in the selective habitat (biotope) mapping (SBK, 1:25,000) is not to be aimed at, since many of these forests exist in gallery form or in small areas along running bodies of water and should either be used not at all or should be coppiced in the traditional manner. Sufficient natural potential exists along running bodies of water for the natural regeneration of black alder, ash and species of willow. However, the active regeneration (replanting) of black alder and ash is necessary in the case of the conversion of coniferous forests. It could also be of value for alder-rich floodplain and marsh forests which are already relatively highly dried out, or for the reestablishment of alder/ash forests in floodplains where the natural succession has to be supported.

The other climax-forest communities, such as beech forests, spruce forests, pine forests, usually regenerate themselves naturally to a sufficient extent – provided that there are sustainable wild stocks. The same applies to azonal forest communities such as slope forests and softwood alluvial forests.

For the estimated calculation of the costs of regeneration of oak forests and stream forests, recourse was added to the cost rates which were used in the FFH calculation (cultural costs, process costs). For a hectare of oak regeneration – including the associated secondary tree species – the following costs are obtained:

- Planting: 6000 €/ha,
- Building/dismantling of fences: 3500 €/ha,

giving a sum of 9500 €/ha of oak forest regeneration.

An annual requirement of 2% of the identified habitat area was estimated as a cycle for the amount of these costs, so that theoretically, within 50 years, a regeneration measure is to be financed for each area. The regeneration periods are normally longer and the proportional regeneration area smaller. However, in the course of the forest habitat mapping only older forest stands were mapped, which will therefore have to be greatly regenerated in coming years. These cost rates were also transferred to the hardwood alluvial forests, since the problem of adequate oak regeneration also arises here.

The determined cost rates of habitat management are presented in Table 1, in part aggregated according to habitat groups.

2.3.3. *Calculation of costs of restructuring measures*

The calculated restructuring measures refer to the planting of hedges or lines of trees and do not include any extensive rededications. Field margins can equally be established using the planned resources, something which would reduce costs. Steep slopes and depth contours within arable land are particularly preferred for extensification since those areas are mostly endangered by water erosion or flooding. Therefore, the intensive use for agricultural purposes on these areas on a long-term basis is questionable. Consequently, a withdrawal, afforestation or grass farming would be appropriate there. The planting of hedges is taken as the general activity for the linear objects. The estimation of the investment costs is based on an average planting width for hedges of 5 m, though the new elements are completed by a further 2.5 m of field margin structures without planting measures on both sides of the new hedges. This is calculated with the corresponding cost rate of

25,000 €/km relative to a planning period of 10 years (means for the calculation 2500 €/km per year).

2.3.4. Cost estimations for the water body related measures

An average rate of 150,000 Euro per kilometer was calculated for the opening of piped flowing bodies of water. These costs include an expenditure of 20 to 30% for the purchase of land (various extend depending on type of stream) as well as for planning and overhead costs. 10,000 €/km were calculated for the planting of missing bank trees. In both cases, the costs are to be seen as investments for the next 10 years, i.e. that the implementation is to be distributed over 10 years.

For restructurings in the environment of the water body, the change of use in the above-mentioned locations to permanent grassland is proposed. The costs are estimated at 345 €/ha, which corresponds to the current compensation rate for the conversion of arable land into grassland. Based on the size of the reference area for this measure in Saxony (21,300 ha) and on the specified period of 10 years for implementation the sum of approximately 3.7 million Euros per year was calculated in this context.

3. Results exemplified for Saxony

The habitat area in Saxony which is relevant in terms of landscape management was identified at about 164,000 ha. This is equivalent to 9.4% of the total area of Saxony. The list of habitat areas and management costs is shown in Fig. 2.

More than half of the relevant habitat area is to be balanced with regular management measures (grassland habitats, heathland and neglected grassland) and with use and management in keeping with conservation objectives (arable land, grassland). The management measures described as episodic are relevant for approximately half of the identified habitat area in Saxony, including all forest habitat types. The habitat types of near natural lakes/ponds, orchard meadows, dwarf shrub heathland, fen and marsh require both regular and episodic management measures.

