

Article (refereed) - postprint

Waylen, Kerry A.; Young, Juliette. 2014 **Expectations and experiences of diverse forms of knowledge use: the case of the UK National Ecosystem Assessment**. The definitive, peer-reviewed and edited version of this article is published in *Environment and Planning C: Government and Policy*, 32 (2). 229 -246. [10.1068/c1327j](https://doi.org/10.1068/c1327j) 2014

© 2014 Pion

This version available <http://nora.nerc.ac.uk/510318/>

NERC has developed NORA to enable users to access research outputs wholly or partially funded by NERC. Copyright and other rights for material on this site are retained by the rights owners. Users should read the terms and conditions of use of this material at <http://nora.nerc.ac.uk/policies.html#access>

This document is the author's final manuscript version of the journal article, incorporating any revisions agreed during the peer review process. Some differences between this and the publisher's version may remain. You are advised to consult the publisher's version if you wish to cite from this article.

The definitive version is available at <http://www.pion.co.uk/>

Contact CEH NORA team at
noraceh@ceh.ac.uk

Expectations and experiences of diverse forms of knowledge use: the case of the UK National

Ecosystem Assessment

For Special Issue of Environment and Planning C: “Embedding an Ecosystems Approach? The utilisation of ecological knowledges in decision-making”.

Authors

Kerry A. Waylen¹ & Juliette Young²

(1) Social Economic and Geographical Sciences Group, James Hutton Institute, Cragiebuckler, Aberdeen, AB15 8QH, UK. Tel: +44 (0)1224 395313 Kerry.waylen@hutton.ac.uk

(2) NERC Centre for Ecology and Hydrology, Bush Estate, Penicuik, Midlothian, EH26 0QB, UK
Tel: +44 (0)131 445 8522 j.young@ceh.ac.uk

Total word count = 8,117 (9,836 incl references and tables)

Acknowledgements

We gratefully acknowledge all the interviewees who gave their time for interviews for this work and the extremely helpful comments and advice of D. Russel, A. Jordan, A. Fischer and K.L. Blackstock and three anonymous reviewers. The research leading to these results has received funding from the SPIRAL project under the European Union Seventh Framework Programme (FP7/2007-2013), contract number 244035. KAW was co-funded by the RESAS Scottish Government 2011-2016 Strategic Research Programme.

Expectations and experiences of diverse forms of knowledge use: the case of the UK National

Ecosystem Assessment

Abstract

Assessments of environmental issues are often expected to tackle the perceived disconnect between scientific knowledge and environmental policy-making. However, their actual influence on processes of knowledge communication and use remains understudied.

We provide one of the first studies of the UK National Ecosystem Assessment (NEA), itself one of the first national-level assessments of ecosystem services. We explore expectations, early experiences and implications for its role in promoting knowledge use, drawing on both documentary evidence and qualitative analysis of interviews with NEA authors and potential users.

Many interviewees expected instrumental use i.e. facts directly assisting problem-solving. This matches the rhetoric surrounding the NEA's creation. However, we found more early evidence of interacting conceptual uses (learning), and strategic uses (sometimes deemed mis-use). Such uses depend not only on assessment outputs, i.e. reports, but also on the processes of communication and interaction by which these are created.

Thus planning and analysis of such assessments should de-emphasise instrumental use, instead focusing on the complex knowledge 'co-production' processes by which diverse and interacting forms of knowledge use may be realised.

Key words: science-policy interfaces, environmental assessments, ecosystem services, ecological knowledge, knowledge co-production.

Introduction

Ecosystems continue to be degraded, despite advancing scientific understanding of the multiple and essential ways in which they support human well-being (Díaz et al, 2006). Many environmental scientists and other commentators have expressed frustration with perceived inadequacies in environmental policy-making (e.g. Herkenrath and Harrison, 2011), but hope these can be addressed by initiatives intended to improve the use of ecological knowledge (Mooney and Mace, 2009).

As a result, there are several on-going initiatives to improve ecological knowledge use, notably the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) (Larigauderie and Mooney, 2010) but also many regional and national scale initiatives. These often take the form of assessments such as the Millennium Ecosystem Assessment (2005) designed to synthesize existing knowledge (Rothman et al, 2009). These initiatives are purposively created to collate scientific knowledge in order to promote awareness and use, particularly by policy. However, in contrast with many other processes and initiatives (e.g. Hockley; this issue), large-scale assessments are typically not focused on certain sectorial audiences or specific decision-making venues.

The design and evaluation of such initiatives are not often explicitly linked to a rich literature on knowledge use (e.g. Dunlop, this issue; Nutley et al, 2007). In order to fully evaluate the short- and long-term implications for knowledge use in policy-making – which after all is what they intend to achieve – it is essential to consider such initiatives in relation to the processes by which knowledge may be produced, communicated and used (Jordan and Russel, this issue).

In this paper we address this challenge by exploring the processes associated with the development of a National Ecosystem Assessment (NEA) for the UK. This was a recent and relatively high profile example of an initiative intended to improve the use of ecological knowledge by policy-makers, focused around concepts of ecosystem services (UK NEA, 2011). It is too soon to evaluate the full range of knowledge uses that may arise from the NEA, since many potential uses or influences may require years to arise or be detectable (Bornmann, 2012). However, exploring the processes of the NEA allows us to understand the role of such assessments in fostering knowledge communication, and to identify early indications and expectations of knowledge use.

