

Improving coherence of ecosystem service provision between scales

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Abstract

High-level consensus about safeguarding ecosystem services for optimal benefits to society is not yet matched by transposition to field scale. Various ‘societal levers’ – markets, statutory legislation, common/civil law, market-based instruments and protocols – have evolved as a fragmented policy environment of incentives and constraints, influencing the freedoms of resource owners. This has produced mosaic landscapes reflecting both natural conditions and landowner aspirations. The Principles of the Ecosystem Approach serve as a framework to consider three case study sites: an English lowland estuary and two in Scotland. Societal levers today safeguard some socially valuable services, but the present policy environment is neither sufficient nor sufficiently integrated to achieve coherence between the choices of resource owners and wider societal aspirations for ecosystem service provision. The heterogeneity of societal levers protects freedom of choice, enables adaptive decision-making related to the properties of the natural resource, and makes allowance for changes in societal preferences. Resultant mosaic landscapes provide flexibility and resilience in ecosystem service production. However, further evolution of societal levers is required to bring about greater coherence of ecosystem service production from local to national/international scales. This paper

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explores how issues of scale, regulation and variability manifest in the ecosystem service framework.

Keywords

Scale, regulation, markets, common law, civil law, societal levers

Introduction

The need to maintain production of the subset of ecosystem services that are currently economically valued whilst also safeguarding or restoring the wider spectrum of services essential for continued wellbeing and system resilience has been well documented from planetary to sub-regional scales. This awareness has evolved from narrow consideration of food sufficiency by Thomas Malthus (1798) to the Club of Rome's 'Limits to Growth' (Meadows *et al.*, 1972), the concept of 'ecological overshoot' (Catton, 1980) and assessment of the consequences of the uneven and excessive exploitation of habitats for production of just a few focal ecosystem services (Millennium Ecosystem Assessment, 2005a). Progressive expansion of focus from one or a few of the benefits provided by ecosystems towards broader recognition of the need to safeguard, and ideally restore, ecosystems and the full range of services that they provide marks a growth in ethical and economic, as well as scientific, perspectives (Everard, 2011a). Various studies underline that this pressing challenge is as applicable at national (UK NEA, 2011), catchment (Everard, 2012) and local landscape unit (Waters *et al.*, 2012) scales as at global scales. Aspirations to protect and rebalance the production of all ecosystem services are articulated globally by bodies such as the United Nations (Millennium Ecosystem Assessment, 2005a) and through the Convention on Biological Diversity. At national scale, vehicles to embody these aspirations include the UK's White Paper *The Natural Choice* (HM Government, 2011) and Scotland's *Getting the best from our land: A land use strategy for Scotland* (Scottish Government, 2011a). At regional or wider landscape scales, the Cairngorms National Park Partnership Plan (CNPPP) is an example of a strategy that seeks to achieve sustainable progress across economic, social and environmental vectors. Catchment Management Plans, Integrated Water Resource Management strategies, Area of Outstanding Natural Beauty plans, regional development strategies and a wide range of other plans relating to EU Directive and other supranational designations as well as national-scale designations are examples of a diverse range of mechanisms to translate elements of this broad aim into increasingly local settings.

In 1995, the Convention on Biological Diversity (CBD: www.cbd.int) developed (with formal adoption in 2000) the Ecosystem Approach as an integrated framework to consider the multiple ways in which the functions of the natural world provide benefits to people. Integration of numerous pre-existing habitat- and region-specific classification schemes into a consistent and generically-applicable categorisation of ecosystem services by the Millennium Ecosystem Assessment (2005a) has since promoted uptake of the approach by governments and global bodies across the world. This has increased recognition of the value of and need for an integrated

approach to the exploitation and conservation of socio-ecological systems to safeguard the full range of services they provide (TEEB, 2008; the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (ipBES: www.ipbes.net/); Everard, 2013).

However, converting aspirations for systemic management into fully integrated operational practice across multiple geo-political scales remains hugely challenging. This is to a significant degree due to a heterogeneity of perceptions and valuations of ecosystems and their benefits (Martín-López, 2009), the different scales at which services are produced and consumed (Fisher et al., 2010; UK National Ecosystem Assessment, 2011), disconnections between institutions charged with management of different environmental disciplines (Baldwin et al., 2009), as well as the intersection of resource rights and market economics (Everard, 2011a). Over time, this has resulted in localised anthropogenic manipulation, creating mosaic landscapes embodying both natural and cultural heterogeneity. Historically, for a variety of reasons including a general lack of clear understanding and oversight of market failure and distributional concerns, there has been little or no consideration of the overall functioning of landscapes to optimise service benefits for all in society and to ensure their long-term resilience.

The Ecosystem Approach is defined by the Convention on Biological Diversity (www.cbd.int) as "...a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way". The twelve 'complementary and interlinked principles' (<http://www.cbd.int/ecosystem/principles.shtml>) defining the Approach cumulatively recognise that humans and cultural diversity are integral components of ecosystems, for which the 'balance' of ecosystem services produced is necessarily socially influenced and, in some landscapes, substantially socially constructed.

However, differential awareness and contested demands across societal groups, power balances, particularly relating to the freedoms of landowners, market forces, and complex institutional and regulatory arrangements create tensions between private and public decisions. Rarely, perhaps never, do these different interests align to balance the continued provision of all ecosystem services and to secure the potential of landscapes to support the current and future needs of all in society. Nonetheless, management for equitable and sustainable outcomes remains particularly important for land use and other natural resource policies due to the biophysical interconnectedness of landscapes (e.g. water flow, transport links) with their often conflicting economic implications (Helming et al., 2011). The current fragmented management of ecosystems at all scales highlights the need for the design of alternative mechanisms in pursuit of sustainable development (Ostrom et al., 1993).