A landscape management assessment for the Free State of Saxony was first put forward in 1999 (LfUG, 1999). At that time, an area was identified whose habitat management requirements were lower by 4.1% in contrast with today (2011). The difference is caused principally by the present inclusion of the category “arable land which is to be used less intensively” (see Section 2.2.1), since the intensity of and, therefore, the necessity of action in the area of arable land have increased significantly, something which has been caused, among other factors, by the improvement of the population of ground-breeding species or the protection of rare segetal weeds. The arable land which is to be used less intensively alone represents 33,000 ha, that is, approximately 3% of Saxony’s agricultural area. But the proportion of forest habitats, trees, hedges and bushes requiring maintenance has also increased and the habitats according to the FFH Directive which were formerly only partially recorded by means of selective habitat (biotope) mapping have now also been integrated.

It has been calculated that about 49 million Euro per year are needed for the management and development of habitats in Saxony recently (Grunewald and Syrbe, 2013). More than 17 million Euro per year would be needed as compensation payments for “arable land which is to be used less intensively” alone.

In the case of running waters and their accompanying structural elements, there was a need for the opening of piped flowing water sections at 300 km, the restructuring of trees along approximately 680 km of watercourses, and the discontinuance or modification of uses on 21.3 thousand ha in the environment of the water body. In addition, a quantitative deficit analysis suggests the reestablishment of 2500 km of linear structural elements in the agricultural landscape, which is a wholly realistic dimension when compared with activities of reestablishment previously carried out e.g. in connection with impact mitigation regulation. In this way, a structural density characterizing the landscape before agricultural collectivization would be achieved, at least in regard to the wooded areas.

The suggested measures are qualitatively supplemented by a determination of focal regions within Saxony for extensive restructuring measures. Because of acute lack, it is recommended that additional field trees and extensively used areas should be established there (Syrbe and Grunewald, 2013). Some landscape regions display very high restructuring requirements with above-average costs. In total, annual restructuring costs of 12 million Euros were assessed for Saxony, which are to be implemented over an area of 25,000 ha. This includes both extensive changes of use as well as linear measures, which have been applied generally to all areas in order to avoid double payments.

With regard to restructuring, the areas in question have increased in comparison with the assessment made in 1999 (LfUG, 1999). The cost estimation, however, turns out to be moderately lower, since the focus is now on the transformation of the use of arable land, instead of the more comprehensive planting of trees as planned in 1999, which has so far been partially implemented. With regard to the restructuring of water bodies, it is important to note that significant individual tasks within the framework of the measure plans according to the EU Water Framework Directive (WFD) are meanwhile being executed and are no longer being assigned to landscape management in the cost assessment, although they still have to be performed.

Special conservation measures for endangered animal and plant species are necessary if the management as part of ‘Good Practice’ or the care and protection of habitats is not sufficient to the preservation of this species in the long term. At present conservation programs exist for Freshwater Pearl Mussel (*Margaritifera margaritifera*), White Stork (*Ciconia ciconia*) and Otters (*Lutra lutra*) in Saxony. Necessary costs to address specific issues of species protection in Saxony were estimated as 2.43 million Euros per year (approximately 1.7 million Euros per year for regional and 0.75 million Euros per year for state-wide significant species). Substantial additional funds for these types of protective measures can be generating via the engagement and compensation scheme or project funding and endowments.

4. Discussion

The ecosystem services approach integrates ecology and economics to help explain the effects of human policies and impacts both on ecosystem properties and on human welfare (Farber et al., 2006; Grunewald and Bastian, 2013). The systematic, data based calculation and thinking about extent and intensity of human activities across the landscape may contribute to achieve important biodiversity conservation, ecosystem/landscape services maintenances as well as sustainable land-use objectives while also generating reasonable economic effects (Polasky et al., 2008). The landscape management accounting system as presented is in the broadest sense a proxy of ecosystem services valuation which reflects the significance or importance of ecological service categories and the valuation of those services across management options (Farber et al., 2006). The annual financial expenditure describes the maintenance costs, but the value of ES for society may be differ in the sense, that the investment in management costs can be overcompensated by the revenues one gain from ES.

