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ORIGINAL PAPER

Changing conservation strategies in Europe: a framework integrating ecosystem services and dynamics

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Abstract Protecting species and their habitats through the designation and management of protected areas is central to present biodiversity conservation efforts in Europe. Recent awareness of the importance of ecosystem dynamics in changing environments and of human needs for the sustainable provision of ecosystem services expose potential weaknesses in current European conservation management strategies and policy. Here we examine these issues in the light of information gained from reviews, workshops, interviews and discussions undertaken within the RUBICODE project. We present a new conceptual framework that joins conventional biodiversity conservation with new requirements. The framework links cultural and aesthetic values applied in a static environment to the demands of dynamic ecosystems and societal needs within social–ecological systems in a changing Europe. We employ this framework to propose innovative ways in which ecosystem service provision may be used to add value to traditional conservation approaches by supporting and

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complementing present European biodiversity conservation strategy and policy while remaining within the guidelines of the Convention on Biological Diversity.

Keywords Biodiversity conservation · Ecosystem services · Habitat management · Policy-science interface · Protected area networks · social–ecological systems

Introduction

The protection of species and their habitats provides the essential backdrop to existing biodiversity conservation management strategies and policy, globally and in Europe. Traditionally, conserving nature has been equated with protecting charismatic and rare species, or protecting their habitats and spectacular landscapes (Shafer 1990; Haslett 2004). Even now, although it is clear that both are essential for the protection of biological diversity, the dilemma as to whether to use limited and usually inadequate human and financial resources to pursue the conservation of particular species or whether to invest in the management and protection of habitats that are of notable biological value remains a critical issue in executing conservation strategy. In practice, they represent extremes of a continuous and overlapping spectrum of valid conservation strategies, relevant to most organisms but depending upon particular circumstances (Haslett 2004).

The species/habitat dilemma notwithstanding, in planned and intensively used landscapes as are typical throughout most of Europe, establishing and managing Protected Areas (PAs) as "islands" within the otherwise strongly human-influenced ground matrix has been an obvious and important tool central to biodiversity conservation. The formal recognition of this has been clearly expressed by IUCN/World Commission for Protected Areas (WCPA, see www.wpca.iucn.org). But until recently, the potential connections and flows between reserves were barely considered. Bennet (1999) and Hannah et al. (2007) have pointed out the shortcomings of biodiversity conservation systems based on reserves alone. Now, the policies of isolated site-based conservation that developed over the last century are being replaced by planning and policy with a focus on spatial networking (see Samways et al. 2010). Ecological networks that link PAs via habitat corridors, green veining and greenways are together considered a more effective approach to biodiversity conservation as they should reduce species extinction risks by facilitating movement of organisms through the landscape (Jongman and Pungetti 2004). This conforms to Article 8 of the Convention on Biological Diversity (CBD) on in situ conservation (http://www.cbd.int/convention/convention.shtml). In Europe, the Pan-European Biodiversity and Landscape Diversity Strategy (PEBLDS) has been developed as a Pan-European response to support the implementation of the CBD (Council of Europe 1996). Action Theme 1 within PEBLDS is the establishment of the Pan-European Ecological Network (PEEN). This involves specifically the creation and management of PAs as core areas surrounded by buffer zones and linked across the landscape matrix by ecological corridors (Council of Europe 2000a; Jongman et al. 2004; and see Bonnin et al. 2007). It aims to achieve connectivity so that organisms may move across the landscape and to address such habitat linkage at multiple scales. Aquatic (freshwater) habitats are not explicitly addressed within PEEN, though such habitats are the subject of Action Themes 6 (River ecosystems and related wetlands) and 7 (Inland wetland ecosystems) of PEBLDS.

Within the EU member States, the Natura 2000 network of PAs has been created within the Habitats Directive (European Commission 1992) and includes the Special Bird

Protection Areas of the Birds Directive (European Commission 1979) and Marine Strategy Framework Directive (European Commission 2008). The Emerald Network of the Council of Europe, set up under the 1979 Bern Convention, provides for an equivalent network of sites for its Member States that are outside the EU (Recommendation Numbers 14, 15, 16 adopted by the Standing Committee to the Bern Convention in 1989 and see Standing Committee to the Bern Convention 2000).

To be effective, all these European instruments need to be translated into national actions and carried out within national institutional structures. Each country has its own framework for the organisation of biodiversity conservation policy, based on its political setting, institutional structure and conservation, political and economic history. Even within some countries, such as Austria, Belgium, Germany, Italy, Spain and the UK, local/regional governments may differ considerably in their approaches. This means that land areas for nature conservation often differ across political borders (Jongman et al. 2006). In addition, NGOs have different roles and degrees of formal recognition in different countries which affects their participation in policy making at different levels (Jongman et al. 2008; Siebert et al. 2008). All such conservation efforts incur economic costs of implementation that need to be integrated into conservation planning by each country (Naidoo et al. 2006).

Although protected areas and networks certainly form the essential backbone of biodiversity conservation, most of the land in Europe is not protected, and much of Europe's biodiversity is still to be found outside the borders of designated PAs (Papageorgiou and Vogiatzakis 2006). This may begin to be addressed within National policies and by the application of the EU Habitats Directive and can be supported by application of the principles of the European Landscape Convention (Council of Europe 2000b, 2002).

Networking policies and conservation strategies that include or acknowledge biodiversity external to PAs imply an acceptance that biodiversity conservation is integrated into all aspects of human society and that spatial planning processes are involved. Parallel, and perhaps coupled to this, a wave of new interest in biodiversity conservation strategy and policy has arisen that involves the sustainable provision of Ecosystem Services (ES): The benefits that humans obtain from ecosystems that support, directly or indirectly, their survival and quality of life (full definition in Harrington et al. 2010, this volume). Populations of one or multiple species responsible for providing a particular ecosystem service constitute so-called Service Providing Units (SPUs) (Luck et al. 2003, 2009; definition in Harrington et al. 2010, this volume).