This is valuable and timely because the NEA is one of the first examples of a national-level initiative to synthesise and assess environmental issues using these concepts, and many other nations are now developing or considering similar assessments¹. A theoretically-informed understanding of how assessment processes and products play out to influence knowledge use could therefore inform and improve future assessments and initiatives such as IPBES, whilst providing empirical evidence to enrich and inform the knowledge use literature.

This paper therefore aims to identify the processes and expectation of knowledge uses in the case of the UK NEA, and explore early implications for use.

The paper is structured around three objectives:

1. To identify the origins and objectives for use that motivated the development of the NEA;
2. To explore communication and interaction processes during the development of the NEA, as experienced by those connected with producing and those expecting to use it;
3. To identify early indications of knowledge use based on the process and expectations.

To address these objectives we follow the NEA processes over time. We first explore its origins, focusing on documentary evidence to identify and objectives for use that motivated the development of the assessment. We then explore the experiences of individuals connected with the NEA, particularly focusing on experiences of processes of social interaction and communication, as well as exploring expectations and early indications for knowledge uses.

We begin by reviewing key concepts relevant to understanding and analysing how such assessments may influence ecological knowledge uses.

How interventions affect knowledge use

This section is split into three parts. Firstly, we highlight how the knowledge use literature suggests that there are a range of outcomes that can be understood as ‘use’. Secondly, we look at practical strategies that interventions can take to increase these uses: although the literature suggests use is fostered by social

¹ For example, in Europe, 15 member states are considering or developing a national ecosystem assessment <http://biodiversity.europa.eu/ecosystem-assessments/assessments>

interactions and communication, this is not always reflected by interventions intended promote knowledge use. Lastly, we consider the specific case of environmental assessments, and how they may be expected to influence knowledge use.

Knowledge and knowledge use

Understandings of ‘knowledge’ and ‘knowledge use’ have developed together over time. In this paper we understand knowledge to be socially constructed (co-produced). As such, scientific knowledge is just one form of knowledge amongst others (Turnhout et al, 2013b). Interactions between actors, their context and different forms of tacit and explicit knowledge shape how scientific knowledge is produced, understood, accepted and used (Huberman, 1994).

As we see research knowledge as something more than a discrete and neutral package of facts (Jasanoff and Wynne, 1998), so we expect that knowledge can be used - or come to have influence - in multiple ways (e.g. Weiss, 1979). We particularly focus on research knowledge use in public policy making, and so build on key aspects of the concepts and prominent typologies advanced by Nutley (2007). Similar to McKenzie et al (this issue) we distinguish three key types of knowledge use: ‘instrumental’, ‘conceptual’ and ‘strategic’:

- Instrumental use is the direct use of knowledge (seen as facts) to solve policy problems by filling data gaps or reducing uncertainty. This type of use is associated with assumptions that use results from the ‘linear’ transfer of facts from producers to users. It is often the focus of many initiatives to achieve or measure ‘impact’ or knowledge use.
- Conceptual use is the influence of knowledge, often incrementally or intangibly, to change mindsets about existing issues, or identify new issues. Such influence can be quite profound, since the credibility and legitimacy attached to scientific forms of knowledge can have particular power in shaping how society conceptualises and understands the world (Allen et al, 2001).
- Strategic use is the tactical or political use of knowledge (both bodies of knowledge and research processes creating it) to support or challenge existing positions (Dahler-Larsen, 1998). Strategic uses relate to instrumental uses in that they are also a form of problem-solving, but are distinguished as depending less on knowledge content *per se* but rather on the symbolic value of a body of research knowledge, and its power to legitimate and justify actions. Any decision to share or use knowledge

invokes values and is hence political (Shaxson et al, 2012), but is typically associated with policy actors.

The instrumental use of knowledge is widely acknowledged, expected and supported by science and policy sectors in the UK and other countries (Nutley et al, 2010). However, it is actually easier to find conceptual uses than direct instrumental uses (e.g. Reid 2003 in Nutley et al, 2007), whilst the existence of strategic uses remains underreported and so less well understood. Strategic uses are not often publically acknowledged (Gudmundsson, 2003), and are often regarded as misuse, particularly from a purist instrumental perspective. However, strategic uses are perhaps particularly likely where knowledge is contested, associated with uncertainty, or relevant to heavily politicised issues (Monaghan, 2011) – as can be the case for environmental topics.

In practice these use-types may interact. For example, conceptual use may in time lead to entirely new policies, decisions or ways of working, thereby indirectly leading to instrumental use (e.g. Lemos and Morehouse, 2005; McKenzie et al, this issue). This is well demonstrated by climate change discourses and research over the last two decades (Shackley and Wynne, 1995). In this field, the shifts in priorities and thinking have interacted and evolved to mutually influence both science and policy. However, publically-voiced expectations for the role of scientific knowledge invoke expectations consistent with the linear model of instrumental use, so highlighting that public rationales about knowledge and its uses cannot be taken at face value (Jasanoff and Wynne, 1998).

A wide conception of ‘use’ is thus needed in any attempt to encourage, understand or evaluate knowledge utilisation. Accordingly, multiple strategies can potentially be taken to promote the perceived legitimacy, relevance and credibility of knowledge (Cash et al, 2003) and hence encourage use.

