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Mainstreaming ecosystem science in spatial planning practice: exploiting a hybrid opportunity space

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Accepted for publication in *Land Use Policy*, October 2017

Abstract

This paper develops a framework for improved mainstreaming of ecosystem science in policy and decision-making within a spatial planning context. Ecosystem science is advanced as a collective umbrella to capture a body of work and approaches rooted in social-ecological systems thinking, spawning a distinctive ecosystem terminology: ecosystem approach, ecosystem services, ecosystem services framework and natural capital. The interface between spatial planning and ecosystem science is explored as a theoretical opportunity space to improve mainstreaming processes adapting Rogers' (2003) diffusion model. We introduce the twin concepts of hooks (linking ecosystem science to a key policy or legislative term, duty or priority that relate to a particular user group) and 'bridges' (linking ecosystem science to a term, concept or policy priority that is used and readily understood across multiple groups and publics) as translational mechanisms in transdisciplinary mainstreaming settings. We argue that ecosystem science can be embedded into the existing work priorities and vocabularies of spatial planning practice using these hooks and bridges. The resultant framework for mainstreaming is then tested, drawing on research funded as part of the UK National Ecosystem Assessment Follow-On programme (2012-2014), within four case studies; each reflecting different capacities, capabilities, opportunities and barriers. The results reveal the importance of leadership, political buy in, willingness to experiment outside established comfort zones and social learning as core drivers supporting mainstreaming processes. Whilst there are still significant challenges in mainstreaming in spatial planning settings, the identification and use of hooks and bridges collectively, enables traction to be gained for further advances; moving beyond the status quo to generate additionality and potential behaviour change within different modes of mainstreaming practice. This pragmatic approach has global application to help improve the way nature is respected and taken account of in planning systems nationally and globally.

Key Words: Ecosystem Science; Ecosystem Approach; Spatial Planning; Nature; Ecosystem Services; Environmental Governance; Natural Capital

1.Introduction

Ecosystem Services (ES) are widely used to identify and assess the value of the natural environment through the quantification and qualification of the multiple societal benefits from finite stocks of Natural Capital (NC) (Bateman et al., 2013; Likens, 1992; Hubacek and Kronenberg, 2013; Raffaelli and White, 2013). They have gained increasing traction as a policy-shaping framework, largely through the Millennium Ecosystem Assessment (MEA) (2003), TEEB (2010) and Ecosystem Services Poverty Alleviation (ESPA) programme which all have exposed significant and ongoing declines in most ES as a consequence of human interventions and actions (see also Constanza et al., 2014; Douglas and James, 2014; Guerry et al., 2015; WWF 2016). This has catalysed significant global, EU and national responses with ES mainstreaming increasingly evident within dedicated national ecosystem assessments (e.g. Schroter et al., 2016; UKNEA, 2011); new environmental markets in the form of payments for ecosystem services programmes (e.g. Reed et al., 2017); multi-criteria assessments to inform strategic policy guidance and priority setting (e.g. Bryan et al., 2011); green accounting methods (e.g. World Bank, 2010) and improved communication on the importance of ecosystems and biodiversity to human well-being (e.g. Luck et al., 2012).

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Mainstreaming can be defined as a process that "*involves taking a specific objective of one issue domain and declaring that this objective should be integrated into other issue domains where it is not (yet) sufficiently addressed.*" (Karlsson-Vinkhuyzen et al., 2017: 145). For example, there was clear evidence from the UKNEA (2011) that government departments did not explicitly consider ES and their values in policy appraisal processes. Hence mainstreaming implies a process requiring improved translation, acceptance and usage of new idea(s) in line with classic diffusion of innovation theory (Rogers, 2003).

In contemporary spatial planning practice signs of mainstreaming are evident in developing ES mapping and baseline indicators as part of evidence bases for plans and programmes (Gómez-Baggethun and Barton, 2013; Söderman et al., 2012). However, as Posner et al. (2016) note, there is limited research demonstrating how policy- and decision-makers use such evidence in their decision-making processes. Indeed, tracing the impact of ES and their additionality remains an unexploited research gap (see also Daily and Matson, 2008; Laurans et al., 2013).

Within this paper we propose the term "ecosystem science" to capture the collective body of work, approaches and tools located within a social-ecological systems perspective. It is an 'umbrella term' incorporating Natural Capital (NC), Ecosystem Approach (EcA), Ecosystem Services (ES), Ecosystem Services Framework (ESF) and Ecosystem Services approach. These terms are often used interchangeably, uncritically and applied selectively ignoring the inter-relationships, thresholds and dependencies that position nature as a complex social-ecological system (Jones et al., 2016; Spash, 2008) although ideally these concepts should help to highlight those interdependencies and complexities. Within ecosystem science we contend that the EcA, with its 12 principles, offers a potential framework for improved sustainable use and management of nature (Waylen et al., 2014). Yet it has become increasingly marginalised and overlooked in favour of NC and ES, and associated market-based instruments and policy tools within a dominant neoliberal narrative of nature (Buscher et al., 2012; Jackson and Palmer, 2015). Waylen et al. (2014) speculate that this may, in part, be due to the intangibility of some EcA principles and the lack of guidance and case studies demonstrating success in policy- and decision-making (see also Posner et al., 2016).

Furthermore, ecosystem science has only gained partial traction in spatial planning processes and outcomes (UKNEA, 2011: McKenzie et al., 2014), partly due to an artificial separation between the governance for the built and natural environment; each with its own policy and legislative frameworks which arguably creates a wider 'disintegrated development' narrative leading to unnecessary duplication, inefficiency and conflict (Scott et al., 2013). There is, however, a pioneering strand of interdisciplinary research working at the interface between ecosystem science and spatial planning that has tried to exploit their potential synergies (e.g. Douvere, 2008; Scott et al., 2013; Mckenzie et al., 2014; Cowell and Lennon, 2014; Ruckelshaus et al., 2015).

In this paper we undertake further exploration in order to develop stronger theoretical, policy and practice foundations for mainstreaming robust ecosystem science in spatial planning practice arguing, in particular, that the ECA - SP interface is key for effective ecosystem science knowledge integration across planning and environmental governance domains (Natural Capital Committee, 2015; Ruckelshaus et al., 2015; Dennis et al., 2016; Jones et al., 2016). Table 1 exposes this potential through a preliminary mapping exercise of the 12 Malawi principles (EcA) against six spatial planning principles advanced by the UNECE (2008). This reveals significant points of intersection with opportunities to maximise social learning and knowledge exchange across the built and natural environment divides.

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Similarly, when definitions for the EcA and spatial planning are compared, the synergies become apparent. For example, the UN Convention of Biological Diversity's definition of the EcA (CBD, 2010: 12) as *''a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way*'', accords with Allmendinger and Haughton's (2010: 83) definition of SP as "*shaping economic, social, cultural, and ecological dimensions of society through `place making' with a shift towards more positive, integrated and resource-based contexts*". Both EcA and SP are rooted in social-ecological systems thinking within an interdisciplinary human-centred perspective crossing environmental, social, economic, political and cultural contexts and sectors (Gomez-Baggethum and Barton, 2013; Jansson, 2013). Both require the adoption of participatory approaches incorporating equity and shared values (e.g. Bryden and Geisler, 2007; Reed et al., 2013). Both involve a change in values and thinking from the negative associations of protection based on policies of control and restraint towards more holistic, proactive and development-led visions and interventions (Scott et al., 2013).

This convergence of definitions and principles can be taken a step further. Rather than maintaining separate narratives and audiences for 'built' and 'natural' environment domains, which have typified their evolutions to date, there could be added value from exploring mechanisms that facilitate their integration to support ecosystem science mainstreaming and knowledge transfer (Cowell and Lennon, 2014; Karlsson-Vinkhuyzen et al., 2017). Indeed, Cowell and Lennon (2014) stress the importance of using social learning and methodological approaches that better incorporate and integrate competing theories and ideas rather than producing yet more complexity and competition through creeping incrementalism. How we might address this challenge becomes the central theme of this paper.

Spatial Planning Principles	**Ecosystem Approach Principles**
The Governance Principle (e.g. authority. legitimacy, institutions power; decision making) (e.g. Tewdwr Jones et al., 2010; Kidd, 2007),	1 The objectives of management of land, water and living resources are a matter of societal choice. 3 Ecosystem managers should consider the effects (actual or potential) of their activities on adjacent and other ecosystems. 9 Management must recognize the change is inevitable.
The Subsidiarity Principle (e.g. delegation to lowest level; shared responsibility; devolution) (e.g. Haughton and Allmendinger, 2014)	2 Management should be decentralized to the lowest appropriate level.
The Participation Principle (e.g. consultation; inclusion; equity; deliberation) (e.g. Albrechts, 2015; Gilliland and Laffoley, 2008)	11 The ecosystem approach should consider all forms of relevant information, including scientific and indigenous and local knowledge, innovations and practices. 12 The ecosystem approach should involve all relevant sectors of society and scientific disciplines.