Societal levers to balance provision of ecosystem services

In a UK context, as indeed in much of the industrialised world, the freedom of choice of owners of land and other natural resources is legally protected. However, it has also become increasingly bounded by a number of socially-agreed limitations and inducements to protect or favour at least some beneficial services. We refer to these

as 'societal levers' (or just 'levers'), recognising their action as external forces to shift the inertia of established norms.

Markets exert a significant, indeed sometimes an overwhelming influence over choices about the management of natural resources. Markets most commonly favour provisioning services, but generally fail to recognise that their production is heavily dependent on the underpinning support of a wide range of additional ecosystem services (Power, 2010). Some market failures are beginning to be addressed, for example the recent evolution of carbon markets and the institution in the UK of an Aggregates Levy on mined substances. However, most ecosystem services remain external to current markets, and their value to society is therefore inadequately incorporated into policy and business calculations. Agriculture has been the foremost pressure leading to the degradation of wetlands and many other semi-natural habitats worldwide, largely driven by consumer pressure (Millennium Ecosystem Assessment, 2005b) reinforced by governments through a food security agenda (Everard, 2011a) as well as favouring short-term economic growth over long-term consequences. Securing adequate food and maintaining economic growth for a growing population are pressing and legitimate priorities for governments and individuals, but exploitation of ecosystems at the expense of longer-term and wider societal needs not only conflicts with stated commitments to sustainable development but also represents short-termism, a substantial market failure and the consequent creation of multiple vulnerabilities.

Statutory legislation and associated regulatory obligations represent formalised 'rules' agreed by society. Some protect the rights of resource owners, but many act to constrain actions that infringe the freedoms of other sectors of society. These agreements may be supranational (such as EU Directives), national (Acts of Parliament and subsidiary Regulations) or local (for example by-laws). Some statutory protections have yielded significant successes for ecosystems and selected services, for example through various wildlife, water resource, air quality and landscape protection legislation. Society has therefore been progressively evolving a body of legislation as leverage to address some of the more acute adverse impacts of land use and other development decisions on ecosystems, though generally to date on a largely issue-by-issue basis as adverse consequences manifest strongly enough to prompt legislative response. The bulk of legacy legislation does not require integrated assessment of impacts across whole ecosystems and their multiple services and beneficiaries. However, notwithstanding practical shortcomings at the implementation phase, systemic assessment is an intent of some more recent requirements such as Environmental Impact Assessment (EIA) and Strategic Environmental Assessment (SEA) (Partidário, 2000), whilst protection or restoration of ecosystem structure and functioning is a key goal of the EU Water Framework Directive (2000/60/EC) (EU, 2000). We can expect to see an increasingly systemic approach in emerging legislation, though the vast bulk of legacy instruments remain often focused on narrow outcomes.

English common law is founded on the protection of rights, evolving since Roman times through a less formalised body of case law to uphold the rights of individuals or

communities potentially infringed by the actions of others.² Case law relating to rights to air, water, soil and views of undiminished quality as well as sporting or access rights demonstrates common law protection progressively extending to some of what we now term ecosystem services (e.g. protection of the quality and enjoyment of recreational fisheries, Carty and Payne, 1998). Representing as they do the multiple ways in which different sectors of society benefit from ecosystems, ecosystem services represent a wider framework of public rights, many of them historically omitted from management considerations, to which common law protection may be extended by case law (Everard and Appleby, 2008; Everard et al., 2012a).

Various market-based instruments have also been developed to promote aspects of societal wellbeing supported by environmental resources and processes. These are commonly related to statutory agreements, including both inducements (such as agri-environment subsidies) and levies to constrain exploitation or generate environmentally-compensating projects (such as the UK Landfill Tax and Aggregates Levy). Successive iterations of the EU Common Agricultural Policy (CAP) represent market interventions that have shifted from a primary focus on output support, from a time when food scarcity drove policy, through to broader social and environmental goals. The EU CAP has had a dominant influence on management of much of the European rural landscape, and hence on the balance of ecosystem services that are either favoured or eroded. Future agriculture and food policy will inevitably have profound implications for the balance of ecosystem service production.

Voluntary payment mechanisms such as 'payments for ecosystem services' (PES) schemes can also specifically secure the supply of valued ecosystem services wherein payments from 'consumers', or 'buyers', of ecosystem services are accepted by those 'producing' those services (Wunder, 2005). A water utility, for example, benefitting from higher quality river water requiring less 'clean up' costs, may pay farmers, typically via an intermediary body, for undertaking water-sensitive farming practices beyond those required by statute (Smith et al., 2013). The OECD estimated that there were already more than 300 PES or 'PES-like' schemes in operation globally by 2010, addressing a diversity of services ranging from water supply to carbon sequestration, conservation of biodiversity, amenity and recreational opportunity, and ranging from global to local scales (OECD, 2010). Interest in PES has since increased substantially, Schomers and Matzdorf (2013) identifying 457 published peer-reviewed papers on PES addressing a small subset of many more schemes around the world.

In addition to legal and market mechanisms, a range of protocols to safeguard selected desirable services has been established. Amongst the wide variety of protocols influencing societal choices, the 1971 Convention on Wetlands (the 'Ramsar Convention': www.ramsar.org) represents a pioneer of the Ecosystem Approach, explicitly acknowledging the global resource of wetland ecosystems not merely as ecologically important but also as central to the livelihoods and future socio-economic prospects of people, therefore requiring 'Wise Use' (since

² Scotland has a civil law, rather than a common law, jurisdiction and thus, while many of the same private law protections have developed, they have done so in different ways and based on different principles. The law cannot be assumed to be the same in the two jurisdictions. The system of English common law is replicated in many countries across the world.

acknowledged as synonymous with 'sustainable development' and mirroring the Ecosystem Approach). Other international protocols, such as the United Nations Framework Convention on Climate Change (UNFCCC: www.unfccc.int) and Convention on Trade in Endangered Species of Wild Fauna and Flora (CITES: www.cites.org), have addressed the safeguarding of key ecosystem resources and their services. At national scale, the target to achieve 25% forest cover in the Scotland Land Use Strategy (Scottish Government, 2011a) is a national-scale aspiration that is not statutory and is supported by a fragmented set of national economic incentives delivered under the Rural Development Programme. Policies established by major landowning or otherwise influential organisations, such as the National Trust in England, in Wales and in Scotland, the Royal Society for the Protection of Birds (RSPB) or the National Farmers' Union, may also be regarded as forms of non-statutory but nevertheless significant protocols establishing governing policies influencing the management of natural resources and the production of ecosystem services.