Strategies to promote knowledge use

Understanding knowledge as something socially constructed naturally suggests that supporting processes of communication and interaction may be key to improving knowledge sharing and use (Lemos et al, 2012). Supporting this, empirical studies support the value of strategies that emphasise communication and interaction by encouraging either informal or formally mediated relationships (Court et al, 2004),

particularly via face-to-face interactions (Weiss, 1995). Since institutional settings can provide tangible and intangible constraints on interaction (e.g. Hemsley-Brown, 2004; Weiss, 1999), use can also be fostered by facilitating strategies that aim to mitigate or overcome these (for example by providing resources for meetings). However, ideas about how to promote knowledge use will invariably be related to prior conceptions of knowledge and use. For example, where there is a focus on linear transfer of knowledge for instrumental use, the packaging and the presentation of facts to improve dissemination is typically seen as key.

In summary there are three types of strategies which interventions can adopt to promote knowledge use: communication, facilitation and dissemination (again following Nutley et al, 2007).

Any single initiative could adopt a combination of these three types to improve knowledge use (Figure 1). Unfortunately, the literature on knowledge use is often not explicitly connected to the planning of initiatives that aim to improve knowledge use. Therefore we use a simple conceptual model (Figure 1) to highlight and summarise key concepts relevant to understanding how initiatives may promote knowledge communication and hence use. Certain links may be difficult to anticipate: in particular, we note that influences on strategic use are challenging to trace, perhaps because this is often regarded as misuse (Weiss, 1979).

It is thought that many initiatives implicitly focus on dissemination rather than communication strategies (Landry et al, 2001; Nutley et al, 2007), due to the persistence of thinking about knowledge as facts to be transferred, rather than co-produced (Turnhout et al, 2013a). This implicit focus on instrumental use, and hence adoption of dissemination strategies, may well be shared by initiatives to promote ecological knowledge use. Common forms of these are assessments and evidence reviews.

Environmental assessments and knowledge use

In general, observations of assessments suggest they are typically justified as supporting instrumental use (Rothman et al, 2009): from those designed to support cross-national environmental agreements and regimes (Engels et al, 2006), to the “rationalist” assumptions associated with Strategic Environmental Assessments (Sheate and Partidário, 2010). As such, these initiatives typically focus on dissemination strategies, to improve the distribution and ‘packaging’ of knowledge outputs. However, since communication processes

underpin use (e.g. Rich, 1997) realising many potential uses of knowledge – particularly conceptual use - may thus depend on the extent to which assessments can allow and promote interactive processes. For example, Cowell and Lennon (this issue) show that the influence of environmental assessments on UK land-use planning is affected by factors shaping and constraining communication, rather than knowledge content *per se*.

The most detailed insight into if and how such assessments influence on knowledge use is available from the extensive studies of the assessments of the Intergovernmental Panel on Climate Change (IPCC) and the use of climate knowledge. Here, public framings of climate science are consistent with the instrumental problem-solving model (e.g. Wynne, 2010), but in practice, climate knowledge more often achieves conceptual use (Lemos and Morehouse, 2005). This results from interactions and ‘iterativity’ between the policy and research communities and precedes other forms of use (Lemos and Morehouse, 2005).

Individuals with experience of designing this and other environmental assessments have themselves therefore recently recommended that future assessments should attend more to process, particularly the involvement of stakeholders (Rothman et al, 2009).

The UK NEA is one of the first national assessments framed in terms of ecosystem services, and therefore offers a valuable opportunity to improve understanding the processes aiming to promote ecological knowledge use in these terms. The following section describes how the methods used to explore this process and address our three research objectives.

Methodology

To address the first objective, to identify the origins and objectives for use originally motivating the NEA, we reviewed documents that accompanied and preceded the commissioning of the assessment. Many of these are UK-level policy documents but we also reviewed the outputs of UK devolved administrations, and of preceding assessment processes.

To address the second and third objectives, exploring experiences of the NEA processes and expectations for use, in late 2011 we conducted twenty-five semi-structured interviews with a range of individuals connected

with or aware of the launch of the NEA report earlier that year, in June. Our sample was designed to capture the views of a range of potential ‘users’ as well as ‘producers’ of knowledge: interviewees were therefore selected to encompass a range of roles connected with the NEA process plus some individuals who were not directly connected with the NEA but may well be expected to read or use it (Table 1).

In our interviews we aimed to explore understandings and personal experiences relating to the process of carrying out the assessment and final NEA report. Our interviews comprised four parts, shaped by a topic guide (see Supplementary material). Firstly, we aimed to understand the role of interviewees in the NEA process, their views on the process and on the final report. Secondly, we explored interviewees’ views on the NEA as a process for improving communication and use of knowledge. Thirdly, we explored views on the NEA’s contribution to current knowledge in the field of ecosystem services. Lastly, we explored any other views, or other experiences relating to science policy interfaces, ranging from informal interactions through to international initiatives such as the aforementioned IPCC or IPBES. The use of the topic guide was flexible, depending on interviewee experiences and interests, and it was iteratively updated over time, in light of previous interviews. The interviews were carried out as part of the “SPIRAL” project, which aims to understand and support science-policy interfaces (<http://www.spiral-project.eu>). As such, the main focus of the interviews was to explore experiences in order to synthesise recommendations for improving science-policy communication, and since we did not prejudge which specific model or theoretical approach might be most relevant, we did not focus on the assumptions of any particular model in our questions.