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The Integration Principle (e.g. holistic; multiple scales and sectors; joined up) (e.g. Low, 2002; Mommas and Jansen, 2008)	3 Ecosystem managers should consider the effects (actual or potential) of their activities on adjacent and other ecosystems. 5 Conservation of ecosystem structure and functioning, in order to maintain ecosystem services, should be a priority target of the ecosystem approach. 7 The ecosystem approach should be undertaken at the appropriate spatial and temporal scales. 8 Recognizing the varying temporal scales and lag effects that characterize ecosystem processes, objectives for ecosystem management should be set for the long term. 10 The ecosystem approach should seek the appropriate balance between, and integration of, conservation and use of biological diversity.
The Proportionality Principle (e.g. deliverable viability; pragmatism; best available information) (e.g. Nadin, 2007)	4 Recognizing potential gains from management, there is usually a need to understand and manage the ecosystem in an economic context. 9 Management must recognize the change is inevitable.
The Precautionary Principle (e.g. adaptive management; limits; uncertainty; risk) (e.g. Counsell, 1998)	6 Ecosystem must be managed within the limits of their functioning, 8 Recognizing the varying temporal scales and lag effects that characterize ecosystem processes, objectives for ecosystem management should be set for the long term. 10 The ecosystem approach should seek the appropriate balance between, and integration of, conservation and use of biological diversity,

Table 1: The 12 principles of the ecosystem approach (CBD, 2010: 12) mapped against spatial planning principles as defined by UNECE (2008)

The research presented in this paper originates from and builds upon workpackage 10 of the United Kingdom National Ecosystem Assessment Follow-On (UKNEAFO) research programme between 2012-2014 which developed a framework to improve the understanding and mainstreaming of ecosystem science across different spatial planning settings[1]. The paper proceeds by illuminating the SP: ecosystem science interface as a conduit for mainstreaming processes, adapting Rogers' (2003) diffusion theory. Within this adaption we introduce the twin concepts of "hooks" and "bridges" as mechanisms to help ecosystem science infiltrate policy and decision-making contexts, priorities and vocabularies. Hooks are defined as key policy or legislative terms, duties or priorities that relate to a particular user group (i.e. spatial planners) into which ecosystem science mainstreaming efforts can then be positioned. Whereas bridges are defined as terms, concepts or policy priorities that are used and readily understood across multiple groups and publics, thereby functioning as integrating mechanisms. We then use four different participant-led narratives of mainstreaming to show the interplay of hooks and bridges in improving SP practice. The commonalities and issues raised within these experiences are then discussed with regard to facilitating wider mainstreaming opportunities and additionality, also paying attention to likely challenges at both national and global scales (Posner et al., 2016).

2.Methodology

The UKNEAFO (2014) was charged with the translation and mainstreaming of the emerging science from the UKNEA (2011) into policy and decision making processes. To do this a transdisciplinary research team of academics, policy and practice participants was established championing a co-

[1] Work Package Report 10: Tools – Applications, Benefits and Linkages for Ecosystem Science (TABLES) The work package was tasked with developing a tools framework for better mainstreaming of ecosystem science in policy and decision making

production ethic across 10 work packages. This paper draws primarily from intelligence gained within work package 10 from three deliberative partner workshops in 2012-2014. Our partners included key players who were actively involved as innovators in trying to mainstream ecosystem science within particular policy and practice settings. This necessarily shaped the case studies selected. Workshop 1 reported on partners' experiences of ecosystem science mainstreaming practice to identify the barriers and opportunities affecting progress. Workshop 2 then devised an analytical framework for tools and techniques as part of ecosystem science mainstreaming. Finally, workshop 3 developed a resource kit to help integrate guidance, tools and case studies as part of an ecosystem science mainstreaming web platform for wider policy and practice impact and dissemination (NEAT tree[2]).

The method was rooted in a managed and deliberative process championing social learning, enabling partners to work collectively and openly to share problems from their ongoing initiatives and use joint problem-solving to build both conceptual and practice-led innovation. We are thus reporting on core workshop outcomes, participant-led assessments of ecosystem science mainstreaming from which our purposive case studies were selected as well as our own post project reflexivity[3].

3. Building our conceptual framework

Our theoretical focus on mainstreaming is centred on ecosystem science knowledge flows and exchange within policy and decision-making processes. Roger's (2003) contribution on the diffusion of innovation provides a useful theory catalyst for considering how any new innovation/knowledge/idea evolves from initial discovery through to implementation and acceptance involving key stages of knowledge generation, persuasion, decision (adoption/rejection), implementation and confirmation (Figure 1). Given that mainstreaming involves the active diffusion of a specific idea from one domain to another where it has not been sufficiently addressed, attention necessarily needs to be focussed on the ways (mechanisms or tools) the innovation/knowledge is spread; partly through the different communication channels and time but also through the prevailing governance frameworks. However, change is not just confined to users modifying or adapting their behaviour, it also is shaped by the emerging science, nature and progress within the idea/innovation/knowledge itself.

We have applied this thinking to characterise the current state of ecosystem science mainstreaming in Figure 1, which exposes the difficulties in securing sufficient traction with ecosystem science ideas for further diffusion in SP practice. The following persuasion "barriers" were evidenced from workshop 1 and reflect the innovative nature of ecosystem science itself in SP theory and practice (Scott et al., 2013); its technocentric diffusion (Fish and Saratsi, 2015); its complex language and multiple terms (Jordan and Russel, 2014); its requirement for advanced skills to understand/use/access many of the tools available (McKenzie et al., 2014); its lack of exemplars and social learning platforms (Dunlop, 2014; Posner et al., 2016) and its lack of champions and local-scale information (Burke et al., 2015). Crucially, it is the cumulative impact of these barriers that hinder its acceptance and integration within decision-making processes in spatial planning.

[2] The NEAT tree http://neat.ecosystemsknowledge.net/ [accessed 5th July 2017]

[3] This was particularly important for incorporating Rogers 2003 theory of innovation diffusion into the paper to help conceptualise ecosystem science as innovation. We also generated much of our thinking on the SP EcA fusion to help illuminate the synergies across both ecosystem science and spatial planning to aid the mainstreaming process.

A further barrier identified related to key gatekeepers who control the flow of "acceptable" knowledge based on their values and how well 'new' ideas and ways of thinking fit their own narrative and agendas (Scott et al., 2013; Jordan and Russel, 2014). Complicating this picture is the wider stakeholder audience, in a given spatial planning setting, each with their own priorities and capabilities. Thus the consequential policies, plans and agendas that emerge often reflect the pragmatic and politically acceptable with only piecemeal ad-hoc (faint arrows) progress indicating limited mainstreaming successes (Turnberry et al., 2014). The complexity and diversity of the spatial planning context makes it difficult to trigger any meaningful conceptual change (McKenzie et al., 2015).

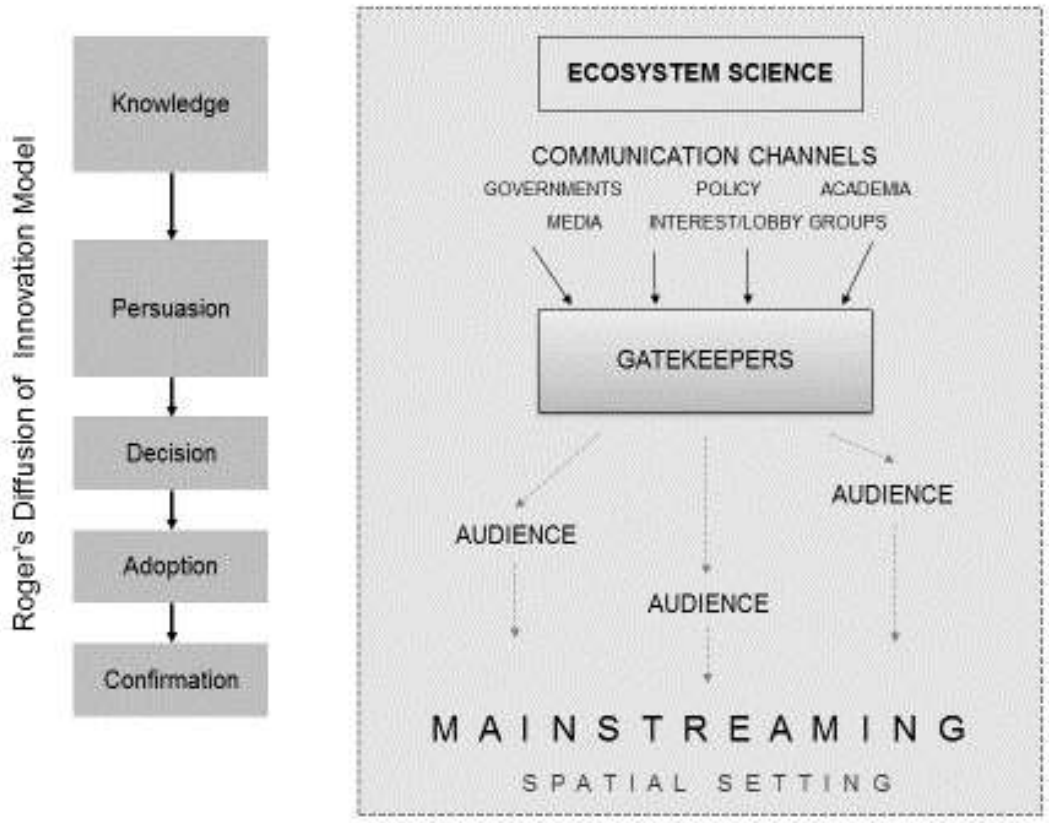

Figure 1. The current model of mainstreaming ecosystem science within the EcA. (adapted from Rogers (2003))

In order to breach the "persuasion" stage successfully (Rogers, 2003), mechanisms need to be identified that enable the necessary ecosystem science traction in a given SP setting thus gaining the support and involvement of the gatekeepers and other stakeholders. It is important that any mechanisms should use and work with familiar terms but also allow deliberation and a change in perspective to move beyond knowledge simply being absorbed into existing systems to actually influence and change values and behaviours (McKenzie et al., 2014). Communication and diffusion of ecosystem science through ES jargon and applications to date has largely been in the hands of natural science experts although there is an increasing move towards more public-led deliberative exercises (e.g. Fish and Saratsi, 2015). Consequently, we argue that more attention needs to be paid on identifying and developing mechanisms that appeal to, and engage with, broader SP audiences, politicians and publics who are not familiar with ecosystem science. It is from this logic that we advance the twin notions of hooks and bridges as mechanisms to facilitate and engineer diffusion and change (Figure 2).