The boundaries between statutory, legal, market and social protocol levers are not fixed, with one measure potentially transforming into another. However, the fragmented manner and service-by-service basis on which these various levers have evolved, often as a reaction to localised and acute issues of concern, does not automatically moderate the freedom of choice of landowners, often in localised geographical contexts to favour the production of service outcomes of optimal benefit to all in society at catchment and other landscape scales. Indeed, the plethora of competing incentives, from CAP to habitat-enhancing support, may make it difficult for landowners to identify what is best for the common good, however defined, and to allow them to choose practices serving this common good whilst at the same time reaping individual benefits.

The purpose of this paper is to explore ways in which linkages between scales operate in practical case study settings, to recognise barriers to the promotion of multiple ecosystem service outcomes of optimal benefit to society rather than just a favoured few, and to highlight opportunities to improve 'societal levers' to influence local management and so to contribute to the greatest net societal benefit.

Methods

In order to explore current and potential linkages between scales in the production of ecosystem services, a number of case study sites were chosen to reflect diversity within the British Isles. The three sites selected included a lowland estuary in south west England supporting multiple conflicting uses, and two sites in a National Park in the Scottish Highlands respectively in private and charitable ownership (see Figure 1).

A case study visit to the Tamar estuary in south west England took place in April 2012. The rivers Tamar, Tavy, Lynher, Plym and Plymouth Sound together constitute one of Britain's finest estuarine complexes, collectively draining an area of approximately 1,800km². The rich and diverse wildlife, landscape and historic heritage are recognised through its national and international protected area status. Because of this natural environment, the area provides a diversity of recreational

opportunities and much needed employment for thousands of people. The challenge therefore, is to conserve this natural and historic heritage, whilst encouraging appropriate opportunities and giving full recognition to the important needs of commerce, tourism, national defence and leisure interests. An estuary management partnership, the Tamar Estuaries Consultative Forum (TECF), has been established to bring together stakeholders to promote the delivery of integrated management for the Tamar estuaries and nearby coastal areas in order to ensure long-term sustainability. In this paper, we pay particular attention to management measures to address the requirements of the EU Bathing Waters Directive and the EU Shellfish Waters Directive in the midst of multiple competing interests. Both Directives include assessment and management of microbial standards at specific designated sites. The research team toured the estuary and held meetings involving a range of local stakeholders, including representatives from a naval dockyard, local science organisations, environmental NGOs, local authorities and the TECF.

The two Scottish case study sites lay within the Cairngorms National Park. Some overarching policy aims of the Cairngorms National Park Authority (CNPA) include woodland expansion and enhancement, wetland enhancement and delivery of the services of flood management, carbon sequestration and storage, and timber and food production (Cairngorms National Park Authority, 2012). Both of the Cairngorms case study sites, visited in May 2012, were perceived as representing good examples of environmentally-sensitive management practices with contrasting management regimes respectively to address the objectives respectively of charitable and private owners. At both Cairngorms case study sites, the project team met with their owners/managers, touring the sites and observing and having explained to them key features. This was followed by discussions with these people on site about their decisions and aspirations. This was followed up by a larger workshop involving these people and others stakeholders, including from the CNPA, as an opportunity for collective discussion and deliberation about the team's observations and wider learning from both sites.

The Abernethy Estate, owned by the Royal Society for the Protection of Birds (RSPB), forms part of the larger Abernethy National Nature Reserve (NNR). The 13,714 ha reserve is managed principally for nature conservation with a predominant focus on birds. The Abernethy Estate is also part of a long-term vision of rewilding, where improvement in habitats for the bird species Capercaillie (*Tetrao urogallus*) and Black Grouse (*Tetrao tetrix*) is one of the key drivers, though other forest species feature in the plans. The RSPB Abernethy Estate management plan (March 2010 – April 2015) (Roberts and Amphlett, undated) records that enhancement of certain 'desirable biodiversity', favoured by the membership and mission of the RSPB, is the primary goal of management change. Forest expansion at the Abernethy Estate also identified national and regional strategies with which proposals were consistent and for which it would deliver benefits, including: *The Forests of the Cairngorms: Cairngorms National Park Forest and Woodland Framework* (Cairngorms National Park Authority, 2008); *The Scottish Forestry Strategy* (Scottish Executive, 2006); *The Scottish Forestry Strategy: Implementation Plan (2011-14) and Progress Report (2010-11)* (Scottish Government, 2011b); *A Five Year Species Action Framework: Making a difference for Scotland's Species* (SNH, 2007); and the *Cairngorms Local Biodiversity Action Plan* (Cairngorms National Park Authority, undated). Potential co-benefits for other ecosystem

services are also noted, though there was no explicit intention to take an Ecosystem Approach.