Landscape management accounting system is structured in main tasks and based on indicators and data (Table 3) in spatial and temporal characteristic and change. The justification for

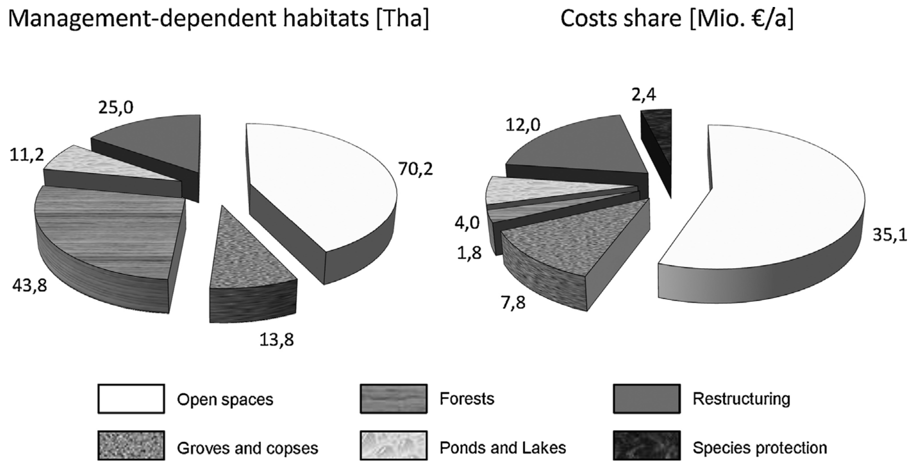

Fig. 2. Areas and costs of habitat/landscape management in Saxony (needs, referring to the area of Saxony of 1,841,971 ha; forest costs only for non-state owned areas).

the selection of specific measures depends on the detected problems/deficits or impairment in the preservation status, for example, compared to the historical status in the 1950s or developments since the last landscape management calculation in Saxony in 1999. This is a difficult negotiation process between science (e.g. our expert opinion for targets and reference times and status) and society (e.g. accepted landscape status), because ecological endowment is first of all value-free.

The data sources which could be used for the creation of a landscape management accounting system are of varying quality (survey status, regionally different mappers, etc.). This applies to the whole analytic section of the landscape management accounting, which is based on facts and settlements. Consequently, error margins and uncertainties have to be taken into account in the overall context. However, the results were verified using both data obtained from the literature and alternative approaches (in particular expert knowledge), and may be regarded as generally reliable, as well as providing a sufficient level of accuracy for the purposes of the landscape management accounting system.

Cost rates as indicator for the need of action for ecosystem maintenance and restoration were calculated for all the care-relevant biotopes, which are based on typical measures of landscape management and at current funding rates in this case for Saxony in Germany. Focal points of action were identified at the district and natural region level, indicating a need for resources and accountability. Accordingly, in rural districts of Eastern Saxony with a large surface area and a high proportion of habitats which require maintenance, a sum of up to 7.7 million Euros per year must be spent, while in the urban municipalities of Leipzig, Dresden and Chemnitz, a considerably lower level of financial investment exists in this regard. That would be a starting point for an ecosystem services based environmental financial compensation between districts or communities, as it e.g. Ring (2008) or Santos et al. (2012) pointed out.

The tasks of landscape management are – as in all EU countries – co-financed by the Free State of Saxony. Although the majority of funding is currently derived from EU funds, the State of Saxony has increased expenditure for nature conservation and landscape management in the last decade by approximately 2 million Euro (from approximately 8 million Euro annually in 1999 to approximately 10 million Euro in 2011). However, the present sum of 10 million Euro represents only 0.06% of Saxony's total budget (Grunewald and Syrbe, 2013).

Table 3
Priorities of landscape management tasks and indicators of its accounting.

Management tasks	Indicators	Data sources
Habitat management	– Share of management relevant habitats of a region, HNV-farmland areas – Frequency of the management or maintenance use – Cost rates	Existing habitat maps, FFH-management plans (Natura 2000), literature, funding rates (EU-programs, nature protection projects)
Restructuring requirements of surface waters and accompanying habitats	– Identification of piped water bodies – Upgrading possibilities/needs of above-ground watercourses – Deficits in the environment of the water body – Cost rates	Official topographical–cartographical information system, selective habitat (biotope) mapping, comprehensive habitat (biotope) types and land use mapping, project costs
Restructuring requirements using trees, hedges and field margin structures	– Restructuring requirements – comparison of target and actual density values – Cost rates	Linear elements of the BTLNK, historical analysis of landscape structures, funding rates and project costs
Specific measures for species protection	– Endangered species – Measures and cost rates	State agencies data, survey, species protection strategy of a state or region
Total tasks of landscape maintenance	– Landscape management measures and costs – Degree of fulfillment of the tasks (e.g. existing funding deficits between target and actual expenditures)	Sum of specific landscape care tasks and its costs as result of a landscape management accounting with costs/expenditure comparisons; agri-environmental programs