Hooks are defined as key policy or legislative terms, duties or priorities that relate to a particular user group or professional network that are used in regular practice whereas bridges are defined as terms, concepts or policy priorities that are readily understood and used across multiple groups and publics, functioning as integrating mechanisms enabling more holistic and integrative thinking and actions across different sectors and policy goals. Using the example of ecosystem science, ideally the 12 EcA principles should be realised within any potential bundle of hooks and bridges to enable optimal ecosystem science mainstreaming.

Figure 2 conceptualises how hooks and bridges when applied in tandem enable ecosystem science to be mainstreamed without the dilution evident in Figure 1. Having secured the necessary initial traction through the identification and usage of relevant hooks and bridges, knowledge/innovation can then flow through the Ecosystem Science and SP interface within the existing governance system(s), engaging gatekeepers and relevant audiences (e.g. public agencies, private and voluntary sectors and publics). The hooks and bridges facilitate the adoption of innovation pragmatically; appropriate to the socio-political context and capabilities of participants with changes in values/rationality occurring through social learning and/or inspired by innovator case studies and individual champions/leaders. This, ideally, creates a virtuous circle leading to further exploration of innovation (applying ecosystem science to inform policy- and decision-making).

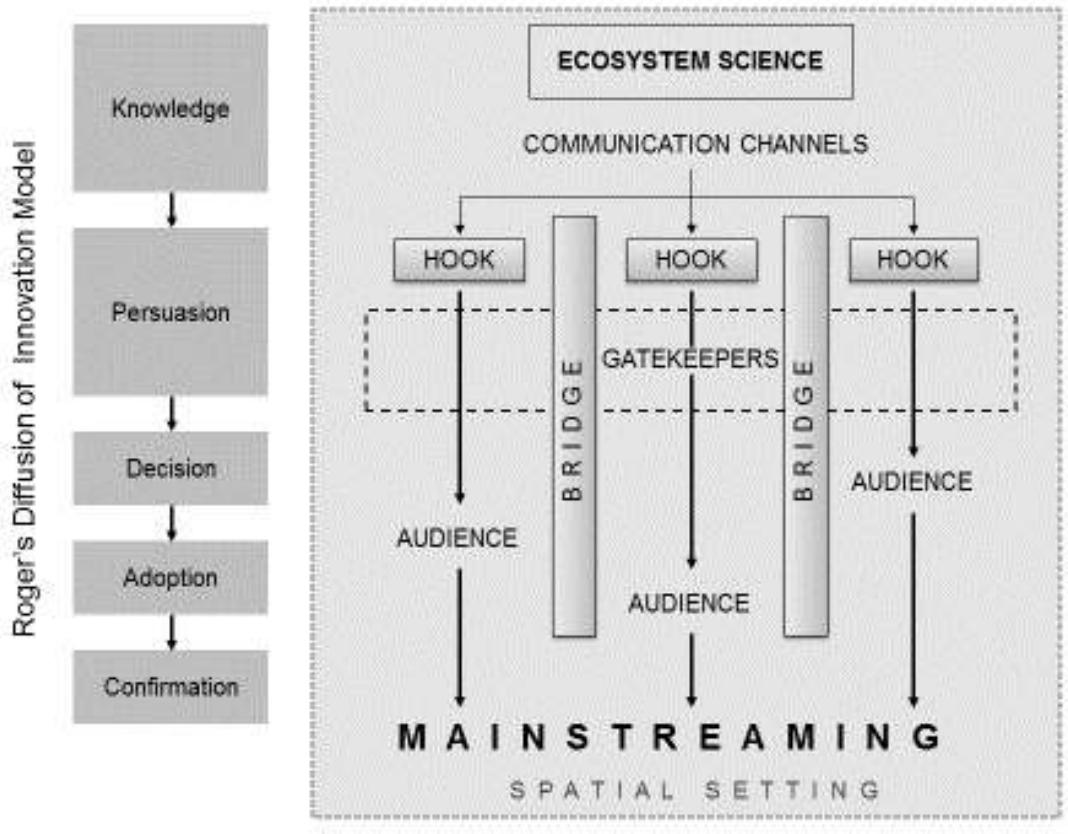

Figure 2: Desired model for mainstreaming showing 'persuasion'/acceptability through use of hooks and bridges. Drawing on Rogers (2003)

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However, different target audiences require different hooks; meaning that the most influential hooks need to be identified in conjunction with the needs, priorities and remits of that audience at that particular time in that SP setting (Douglas and James, 2016). Equally important, is ensuring the selection of bridges that are intelligible as mechanisms to engage multiple audiences and publics to progress ecosystem science ideas. Thus it is the communication, adaption, use and impact of the hooks and bridges cumulatively that will determine mainstreaming success. In the next section, we identify and unpack how specific hook and bridge 'bundles' have been used within four case studies from the UKNEAFO work in different SP contexts. However, the general process of embedding ecosystem science through the interface of EcA and SP principles and identifying suitable hooks and bridges is directly transferable to other countries considering or already working on mainstreaming ecosystem science within their own built environments (see e.g. Brink and Ketunen, 2016; Posner et al., 2016; McKenzie et al., 2014).

Table 2 locates the four case studies in relation to their spatial planning challenge and context.

Case Study	Spatial Planning Challenge (framed by participants)	Approach to Ecosystem Science Mainstreaming
DRAFT North Devon/Torridge Joint Local Plan	How can we recognise the value of ES in a local plan? How can we adapt local policies to maintain/improve benefits from nature?	Used the biosphere reserve concept to frame the ES narrative. Developed an ES policy within the environment chapter of the plan Mapping ES and doing a ES assessment of housing masterplans.
South Downs National Park SDNPA DRAFT Local Plan	How can the EcA be used within a park local plan to improve policy and decision making?	EcA principles rewritten in SDNPA setting. Using framework from Park Management plan and developing an ES policy as one of 4 core polices pervading across all plan areas. Mapping ecosystem services. Green infrastructure workshops and strategy.
Cotswolds Area of Outstanding Natural Beauty (AONB) management plan review	How can we review our AONB management plan mindful of the benefits offered by ES?	Management plan created with an ES framework imported in the action plan. Post adoption consideration of using ES to evaluate the plan and to develop PES schemes for flood management.
Birmingham City Council non statutory Green Living Spaces Plan 2014	What is the value of green infrastructure to the residents and businesses of the city? How can the council embed this information to improve its policies, plans and investment opportunities?	ES assessment of green infrastructure. Created green commission at Cabinet level. Used ES data sets to create demand and supply maps showing areas requiring ES investment. Used as evidence base to support other statutory (Birmingham Local Development plan) and non-statutory plan. Created 7 principles as proxy for EcA.

Table 2 : Spatial challenges of the case studies and approaches to mainstreaming

Table 3 identifies the principal hooks and bridges evident within the four case studies detailing their different approaches to ecosystem mainstreaming. The hooks were identified primarily from UKNEAFO stakeholder workshops and, given the English SP context, were heavily focussed towards the National Planning Policy Framework.