The second Cairngorms study site was Balliefurth Farm, a working diversified farm holding of 170 ha bordering the River Spey. The key focus of farm management is to ensure the economic viability of the farm (mainly beef, lamb, wool and on-farm tourist accommodation) with additional (supported by public subsidy) environmental land management practices including the management of some lower meadows for wading birds, planting seed crops to feed birds over winter, protecting a stand of aspen trees, and providing facilities for education and interpretation. Balliefurth Farm also includes 36 ha of pine woodland, much of it purchased for practical usage including shelter for stock particularly for overwintering (the regulatory service of hazard regulation supporting provisioning service outcomes in terms of stock productivity) with a limited amount of wood extraction mainly for private use (a provisioning service).

Management decisions at Balliefurth Farm, including suggested additional planting of long-term forestry, invoked discussion about the virtues and hazards of locking up potentially food-producing land as well as vulnerability to uncertain long-term markets for forestry. Increased tree cover in some areas of the farm was also seen as encouraging corvids and other predators, thus inhibiting other environmental aims including encouraging waders, songbirds and other desired species. The floodplain has been flood-banked since the 1850s to prevent water overtopping from the Spey onto the lower-lying land, and it is drained by channels that discharge via tidal flaps. The impacts of ongoing 'defence' of this substantial floodplain area on the exacerbation of flood peaks elsewhere in the Spey system have not been researched, nor have impacts on water abstraction elsewhere in the catchment.

Evidence-gathering focused on interviews, both with individual interests and in deliberative settings where stakeholders interacted, in all case study sites. The research team were part of these reflective discussions, with additional focus group discussion on key points emerging. An in-depth literature review was not undertaken, though relevant learning from the literature as well as consideration of the wider policy environments surrounding each case study location were incorporated into our insights.

We used the twelve Principles of the Ecosystem Approach to structure our thoughts, as will be picked up in Table 1 and in the Discussion of this paper.

Results

At no case study site was management explicitly driven by higher-scale management strategies, other than nature conservation subsidies (in the form of grants under the Rural Development Payments subsidy scheme) in the case of Balliefurth Farm and to some extent at the Abernethy Estate. At both Cairngorms sites and in the Tamar Estuary, the emphasis was on locally defined goods. In no case did we observe detailed exploration of the effects of individual enterprises on catchments either upstream or downstream, other than local flooding concerns in the case of the Abernethy Estate. Neither were the impacts of other activities in the

catchment on the case study sites central considerations. Though all sites are situated within areas subject to wider-scale regional plans and aspirations, only at the Abernethy Estate was reforestation consistent with CNPA aspirations to reforest the National Park, though these are driven primarily by organisational objectives that pre-date many of the strategies (although the contributions of plans at Abernethy to wider strategies and wider-scale benefits are now acknowledged). By majority the weighting and 'balance' of planned ecosystem service outcomes at each location depended predominantly on owner/manager aspirations and objectives, rather than any loosely defined public interest or common good.

Whilst the natural character of landscapes reflects their inherent potential to provide a particular range of ecosystem services, current status may reflect significant former modifications to serve pre-existing priorities. In the Tamar, extensive building and land use on the floodplain provides a range of economically valued services, yet with multiple associated pressures including constraints upon the physical extent and natural functioning of the estuary system and hence the breadth of services that it provides. From our focal perspective on microbial standards, the estuary has less natural disease regulation capacity yet is a source of microbial contamination. However, plans for addressing microbial concentrations in the estuary for EU Directive compliance purposes seemed to be addressed with little or no connections with the multiple plans for the Tamar upstream that are likely to influence diffuse loads of microbial contaminants entering the estuary. (Tamar-centred plans include catchment management plans, catchment flood management plans, catchment abstraction plans, Special Area for Conservation plans, World Heritage Site plans, 'Upstream Thinking' farm plans, as just a small subset.) At Balliefurth Farm, historic separation of the floodplain from the river by flood banks and drainage channels influences the hydrology of the Spey, contributing to impacts for recipients downstream, though current land management offers compensatory service benefits including the buffering of nitrates entering the river, creation of habitat for waders and songbirds with associated ecotourism interest, and enhancement of food production. At the Abernethy Estate, former commercial woodland management has been abandoned whilst natural woodland regeneration on formally cleared moorland up to the tree line is being encouraged under the current conservation management regime.

Therefore, at all sites, the socially constructed nature of ecosystem service production was evident. Only at the Abernethy Estate was there an intention to revert to a more natural baseline condition. A range of other conservation measures emphasise restoration to 'benchmark' condition (for example achievement of Good Ecological Status under the EU Water Framework Directive). However, the very concept of a 'natural' baseline is contested as ecosystems have always responded to changing natural and societal pressures and will continue so to do (Everard, 2011a). Principle 9 of the Ecosystem Approach, as defined by the Convention on Biological Diversity, recognises that change is inevitable as there is no unequivocal 'baseline condition', contemporary landscapes being a product of continual change. Indeed, a number of Principles of the Ecosystem Approach highlight that ecosystem management and the balance of services produced are socially constructed. These include, for example, that environmental management is a matter of societal choice (Principle 1) with economic contexts (Principle 4), and that it depends on a range of

forms of knowledge and information (Principle 11) involving all relevant sectors of society including scientific disciplines (Principle 12).

Table 1 outlines the ways in which management priorities within the three case study sites fit with the twelve 'complementary and interlinked' Principles of the Ecosystem Approach. This analysis reflects the primary emphasis on different drivers at the study sites:

- (i) Statutory legislation and associated regulatory obligations under the EU Bathing Waters and Shellfish Waters Directives in the Tamar estuary, which operate at locally designated sites and for which management measures appear to focus almost entirely on local emissions;
- (ii) Social (RSPB membership) protocols at the Abernethy Estate in addition to statutory (National Nature Reserve) and market (membership requirements) levers; and
- (iii) Market forces, albeit altered substantially by policies and associated market-based instruments such as the Single Farm Payment (SFP) and Less Favoured Area Scheme for Scotland (LFASS), at Balliefurth Farm.