The interviews were recorded and transcribed verbatim for qualitative analysis, and the software programme Nvivo 9 was used to manage the data, enable data to be coded and queries to be undertaken (QSR International, 2010). The use of qualitative research and interview data has been demonstrated as a useful way to explore individuals’ perceptions and processes relevant to understanding knowledge use (e.g. Holmes and Clark, 2008; Turnhout et al, 2013a). We initially used an iterative and inductive approach influenced by grounded theory to identify these themes, and then applied more deductive themes arising from the literature and conceptual model presented above, together with the constant comparison method to compare emerging interpretations with previous ideas (Strauss and Corbin, 1998). For example the first themes coded as far as possible represented all topics discussed by the interviewees themselves, and we then

reviewed the literature on science-policy interfaces and knowledge use to identify potential links with these themes, and to identify additional themes to check and search for. We use verbatim quotes from our transcripts to illustrate key themes in our data. To protect interviewee confidentiality, such quotes are anonymised with reference to Table 1.

In the sections that follow we present, connect and explain key themes in our findings as per the objectives. Firstly, we explore the expectations and conceptions of use that gave impetus to the NEA. Secondly, we build on individual experiences to understand how the NEA processes may influence uses, and lastly we use interviewee observations to explore early indications and expectations for use.

The origins of the UK National Ecosystem Assessment (NEA)

In this section we explain the origins of the assessment process which lead to a 2011 report, and assess its intended role in improving knowledge use. We suggest that its rationale – to synthesise data and collate knowledge to inform and improve decision-making by policy-makers – is consistent with the instrumental model of how research can be of use to directly inform decision-making.

The UK NEA has its roots in the Millennium Ecosystem Assessment (MA), whose high profile reports published over 2005 and 2006 were hailed as giving an unprecedented overview of the state of the global environment and its links with human well-being (Millennium Ecosystem Assessment, 2005). The rationale for the MA unambiguously conforms with the instrumental model: it was set up to provide "definitive information" to "directly meet the needs of decision-makers" (Reid, 2004, p 170). Nation states were anticipated as key users. The MA's processes were strongly influenced by those of the IPCC, and chosen to emphasise credibility, relevance and legitimacy (Miller and Dublin, 2003), properties thought key for knowledge to be actionable (Cash et al, 2003). Despite this, in the mid-term evaluation, target users already expressed concerns that it would not support "practical outcomes" (Miller and Dublin, 2003). Its "terminal evaluation" noted there was little evidence of "direct impact" on policy formulation or decision-making (Wells et al, 2006). An early review of responses to the MA by its director (Reid, 2006) reported that whilst some states appeared to have been little influenced, several – including the UK – were considering creating national-level assessments. For the UK the MA was reported to have influenced "thinking" related to

strategic policy on the natural environment, and specific content had informed projects in the departments concerned with development and the environment (Reid, 2006, p 6-7).

In the year following the release of the final MA reports, the UK Parliament's House of Commons Environmental Audit Committee (2006) reviewed the MA and identified a number of recommendations for the UK Government. This report was generally very positive about the MA. However it did note a "lack of focus on the economic valuation of ecosystem services, as well as a lack of policy proposals directly relevant to many decision makers" (p 7), and its recommendations were aimed at improving the relevance to UK policy-makers. The MA Director's evidence to this report (Walter Reid, p 22) noted that he believed national level assessments, together with better and simpler communication of findings would enable this, and "encourage governments to act upon its findings". The report therefore suggested a UK-scale assessment "to enable the identification and development of effective policy responses" (p 8). This idea was supported not only by environmental policy teams: evidence from the Treasury (p 41) also showed support for further work on quantifying and valuing ecosystems as this would enable departments "to take such better policy decisions".

The Environmental Audit Committee's report and recommendation for a UK assessment was favourably received by the wider government (Environmental Audit Committee, 2007) and work commenced to produce a 'National Ecosystem Assessment' (NEA) for the United Kingdom. Its stated aim was to provide a "first analysis of the UK's natural environment in terms of the benefits it provides to society and continuing economic prosperity" (UK NEA, website homepage). A large part of the rationale seemed to be that a UK-scale assessment could produce insights relevant to informing improving decision-making by policy makers working at the same scale. Although the UK Government's Department of Environment, Food and Rural Affairs (DEFRA) led the commissioning and funding of the NEA, the devolved administrations of Scotland, Northern Ireland and Wales subsequently became involved.

Although the NEA was clearly expected to be of use to policy making, there was no clear definition of who the actual intended users would be, what use would look like, and how this would be achieved. For example its 2011 report does not mention 'use' though it has objectives such as assessing the state and value of the UK environment and fostering collaboration and awareness (UK NEA, 2011, p 3). We understand there is

no document which explicitly lays out how the NEA conceptualised use types nor how it planned processes to achieve expected uses. To understand this, we explore how the NEA implicitly conceptualised use and considered process by analysing the statements associated with its creation, and likely influences on those commissioning it.

Since the NEA was a response to the MA, expectations and processes of this assessment were probably the strongest single influence on the new national level initiative. Although the early evaluation of the MA showed evidence of a mix of instrumental and conceptual use by policy-makers (Reid, 2006), a UK-scale assessment was expected to provide more instrumental uses for UK policy-makers (Environmental Audit Committee, 2006). As noted in the previous section, direct instrumental uses are typically the focus and justification for environmental assessments and data collection processes (e.g. Wynne, 2010). Although the official rationale for the NEA did not list expected uses, a multitude of possible benefits or expectations had been earlier mentioned in the evidence collected by the Environment Committee in its 2006 report. Here references to a national-level assessment mentioned that this would: mirror the “scales where decisions influencing ecosystems are actually made” (p 44); provide “validation” or testing of the MA methodologies (p 44); provide “tools... to make better policy decisions” (p 45); and assist with “better identification of effective policy responses” (p 46). We therefore infer that multiple instrumental-type uses were expected when the NEA was commissioned, to inform decisions made at the national-scale. This focus would also accord with how other research use is typically presented in the UK: this has tended to focus, at least publically, on ideas of value-free scientific knowledge for policy problem-solving (Sanderson, 2003) including on environmental topics (Holmes and Clark, 2008).