The relevance of ES provision to biodiversity conservation is highlighted in the Millennium Ecosystem Assessment (MA) (Hassan et al. 2005). The MA distinguishes between four major groups of services—provisioning, regulating, cultural and supporting, with different categories and subcategories. It is clearly recognised that there are many (global) drivers of environmental change which lead to pressures on ecosystems and their ability to provide services. The MA identified that the greatest threats to biodiversity resulted from the combined effects of land use/cover change due to agricultural development, urbanisation, forestry practices, and accelerated climate change (Gitay et al. 2002; Fischlin et al. 2007). These threats will continue to have a significant impact on biodiversity into the future (Lee and Jetz 2008) and thus there is a need for the cross-sectoral integration of policies. This means that stakeholder involvement in biodiversity conservation is essential, as land users will have to share common space with biodiversity and allow species to use land that is not especially set aside for them. All of this needs to be set in the context that species populations, communities and ecosystems are not static—they change continuously at all scales of space and time.

In the present paper, we consider the current and future needs of European conservation strategies and policy in the light of the demands of the dynamic nature of ecosystems, environmental change and the necessity to sustain the provision of ecosystem services. Thus we address directly the need to integrate traditional conservation of species and habitats with changing climate and the ever-increasing requirement for the long-term, sustainable provision of ecosystem services within social–ecological systems (SES). To do this, we draw upon previous reviews and assessments within and beyond the RUBICODE project to provide a new conceptual framework for developing functioning habitat management strategies that will allow biodiversity conservation in Europe to be approached from the perspective of entire SES.

We employ this framework to illustrate ways in which ecosystem service provision may be used to support and complement present European biodiversity conservation strategy and policy while remaining within the guidelines of the Convention on Biological Diversity.

Rationale for the framework

From the above it is clear that there are both ecological and political/organisational grounds for revising and extending present conservation management strategies and policies across Europe to encompass biodiversity protection, the dynamics of the ecological and sociological systems concerned, and our increasing demands for ES provision. Within ecosystems the dynamics of species activities, interactions and abundances dictate whole-ecosystem functioning, stability, resilience and ecosystem health. Thus, natural dynamics and the processes responsible need to be maintained and appropriate habitat management is necessary to ensure this.

Anthropogenic pressures and drivers of change (for full definitions see Harrington et al. 2010, this volume) are of overriding concern to biodiversity conservation, as has been made clear in the MA. Habitat management and conservation policies need to take into account the effects of such environmental pressures to facilitate adaptation, protect against or otherwise mitigate adverse effects, or restore habitats after adverse impact. In the past, most conservation instruments have assumed an unchanging, static situation, and implications of ecosystem dynamics for conservation management tended to be overlooked. However, since the early 1990s conservation biology and landscape ecology research has also recognised that the patch/matrix/corridor approach is not necessarily an accurate reflection of real landscapes. Instead, landscapes should be regarded as an almost endless series of nested mosaics of patches at different spatial scales. These mosaics are perceived and used differently by different organisms (e.g. Wiens 1989, 1995; Haslett 2001; Vos et al. 2001; Murphy and Lovett-Doust 2004; Billeter et al. 2008). Variable and flexible strategies must be developed to incorporate different dynamics across many scales (Ejrnaes et al. 2002; Pärtel et al. 2005). Although the EU Habitats Directive recognises priority habitats and species to be conserved (Annex I and II), it does not consider that ecosystems can change through succession, inherent ecosystem dynamics (Evans 2006; Hobbs et al. 2006), land use and climate change (Devictor et al. 2008). Indeed, site-based conservation strategies, whether local or European such as the Emerald Network (that includes Natura 2000), may be inadequate under a changing climate, whereby a shifting climate space could result in species extinctions within, and migrations from, the designated PAs to areas not managed for conservation. Further, the networking and corridor systems linking PAs are also site-based and static, so may no longer function efficiently as conduits. This could result in changing ecosystem functioning within the designated sites, and the sites becoming more vulnerable to alien invasions and to biodiversity loss.

Consideration of ecosystem service provision lends further argument to the need for changes in conservation strategy and policy. Populations that function as service providers may be rare or threatened and thus require habitat management for their conservation, just as any other population or species. However, service provision at the level required by beneficiaries may be jeopardised at population levels where the numbers of individuals are still sufficient to maintain a viable population. By identifying this potential loss of service provision, its continuation can be protected, and active conservation management at this early stage affords "insurance" to species populations that are rare or threatened in the conventional biological sense, where risks are based upon extinction rather than services. Indeed, this may be widened to embrace the common situation where ES are provided by common species or functional groups or entire communities of organisms. Also, the provision of ES is not necessarily site-dependent and hence services may be sustained, and their levels assessed and monitored at different, appropriate scales in a changing environment. Thus analysis of ES provision may be used to explore different management strategies for the maintenance and, where necessary, restoration of ecosystems, habitats, species and their services both within protected areas and outside, across the wider landscape.

Methods employed

In RUBICODE, different methodologies were applied to shed light on the effectiveness of nature conservation strategies and policy in Europe and to explore the potential of the ES concept for enhancing their effectiveness. Reviews were undertaken of present habitat management strategies for conservation (Haslett et al. 2008) and of the effectiveness and appropriateness of existing conservation policies in Europe (Jongman et al. 2008). Also, qualitative semi-structured interviews were carried out to explore how different professional stakeholders interpret and use the concepts of ES and view their effectiveness. Thirty-seven interviews were conducted with different professional stakeholders (public officials, NGO experts, academic professionals) in three EU countries and used as case studies (France, Germany and Hungary) (Jongman et al. 2008). Also, an e-survey was conducted targeting a sample of 668 professional stakeholders across Europe by e-mail, of whom 112 responded (15.2%). A specimen of the questionnaire is provided by Bela and Pataki (2008). The reviews and the results from the interviews were discussed at a workshop held in Kranjska Gora, Slovenia (29–30 April 2008) involving 37 conservation stakeholders and scientists (RUBICODE 2008). Outputs from all theses sources were used to test and inform the development of the frameworks.