One of the immediately striking features of Table 1 is the heterogeneity of 'fit' with principles of the Ecosystem Approach, lessons from which will form the primary structure of the Discussion.

Discussion

One of the key principles relating to how broader-scale global, national and regional aspirations are met by management of matrices of habitats under diverse ownership and/or management control is how inducements and compulsions act to protect local rights whilst favouring optimally beneficial outcomes for all in society. We have defined our use of the term 'levers' or 'societal levers' as the various mechanisms by which local choices are 'levered' by evolving societal requirements.

'Societal choice' is itself a complex and contested term. For example, many ostensibly democratic structures can become captured by powerful and/or better educated players (Issacharoff and Pildes, 1998; Schneider and Ingram, 1997). All three of the case studies in this paper highlight how decision-making remains dominated by local focal outcomes, with wider-scale impacts on adjacent ecosystems being considered largely retrospectively to decisions, if at all. (Examples include the broader impacts of more intensive sewage treatment techniques to address microbial levels in the Tamar, or the impacts of flood banks of the hydrology, fluvial geomorphology and associated ecology of the Spey). Nor were potential local benefits arising from services provided by adjacent ecosystems key considerations in the achievement of desired outcomes. This is illustrated by the disconnection of management strategies in the Tamar estuary from the many potential co-benefits flowing from upstream catchment management plans. Some connections between scales were apparent in the case studies, for example with nature conservation subsidies working to support the aspirations of land managers at Balliefurth Farm and the Abernethy Estate. However, in all three case studies, pursuit of a discrete set of localised service benefits can also result in conflicts with

wider-scale aspirations such as the 'defence' of floodplain for local farming and preferred avifaunal benefits regardless of hydrological impacts downstream. Only at the Abernethy Estate was there a strategy to make links between scales, where the RSPB consults with local community councils, advises immediate neighbours of its plans and proposals, sets up community drop-in sessions in local village halls, and advertises in local papers on its five-yearly Management Plans, with further regular attendance by RSPB staff at Community Council meetings and the involvement of key agencies (including Scottish Natural Heritage, Forestry Commission Scotland and the CNPA) in decision-making through the Management Plan process.

One can expect a mosaic of different preferred services arising from mosaic landscapes, reflecting both natural conditions and local preferences. Heterogeneity within the landscape may be advantageous in terms of retaining resilience and flexibility to address emerging needs. However, evidence from the case studies suggests that the freedom of owners to manage sites does not at present automatically deliver outcomes that connect with broader-scale strategies. At all sites, localisation of decision-making by resource owners dominates decision-making within legal and market constraints. These range from a spectrum from common management aspirations at the Abernethy Estate, where landowner nature conservation aspirations coincide but are essentially not driven by strategic aspirations at National Park scale, through to an almost complete disconnection of management approaches to address local microbial concentration in the Tamar estuary. In particular, significant investment is taking place in the upstream Tamar catchment under the 'Upstream Thinking' programme (<http://southwestwater-cr-report.co.uk/pure-water/catchment-management-upstream-thinking-developments/>) as a cost-effective means for averting treatment costs of abstracted water through prevention of pollution of river water at source. Actions under Upstream Thinking also reduce diffuse loads of microbial pollutants, which may help local estuary managers achieve their goals as one example of a wide range of ecosystem service co-benefits. This contribution to reducing microbial loads in the estuary could be far more economically efficient than the current focus on point source emissions in the estuary, firstly when net societal benefit of such a strategy is taken into account, but also as a way to pool expenditure on integrated goals which may represent a significant cost saving. Similar co-benefits may be possible if measures advanced to address local microbial contamination are considered more broadly in terms of their benefits to other services and their beneficiaries, with a sharing of costs. From these observations, we can conclude that current market, regulatory and other policy levers, including other strategies within the catchment, are manifestly not yet cohesive nor consistent with broader aspirations to achieve a wider range of publicly beneficial ecosystem services rather than a subset of individually beneficial services.

Principle 2 of the Ecosystem Approach begs the question: what is an appropriate level for management? On the one hand, decentralised management can lead to greater efficiency, effectiveness and equity in decision-making, potentially balancing local with regional, national and international aspirations. However, unconstrained private property rights can lead to major spill-over effects (addressed by CBD Principle 3), and devolved governance can be appropriated by powerful local interests. Furthermore, some services are expressed at wide scales or their costs are borne by many diffuse stakeholders, including, for example, the global impacts of climate change or catchment-scale implications of both diffuse pollution and reduced

floodplain storage capacity, calling into question what constitutes the 'lowest appropriate level'.

Narrow interpretation of legislation neither automatically safeguards ecosystem services nor represents best return of societal value per unit of investment, highlighting how reform of statutory levers, or at least the ways in which they are interpreted during implementation, can make a significant contribution to connecting management actions across services and across spatial scales. We also observed that synergies between management at the Abernethy Estate and the aspirations of the Cairngorms National Park Authority (CNPA) and the Scotland Land Use Strategy (Scottish Government, 2011a) to increase forest cover in the Cairngorms was largely serendipitous rather than a matter of explicit connection of goals, whilst increasing woodland cover at Balliefurth Farm was actively rejected as it conflicted with current farming and wildlife objectives. Stronger market-based (including subsidy), regulatory and other levers are required to enable local site managers to make decisions that are consistent with broader-scale aspirations for a rebalancing of ecosystem service production.