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Case Study	Hook (H) / Bridge (B)
Cotswolds AONB Management Plan	**H Natural Environment White Paper** **B Connectivity** **B Multiple benefits**
North Devon and Torridge Joint Local Plan	**H NPPF paragraph 109** **H NPPF Duty to cooperate** **B Multiple benefits and assets** **B Green infrastructure**
Birmingham City Council Green Living Spaces Plan	**H NPPF Duty to Cooperate** **H NPPF paragraph 109** **H B Green infrastructure**
South Downs National Park Plan	**H NPPF paragraph 109** **H NPPF Duty to Cooperate** **B Green infrastructure** **B Multiple benefits**

Table 3: Hooks and Bridges within the NEAFO case studies (detailed case studies in bold)

Hook 1: NPPF Paragraph 109 - Value Ecosystem Services

"The planning system should contribute to and enhance the natural and local environment by:

- *protecting and enhancing valued landscapes, geological conservation interests and soils;*
- *recognising the wider benefits of ecosystem services;*
- *minimising impacts on biodiversity and providing net gains in biodiversity where possible, contributing to the Government's commitment to halt the overall decline in biodiversity, including by establishing coherent ecological networks that are more resilient to current and future pressures"*

(DCLG, 2012: paragraph 109)

Paragraph 109 of the National Planning Policy Framework (NPPF) is significant in English planning policy as for the first time explicit reference is made to ES. However, the relatively weak wording of "recognising" imposes limitations as to its influence in policy and decision-making processes. It does, however, provide an opportunity for using ES as part of an evidence base from which to inform policy. Thus it has commonly involved identifying, mapping and modelling the amount, spatial distribution and quality of ES and NC in a given area, identifying opportunities for enhancing particular services, analysing trade-offs and alternatives and targeting policy interventions (Baker et al., 2012; Attlee et al., 2015).

Hook 2: Duty to Cooperate - NPPF paragraph 158 and Localism Act 2011

The Duty to Cooperate (DTC) is a legal requirement within the NPPF, enshrined within the Localism Act 2011, requiring all development plans to demonstrate active co-operation on strategic matters in their process of plan formation. This is tested legally at an examination in public by government-appointed planning inspectors (HM Government, 2011a; DCLG, 2012). DTC depends on the extent to which a planning authority has "*engaged constructively, actively and on an ongoing basis to maximise the effectiveness of Local Plan preparation in the context of* ***strategic cross boundary matters***" (HM Government, 2011a; our emphasis). These strategic cross boundary matters dovetail with the integration principle (Table 1), in theory. However, at the present time, ministerial advice

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and national practice policy guidance (NPPG) has exclusively focussed on securing housing need assessments for plan approvals/rejections.

Hook 3: Natural Environment White Paper

The Natural Environment White Paper (NEWP) entitled *The Natural Choice: Securing the Value of Nature* (HM Government, 2011b) is signed up to by all UK government departments, representing a powerful hook. It includes principles towards the improved valuing of nature in policy and decisions, recognising the intrinsic value of nature and the key role the planning system has in protecting biodiversity (although framed largely within a human-environment duality and no-net-loss neoliberal narrative). However it has become evident that the NPPF trumps NEWP in policy and decision making considerations (House of Lords Built Environment Committee, 2016). Still, the NEWP is probably the most important policy document in terms of capturing and promoting ecosystem science thinking.

"*We need a more strategic and integrated approach to planning for nature within and across local areas* […] *We want the planning system to contribute to our objective of no net loss of biodiversity*" (HM Government 2011b:2.37)

As part of the approach there is endorsement of ES as a key concept:

"Taking account of all the economic and non-economic benefits we get from these (ecosystem) services enables decision-makers to exercise judgement about how we use our environment". (HM Government, 2011b: 11).

Bridge 1: Green Infrastructure (GI)

GI is a term that seems to be widely used by built and natural environment professionals and also understood by many publics. GI is explicitly addressed in the Natural Environment White Paper (HM Government, 2011b) and NPPF/National Planning Policy Guidance (NPPG)[4] and is a term widely used in public policy discourses globally (Mell , 2014). The NPPF recognises the value of GI within the concept of ecological corridors, improved connectivity and the multiple benefits it delivers in (re)development projects. NPPF Annex 2 defines GI as "[…] a *network of multi-functional green space, urban and rural, which is capable of delivering a wide range of environmental and quality of life benefits for local communities*". National Planning Guidance has also been recently updated to include specific guidance to help with defining GI scope and extent; *"As a network it includes parks, open spaces, playing fields, woodlands, but also street trees, allotments and private gardens*" (NPPG: par 27). The explicit mention of gardens helps it have relevance at the individual household level which is important in terms of public engagement and appeal but is a largely neglected dimension in mainstreaming efforts (Dewaelheyns et al., 2016). The NPPG also recommends embedding GI into the development process at an early stage linking it explicitly to ES. "*Green infrastructure provides multiple benefits, notably ecosystem services, at a range of scales, derived from natural systems and processes, for the individual, for society, the economy and the environment.*" (NPPG: par 27).

Bridge 2: Multiple benefits/assets

Multiple benefits language has been used to secure initial public and/or political support for ecosystem science particularly where ecosystem terminology was unfamiliar (Fish and Saratsi, 2015). The term has been used on its own but has also been linked to environmental assets. This helps challenge perceptions of nature as a constraint to development and economic growth with the

[4] National Planning Practice Guidance http://planningguidance.communities.gov.uk/ [accessed 1 September 2016]

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multiple benefits being presented as financial values to help highlight nature's value to society (Baker et al., 2012).

Bridge 3: Connectivity

Connectivity was often encountered when dealing across complex spatial geographies associated with political and administrative boundaries meeting natural boundaries. The idea of connections is important in allowing multiple audiences to understand the flows of ES between one place and another and to understand the interrelationships between these interactions (provider and beneficiary); for example, in water management (flood and drought management). It also enabled an understanding of winner and losers when ES flows of benefits are mapped (Scott et al., 2013).

4.Mainstreaming Ecosystem Science in Spatial Planning Practice

This section provides a commentary on four UKNEAFO project participant self-assessment narratives illuminating how specific hooks and bridges were used in response to particular opportunities/challenges and how they influenced the mainstreaming process and resulting outcomes in different SP settings. The case study narratives are summarised in Table 4 exposing the most influential EcA (1-12) and SP principles (UNECE, 2008). It is noteworthy how both subsidiarity and precautionary principles were less evident perhaps reflecting the quasi-judicial nature of English spatial planning practice. It also suggests a wider challenge that there are inherent problems in trying to capture all 12 EcA principles simultaneously.

SP Principles EcA Principles	Governance 1 3 9	Subsidiarity 2	Participation 11 12	Integration 3 5 7 8 10	Proportionality 4 9	Precautionary 6 8 10
Cotswolds	++	-	+	-	++	0
North Devon	++	-	++	-	++	-
Birmingham	++	+	++	++	++	+
South Downs	++	+	++	++	+	+

Table 4. Case Study summary impact analysis in relation to EcA / SP principles (++ very positive; + positive; 0 not evident; - negative; - - very negative)

Cotswolds AONB Management Plan[5]

Governance and Participation Principles: The Cotswolds Area of Outstanding Natural Beauty (AONB) is designated for its high quality landscape. A statutory Conservation Board across seven local authorities is charged with ensuring that the landscape is conserved, enhanced, better understood and enjoyed. The Board's Management Plan is updated every five years and provides a

[5] Participant led report adapted from http://neat.ecosystemsknowledge.net/cotswolds.html [accessed 6 July 2017]

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statutory document which all relevant public agencies must take into account in their decisions and operations. The Plan is also a crucial communication tool helping to inform land managers, stakeholders and wider publics about the value of the AONB. It is subjected to formal public consultation processes.

Ecosystem science did not feature at all in the initial development and discussions of the plan review. There were differing levels of knowledge about ES across the members of the Board but the AONB officers did have a working knowledge. The priority in the plan review process was to address criticism of the previous management plan for being too complex and too generic and for a failure to engage partners, public bodies or parish councils sufficiently.

Proportionality and Integration Principles: The publication of the Natural Environment White Paper (hook) helped re-invigorate the ecosystem science discussions within an AONB plan workshop in 2011. The officers shifted from the traditional 'exploitative' view of natural resources using the bridge of the environment as an asset with multiple benefits. A Strategic Environmental Assessment (SEA) was undertaken to inform the plan making process using ES explicitly. However, the draft plan presented them as an add-on benefit alongside scenic beauty, cultural heritage, economic development and GI. At the final stages of plan preparation ES did not feature at all, but pressure from some board members, drawing on their own experience in the NEAFO research process, persuaded the Board to retrofit ES into the draft plan. Consequently, the final Cotswolds AONB Management Plan for 2013-18 presents ES as one of five multiple benefits for society delivered by good management and conservation measures (Figure 3: provisioning services shown as an example).

Ecosystem Services

Provisioning Services	Link to Plan Objective/s
Food (e.g. crops, livestock, fish, game) Cotswold farmers produce food through arable crops, the breeding of store lambs, suckled calves and, increasingly, finished lamb and beef and a limited quantity of dairy products.	CEO2
Water supply The catchments on the Cotswolds provide drinking water for much of the population of south-east England.	CEO3
Fibre (e.g. timber, arable crops, wool) Historically, the Cotswolds has been an important producer of wool and timber, and there are opportunities to develop local markets and innovative uses.	CEO2
Fuel (e.g. renewable energy) The Cotswolds provides good conditions for renewable energy including hydro, solar and biomass and there is considerable scope for further development of this resource, particularly woodfuel.	CEO3
Genetic diversity The "Cotswold Lion" local breed of sheep helps retain important genetic diversity as well as contributing to local distinctiveness.	CEO2 CEO3

Figure 3 Extract of Provisioning Ecosystem services in the Cotswolds AONB linked to Plan Objectives (Source Cotswolds AONB management Plan 2013-2018 (2013:10)

The final plan identified the main ES flowing from the AONB area and links them to individual plan objectives to show how they will be secured and/or enhanced. This retrospective mapping approach

directly replicated the Exmoor National Park Plan[6] model which was used as an exemplar within a UKNEAFO workshop in demonstrating how an ESF could be embedded pragmatically into a management plan setting. This partial mainstreaming provides an initial foundation for further progress as the management plan is reviewed. Also, discussions have taken place over the development of a Payment for Ecosystem Service scheme regarding improved management of the upper catchment of the River Thames within the AONB.