Erecting a framework

Current biodiversity in any particular area has a historic precedent (Poschlod and WallisDeVries 2002; Pärtel et al. 2007; Zobel and Pärtel 2008). This means that both natural changes and human-induced changes to the landscape must be taken into consideration when making conservation decisions at the present time. The various factors which constitute these changes interact with each other, so conservation is as much about dynamics, as it is about entities, such as charismatic species or species which supply a particular service. This is a challenge for the integration of ecosystem services into conservation as the services will vary in extent and magnitude, hence value, over time. Threats too, will vary over time. In particular, they will vary in magnitude and consequence when the various threats are synergistic. For example, anthropogenic climate change is synergistic with, among other things, landscape fragmentation, stimulating or preventing species dispersal and changing population dynamics (Honnay et al. 2002; Tscharntke et al. 2005; Vollhardt et al. 2007; Hannah et al. 2007). Similarly, land use change and invasive species may interact synergistically in their effects on native species decline (Didham et al. 2007). Such synergisms will have differential effects upon the various species and their interactions. This emphasises that service provision will differ according to varying and interacting external forces. Conservation and ES provision must therefore build in contingency plans to cater for the various changing dynamics and scenarios that arise because the world is made up of complex, interactive and non-linear dynamic systems that are often unpredictable (Dawson et al. 2010, this volume). It must also consider the future and longer term genetic changes over evolutionary time as well as over current ecological time (Silvertown et al. 2006).

These points illustrate that in addition to identifying the more obvious ecosystem services in each of the MA classes there must also be a precautionary approach, where ecosystems are maintained intact as far as possible to ensure continued service provision in the face of changing environmental conditions and biotic interactions, even if there is presently insufficient supporting scientific evidence (Cooney and Dickson 2005). In adopting this view we also recognise the complex scientific discussions relating to species redundancy within individual ecosystem functions (Balvanera et al. 2006; Cardinale et al. 2006) and the necessity of having large numbers of species to fulfil inherent multifunctionality of ecosystems (Hector and Bagchi 2007). The precautionary approach also caters for many possible services that have not yet been identified, including a supporting role for the identified main players in an already recognized provision of service. Many uncharismatic, speciose groups of organisms, such as the invertebrates, are likely to be particularly important in this direction, although their protection is often largely ignored (Haslett 2007). The upshot of all this is that conservation cannot simply be focused on ecosystem *function* alone (Srivastava and Velland 2005). There must also be due consideration to all the biotic players (Diaz et al. 2006). This means maintaining ecological integrity as well as ecosystem function.

A new framework that takes account of the above challenges and links the main issues addressed in the preceding sections of this paper in a manner appropriate for overall biodiversity protection is summarised in Fig. 1. In this diagram, present conservation approaches are depicted by the inner loop (boxes inside the dashed border), while the relation of these to wider societal needs, the provision of ES and dynamic ecosystems are indicated on the outer loop. The main links between the two are also indicated. Thus in the conventional approach, it is our aesthetic/cultural values that provide the stimulus for conserving nature. Policies and management strategies arising from this during the last century have led to the present system of protected areas. Visiting these PAs or seeing photographs of them reinforces our aesthetic appreciation and the value of feeling somehow "close to nature".

But such aesthetic and cultural values are only one of the four types of ecosystem services considered by the MA. Societal needs from nature are much broader and require the supply of provisioning, regulating and supporting services at levels relevant for beneficiaries, while also protecting biodiversity. This is seen in the outer loop. It involves appropriate management and policy for ES provision in different sectors being integrated

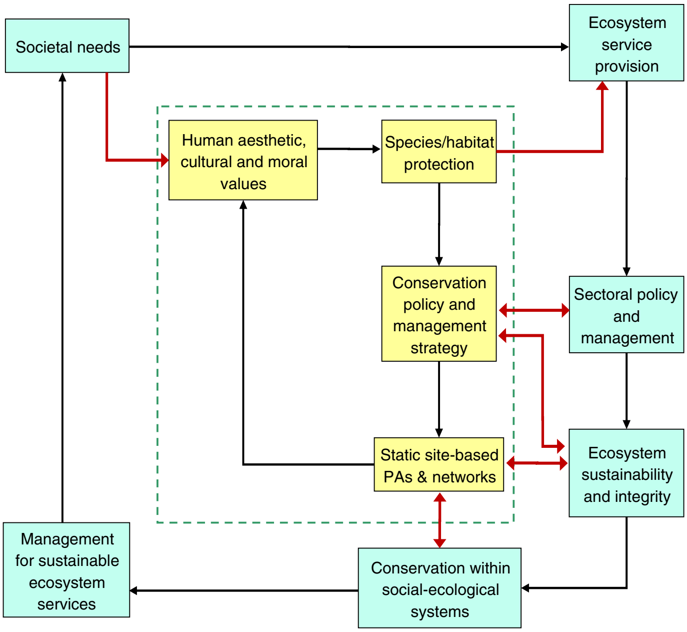

Fig. 1 A framework for conservation in Europe integrating Ecosystem Services (ES). Traditional conservation strategy is represented in the inner loop (within *dashed line*, PAs = protected areas) while wider societal needs and ES provision are depicted in the outer loop. The main links between the two loops are indicated by arrows. For further explanation see text

with ecosystem sustainability, integrity and health to provide conservation within the framework of a social–ecological system. Such conservation strategies (box placed bottom right in the loop) must also encompass management for sustainability of ES provision, but under the limitations of ecosystem sustainability and integrity demands indicated earlier in the loop (bottom of right side) Such management then reflects, and may influence, changing societal needs. Thus the loop represents a continuous, iterative process with associated dynamic and adaptive properties.