Consideration of co-benefits between services, beneficiaries and institutions undertaking ecosystem management might open up opportunities for novel markets for these services, including their capture in emerging PES markets that reward land and other nature resource managers for target service outcomes (Smith et al., 2013). Policy formulation often requires an impact assessment (de Jonge et al., 2012; de Smedt, 2010), and this regulatory lever could be readily extended to encourage the consideration of adjacent and other ecosystems, all of which have an economic context. The UK has been a signatory to the developing Ecosystem Approach since 1995, and formally so since 2000, so the statutory requirement is already established to take greater account of outcomes for interconnected ecosystem services and the geographical and socio-economic contexts in which they are situated. More directed progress has to be made in reflecting this systemic intent as exploitation of habitats for narrowly self-beneficial outcomes, overlooking impacts on ecosystem integrity and service production, are recognised by the CBD as the greatest threat to biological diversity, particularly where driven by market distortions that undervalue natural systems and impacts on affected people. The economic context in addressing microbial standards in the Tamar Estuary seems to be shaped almost overwhelmingly by influencing water industry investment and averting the risk of heavy fines from the EU for non-compliance, with little or no consideration of wider ecosystem service outcomes and associated benefits. The economic context at Balliefurth Farm is driven largely by profitability from food production and ecotourism, balanced against maintenance of desirable biodiversity for which some subsidy payments are available, whereas management of the Abernethy Estate has desirable biodiversity as a key outcome, which is remunerated by membership subscriptions and nature conservation subsidies. In all three case studies, the economic context is not the driving force of ecosystem management, highlighting shortfalls in the set of inducements and requirements comprising the societal levers that aspire to optimise benefits across the full spectrum of ecosystem services underpinning future human wellbeing.

Conservation of preferred models of ecosystem structure and functioning to maintain ecosystem services shape the management of the Abernethy Estate and Balliefurth

Farm, respectively favouring desired subsets of biodiversity as well as returns from food production and ecotourism. However, management of microbial contamination in the Tamar estuary overlooks the potential regulatory services of ecosystems in moderating microbial loads as part of a wider set of publicly beneficial outcomes likely to arise from ecosystem-based management approaches. Aspirations in the CNPPP and at the Abernethy Estate for the reforestation are largely coincidental, whereas at Balliefurth Farm there is a strong presumption against increased tree cover despite the farm lying within the National Park. There are then no compelling linkages between the desire for a particular structure, functioning and service outcome from landscapes set in wider-scale plans and the decisions of local land managers.

Consideration of the time horizon of three case studies reveals a spectrum of approaches. At one extreme, plans for the Abernethy Estate address long-term habitat regeneration under management guidance. Conversely, the landscape of Balliefurth Farm is being maintained in a static condition. No clear time horizon is addressed in the Tamar estuary, other than immediate compliance and submissions to influence wastewater treatment investment to reduce microbial concentrations. Only at the Abernethy Estate is change recognised as inevitable, whilst population, climate and wider geopolitical and economic pressures will affect all three case study sites.

The forms of knowledge used to shape management of all three case study sites also exhibits significant variability. In the Tamar estuary this comprises technical expertise to address localised microbial concentrations, management of Balliefurth Farm is shaped by the aspirations of the farmer to balance revenue from food production and ecotourism with maintenance of desirable biodiversity, whilst the Management Plans for the Abernethy Estate is driven principally by specialist conservation knowledge though significant efforts are also being made to integrate the perspectives of agencies and local communities. Principles 11 and 12 of the Ecosystem Approach encourage greater accounting for different forms of knowledge and for greater participation in decision-making, which would certainly benefit management of microbial concentrations in the Tamar estuary through engagement with various initiatives in the freshwater region of the Tamar catchment.

This discussion, informed by the principles of the Ecosystem Approach, suggests that the current framework of statutory, common law, market, market-based and other instruments comprising society's toolkit of 'levers' influencing resource management decisions is deficient with respect to shaping local land management decisions consistent with broader global, national and regional aspirations. This current gap highlights the need for a future regulatory regime connected more directly with the imperative of sustainable development, accounting for all risk and benefits, and so which is more integrated and reflective (Gemmell and Scott, 2013). Everard (2011b) and Everard and McInnes (2013) highlight the potential for revision of guidance about the interpretation and implementation of often more blinkered legacy environmental regulations, addressing the primary purpose of the regulations and hence the broader ecosystem outcomes of actions undertaken, rather than slavish and fragmented adherence to individual clauses within regulations. As noted above, this reinterpretation of more narrowly framed legacy regulations is entirely consistent with UK commitments under the Convention on Biological Diversity, and it

also accords with UK commitments under the Aarhus Convention (UNECE, 1998) and the intent of HM Government (2011) Natural Environment White Paper *The Natural Choice* to 'mainstream' the value of nature across all policy areas.

Site management currently tends, and potentially will continue to tend in future, to focus on local scale aspirations of site owners/managers. However, there is evidence of how these local perspectives are shaped by statutory, economic and other 'societal levers' that are as yet poorly integrated and aligned with society's longer-term aspirations for a sustainable relationship with ecosystems essential for securing continuing human wellbeing. Long-term evolution of these various levers has safeguarded some ecosystem services recognised as of societal value, the cumulative impact of which has played an important role in societal transition throughout the past century (Everard and Appleby, 2008). Evolution of these levers continues today, for example with emerging carbon markets seeking to encompass formerly overlooked services, and flood risk management taking on a greater sense of how catchments functions as integrated hydrological systems rather than simply focussing on stronger 'defences' to protect localised assets at risk. Furthermore, reform of the EU Common Agricultural Policy is taking increasing account of the need to direct subsidies at a wider range of beneficial outcomes beyond supporting food production. The rights-based nature of the common/civil law means that it is continually being extended to protect ecosystem service beneficiaries, and is potentially amenable for application to 'class actions' addressing a broader set of public rights service by ecosystem services that are not under private ownership (Everard and Appleby, 2008). The heterogeneity and continuous evolution of societal levers serves a valuable role in protecting the freedom of choice of resource owners, enabling adaptive decision-making related to the natural resource type, quality, quantity and location, and making allowance for changes in societal preferences over time due to increasing knowledge, environmental capacity and socio-economic conditions. This in turn safeguards the resulting mosaic nature of landscapes that provides flexibility and resilience in ecosystem service production.