North Devon and Torridge (Draft) Joint Local Plan[7]

Governance Principle: The development of the North Devon and Torridge Joint Local Plan (North Devon and Torridge District Councils, 2014) involved a statutory development plan process crossing two local authority areas in a bold joint working endeavour. The lead planning officer was familiar with ecosystem science, having had extensive working relationships with academics and research communities, as well as being a member of the NEAFO research team. However, there were significant internal and external challenges (and thus learning spaces needed) for all planning officers, elected councillors across both authorities as well as their wider publics to understand and accept ecosystem science thinking in the plan.

Proportionality and Integration Principles: The mainstreaming process was framed using ES within a pragmatic understanding of the national and local political discourses dealing with the peripherality, world-class environment assets (UNESCO Biosphere Reserve) and economic challenges of the joint council area. Paragraph 109 of the NPPF was used as a key hook by the lead planning officer as part of the political persuasion process to legitimise ES thinking internally across both planning teams and elected members. This secured resources for mapping the different ES across the area as an evidence baseline for future monitoring and evaluation of plan policies. The outputs were translated into a strategic aim within the draft local plan promoting the environment as an asset intimately tied up with the development of the area and with ES as adaptable outcomes responding to changing needs. This is now under consideration by a government appointed planning inspector.

"Aim 2: A World Class Environment – where important assets are valued and enhanced for future generations […]. (c) land is used efficiently and effectively – optimise how ecosystem services provide and result in productive living landscapes and townscapes that adapt to our changing needs". This shaped a more detailed but isolated local plan policy ST14.

"*Policy ST14: Enhancing Environmental Assets:*

The quality of northern Devon's natural environment will be protected and enhanced by ensuring that development contributes to:

(a) providing a net gain in northern Devon's biodiversity where possible , through positive management of an enhanced and expanded network of designated sites and green infrastructure, including retention and enhancement of critical environmental capital; […]

(h) conserving and enhancing the robustness of northern Devon's ecosystems and the range of ecosystem services they provide;"

The ES policy, although innovative, was in addition to the existing suite of environmental policies rather than integrated or aligned to other policies and chapters of the plan. Importantly, there were

[6] Exmoor National Park Partnership Plan 2012-2017 http://www.exmoor-nationalpark.gov.uk/?a=260857 [accessed 30 September 2016].

[7] Participant led report adapted from http://neat.ecosystemsknowledge.net/devon.html [accessed 6 July 2017]

few cross-references to ecosystem science outside the environmental chapter itself. However, this was seen as a necessary and proportional compromise to the local political and public mindset that was unfamiliar with ecosystem science. This led to the sole use of the ES term in the plan rather than wider ecosystem science terms. At the time of writing (March 2017) the plan is awaiting examination in public and it remains to be seen how accepting the inspector and wider public are of this approach.

Participation Principle: The local plan process was able to build upon a foundation of ecosystem science knowledge from a number of other work streams which recognised the value of environmental assets in the area and their multiple benefits for the local economy. These included participation as a pilot authority in a county-wide biodiversity offsetting programme; involvement in the Ecosystems Knowledge Network[8]; and contribution towards other spatial strategies such as for the UNESCO Biosphere Reserve at Braunton Burrows[9] and the Nature Improvement Area on the culm measures[10]. The cumulative impact of these joint endeavours created the necessary social capital to advance ecosystem science into their local plan using the global importance of the natural environment as an asset for growth. The plan had been consulted upon as part of its statutory duty. In general there was support for the approach to ecosystem science diffusion taken by the council as stated in the response to the public consultation document par 343 "*The plan's ecosystem approach is supported*"[11]. However, issues of scale were raised resulting in a change to the plan to "19. *recognise the importance of protecting ecosystems and ecosystem services at an ecosystem scale"* (p89).

Birmingham City Council's Green Living Spaces Plan (GLSP)[12]

Governance Principle: The establishment in 2013 of a Green Commission, a cabinet level body involving experts, influencers and decision-makers with its ambition and vision to make Birmingham a leading global green city was influential in obtaining higher level political support for ecosystem science ideas and initiatives. The multiple benefits (bridge) was embedded into the city's governance framework through a suite of strategic planning processes and associated documents including the statutory local plan (Birmingham City Council, 2014). Key policy-related hooks were the climate change related national performance indicators against which local authorities had to report in England between 2008 and 2010, the Lawton Review (2010), the Natural Environment White Paper (HM Government 2011b), the UKNEA (2011) report and the NPPF's paragraph 109. The city council's (GLSP) initiative has evolved over time with the environmental and sustainability sections of the council driving the organic and pragmatic research and local policy-making process, adjusting to changes/opportunities in national policies and planning frameworks as they presented themselves.

[8] Ecosystem Knowledge network http://ecosystemsknowledge.net/ is a UK based knowledge exchange network to promote improved understanding and use of the ecosystem approach
[9] http://www.northdevonbiosphere.org.uk/ Braunton Burrows Biosphere Reserve
[10] http://www.northerndevonnia.org/culm-grassland Nature Improvement Area Culm Measures Devon accessed 30 September 2016
[11] North Devon and Torridge Local plan Consultation Document Response (2014) http://consult.torridge.gov.uk/file/3001633 par 343 p87 accessed 8 April 2017

[12] Participant led report adapted from http://neat.ecosystemsknowledge.net/birmingham2.html [accessed 6 July 2017]

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Participation Principle GI was used as a policy bridge to engage stakeholders from different departments across the council as well as external stakeholders around common goals and interests. A key output of that process was the publication of the GLSP (Birmingham City Council, 2013) where its non-statutory status provided much needed flexibility, but with the necessary elected member and officer buy in to inform future policies and decision-making across the council It also was championed as an exemplar for other urban areas nationally and globally (UKNEAFO, 2014). The GLSP process involved the formation of a cross-disciplinary working group involving both internal and external members from Climate Science; Water; Biodiversity; Green Infrastructure; Sustainable Transport/Mobility; Planning; Community & Resilience; Business and Public Health, each bringing their evidence bases, policies and delivery plans to the shared table. The bridges of multiple benefits and risk were used to help secure greater buy in across these stakeholder communities. Collectively they were able to agree seven cross cutting key principles[13], each with associated outcomes/targets that now form the backbone of the GI policy.

These seven principles have then informed the statutory planning framework for the city; i.e. the Birmingham Local Plan as well as the Sustainable Development Plan Your Green and Healthy City. Direct engagement with community representatives and third sector organisations broadened the democratic nature of the policy which has led to further developments with natural capital involving working with planners, developers and industry consultants on a toolkit (RICS, 2015[14]) to help further mainstream nature into planning decision making.

Integration and Precautionary Principles: The NPPF (par 109) hook helped persuade the council to fund a series of research studies applying the ES methodology to six dominant urban issues (aesthetics and mobility, flood risk, urban heat island effect (local climate), educational attainment/provision, recreation and biodiversity) with each displayed as Geographic Information System maps of the city (BUCCANEER, 2010; Scott et al., 2014). These individual maps depicted areas of high and low demand/supply of each ES. The maps were then integrated into a single multi-layered challenge map for Birmingham which could be interrogated at different scales for use by residents, community groups, non-governmental organisations, strategic planners and elected members (Figure 4[15]). These maps provide a powerful link between ES and social/environmental justice considerations acting as an evidence base for place-specific policy interventions. In addition, they also provide a baseline for climate change mitigation and adaptation priorities and actions, revealing areas at risk from flooding and urban heat island effect.

[13] 7 principles; An Adapted City; The City's Blue Network; A Healthy City; The City's Productive Landscapes; The City's Greenways; The City's Ecosystems; and The City's Green Living Spaces

[14] Natural Capital Planning Tool http://www.rics.org/uk/knowledge/research/research-reports/natural-capital-tool-planning-/ accessed 8 April 2017

[15] This map represents a city as depicted by its relationship with its ecosystem. GIS layers of data are combined to create as multiple challenge map. The lighter the tone the greater the benefits being obtained from that local environment. Darker tone shading indicates are areas where the current quality or availability of the local environment, does not meet the full demands of the local population.