However, as this outer loop refers to all societal needs and ES, it will contain elements (services) whose provision will be antagonistic to biodiversity conservation interests or to other services (Ecosystem Service Antagonisers, definition in Harrington et al. 2010, this volume). If left to run in isolation, this loop may have severe detrimental effects on biodiversity (because it is focussed on ES provision). This means it is of utmost importance that *both* loops of Fig. 1 are maintained and that the loops not be considered in isolation, but must be closely linked in all appropriate places (arrows between the loops in the figure) and at all scales of organisation. Considering the two loops together ensures the precautionary approach and the maintenance of ecosystem integrity. Thus aesthetic and cultural values are a subset of societal needs, providing an important link from the outer to the inner loop (top left of diagram). Similarly, species/habitat protection is required for ES provision, giving a link from the inner to the outer loop (top right of the diagram). Note that each of these two links, while working primarily in one direction, may in some situations work in reverse or in both directions (e.g. if aesthetic values are strong enough to inhibit management for other, conflicting services of direct economic value, as occurs in core areas of National Parks, or if the necessary management for an economically important ES inherently protects all the species and habitats and ecosystem integrity, such as clean water catchments in mountains). The other main connections between the inner and outer loops are more obviously two-way relations and are concentrated in the bottom right corner of the diagram. Traditional conservation policy and management needs to be closely intertwined with both policy in other sectors and with ecosystem sustainability and integrity. Linking issues of land use planning and agricultural policy to biodiversity conservation needs is a clear, if multi-faceted example here, but there are many, rather less obvious examples, such as evaluating the pros and cons of road or rail transport in maintaining the flow of freight across the Alps (Truffer et al. 1998). Present site-based PAs and networks have close relationships with ecosystem sustainability and integrity across the wider landscape and also with conservation in the broad framework of an SES (e.g. human attitudes in buffer zones around National Parks and other PAs where activities of local inhabitants and conservation requirements are mutually accepted). Note that there is no direct link in the diagram between conventional site-based PAs and sectoral policy. This reflects the present weakness of taking a static rather than dynamic approach to PAs and networks that does not include areas outside PAs.

Within RUBICODE, a general framework (Framework for Ecosystem Service Provision, FESP) was developed to investigate the complex dynamics of environmental change drivers as well as the identification of the internal and external perturbations that influence ecosystem services (Rounsevell et al. 2010, this volume). FESP is based on coupling the Drivers-Pressures-State-Impact-Response (DPSIR) framework used by the European Environment Agency (EEA 1999) and the concept of social–ecological systems (Berkes and Folke 1998; De Aranzabal et al. 2008).

Figure 2 is a simplified adaption of this general framework, with a specific focus on biodiversity conservation. It incorporates the ideas behind Fig. 1 within the FESP structure. Thus, within the FESP we may start by considering the needs of all Ecosystem Service Beneficiaries (ESBs), (the left element of the loop within the SES box of Fig. 2). In DPSIR terms, these are pressures that influence the content of the next box, the states of conservation of biodiversity across the board, covering all MA service classes and including our cultural values; in other words, the conservation of species that are considered as Ecosystem Service Providers (ESPs), full definition in Harrington et al. (2010, this volume). To attain this broad scale conservation requires environmental management and policy to span all the different sectors at different organisational scales (the impacts), which necessitates appropriate responses to maintain ecosystem integrity and the sustainable provision of all ecosystem services at levels required by the beneficiaries, which in turn, reflects societal needs. Of course, within Europe (or any other definition of scale), any of a number of indirect drivers may operate externally, such as climate change, global economy, global sectoral policy, etc. These are depicted as being influential on societal needs and are also sometimes themselves affected by ecosystem integrity and by the demands of ecosystem service provision, but as they are not part of the immediate system they are placed outside the SES box in Fig. 2. Given the dynamic drivers of change, then iteration of the stages in Fig. 2 is important to ensure that human needs continue to be met and that biodiversity is still capable of delivering them. Note that Fig. 2, just as the outer loop of Fig. 1, also includes antagonisers that may have a negative effect on conservation, creating potential conflicts of interest. Further discussion of Ecosystem Service Antagonisers and resulting conflicts is provided by Luck et al. (2009).

A specific example of the application of the FESP approach to biodiversity conservation and Ecosystem Service provision is provided by Samways et al. (2010). These authors focus on the forestry industry in large-scale ecological networks in South Africa, and

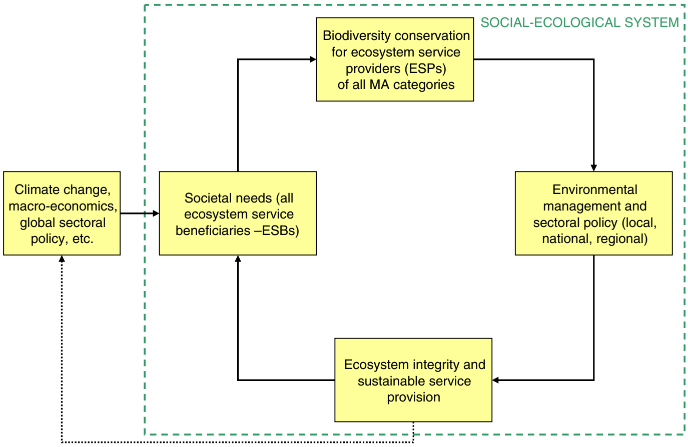

Fig. 2 Elements of biodiversity conservation in dynamic systems summarised from Fig. 1, set within the general framework of a social–ecological system (within the *dashed line*). For further explanation see text

provide a model that elaborates on the broad framework of Fig. 2. The case study combines the requirements of PAs, ecological networks and wider ecosystem integrity with the sustainable provision of forestry ecosystem services. Although the example is not in Europe, the system has been designed for the European market and the timber products only have market access by conforming to conservation network regulations. Findings suggest that the large-scale ecological networks can play an important mitigating role in both biodiversity conservation and ecosystem service provision, though further research will be required for the design of new strategies. Indeed, the work demonstrates that by monitoring service provision at the end, or at different stages during each iteration of the loop, the FESP model can act as a verification process that enables cross-checking of the effects of changes occurring in different parts of the Social Ecological System. Identification of these changes enables actions to be taken to re-adjust the system to meet service provision and conservation demands. This is new and is of considerable added value to previous, traditional conservation strategies.