However, the fragmented development of these societal levers, often instituted on an issue-by-issue basis as adverse consequences became evident, means that they are not yet either sufficient or sufficiently cohesive to align the compulsions and rewards of site-level management with the optimisation of ecosystem services of wider benefit to society at landscape scales. This produces a conflicted set of messages for resource managers that may blind them to potentially more beneficial outcomes (such as linking with catchment management initiatives in the Tamar) and a lack of clarity about what society requires and for which it is willing to pay. Better alignment of these diverse levers is essential if clear messages reinforced with appropriate inducements and mandates are to inform local decision-making with broader-scale aspirations for a better balance of net outcomes. This desire for 'joining up' is illustrated in Figure 2. The natural character and the aspirations of owners affecting management affect the set of ecosystem services provided by natural resources (to the left of the Figure), contributing to a range of societal benefits which should ideally be cemented into a range of 'societal levers' serving and compulsions and inducements to favour management that optimises collective benefit. This will act much as current markets and subsidies favour food production with some subsidy of practices sympathetic with the needs of some priority species, but ultimately broadening out to reflect wider societal benefits and beneficiaries

across the full spectrum of ecosystem services. This 'virtuous circle' is only connected when that broad range of services is recognised, and measures are taken to connect societal need at broader spatial and temporal scales with local management 'levers'.

This links back to the 'colour coding' used in Table 1, a useful interpretation of which is that it highlights opportunities for addressing current deficiencies in levers. This clearly includes reform of the statutory drivers (EU Directives) requiring compliance with microbial standards in the Tamar estuary, which offer little flexibility in implementation to address management in more socially connected, economically relevant and systemic ways. Also, a requirement for the democratic shaping of local management decisions is lacking, though this may be most effectively achieved not by a top-down mandate for more stakeholder input to landowner plans (which may conflict with landowner rights) but through a clearer and more consistent articulation of the aspirations of outcomes from all in society in reform of inducements and requirements that constitute society's 'levers' to shape landowner decisions.

This Ecosystem Approach-based perspective can then in turn promote better dialogue to integrate the currently fragmented action of regulators with other organisations responsible for implementing the current disconnected suite of societal levers. This is essential to ensure that resource owners and managers receive clear signals, to secure a better integrated approach to ecosystems and their multiple beneficial services for all sectors of society.

Conclusions

The 12 principles of the Ecosystem Approach, which emphasises outcomes for interdependent ecosystem services set within broader geographical and socio-economic contexts, serves as a useful framework against which to assess the outcomes of decision-making and the ways that they connect, or fail to connect, across spatial scales.

The various regulatory, membership-driven social protocol, market and subsidy levers explored in the three case studies are far from consistent with connecting higher-level aspirations set at international, national and regional scale with the decisions taken at local scale. Most of these levers have evolved in a fragmented way, so there is scope for systemic reassessment to begin to manage out conflicts and to provide clearer consistent signals to resource managers at local scale.

If connections between local management initiatives and broader-scale aspirations and strategies are allowed to continue, inefficiencies will continue in terms of net value to society. However, we have sufficient knowledge today, as well as a broad set of mandates, to embed an Ecosystem Approach progressively to realise societal and economically efficient outcomes from integrated management.

Although there is a need for revision, integration and innovation of new, more effective levers to better join up local practice with broader-scale aspirations, a great deal of progress could be made by explicit requirements for the interpretation and implementation of existing levers in a systemic context. The ecosystem service

framework and the Ecosystems Approach can serve this purpose, which is also supported by other international and national commitments.

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Table 1: Connections between levels of management priorities articulated for three case study sites against the 12 Principles of the Ecosystem Approach. **Green shaded cells** indicate that the Principle is fully addressed, **amber shaded cells** denote that it has been partly accommodated, whilst **red shaded cells** indicate that the issue has been overlooked.

Ecosystem Approach principle	Tamar Estuary management for EU Directive microbial standard	Conservation management at the Abernethy Estate, Cairngorms National Park	Land and habitat management at Balliefurth Farm, Cairngorms National Park
Principle 1: The objectives of management of land, water and living resources are a matter of societal choices	Directive requirements are socially constructed, yet measures to implement them are based on local measures only with no input for local knowledge	The values of the RSPB's membership and wider societal nature conservation values affect site management, though not all management reflects the will of all people (e.g. commercial foresters)	Farm management reflects society's demand for food, ecotourism and aspects of nature conservation, though wider potential benefits from the particular managed ecosystems (hydrological, other forms of wildlife, natural river character, woodland cover, etc.) are not included
Principle 2: Management should be decentralized to the lowest appropriate level	Management is driven by the need to comply with standards in locally designated sites	Management is determined by RSPB site managers in consultation with RSPB higher management	Land management is determined by the farmer's priorities
Principle 3: Ecosystem managers should consider the effects (actual or potential) of their activities on adjacent and other ecosystems	There is an overwhelmingly local focus on measures that might influence compliance with standards at designated sites	Impacts on adjacent ecosystems have been considered in connection with landscape management plans of a range of organisations and direct dialogue with agencies, local communities and adjacent landowners	Effects on adjacent ecosystems are not an influential concern
Principle 4: Recognizing potential gains from management, there is usually a need to understand and manage the ecosystem in an economic context	A local focus on both microbial levels at designated sites and compliance with standards as an outcome measure is not undertaken in an economic context, benefits not offset against costs	The ecosystem is managed largely to reflect the interests of the membership that pays for RSPB management, with additional contributions from land use subsidies	Farm management is set in the economic contexts of food production and ecotourism, with additional contributions from land use subsidies
Principle 5: Conservation of ecosystem structure and functioning, in order to maintain ecosystem services, should be a priority target of the ecosystem approach	Compliance will safeguard some services (bathing and shellfishery health) yet management is not based on ecosystem structure, functioning nor wider societal benefits	Conservation of a particular form of ecosystem structure and functioning to maintain a selected subset of ecosystem services is central to management plans	Conservation of a particular form of ecosystem structure and functioning to maintain a selected subset of ecosystem services is central to management plans
Principle 6: Ecosystem must be managed	Management of microbial concentration	The restoration of a selected subset of	Maintenance of selected subset of preferred