Based on Figure 1, we can make several inferences about how a process may be planned or focused, if instrumental uses were expected. Where instrumental use is the focus, the key challenge is seen as presenting that knowledge in a form that is accessible and relevant to decision-makers. Transparent and independent input from value-free science is seen as key to supporting credibility (Cash et al, 2003), whilst interaction is valued for allowing policy-makers to frame questions correctly, and scientists to pursue appropriate lines of enquiry (e.g. Government Office for Science, 2010). However, questions of who

interacts to share or collate knowledge may be less important *per se*, as long as the final output is seen as relevant and credible. This focus indeed seems to fit with that of the NEA.

The assessment process was led by two co-chairs (one based within the research sector and the other DEFRA's chief scientific advisor) and coordinated by a secretariat hosted by UNEP-WCMC. This arrangement was designed to demonstrate independence, with the assessment being the product of scientific authors. The co-chairs and secretariat commissioned and coordinated scientific researchers (the author group) who were organised in separate chapter teams. They aimed to build on the MA's approach of understanding ecosystems in terms of ecosystem services, but also incorporated influences and latest updates from related and parallel policy and research developments (Simpson, 2010), in particular The Economics of Ecosystems and Biodiversity (TEEB) initiative (Balmford et al, 2008).

Oversight and feedback came from a client group representing the funders, and a user group, representing some other key public agencies and departments, but also some large private and third sector organisations that might be expected to use or benefit from the report. The authors were given about two years in total to produce the chapters, though this time included a cross-sectorial review process, whereby draft chapters were commented on, not only by academic peers, but also by the user and client groups and other stakeholders. The roles designated for these different groups were informed by the coordinators' experience of other global assessments including the MA and IPCC, and can be seen to respond to the need to demonstrate both credibility and relevance. The credibility of the final product was linked to independent leadership and scientific contributions, whilst the involvement of client and user groups aimed to promote their 'buy in'.

In June 2011 a synthesis report of the assessment was published (UK NEA, 2011). This was supported by press releases and a public launch event that gained attention with the national media (e.g. Black, 2011; Morrison, 2011). The chapters of the full report were available online at this time, though not finalised and physically bound until later in Autumn 2011. The report's six 'key' messages reiterated the importance of natural resources to UK society and economy, and that the UK population and future changes was increasing pressure on ecosystem services. The report contained a chapter on 'response options' but did not advocate particular government actions. At the time of this writing the NEA process continues in a 'follow-on phase',

but the production of 2011 report was the focus of the first phase (itself sometimes referred to as ‘the NEA’ both by its audiences and those involved in its production).

In summary, the origins and objectives that motivated the NEA were not precisely defined in relation to the knowledge use literature but seem consistent with the linear model of how science knowledge can inform policy, and instrumental problem-solving use of scientific knowledge. For example, objectivity was emphasised, interaction and communication less so. This is in line with many other assessments (Rothman et al, 2009). However, if the process was indeed focused on reports and demonstrating objectivity, it may limit opportunities for interaction and hence limit the extent to which knowledge is communicated and used beyond scientific arenas. To better understand exactly how the NEA process played out, in the following section we present experiences of some individuals connected with the first phase of the process.

Experiences of the NEA process

We consider in turn how experiences with the NEA process reflect on its actual role in promoting dissemination, interaction and facilitation of knowledge use.

Interventions which focus on dissemination would be particularly focused on improving the packaging and presentation of knowledge, in order to maximise its perceived relevance to potential users (Figure 1). This was also focused on by many interviewees. When invited to comment on the NEA, many focused on its format and presentation style, often voicing strong criticism of this. In particular, when the report was launched many chapters were only available as online drafts, and when the final report was printed and bound, it was so large that it was referred to as an inaccessible “doorstop” (P7). Both users and producers felt this could deter potential readers. Although interviewees had different expectations of whom and how the report might be used (see also next subsection), nobody judged the report to be well targeted at any particular audience. For example, a member of the client group frustrated by its style was lost for words when trying to summarise to whom the outputs might be accessible: “Who do we expect to pick up and read it, I just don’t know. Even the synthesis is..... [silence]” (U2).

Interviewees were asked about their views on ecosystem service topics, but there was often ambivalence about whether these concepts and terminologies were the best way to communicate with non-academics or

non-environmental audiences. However, many quickly moved on to critique a perceived emphasis on economic valuation. Natural science authors were particularly negative, since this was seen to eclipse other messages, particularly the complexity and interconnectedness of natural processes. However, no users we interviewed strongly felt the assessment should be focused on valuation, and indeed some identified this as originating from academia. We cannot trace the complex processes of co-production through which economics concepts came to be emphasised. One influence may have been a drive to promote accessibility e.g. by press departments focusing on economic metrics since they are already familiar to all and hence easier to understand (P6). If so, this may have been misguided, as much of the debate after the report's release was critical of this aspect (UK NEA, 2012a). This may caution against efforts to promote relevance by eliding complexity, or assumptions that economic framing is acceptable in all contexts and for all audiences.