All this implies an acute awareness of the dynamic nature of ecosystems and our societal interactions with them—change to any part of the system, biological or socio-economic, from within or external, is likely to have profound consequences for the other components and their relationships. This re-emphasises that it would be naïve to continue to consider biodiversity conservation as something on its own; rather, entire SESs are the appropriate level for responding to future conservation needs, although it is recognised that these complex systems need to demonstrate properties of resilience, stability, durability and robustness to be sustainable (Dawson et al. 2010, this volume). Also, this iterative and reactive approach will not always ensure that supply meets needs immediately, as there will be time-lags involved in any adjustments to the system. We should, therefore, be looking to project future needs and supplies. In the absence of such future projections, a precautionary approach to biodiversity conservation may be advocated.

Another complicating factor is that ecosystems are multifunctional, that is they deliver multiple ecosystem services jointly in associated bundles, often across different trophic levels and over a range of spatial and temporal scales (Rollett et al. 2008). Also, different ecosystems provide different bundles, such that the services and/or their relative importance can vary greatly (Harrison et al. 2010, this volume). Further, the bundles may be associated with the functional traits of organisms, rather than with particular taxa (Diaz et al. 2007), offering a traits-based ES approach complementary to traditional species-based conservation approaches (Vandewalle et al. 2010, this volume) The framework of Figs. 1 and 2 allows for all this, as the loops may refer to single or multiple services, but the necessity of managing for such bundles of services will need to be taken into account in the future design of land use and sectoral policy.

Discussion and conclusions

In this paper we have argued that inclusion of sustainable ES provision within European biodiversity conservation strategies and policy could greatly enhance present conservation efforts. We have presented a conceptual framework for this, taking account of the dynamics of both ecosystems and human needs in socio-ecological systems. The ecosystem services approach to conservation is presented here as a communication tool and framework for structuring thinking about the relationships of humans with natural systems. It helps to demonstrate and explain how humans benefit from, and depend upon, natural systems, via the services these systems provide and how this perspective can effectively add value to traditional biodiversity conservation practices. It also helps extend conservation to the wider landscape, with PAs embedded within a heterogeneous landscape mosaic definable at different spatial scales (e.g. Haslett 2001). This extension should ensure that the fabric of the landscape is maintained as a functioning whole, where a multitude of services are provided, even though we may not have yet identified all these services or the relevant portion of unprotected biodiversity that is necessary to provide them, i.e. the ESPs and SPUs.

The dynamic nature of ecosystems means that information on how service provision alters as the characteristics of SPUs change along a continuum of variation, is fundamental to policy-makers and land managers who need to make trade-offs between different management strategies (e.g. trade-off decisions arising from conflicting interests within and between services) (Luck et al. 2009). Indeed, it is the provision of quantitative information that is of most value to policy-makers and land managers because it facilitates specific rather than vague management guidelines, which ensure the sustainability of ecosystem services (Harrison et al. 2010, this volume). Where there is an obvious link between an identifiable element of biodiversity (SPU) and a service (see examples listed in Luck et al. 2009), then appropriate environmental management practices and policies need to be decided and put in place to ensure the continuation of that service. These practices should include the quantification of the numbers of individuals and/or species essential to the maintenance or enhancement of the SPUs and ecosystem integrity in a dynamic world (Luck et al. 2009; Rounsevell et al. 2010, this volume). This will ensure that society's needs are met into the future.

The services approach is often viewed within a market framework. Society depends directly on selected aspects of biodiversity in order to fulfill its various physical needs. However, it also values the cultural and aesthetic contribution of biodiversity (Fig. 1). In both cases, the ecosystem service beneficiaries (ESBs) find that biodiversity is worthy of conservation, but for different, complementary reasons. Some argue that the market/monetary framework helps to shift context from "nature free" to "nature valuable", and can enhance the efficiency of policy. Others feel that it is inappropriate, unethical or dangerous, shifting focus from real ecological changes to monetary changes, and from sustainability constraints to trade-offs (RUBICODE 2008). It is important to bear in mind that these methods are merely tools for aiding thinking and decision-making, and that the ecosystem services approach does not necessarily or logically entail the market/monetary approach. However, it must be reiterated that the ways we identify and categorise ecosystem services are not value free, nor are they independent of the social and economic organisation of societies.

Further criticism of the ES approach is exemplified by Ridder (2008) who argues that the ecosystem services approach as a justification for conservation is flawed as only a relatively small number of species provide the service. What this author overlooks are both the biological realities and philosophical underpinning of biodiversity conservation based on a sense of value (Rolston 1994). Those service-providing species (the ESPs) are embedded in an ecosystem, and to separate out some species from the rest is generally biologically unrealistic as there are many interactions taking place that are not observed and certainly not measured.

What we are arguing for here is an integration of biological realities (the natural fabric and interactions among species which make up the whole ecosystem) with utilitarian value and intrinsic value, as indicated in the framework presented above. In short, species populations are connected and those connections must be conserved to maintain a functioning, service-providing whole.

Amending existing strategies/policy and adding new policy

The information presented in this study strongly suggests that present European strategies and policies directly addressing or affecting biodiversity conservation could be usefully changed and/or supplemented to include the elements of ecosystem dynamics and service provision. Discussions within the activities of RUBICODE involving scientists and policy-related stakeholders reflect this view (RUBICODE 2008), such that general agreement emerged that in many areas it is not so much new policies that are needed but rather existing ones need changing and adapting.

There is an urgent need to accept, and deal with, the requirements of protecting species, their habitats and ecosystems and their services that are all continuously changing in space as well as time. Although there is some evidence that present pan-European conservation policy may be helping birds (Donald et al. 2007) and it is hoped that the recent European Strategy for the conservation of invertebrates (Haslett 2007) and the newly revised Strategy for plants (Planta Europa 2008) may similarly help these organisms, we need overall strategies and policies that have new “on the ground” flexibility to deal with such dynamic systems. Also, if conservation policies were already delivering sufficiently to attain their targets, and if their importance was accepted by other sectors, there would not be a need to develop strategies and policies that refer explicitly to (*dynamic*) ecosystem services. However, particularly outside core protected areas, the need for inclusion of ecosystem services is very evident. Ecosystem dynamics and ecosystem service provision are closely interlinked and both must be reflected in the relevant legislation.