within the limits of their functioning	does not take account of ecosystem functioning	preferred ecosystem functions is the aim of management	ecosystem functions is the aim of management
Principle 7: The ecosystem approach should be undertaken at the appropriate spatial and temporal scales	There is no evidence of connections with other flows of microbial contaminations into the estuary, which could enhance prospects of compliance	The focus of management is largely localised, though this is appropriate for a subset of desired functions and services	The focus of management is localised, though this is appropriate for a subset of desired functions and services
8 Recognizing the varying temporal scales and lag-effects that characterize ecosystem processes, objectives for ecosystem management should be set for the long term	Local and immediate compliance with EU microbial standards are the overriding priorities of management, though some measures affect long-term investment (such as enhancements to sewage treatment performance)	Long-term management is the of goal, especially allowing long-term forest regeneration to support a desired range of wildlife	Long-term stability is the management goal, supporting food production, preferred biodiversity and ecotourism
Principle 9: Management must recognize that change is inevitable	Management focuses on compliance with narrow metrics that do not change over time	Management is focused on ecosystem regeneration, with deselection of some undesirable wildlife	The long-term intent is to maintain the current regime balancing production with conservation of desired subset of wildlife and ecotourism
Principle 10: The ecosystem approach should seek the appropriate balance between, and integration of, conservation and use of biological diversity	Conservation of biodiversity is not part of management, merely of use of two primary services	'Use' of biodiversity in this sense is value of the inherent worth of selected priority species and landscapes, though conservation rather than other forms of use is the driver	Selected biodiversity is conserved within a working landscape in a balance determined by the farmer
Principle 11: The ecosystem approach should consider all forms of relevant information, including scientific and indigenous and local knowledge, innovations and practices.	Forms of knowledge other than technical measures to seek compliance with standards is not used	Specialist conservation expertise is the principal driving force, but the perspectives of agencies, local communities are other bodies are actively sought to inform Management Plans	Specialist farming and conservation expertise is the driving force rather than wider societal choices
Principle 12: The ecosystem approach should involve all relevant sectors of society and scientific disciplines.	Technical specialists only are involved in seeking compliance with microbial standards	The Management Plan cycle includes extensive engagement with and input from a wide range of agencies, local people and adjacent landowners	The farmer's perspective on an optimal balance of outcomes from land management drive decision-making, which is not substantially influenced by external views other than through subsidies for particular management activities

Figure 1: Location of Cairngorms and Tamar estuary case study sites

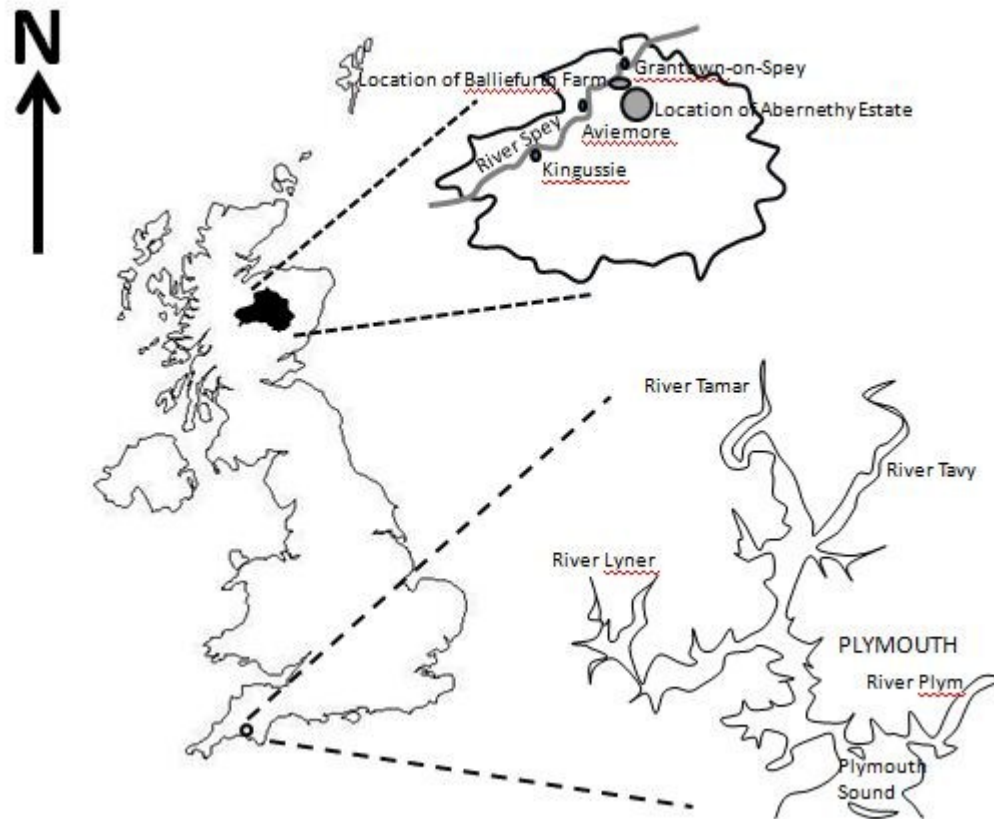


Figure 2: Linkages between resource owner choices, societal levers and stakeholder feedback