Both the official process and participants' own attention focused on production of the report as the main means to facilitate knowledge use. However, when prompted to discuss experiences of producing the NEA report, interviewees offered extensive reflections on interactions. These interactions were not only between producers and users, but between different producers, as academics came together in new teams to produce chapters. For example, a lead author described working with his team as a "brilliant" experience (P2). In discussions of interaction, the key role of individuals in sharing ideas across groups was highlighted, with particular reference to an example of a charismatic economist. This individual's excellent communication skills and ability to forge a personal connection with senior policy makers was identified by many as another key factor that contributed to an increased emphasis on economics in the process.

Although there were some opportunities and meetings where users and producers could interact (particularly those working at a senior-level), these did not involve the majority of authors or potential users. By contrast, a cross-review process in the second year allowed more producers and users to share views. In this process a wide range of potential users, including groups hitherto not connected to the NEA process, were invited to see and comment on draft chapters prepared by authors. The interaction was not face-to-face but it did allow many more to get involved. For the authors it was interesting to receive feedback from non-academics, though challenging and time consuming to address or respond to all comments. For users,

particularly those groups not formerly connected, this process could have increased the report and process' salience, so increasing the perceived relevance of the final report. Furthermore, it may also have assisted with perceived credibility - since reviewing was widely supported by interviewees as an essential tool for quality control – and also have increased legitimacy, since those organisations who were invited to comment could not so easily argue later that their views had not been taken on board.

However, there were also many frustrations with limited opportunities for interaction and communication. Many authors felt that the report was rushed, and perceived that limited opportunities to interact with other author teams meant the chapters were disjointed. Meanwhile, users had limited interactions with the authors and there were a limited number of meetings that brought together producers and users. Even a lead author (P8) could not confidently describe the roles of the client and user groups. As a result, one policy advisor (U3) observed that scientists and policy-makers seemed to be “living in parallel universes”. If so, it seems that the NEA was an imperfect facilitator of interaction. However, that interviewees were frustrated with the limited interaction suggests that they implicitly value it, even if their explicit rationalisations of knowledge use focussed on the importance of dissemination of the report.

The assessment invested in two key aspects to facilitate the assessment process: hiring professional writers, and payments to lead authors. Professional writers were recruited in the second year specifically to improve the accessibility of the report text. This was intended to promote dissemination. The second aspect, author payments, could facilitate interaction by recognising authors' time requirements. However, rather than reflecting real salaries, this was an honorarium that did not realistically compensate them for the amount of time spent. As a result authors worked without “the time or the wherewithal” (P1), motivated instead by goodwill, interest in the topics, and the hope this might advance their careers. Many frustrations reflected these time constraints. Time constraints also arose from the scale of work itself that was to be compressed into two years. Indeed, draft chapters had to be delivered in a little over a year to allow time for the cross-group reviewing, though this may be judged a reasonable trade-off given the interaction benefits that cross-reviewing brought.

In summary, the NEA process did allow for some opportunities for communication and interaction between scientists and policy-makers. A cross-review process was particularly valued and valuable for bringing

together different sectors. However, by the judgements of those involved in production and consumption, these opportunities for interaction were frustratingly limited and so may in turn limit the extent to which knowledge is shared across science and policy.

Expectations and early indications of use

Here we build on the previous sections, and also synthesise interviewees' expectations, to identify early implications for knowledge use. We consider in turn instrumental use, conceptual use, and then strategic use.

Interventions which focus on dissemination are focused on conceptual use, by improving the packaging and presentation of knowledge in order to maximise its perceived relevance to potential users (Figure 1). This seems to accord with many interviewees' expectations for the NEA: some users at senior policy levels hoped that the report could help "operationalize" ecosystem services concepts into policy. This expectation is consistent with the NEA's stated rationale. However, there was no evidence that these expectations were being fulfilled:

"I would have thought that it was intended to help the government come to some better decisions on um...on the allocation of resources for and the management of um...um...environmental resources generally. When I say the government I mean in this complicated country we now live in, all the different levels of government. ... I think they should all be feasting on this and I just don't see that".

(U3)

Many other interviewees in all policy roles were similarly disappointed, and none could identify the content as directly solving or resolving any existing policy problems. As U10 put it, "it's still not giving us the sort of evidence policy-makers can work with". The general impression was typified by U9 who had scrutinised the report looking for ideas to feed into land use policy: "I didn't necessarily feel that it was terribly informative for me as a policy maker in thinking 'well how can I take that forward'".

The report's limited accessibility, as identified by many interviewees, may hinder its salience to many potential users, who commonly complain of limited time and resources to read or discuss new information (e.g. Slob et al, 2007). However, although the report is so large precisely because of all the detail it

contains, this may still be insufficient to actually change or inform ongoing work for any particular user. For example, a young civil servant who had read all the detail of the chapter relating to his field could not find anything to inform his work: “We got it...sat and looked at it and flicked through and we couldn’t see anything obvious there” (U8). Similarly, the policy maker U9 concluded that the contents were at too high a level. Even personalised communication efforts from authors did not necessarily help:

“I haven’t had a lot of feedback that it’s been very useful you know. I’ve given a talk about it to [non-departmental public body] who I think are quite puzzled by it”. (P9)

This suggests the content as well as the presentation may be unsuitable for direct problem-solving. This may be because instrumental uses are better supported by processes tailored for specific questions, user groups or scales (see also Hockley, this issue). These problems may already be perceived, as the ongoing NEA follow-on phase seems partly focused on improving dissemination and particularly perceived relevance, to “unblock that shared potential to deliver something that’s actually fit for purpose” (P6).

Linked to this was the recognition by many interviewees that messages must be tailored to specific audiences: “ask who do you want to influence and how?” (P2).