A systematic approach encompassing all this would appear to be the challenge for the near future. Some existing legislation can be interpreted as implying ES protection, but it is not named as such (e.g. the EU Birds Directive, The Council of Europe Bern Convention, [Haslett et al. 2008]). These opportunities for change simply by modifying wording need to be clearly identified and utilised to the full. Similarly, present European legislation covering cultural conditions and traditional knowledge, such as medicinal plants within the European Plant Conservation Strategy (Planta Europa and Council of Europe 2002; Planta

Europa 2008) or cultural heritage and its connection with landscapes under the European Landscape Convention (Council of Europe 2000b) are important and can be built upon.

There is a similar need for a more flexible interpretation of existing legislation and instruments in order to allow for ecosystem dynamics and the dynamics of SES. The current 6-yearly review process in the EU Birds and Habitats Directives allows for some consideration of dynamics and is certainly a step in the right direction. It may well be that as expressed in the Slovenia Workshop and also with discussions with representatives of the Royal Society for the Protection of Birds, the main problem is in achieving full implementation of the strategies, not the strategies themselves (PA Harrison, personal communication and see Wolfe 2005). Indeed, there is even political pressure in some countries and by some organisations to weaken existing conservation instruments to allow greater flexibility in other sectors.

In conservation policy, to incorporate an ecosystem services approach requires a focus on governance and institutions and increased communication and integration across the different sectors. There is now some evidence to suggest that in addition to the adaption of existing policies, new policy, perhaps in the form of a new EU Directive that focuses on the conservation and management of important ecosystem services in Europe may also be an effective route to follow (RUBICODE 2008; EASAC 2009; Harrison et al. 2010, this volume). We need to create policies that can allow factoring of ecosystem service change into, for example, rural development planning and conservation planning, including the design of reserve systems and protected areas or corporate environmental management systems, or into environmental impact assessment processes. This type of integration is already starting to happen, as for instance in the case of integration of the biodiversity issue in the proposed Soil Directive (Commission of the European Communities 2006). At the national level, it is being attempted in the UK in the Department of the Environment, Food and Rural Affairs (DEFRA) Action Plan for an ecosystems approach across government, shifting the focus away from separate policy groupings towards an integrated approach (DEFRA 2007) and in the Dutch Biodiversity Action Plan (Ministry ANF et al. 2008).

Still, the challenges facing biodiversity conservation management strategies and policy remain considerable and success or failure needs to be closely monitored. The framework we have presented here may serve as a guide for amending and supplementing existing legislation to enable biodiversity and the integrity of ecosystems to be conserved and human societal needs to be met in a mutually beneficial manner across Europe.

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References

Balvanera P, Pfisterer AB, Buchmann N, He JS, Nakashizuka T, Raffaelli D, Schmid B (2006) Quantifying the evidence for biodiversity effects on ecosystem functioning and services. Ecol Lett 9:1146–1156

Bela G, Pataki G (2008) Web survey template questionnaire. Available from: http://www.essrg.hu/english/survey/rubicode.html. Cited 29 May 2009

Bennet AF (1999) Linkages in the landscape: the role of corridors and connectivity in wildlife conservation. IUCN Gland

Berkes F, Folke C (1998) Linking social and ecological systems for resilience and sustainability. Cambridge University Press, Cambridge

Billeter R, Liira J, Bailey D, Bugter R, Arens P, Augenstein I, Aviron S, Baudry J, Bukacek R, Burel F, Cerny M, De Blust G, de Cock R, Diekoetter T, Dietz H, Dirksen J, Dormann C, Durka W, Frenzel M, Hamersky R, Hendrickx F, Herzog F, Klotz S, Koolstra B, Lausch A, Le Coeur D, Maelfait JP, Opdam P, Roubalova M, Schermann A, Schermann N, Schmidt T, Schweiger O, Smulders MJM, Speelmans M, Simova P, Verboom J, van Wingerden WKRE, Zobel M, Edwards PJ (2008) Indicators for biodiversity in agricultural landscapes: a pan-European study. J Appl Ecol 45:141–150

Bonnin M, Bruzik A, Delbaere B, Lethier H, Richard D, Rientjes S, van Uden G, Terry A (2007) The pan-European ecological network: taking stock. Nature and Environment No. 146. Council of Europe Publishing, Strasbourg

Cardinale BJ, Srivastava DS, Duffy JE, Wright JP, Downing AL, Sankaran M, Jousseau C (2006) Effects of biodiversity on the functioning of trophic groups and ecosystems. Nature 443:989–992

Commission of the European Communities (2006) Proposal for a Directive of the European Parliament and of the Council for establishing a framework for the protection of soil and amending Directive 2004/35/EC. http://ec.europa.eu/environment/soil/index_en.htm. Cited 20 June 2009

Cooney R, Dickson B (eds) (2005) The precautionary principle. Earthscan, London

Council of Europe (1996) Pan-European biological and landscape diversity strategy. Nature and Environment No. 74. Council of Europe Press, Strasbourg

Council of Europe (2000a) General guidelines for the development of the Pan-European ecological network. Nature and environment No. 107. Council of Europe Publishing, Strasbourg

Council of Europe (2000b) European Landscape Convention and explanatory report. Council of Europe, Strasbourg

Council of Europe (2002) The European Landscape Convention. Naturopa No. 98. Council of Europe, Strasbourg

Dawson TP, Rounsevell MDA, Kluvánková-Oravská T, Chobotová V, Stirling A (2010) Dynamic properties of complex adaptive ecosystems: implications for the sustainability of service provision. Biodivers Conserv (this volume)

De Aranzabal I, Schmitz MF, Aguilera P, Pineda FD (2008) Modelling of landscape changes derived from the dynamics of socio-ecological systems: a case of study in a semiarid Mediterranean landscape. Ecol Indicators 8:672–685