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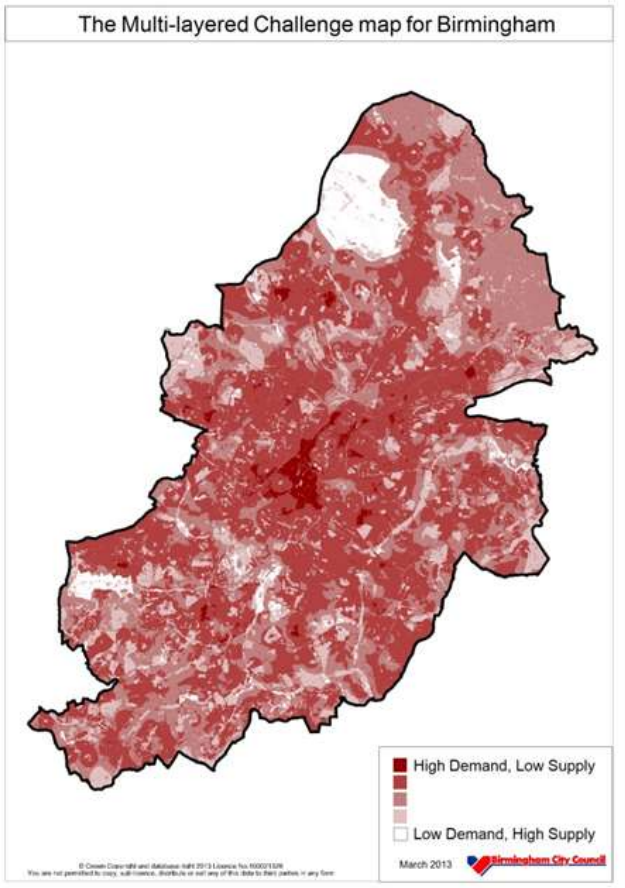

Figure 4: ES Multi challenge map. Source: Birmingham City Council (2013 [f])

Ecosystem Approach-led: South Downs National Park Authority Local Plan[16]

Governance Principle: The South Downs National Park Authority (SDNPA) was created in 2011 and manages one of the newest UK National Parks. The SDNPA has statutory responsibilities for the protection of the national park's natural beauty and special qualities and the promotion of informal recreation. As a new national park it positioned itself as an innovator and champion in ecosystem science planning and delivery seeking to mainstream ecosystem science into all its plans and policy processes. This meant that all staff and board members were actively involved in the mainstreaming process. The NEA (2011); NEWP (2011) and NPPF (2012) were used as highly influential hooks to facilitate this. Its first park management plan (SDNPA, 2013) set out the statutory framework for the protection of the park and its special qualities using the ESF. The park authority also developed and approved its own papers highlighting the relationship between ES and NC which further consolidated their own particular way of mainstreaming ecosystem science[17].

[16] The participant led report has been provided by Tim Slaney Director of Planning South Downs National Park Authority

[17] Committee Paper https://www.southdowns.gov.uk/wp-content/uploads/2015/02/pp_2014Jul24_Agenda-Item-10.pdf (approved) [accessed 1 June 2016]

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The draft local plan (preferred options document[18]) builds on the statutory Park Management plan (SDNPA, 2015) providing the legal planning policy framework and area plans for deciding planning applications within the park boundary. It also set out to incorporate EcA at its heart drawing on its fast growing national network of ecosystem science practitioners and experience in the UKNEAFO project.

Participation Principle: Initially there was a targeted strategy of consultation and awareness-raising of ecosystem science amongst its members, partnership board and 15 planning districts through a number of meetings and workshop events. This helped build capacity and support for the statutory management plan to incorporate ecosystem science at its heart. This then was translated to the planning team as part of its local plan process and, to help maximise social learning and knowledge exchange, close relationships were formed with research communities during and after the UKNEAFO work to help facilitate local plan related workshops within which key hooks and bridges were identified. The draft plan was sent out for consultation and the dedicated ES policy SD2 was broadly welcomed and supported within the 52 responses received. However East Hampshire District Council submitted a response that they "*consider that this policy duplicates other policies and makes the policy repetitive and whole document unnecessarily long*".[19]

Integration and Proportionality Principles: The SDNPA translated the 12 EcA principles into the South Downs context in keeping with their statutory objectives and vision (Box 1). This provided a powerful sense of ownership; translating the EcA language to their own setting and priorities and thus creating a useful umbrella within which to position the local plan process as well as helping to inform new ways of internal thinking across the staff.

1. Be based upon the public interest both inside and outside the plan area, including in particular, the opportunities for recreational activities and learning experiences and conserving the diverse, inspirational landscapes, breath-taking views and tranquillity.

2. Delegate decision making to the most appropriate level, particularly for the communities with pride in their distinctive towns and villages

3. Identify and assess adjacent effects at different scales, in particular taking into account, views, priority habitat connectivity, rare and internationally important species, river and water catchment issues and the associated flooding, water quality and supply issues.

4. Understand the economic context and aim to reduce market distortion, particularly to enable farming to enhance the environment and continue to embrace new enterprise.

5. Support the enhancement of Natural Capital, historic features and rich cultural heritage so it can be enjoyed by future generations

6. Respect known environmental limits using best available evidence but develop flexible policies to respond to issues of uncertainty

7. Operate at appropriate spatial and temporal timescales, linking in particular with partnership landscape-scale approaches, the National Character Assessment and local data and evidence

8. Manage for the long-term, considering lagged effects

[18] The preferred options stage is part of the formal stages that all development plans have to go through. When compared with North Devon and Torridge draft local plan this is an earlier phase of plan development as it has yet to go formally to a planning inspector. The usual stages include an options document; preferred options; local plan submission; examination in public; modifications and approved document.

[19] SDNPA (2015) South Downs Local Plan Preferred Options Consultation Responses page 27 https://consult.southdowns.gov.uk/consult.ti/localplanpo/listresponses [accessed 8th July 2017]

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9. Accept and manage change as inherent and inevitable, particularly considering recreation, housing, farming and land management as significant aspects of this change

10. Deliver the National Park's two purposes as a priority and whilst doing so, the Authority duty using the Sandford Principle in case of conflict between purposes (Partnership Management Plan / Delivery Framework reference)

11. Use a robust evidence base and the sustainable development precautionary principle where the data or evidence is not complete

12. Maximise and maintain stakeholder engagement.

Box 1 SDNPA Ecosystem Approach Principles (SDNPA, 2014)

The NPPF (par 109) hook helped justify the involvement of the entire planning team (strategic and development management) in the local plan process with the thought-leadership and enthusiasm of the director of planning. It created a bridge to communicate and work jointly with other section leads in the park (e.g. landscape and park management). This collaborative working also enabled the park to secure resources for mapping ecosystem services (ECOSERV[20]); using this data as an evidence base to inform subsequent policy development. The cumulative social learning resulted in draft policy (SD2) which sits as one of only four higher-level policies that all other policies in the plan are subservient to.

Draft Core Policy SD2: Ecosystems Services SDNP 2015 Local Plan Preferred Options document

1. Proposals that deliver sustainable development and comply with other relevant policies will be permitted provided that they do not have an unacceptable adverse impact on the natural environment and its ability to contribute goods and services. Proposals will be expected, as appropriate, to:

- *a. provide more and better joined up natural habitats;*
- *b. conserve water resources;*
- *c. sustainably manage land and water environments;*
- *d. improve the National Park's resilience to, and mitigation of, climate change;*
- *e. increase the ability to store carbon through new planting or other means;*
- *f. conserve and improve soils;*
- *g. reduce pollution;*
- *h. mitigate the risk of flooding;*
- *i. improve opportunities for peoples' health and wellbeing;*
- *j. stimulate sustainable economic activity; and*
- *k. deliver high-quality sustainable design*

Unlike many planning policies for conservation, the positive framing of this policy, with a presumption in favour of development, enables, in theory, some beneficial ES/NC outcomes to be achieved from all planning applications. Crucially, the policy becomes a negotiating tool for planners to have a dialogue about securing positive ES and NC outcomes. It is also important to note how ES language is used explicitly in headline form but then translated into plain English concepts in categories (a-k) which improve accessibility and intelligibility to planning applicants and wider publics thus engaging the public in meaningful ecosystem science dialogues.

This thinking has also shaped the newly emerging GI framework and roadmap (SDNPA, 2016) which collectively now provides a strong suite of plans and policies all with ecosystem science at their heart.

Subsidiarity Principle: Under the NPPF and Localism Act 2011, the park is carrying out its DTC function to ensure that ES are protected and enhanced. From their interim statement on DTC

[20] ECOSERV http://ecosystemsknowledge.net/ecoserv-gis accessed 8th April 2017

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(SDNPA, 2015: 4.2) the following strategic principles are identified for collaborative work with the surrounding 15 district authorities:

- *Conserving and enhancing the natural beauty of the area*
- *Conserving and enhancing the region's biodiversity (including GI issues*
- *The delivery of new homes, including affordable homes and pitches for Travellers*
- *The promotion of sustainable tourism*
- *Development of the rural economy*
- *Improving the efficiency of transport networks by enhancing the proportion of travel by sustainable modes and promoting policies which reduce the need to travel.*

The translation of DTC within SDNPA priorities has necessitated the forging of new dialogues and partnerships with the surrounding authorities, forcing their planning staff outside usual DTC priorities associated with housing need to deal with water management, GI and public rights of way. The legal obligation to cooperate under the Localism Act helps the SDNPA engage with other planners providing the initial traction to what are likely to be challenging discussions.