So, early indications are that the NEA may be of limited direct instrumental use, despite its original rationale and the hopes of some policymakers. By contrast, although its rationale does not overtly highlight conceptual use, there is some evidence of this from our interviews. We can infer that this could be supported from the assessment process, since despite imperfections this clearly did create new opportunities for interaction which can support learning. This interaction occurred not only between producers and users (particularly through the review process) but also within author groups. Within our sample, academics were keen to say that they had enjoyed working in new groupings for “intense” (P2) thinking about new topics. Ecosystems service concepts were perceived as “conceptually challenging” (P9) and to require entirely new ways of thinking and analysis that were beyond many authors’ comfort zone. Chapter writing was thus seen as ideally more than an exercise in collating existing information – though this was certainly a large part of the task, and a challenging one since datasets were not set up with ecosystem services in mind. For example, in the previous section we noted that economic concepts became increasingly prominent over time and for many natural scientists it was a new opportunity to link with this discipline. Unfortunately the

limitations of time and the lack of connections mingled to leave some authors dissatisfied with their work, or feeling they did not progress sufficiently beyond data gathering. A policy advisor with background in the field also observed that the chapters did not “go deep enough” (U10). However, for authors, the opportunity to create, learn, discuss and share new ideas was a large part of the appeal of involvement in the NEA, even if these ideas were not fully realised or reflected in the chapters. Interviewees’ suggestions for the NEA follow-on phase also seemed to value this: for example “looking for consistencies and linkages” (P1) was thought needed to ensure all interesting and unique insights from the NEA were recognised.

Many authors expected that the assessment should therefore help to shape and change the thinking of non-academic users. However, the users we interviewed typically had little awareness of such changes within their own thinking. They reported that they were already familiar with the general concepts in the assessment, and they were not conscious that the assessment was particularly changing their way of understanding any issues. It may be that the MA was the assessment which introduced the key concepts (Reid, 2006) so less radical changes in thinking would be required to understand and digest a similar assessment carried out at the UK-scale. Some interviewees suggested the NEA could instead be of more relevance for introducing concepts to audiences who might traditionally not consider or strongly value environmental issues. Thus the NEA might help in “trying to explain” (P1) new ideas to non-environmental policy departments:

For me the NEA-sort-of-messages, on the broad scale, is nothing...new for us in biodiversity policy, but it is probably new to lots of other areas of government.” (U7)

For these audiences this might result in “not so much making...making use of it in detail but it’s partly about a kind of...almost like a cultural change I suppose in the way of thinking” (P8). Although efforts were made to make the quality of the writing accessible to a wide audience, and to relate the content to “mainstream policy issues” (U1), there were worries that the overall process may still have been best “targeted” (U8) at audiences already working in these issues.

However, the narratives of those users who discussed the use of NEA with non-environmental audiences suggest the primary use may be better characterised as strategic rather than conceptual. For example, it was

judged important that the information contained in the report was “crystallised” (U1) in a process that was not led by any government department. Being seen as the product of independent scientists was important:

“It will be useful, it will be useful, and it gives credibility because you know it is [pause] it is proper science” (U2).

The resulting credibility meant the report could have strategic use, to support existing ideas and approaches already held by the environmental policy sector. Environmental policy has long been perceived as a relatively peripheral issue (Revell, 2005), despite efforts to mainstream it across government (e.g. Russel and Jordan, 2009). Users were particularly aware of this challenge, “especially in the time of recession” (U10), although academics may also have been sympathetic given that the origin of ecosystem services concepts is thought to be linked to academics’ desire to better demonstrate nature’s value to people (Costanza et al, 1997), and so better prioritise it in decision-making. Therefore, tools to gain leverage against other departments, such as transport were welcomed.

“I mean when we try and sell – sell the message is maybe the wrong term – when we’re trying to influence other areas of policy it can quite helpful... the NEA should give us a bit more ammunition” (U7).

Perhaps the most obvious example of this was in the White Paper (DEFRA, 2011) published by DEFRA just one week after the NEA report was launched. White papers are documents produced by the UK Government setting out details of future policy. They allow the Government of the day to receive feedback before it formally presents the policies as parliamentary bills, and political positions and statements that can be backed by science evidence will be judged more ‘robust’ and thus defensible (Shaxson, 2005). A member of the client group (U5) described how his connection with the NEA meant he was personally aware of the report’s content and conclusions well before its official publication, and so his department could ensure this was referred to in the White Paper. This supports the value of the interaction for encouraging use. However, it is somewhat in tension with the views that the “independent” and “non-judgmental” content of the report (U5) that meant it was seen as a more legitimate source of information for justifying environmental policy-making. Other interviewees also made reference to influencing non-environmental policy but it is often not possible to categorise what type of use was expected, especially

since strategic use can be hard to directly discuss in interviews. For example, the policy maker U2 hoped the health chapter could be used “as a way into talking more to our health colleagues”: this statement suggests a blending of conceptual and strategic use. Overall these kinds of quotes illustrate how the links between all use-types are fluid and hard to disentangle. For example the “persuasive” power of the NEA report could open doors to productive collaboration that would later allow its content to be used in more efficient policy-making and problem-solving.