DEFRA (2007) Securing a healthy natural environment: an action plan for embedding an ecosystems approach. Department of the Environment Food and Rural Affairs, London

Devictor V, Julliard R, Couvet D, Jiguet F (2008) Birds are tracking climate warming, but not fast enough. Proc R Soc B 275:2743–2748

Diaz S, Fargione J, Stuart Chapin F III, Tilman D (2006) Biodiversity loss threatens human well-being. PLOS Biol 4:1300–1305

Diaz S, Lavorel S, De Bello F, Quetier F, Grigulis K, Robson M (2007) Incorporating plant functional diversity effects in ecosystem service assessments. PNAS 104:20684–20689

Didham RK, Tylianakis JM, Gremmell NJ, Rand TA, Ewers RM (2007) Interactive effects of habitat modification and species invasion on native species decline. Trends Ecol Evol 22:489–496

Donald PF, Sanderson FJ, Burfield IJ, Bierman SM, Gregory RD, Waliczky Z (2007) International conservation policy delivers benefits for birds in Europe. Science 317:810–813

EASAC (European Academies Science Advisory Council) (2009) Ecosystem services and biodiversity in Europe. EASAC policy report 09. The Royal Society, London

EEA (1999) Environmental indicators: typology and overview technical report no. 25. European Environment Agency, Copenhagen

Ejrnaes R, Aude E, Nygaard B, Münier B (2002) Prediction of habitat quality using ordination and neural networks. Ecol Appl 12:1180–1187

European Commission (1979) Birds Directive. Council Directive 79/409/EEC. http://ec.europa.eu/environment/nature/legislation/birdsdirective/index_en.htm. Cited 22 June 2009

European Commission (1992) Habitats Directive. Council Directive 92/43/EEC. http://ec.europa.eu/environment/nature/legislation/habitatsdirective/index_en.htm. Cited 22 June 2009

European Commission (2008) Marine strategy framework directive. Directive 2008/56/EC. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:164:0019:0040:EN:PDF Cited 22 June 2009

Evans D (2006) The habitats of the European Union Habitats Directive. Biol Environ Proc Royal Irish Acad 106b:167–173

Fischlin A, Midgley GF, Price JT, Leemans R, Gopal B, Turley C, Rounsevell MDA, Dube OP, Tarazona J, Velichko AA (2007) Ecosystems, their properties, goods, and services. In: Parry ML, Canziani OF, Palutikof JP et al (eds) Climate change 2007: impacts, adaptation and vulnerability. Cambridge University Press, Cambridge, pp 211–272

Gitay H, Suárez A, Watson RT, Anisimov O, Chapin FS, Cruz RV, Finlayson M, Hohenstein WG, Insarov G, Kundzewicz Z, Leemans R, Magadza C, Nurse L, Noble I, Price J, Ravindranath NH, Root TL, Scholes B, Villamizar A, Rumei X (2002) Climate change and biodiversity. IPCC Technical Paper V, 77 pp

Hannah L, Midgley G, Andelman S, Araújo M, Hughes G, Martinez-Meyer E, Pearson R, Williams P (2007) Protected area needs in a changing climate. Front Ecol Environ 5:131–138

Harrington R, Dawson T, Feld CK, Haslett JR, Kluvankova-Oravska T, Kontogianni A, Luck GW, Rounsevell MDA, Samways MJ, Settele J, Zobel M, Harrison PA (2010) Terminology used in the RUBICODE approach to biodiversity conservation. Biodivers Conserv (this volume)

Harrison PA, Vandewalle M. Sykes MT Berry PM, Bugter R, de Bello F, Feld CK, Grandin U, Harrington R, Haslett JR, Jongman RHG, Luck GW, da Silva PM, Moora M, Settele J, Sousa JP, Zobel M (2010) Identifying and prioritising services in European terrestrial and freshwater ecosystems. Biodivers Conserv (this volume)

Haslett JR (2001) Biodiversity and conservation of Diptera: A fly's eye view. J Insect Cons 5:71–75

Haslett JR (2004) Is habitat protection still a relevant conservation tool? Naturopa 101:16–17

Haslett JR (2007) European strategy for the conservation of invertebrates. Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention). Nature and Environment No. 145, Council of Europe Publishing, Strasbourg

Haslett JR, Berry PM, Zobel M (2008) European habitat management strategies for conservation: current regulations and practices with reference to dynamic ecosystems and ecosystem service provision. RUBICODE Report available from www.rubicode.net/rubicode/outputs.html. Cited 20 May 2009

Hassan R, Scholes R, Ash N (2005) Ecosystem and human well-being. Millennium ecosystem assessment. Island Press, Washington

Hector A, Bagchi R (2007) Biodiversity and ecosystem multifunctionality. Nature 448:188–191

Hobbs RJ, Arico S, Aronson J, Baron JS, Bridgewater P, Cramer VA, Epstein PR, Ewel JJ, Klink CA, Lugo AE, Norton DA, Ojima D, Richardson DM, Sanderson EW, Valladares F, Vila M, Zamora R, Zobel M (2006) Novel ecosystems: theoretical and management aspects of the new ecological world order. Global Ecol Biog 15:1–7

Honnay O, Verheyen K, Butaye J, Jacquemyn H, Bossuyt B, Hermy M (2002) Possible effects of habitat fragmentation and climate change on the range of forest plant species. Ecol Lett 5:525–530

Jongman RHG, Pungetti GP (2004) Ecological networks, concepts methods and implementation. Cambridge University Press, Cambridge

Jongman RHG, Külvik M, Kristiansen I (2004) European ecological networks and greenways. Land Urban Plan 68:305–319

Jongman RHG, Bouwma IM, van Doorn A (2006) Indicative map of the Pan-European ecological network in Western Europe. Technical Background Document. Alterra Report 1429, 103 pp

Jongman RHG, Bela G, Pataki G, Scholten L, Méri Á, Mertens C (2008) Web report on the effectiveness and appropriateness of existing conservation policies and their integration into other policy sectors. http://www.rubicode.net. Cited 20 May 2009, 122 pp