One of the goals of nature conservation is to stimulate the interest of the relevant actors in the successes of long-term nature conservation work. In order to realize this, an incentive system for ecosystem services is necessary, in addition to the compensation of expenditure. Priority should be given to technical nature conservation consultation, instead of a too great degree of monitoring (EU stipulated), which can be seen as interfering. It should not be expected that agricultural businesses, who bear the responsibility for their staff, will carry out measures in the desired scope in the longer term, the financing of which just offsets expenditure. Companies which generate too little profit will be forced out of the market in the future and will therefore also not be available as partners in landscape management. As long as incentive components cannot be financed from EU funding sources, other financing possibilities will certainly have to be developed. Two successfully tested systems should be considered in this case: success premiums and (regional) eco-labels. From the point of view of agricultural economics, additional revenue generated by ecologically certified (qualitatively upgraded, more expensive) agricultural products in the food, luxury foodstuff and wellness markets could cover at least half the costs for the general welfare services provided by agriculture.

In addition to the monetization of the regular costs of habitat management, the landscape management accounting system included the development of those methodological components (indicators, data, setting of norms) which are particularly suitable for the identification and quantification of structural deficits in the configuration of landscapes with landscape elements or ecosystems (Syrbe and Grunewald, 2013, Table 3). On this basis, costs and implementation periods were ascribed to the measures in order to be able to estimate the financial requirements. This together represents a planning basis for the specialized policy aims of implementation. As outlined, the degree of accuracy of the analysis and evaluation steps of large-scale regional planning with regionalization possibilities must here suffice on both the district level and the physical region level.

Within the context of landscape management strategy, protection and use should be closely integrated with one another (Federal Nature Conservation Law; Section 2, BNatSchG, 2009). Restructuring is directed principally at areas which serve agricultural production. In order not to restrict this main area use any more than necessary, the proposals for landscape management measures should concentrate on areas which are economically less interesting but especially worthy of protection (BMU, 2007). The evaluation of landscape services of corresponding areas can represent a suitable basis for this.

Among other factors, the various data types of the structural elements present methodological challenges. While solitary trees and shrubs are often recorded in the geo-data as points, smaller running waters (with wooded banks), hedges, field margins, lines of trees and avenues are presented as lines. Comparison of both with the area size of the trees, bushes, bodies of standing water etc. is extremely difficult. Linear objects are usually transferred by multiplying them by their area width (Enzian and Gutsche, 2005), a procedure, however, which is inaccurate when width specifications are lacking. We therefore considered linear objects separately in units of km/km^2. This corresponds to the area percentage, by setting a general width of 10 m as a lump rate for planning purposes.

The analysis of piped running waters is also both complex (cf. Krämer, 2006) and imprecise, since it is necessary to proceed it on the basis of the comparison of data rather than on direct findings. Within the framework of the investigations, it was possible to undertake only a random sample survey of the terrain of the waters under investigation. This means that a considerable degree of uncertainty is to be assumed, which could be improved only by means of systematic investigation in the course of a detailed study. In particular, enough space should be provided for the natural processes along watercourses. Instead of construction interventions, which would cause disruptions to the participating ecosystems, not to mention very high costs, extensions of use and the planting of trees in the environment of the water body are therefore to be recommended (Niehoff, 1996). Use of the depth contours of the landform configuration are aggravated due to potential inundation, flooding and deposition, as well as the steep slopes caused by local problems connected with soil loss, drought or erosion (Voß, 2010). If environmentally harmful subventions are subject to examination, then the agricultural use of such areas should no longer be funded.

Various density target values of between 5 and 22% according to landscape type have already been stipulated for the proportional area of structural elements in the agricultural landscape which are of value for nature conservation (Enzian and Gutsche, 2005). Comparing the current situation, e.g. on the basis of the 13.1% HNV areas (High Nature Value Farmland) in Saxony (PAN, 2011), and the national goal of 19% by 2015 (www.biologischevielfalt.de/ind_hnv.html), leads to the identification of greater restructuring requirements.