At the time of writing (April 2017) the local plan is going through a formal consultation process with an impending examination in public for approval in 2017 which will be its ultimate test. In addition there is ongoing collaboration as part of the NEAFO legacy process and new work on NC to undertake ES assessments of major developments to improve ES/NC outcomes.

Summary

Together these case studies reveal the combined influence of hooks and bridges in progressing ecosystem science mainstreaming beyond the persuasion barrier in different ways that suit specific contexts set within the political realities. Each case study showed some progress and initial traction in ecosystem science mainstreaming. These processes have and will evolve differently over time and whilst all our case studies are front runners, or champions, acting at an early stage of ecosystem knowledge diffusion, they represent innovators with important lessons to be learnt for future ecosystem science diffusion. It is to this that attention now turns.

5.Discussion and Conclusions

Realising ecosystem science mainstreaming in spatial planning practice

The diverse approaches to mainstreaming ecosystem science encountered within our four case study narratives reflect different capabilities, vulnerabilities and pragmatism required when trying to introduce new ideas within policy and decision-making processes. This finding is important as it suggests that mainstreaming is an evolutionary and dynamic process which can be conceptualised as different modes of ecosystem science mainstreaming (Figure 5).

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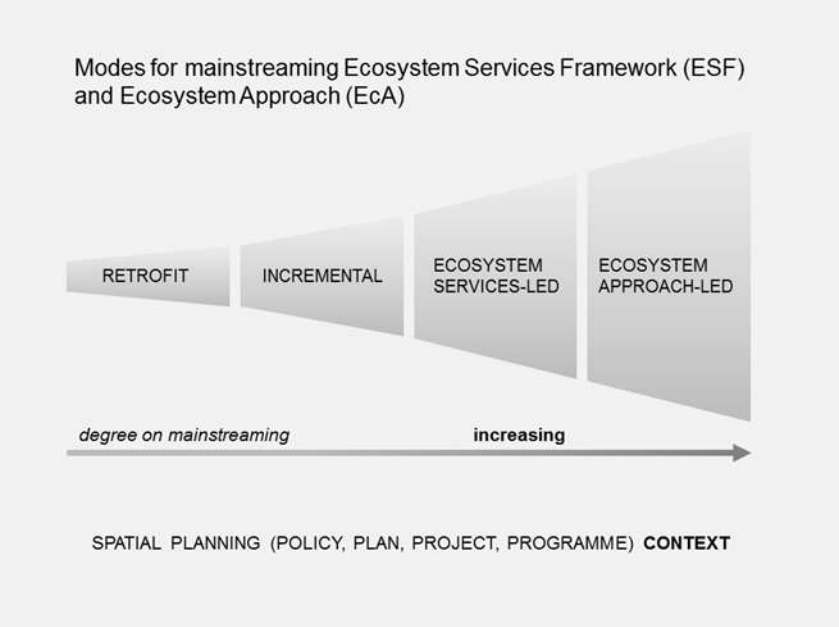


Figure 5 Different modes of mainstreaming ecosystem science as observed in practice. (adapted UK NEAFO 2014:11)

The Cotswolds AONB case study conforms to the 'Retrofit' mode where ecosystem science is bolted-on to a management plan retrospectively without influencing the rest of the plan process or document itself. The lack of knowledge of ES, together with other policy priorities emerging from critiques of the previous management plan were crucial barriers to further progress. But the linking of ES to the management plan objectives, allows, in theory, future progress to be made in subsequent plan reviews.

The Torridge and North Devon local plan case study conforms to the 'Incremental' mode where ecosystem science largely through ES and critical natural capital were incorporated into the plan within an overall Aim 2 and as part of a dedicated policy (ST11). Although having a ES evidence base to inform the policy it currently sits as an extra layer with limited integration across other economic or social policies in the plan.

The Birmingham GLSP case study conforms to the 'Ecosystem Services led' mode where ES have been embedded in the process from the outset as evidence bases and subsequently incorporated into outputs (challenge maps) that can help target interventions. With bespoke ES participation using the 9 piece jigsaw with stakeholders across Birmingham the plan was able to inform other plans (e,g. the approved Birmingham Local Plan as part of its impact.

The South Downs National park draft local plan conforms to the 'Ecosystem Approach led' stage where the EcA principles and associated ecosystem science concepts were embedded in the process from the start and inform successive stages. Crucially the management plan was championing an ecosystem approach as a statutory framework for delivery within which the local plan process could fit. The wholesale involvement of the planning team in this reflected a cultural buy in to the idea in a way that the previous stages were unable to secure.

In each case study hooks and bridges provide evidence of getting through the persuasion phase (Rogers, 2003) within ecosystem science mainstreaming (Figure 2). Here hooks and bridges provide

important mechanisms using the vocabularies and work priorities of particular target groups to secure traction but with wider potential to embed ecosystem thinking and conceptual/behaviour change. In the SDNPA case there is clear evidence of a culture change within the planning department as they embrace ecosystem thinking in their local plan and suite of documents that drive the national park's core work. Crucially, it is not confined to one champion or sector of the authority. However, each of the four case studies captured a particular stage of mainstreaming at the time of the research. The dynamic nature of ecosystem science mainstreaming diffusion will enable future progression or regression depending on their particular experiences, learning and external drivers of change. Here the role of gatekeepers (influenced by local / national / international changes or challenges) become critical in their future evolutions in terms of restricting, enabling or supporting change of ecosystem science ideals.

For example, the Birmingham example shows that mainstreaming processes can move negatively in responses to external drivers. Progress has now stalled with the transformational change in governance with the establishment of a Mayor and a new combined authority model which has relegated environmental considerations in favour of an agenda focused on jobs and growth[21]. Within the South Downs and North Devon and Torridge case studies, the government-appointed planning inspectorate has the role to approve or reject both local plans following their examination in public in late 2017/2018. If approved, they will provide the much needed exemplar case studies to help legitimatise and catalyse the diffusion of ecosystem science policies in other local plans (Posner et al., 2016); but equally, the converse applies. Indeed, it is only when other policy makers see how ecosystem science can be validated and approved in policy and planning decisions that the new knowledge / innovation will gain momentum and lead to further mainstreaming activities (Cowell and Lennon, 2014; Rogers, 2003). The example of the Cotswolds AONB using the approved Exmoor National Park plan as a model serves to illustrate this point.

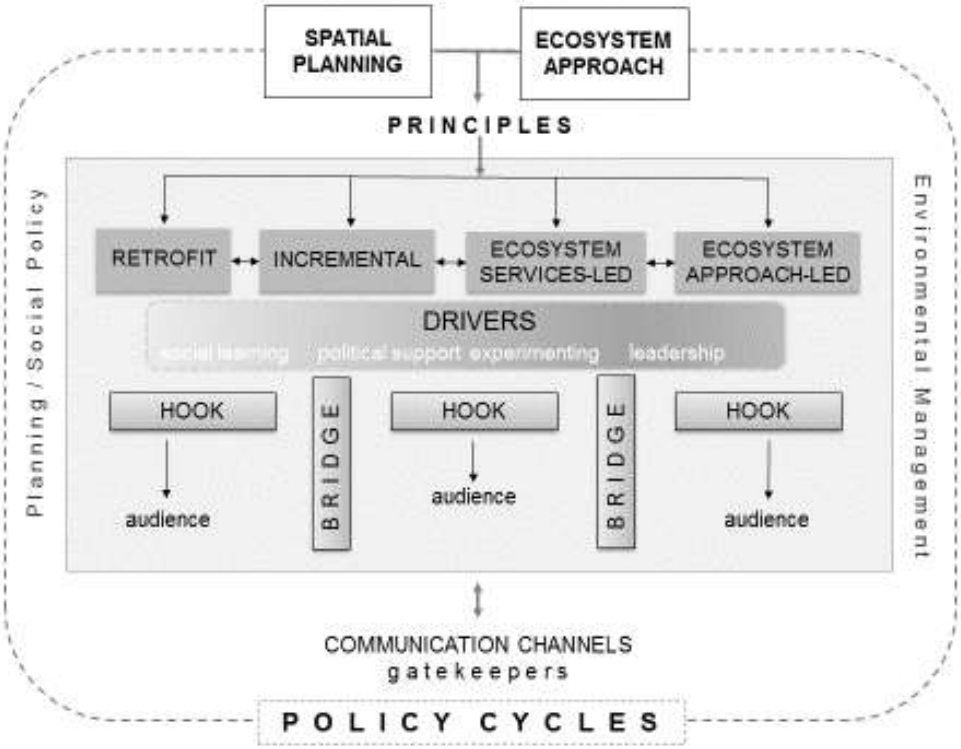
Part of the difficulties in mainstreaming ecosystem science lies in the fact that the encompassed concepts largely reside in natural environment policy and practice and only slowly infiltrate SP practice where it has yet to be fully accepted and valued (UKNEA, 2011; Karlsson-Vinkhuyzen et al., 2017). Figure 5 provides a schematic representation of how mainstreaming can be achieved. The initial step necessitates working explicitly at the SP: EcA interface where hooks and bridges are identified within a bundle for ecosystem science mainstreaming. It is important that they map successfully on to all the EcA:SP principles. Our case study narratives have then identified a set of common ingredients that support the operationalisation of hooks and bridges leading to successful mainstreaming outcomes. These are unpacked in the next section; the need for political support; effective leadership; safe social learning spaces; and a willingness to experiment by operating outside usual comfort zones.