Lee TM, Jetz W (2008) Future battlegrounds for conservation under global change. Proc Royal Soc B 275:1261–1270

Luck GW, Daily GC, Ehrlich PR (2003) Population diversity and ecosystem services. Trends Ecol Evol 18:331–336

Luck GW, Harrington R, Harrison PA, Kremen C, Berry PM, Bugter R, Dawson TP, de Bello F, Díaz S, Feld CK, Haslett JR, Hering D, Kontogianni A, Lavorel S, Rounsevell M, Samways MJ, Sandin L, Settele J, Sykes MT, van den Hove S, Vandewalle M, Zobel M (2009) Quantifying the contribution of organisms to the provision of ecosystem services. Bioscience 59:223–235

Ministry ANF (Ministry of Agriculture Nature and Food Quality, the Netherlands) (2008) Biodiversiteit werkt, voor natuur, voor mensen, voor altijd. Policy Programme Biodiversity 2008–2011, 67 pp

Murphy HT, Lovett-Doust J (2004) Context and connectivity in plant metapopulations and landscape mosaics: does the matrix matter? Oikos 105:3–14

Naidoo R, Balmford A, Ferraro PJ, Polasky S, Ricketts TH, Rouget M (2006) Integrating economic costs into conservation planning. Trends Ecol Evol 21:681–687

Papageorgiou K, Vogiatzakis IN (2006) Nature protection in Greece: an appraisal of the factors shaping integrative conservation and policy effectiveness. Environ Sci Pollut 9:476–486
Pärtel M, Kalamees R, Reier Ü, Tuvi E-L, Roosaluste E, Vellak A, Zobel M (2005) Grouping and prioritization of vascular plant species for conservation: combining natural rarity and management need. Biol Conserv 123:271–278
Pärtel M, Helm A, Reitalu T, Liira J, Zobel M (2007) Grassland diversity related to the Late Iron Age human population density. J Ecol 95:574–582
Planta Europa (2008) European Strategy for plant conservation (2008–2014): a sustainable future for Europe. Plantlife International, Salisbury, UK and Council of Europe, Strasbourg
Planta Europa, Council of Europe (2002) European plant conservation strategy. Council of Europe, Strasbourg
Poschlod P, WallisDeVries MF (2002) The historical and socio-economic perspective of calcareous grasslands—lessons from the distant and recent past. Biol Conserv 104:361–376
Ridder B (2008) Questioning the ecosystem services argument for biodiversity conservation. Biodivers Conserv 17:781–790
Rollett A, Haines-Young R, Potschin M, Kumar P (2008) Delivering environmental services through agri-environment programmes: a scoping study. Report to the Land Use Policy Group, Peterborough, England
Rolston H III (1994) Conserving natural value. Columbia University Press, New York
Rounsevell MDA, Dawson TP, Harrison PA (2010) A conceptual framework to analyse the effects of environmental change on ecosystem services. Biodivers Conserv (this volume)
RUBICODE (2008) Final report of the international workshop on habitat management and conservation policy—strategies for a new dynamic approach focused on ecosystem service provision, Kranjska Gora, April 2008. Available via http://www.rubicode.net/rubicode/RUBICODE_Slovenian_Workshop_Report.pdf. Cited 20 May 2009
Samways MJ, Bazelet CS, Pryke JS (2010) Provision of ecosystem services by large-scale corridors and ecological networks. Biodivers Conserv. doi:10.1007/s10531-009-9715-2
Shafer CL (1990) Nature reserves. Island theory and conservation practice. Smithsonian Institution Press, Washington
Siebert R, Tiemann S, Lange A (2008) Identification and analysis of stakeholders for ecological network implementation in Europe—case studies from Germany, United Kingdom, Croatia, Estonia and Switzerland—KEN—knowledge for ecological networks: catalysing stakeholder involvement in the practical implementation of ecological networks. ECNC Tilburg
Silvertown J, Dodd M, Gowing D, Lawson C, McConway K (2006) Phylogeny and the hierarchical organization of plant diversity. Ecology 87:S39–S49
Srivastava DS, Velland M (2005) Biodiversity-ecosystem function research: is it relevant to conservation? Ann Rev Ecol Syst 36:267–294
Standing Committee to the Bern Convention (2000) Abridged report of the 19th meeting (Strasbourg 29 November–3 December 1999). Council of Europe CM, 28 pp
Truffer B, Cebon P, Dürrenburger B, Jaeger CC, Rudel R, Rothen S (1998) Innovative social responses in the face of global climate change. In: Cebon P, Dahinden U, Davies D, Imboden DM, Jaeger CC (eds) Views from the Alps: regional perspectives on climate change. MIT Press, Cambridge
Tscharntke T, Klein AM, Kruess A, Steffan-Dewenter I, Thies C (2005) Landscape perspectives on agricultural intensification and biodiversity—ecosystem service management. Ecol Lett 8:857–874
Vandewalle M, de Bello F, Feld CK, Lavorel S, Martins da Silva P, Moretti M, Sousa JP, Santos P, Sattler T, Sykes MT, Vanbergen AJ (2010) Functional traits as indicators for monitoring biodiversity response to land use changes across ecosystems and taxa. Biodivers Conserv (this volume)
Vollhardt IMG, Tscharntke T, Wackers FL (2007) Diversity of cereal aphid parasitoids in simple and complex landscapes. Agric Ecos Environ 126:289–292
Vos CC, Verboom J, Opdam PFM, ter Braak CJF (2001) Toward ecologically scaled landscape indices. Am Nat 157:24–41
Wiens JA (1989) Spatial scaling in ecology. Funct Ecol 3:385–397
Wiens JA (1995) Habitat fragmentation—island versus landscape perspectives on bird conservation. Ibis 137:S97–S104
Wolfe D (2005) Climate change and the EU Birds Directive. A perspective from The Royal Society for the Protection of Birds. The Royal Society for the Protection of Birds, Sandy, UK
Zobel M, Pärtel M (2008) What determines the relationship between plant diversity and habitat productivity? Global Ecol Biog 17:679–684