The target values for the restructuring of lines of trees, hedges and field margin structures are settlements based on an analysis of historical remote sensing data. They are considerably below the target values of other studies (see above), which, however, often mix area and linear data and are therefore less accurate for special measures. Although the data analysis serves as an orientation, it should not be inferred that these values are therefore scientifically proven, as this would be just as much a naturalistic fallacy as the derivation of such target values from any other data analysis. Various alternative approaches are possible for this, as, for example, the evaluation of historical maps (Schmidt and Richter, 2009), the consideration of application of agrochemicals (Enzian and Gutsche, 2005), or a comparison with the habitat claims of target species. Finally, we are always dealing with standards which have to be negotiated on a social basis.

However, just how far certain conditions or effects can be classified as desirable requires the formation of public opinion and cannot be ascertained on the basis of scientific reasons alone (cf. Valsangiacomo, 1998). It should also be remembered that the goals of nature conservation repeatedly come up against the limits of the possible in a narrow system framework, in the form of so-called practical constraints.

5. Conclusion

The fact that the EU has failed to achieve their self-posed aim to halt by 2010 the loss of biological diversity requires new or modified approaches to be more successful in the current decade. An economic competition can work the guiding principle of voluntariness only when the limits of use are fixed. A landscape management accounting system based on an accepted indicator and data sets can make a contribution for indicating the need of action for ecosystem and ecosystem services maintenance. In this context cost rates represent an important indicator of required financial resources to maintain ecosystem services for public welfare. The accounting system (for additional details see Grunewald and Syrbe, 2013) describes indicators, measures and patterns of behavior for the achievement of these goals, taking the available resources into account.

Along with the spatial strategy of nature conservation, the conception of the protection of species, habitat network planning, as well as the specialist contribution of "nature conservation" to the development plan for the state, the landscape management assessment counts as one of the important technical bases for environmental and nature conservation authorities in

Saxony and aids, among other things, in the implementation of the program for biological diversity. As a cross-sectional conception, it integrates the various objectives of the other strategies and provides an estimation of the annual financial expenditure, which will be required for implementation. The comparison of financial requirements and actual financial expenditure for the implementation of landscape management performances displays considerable deficits and requirements for action (Grunewald and Syrbe, 2013).

The financial resources available for landscape management are distributed very unevenly on a regional basis. Rural regions with a low population often have higher costs than, for example, the financially better-off large cities. In this context, financial allocation should be the subject of a debate (keyword – municipal financial equalization; Ring, 2008; Santos et al., 2012), though there is a need for further research in this area.

The quantitative, normative fixing of values is helpful to policy makers and administration in terms of implementation and oversight. Within the framework of the landscape management accounting, situation analyses and justification contexts in particular were drawn up and specific nature conservation goals were proposed. The basic procedure of the presented landscape management accounting system should be transferable to other regions, albeit priorities, habitat types and cost rates may vary.

There is a social need for landscape management measures, since the relevant ecosystems provide ecosystem services which are demanded by society (e.g. Farber et al., 2006; Naidoo and Ricketts, 2006). The costs which arise in the implementation of these measures can be regarded as indicators for the need of actions to maintain ecosystems.

The study has considered how the inclusion of spatially and time explicit information about economic costs can affect the outcomes of management planning. We illustrated how costs can fit into a dynamic framework for landscape planning, and end by discussing impediments and ways forward to include landscape management costs in planning. The empirical example of landscape management accounting system for Saxony presents a valuation particularly for a better integration of the ecosystem services concept into landscape planning and policy. It is a new approach for evaluation of those management measures required for maintenance of landscapes in both protected (Natura 2000 sites) and non-protected areas, a very important aspect in conservation (Naidoo et al., 2006; Polasky et al., 2008).

We have shown in the paper that landscape management is needed for the maintenance of the character and the functioning of landscapes and entails costs, which can be calculated for particular measures, habitat types, restructuring requirements, physical and administrative units and for a whole country.

As society is ready to burden financial means for the maintenance of ecosystems, we can conclude society's appreciation of landscapes and the services they supply. On the other hand this is strongly influenced by overall political negotiations and other influences. Nevertheless the accounting system delivers valuable information of the minimum investments society would have to pay to gain the broad variety of services delivered by the relevant ecosystems. We could also show that the actually available public budgets are much lower than the means to perform the necessary measures.

Further research should reveal to which extent such cost calculations can be used as an indicator of the value of ecosystem services, may in comparison to WTP- or conjoint-analysis. We also need more information about the economic value of the ecosystem services supply improved by the landscape management measures.

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