However, there is a danger that simple accommodation or incorporation of ecosystem science terms in existing work practices as bolt-ons could lead to little or no behaviour change, with accusations of "ecosystem-wash" mirroring the greenwash accusations observed in sustainability and environmental valuation discourses (e.g. Spash, 2015). All our case studies hopefully demonstrate that there is more to this than that.

For example the reframing of EcA principles in SDNPA (Box 1) and Birmingham's 7 cross cutting GLSP principles (Footnote 8). This translation and adaption of EcA principles within a local context helps

[21] See the prospectus for the WMCA https://www.wmca.org.uk/media/1383/sep-executive-summary.pdf where there is a section devoted to "transformational environmental technologies" .

723 engender a sense of ownership and purpose, creating shared values and the conditions where
724 culture and behaviour change can take place. This process parallels findings by McMorran et al.
725 (2014) after crofters had taken ownership of "their" land post Land Reform in Scotland where
726 previously a landowner had control (See also Lienert et al., (2013) paper on water infrastructure
727 planning).



728
729 *Figure 5. Mainstreaming Ecosystem Science in different SP settings: An environmental governance diffusion model*

730

731 Likewise the NPPF hook provides potential mainstreaming opportunities through creative
732 interpretations of "recognising the value of ES" in paragraph 109. This is evidenced globally where
733 INVEST and other ES mapping models are now becoming much more influential (Gómez-Baggethun
734 and Barton, 2013; Söderman et al., 2012). Creative policy development such as evident in SDNPA's
735 core policy ST2 also enables ES to become a negotiation tool to help achieve better ES outcomes in
736 all planning applications. This more progressive use of ES in policy approaches is key to unlocking
737 important ES gains locally, nationally and globally and indeed has served as a catalyst for further
738 research work in Birmingham and South Downs plus 6 other local authorities on a natural capital
739 planning tool[22].

740

741 The DTC, equating with strategic regional planning in more global contexts, also provides a potential
742 opportunity tool to engage in new dialogues and partnerships, creating new social learning and
743 knowledge-sharing spaces, addressing a range of strategic planning challenges of local, national and
744 international significance such as flood and drought management (e.g. Reed et al., 2017); green
745 infrastructure creation and improvements (Connop et al., 2016); provision for recreation, and
746 climate change mitigation and adaptation (Jordan and Huitema, 2014). However, in England this is
747 inhibited by the dominance of the economic growth narrative and priority in DTC matters towards

[22] The Natural Capital Planning Tool is now one of 12 GI Innovation projects funded by NERC. http://gtr.rcuk.ac.uk/projects?ref=NE%2FN017587%2F1 accessed 8th July 2007

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joint housing need assessments (Scott, 2016). Here, the new dialogues started by SDNPA with surrounding local authorities, developers and other built environment professionals within their bespoke DTC policy, provides a more progressive exemplar model for strategic planning, that can be applied beyond a protected landscape planning context.

Core ingredients for mainstreaming ecosystem science globally

As depicted in Figure 5, the four case study narratives reveal core ingredients which drive successful ecosystem science mainstreaming processes. These have wider global applicability; the need for political support; effective leadership; safe social learning spaces; and a willingness to experiment by stepping outside usual comfort zones.

Getting high-level political support early on in a mainstreaming process is a significant but often neglected step as it builds political capital which is essential in subsequent plan validation and legitimatisation; whether for non-statutory (GSLP) or statutory plans (SDNPA and North Devon and Torridge local plan) (Scott et al., 2014; see also City of Vancouver, 2012). Within Birmingham, the establishment of the Green Commission with its vision to make Birmingham a global green city provided a cross-departmental cabinet level body in the Council within which ecosystem science could be championed. In the SDNPA case study, the NPA committee played an important role endorsing the EcA as proposed by staff, combined with a willingness to innovate in their plans and policies as a new National Park Authority.

Effective leadership enabled people to work outside their usual comfort zones as innovators with ecosystem science. In three cases (SDNPA, Birmingham, North Devon and Torridge), senior policy officers commanded respect internally within their respective policy arenas as well as being proactive in engaging externally with academic research communities (e.g. the NEAFO amongst others) on their own terms. This willingness to engage with research communities is significant in connecting knowledge across research, policy and practice boundaries. Here the co-production of research to support the policy- and plan-making created important social learning space where outcomes had both academic credibility and practical usability (Tress et al., 2005; Cowell and Lennon, 2014; Scott et al., 2014).

All case studies had collaborative workshop activities both as ongoing internal requirements but also as part of the UKNEAFO exercise which gathered and discussed evidence from different sectors and helped connect people across sectors, disciplines and/or municipal boundaries for the first time with a specific focus around mainstreaming ecosystem science in spatial planning. The workshops as part of the UKNEAFO research itself provided safe social learning spaces, outside existing work patterns and pressures. Policy makers and decision makers engaging in research programmes can play an important role in driving innovation by building social capital and confidence within such knowledge exchange flows as illuminated by Cowell and Lennon (2014) and McKenzie et al (2014). Dialogues with publics and stakeholders can also be a powerful mechanisms for social learning. For example, work by Fish and Saratsi (2015) help illuminate the power of deliberation with public audiences to optimise social learning within an ES format. This was also evident in the SDNPA and Birmingham examples through a range of learning activities and knowledge exchange workshops between planning staff, elected members and wider partners as well as wider statutory public consultation activities. Furthermore, the construction of the SDNPA policy SD2 enables that policy itself to become a hook in its own right from which planners can hold dialogues with developers and householders to try and optimise the ES/NC gains from any development. This Russian doll model of hooks within hooks has real potential to change the way people behave in drafting and justifying planning applications in the SDNP.

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Our case studies and discussions have highlighted innovative thinking and practice but they are still very much pioneers. Indeed, it is fallacious to view our case studies as 'successful'. Their journeys are evolving and will be affected positively and negatively by both internal and external drivers of change as innovators and the extent to which they can overcome the other barriers to ecosystem science; its technocentric nature (Fish and Saratsi, 2015); the need for advanced skills to understand/use/access many of the tools available (McKenzie et al., 2014); the lack of exemplars and social learning platforms (Dunlop, 2014; Posner et al., 2016) and lack of local-scale information (Burke et al., 2015).

Indeed, as reported the statutory local plans (SDNPA and North Devon and Torridge) are facing examination procedures within the current governance framework that will have major repercussions for the adoption of ecosystem science mainstreaming in English planning whatever the decisions. Furthermore, all our case studies will need to make difficult resource management and planning decisions that require making trade-offs between different SP and/or EcA principles with resulting winners and losers that typify any decision-making processes. Moreover SP practice is an arena where here is an explicit tension between the holistic and integrated and the legalistic (quasi-judicial) which presents real challenges for translating some aspects of EcA thinking into practice (see Inch, 2012) ; the precautionary and subsidiarity principles being cases in point (Albrechts, 2015; Scott et al., 2014; Raudsepp-Hearne et al., 2010). Within the four case studies discussed in some detail in this paper there is a collective appetite to take up this challenge. How that is played out in the political arenas of the future remains to be seen and reported upon.

Conclusion

This paper has developed and used a framework to assess and progress mainstreaming ecosystem science within four case studies. Hooks and bridges are key mechanism that enable ecosystem science language and concepts to be transferred into spatial planning practice. This is facilitated by a mapping exercise of SP-EcA principles which revealed significant convergence and thus establishing the hybrid opportunity space for mainstreaming. Mainstreaming itself is a dynamic process constrained by setting, capacities, knowledge and familiarity within a particular spatial planning setting. We have identified key drivers that influence success: the need for political support; effective leadership; safe social learning spaces; and a willingness to experiment by stepping outside usual comfort zones. Thus when hooks and bridges are used collectively with these ingredients ecosystem science becomes embedded in spatial planning domains enabling key actors and gatekeepers to accept, use and ultimately legitimise the concepts within their own policy and practice vocabularies and work priorities thus creating the traction for further exploration and development of the idea within an adoption process (Rogers, 2003). However, significant challenges remain in both the legitimisation of ecosystem science within existing governance frameworks and the sharing of progress and additionality within wider social learning spaces that typify innovators in any diffusion process. In such pioneering endeavours it is the collective social learning from both successes and mistakes that that will provide the opportunity spaces for a culture and behavioural change in policy and decision making.

Successful ecosystem science mainstreaming can occur at all modes; retrofit, incremental, ecosystem services-led and ecosystem approach-led. However, most progress can be made where use or adaptation of the EcA higher level principles or ES have been embedded from the outset (e.g SDNPA and Birmingham), rather than using the ESF or focusing on ES selectively and uncritically (Gaston et al., 2013). Our research at the EcA SP interface illuminates how hooks and bridges can

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help to plant the seeds of transition towards a more integrated planning which when combined with the necessary political support, leadership , social learning and a willingness to experiment, innovate and "boldly go", may help point a way forward.

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