It is also possible that another type of strategic use may be associated with the NEA, that is by academics. Each chapter was mandated to identify knowledge gaps, and as authors wrote the report, they were aware that gaps highlighted could influence where funding was allocated for future research. One interviewee (P11) therefore alleged that scientists might tend to emphasise uncertainties “to cover their backs” and for use when “putting down a grant application”. Whilst this is not an accusation of deliberate manipulation of the research agenda, the topics discussed will inevitably have been influenced by the interaction between authors’ past research interests and evolving ideas from the assessment. For example, the NEA provided the conceptual framing for research projects funded in autumn 2011 by a new ‘Valuing Nature Network’ (NERC, 2011), which involved many of the same academics who produced the NEA.

In summary, experiences of process and early indications of use suggest that the NEA process had fostered little early instrumental use, some conceptual use, and some strategic use, but these uses interact and may not be easily disentangled.

Conclusions and new directions

We identify a contrast between the expectations of knowledge utilisation embedded in the UK National Ecosystem Assessment and experiences in practice. The NEA – as with many other assessments – was created to promote instrumental knowledge use, i.e. present directly usable information to policy-makers. The assessment process was accordingly focused on a final report to achieve this, but also allowed limited opportunities for interaction. Due to this, some conceptual and strategic uses were realised. Instrumental uses were not yet evident, though may only become apparent in the longer term (Bornmann, 2012).

There are implications for knowledge and use as influenced by the NEA. Because the process and 2011 report did not target a single audience, this could well be an important constraint on achieving appropriate dissemination to facilitate instrumental uses. Frustration with a lack of directly useable information has already informed some follow-on work in a second phase of the NEA, which, amongst other aims, intends to better target assessment knowledge towards specific types of users (UK NEA, 2012b). Tracing these efforts will allow further insight into when instrumental use can be achieved by improved dissemination, or is impeded due to other issues such as the inherent complexity and uncertainty of ecological concepts and fit with existing knowledges (Pahl-Wostl, 2007).

However, framing knowledge for specific audiences to target will inevitably exclude other actors and/or needs (Turnhout et al, 2012). Thus, it may be inherently exclusionary for this and other initiatives to focus on refining dissemination strategies and improving instrumental uses in this way. Furthermore, conceptual uses are ultimately likely to underpin other types of use, since understanding and acceptance of concepts necessarily precedes more specific actions (Rich, 1997). Therefore wider conceptions of use should be encouraged (Nutley et al, 2007) . If it is possible for this and other processes to adopt strategies that more explicitly prioritise communication and interaction, this will support knowledge co-production and likely underpin a wider range of uses in the long-term (Lemos et al, 2012).

Looking beyond the NEA, there are implications for research into processes of knowledge communication and use. Firstly, simple conceptual models (e.g. Figure 1) or typologies can be analytically useful, and can highlight multiple forms of knowledge communication and use. However, in reality we cannot so neatly separate knowledge communication and different types of knowledge use (Greenberg and Mandell, 1991). Knowledge use is messy (Haines-Young and Potschin, this issue). For example any strategic use will support positions constructed as a result of earlier communication, and may link to or overlap with instrumental uses. Therefore typologies must not become limiting: adoption of a co-production perspective is needed to understand how multiple knowledge uses interact, particularly including strategic use, by multiple users, and over time (e.g. Lemos and Morehouse, 2005).

Secondly, and related to this, more attention to power is needed (Turnhout et al, 2013a). This includes the power and interests of different actors as well as the perceived power of different bodies and forms of

knowledge. What we identify as strategic use seems to depend on the privileged role or epistemic authority that scientific knowledge is accorded versus other knowledges when justifying decision-making (Allen et al, 2001). This may be particularly true if linked to economic concepts, and so could explain their dominance in the face of scepticism from scientists (Walker et al, 2009) and limited direct uses by policy-makers (Hockley, this issue). It is even possible that leveraging ecological knowledge for strategic or symbolic use is particularly common, due to frustrations arising from the perceived neglect of environmental issues versus other topics (Revell, 2005; Turnpenny et al, this issue). Such frustrations are not often formally recorded (Kaiser, 2000). However if this is the case, any conceptual and strategic knowledge use achieved may address some privately-held frustrations and aspirations, despite not (yet) matching publically-voiced expectations of instrumental use. However, to understand this, a better understanding of potential users' decision-making priorities, processes and contexts is needed. Furthermore, new innovative methods will be needed, given the difficulties of directly discussing conceptual shifts and strategic or political uses.

A focus on the interactions between processes of production and use also highlights an apparent paradox: if independent science is seen to give credibility for strategic uses, as in this case, this could encourage efforts to preserve the 'objectivity' of science, and thus deter interactions and communication between science and other sectors. This would, in turn, limit the ability to support conceptual and eventual instrumental uses of the same knowledge. We have already noted that knowledge uses can interact, but perhaps these interactions are not always mutually supportive (Cash et al, 2003). More attention is needed as to how different knowledges are represented and interact to affect use (Hoppe, 2005).

It is challenging to understand and promote knowledge use, given the multitude of ways in which this may be understood, and the complex interactions between processes producing use. Furthermore, there may be additional challenges arising from the complexity associated with environmental topics (Briggs, 2006) and policy (Ney, 2009). There is a clear need for further research to disentangle these issues. Nevertheless, this study and the wider literature suggest some steps that could be taken to improve ecological knowledge use. In particular, it is crucial to take a more nuanced view of knowledge and knowledge use, underpinned by communication and interaction, rather than a narrow focus on instrumental use. The value of assessment processes – not just products – must be better appreciated.

References

- Allen T F H, Tainter J A, Pires J C, Hoekstra T W, 2001, "Dragnet Ecology—"Just the Facts, Ma'am": The privilege of science in a postmodern world" *Bioscience* **51**(6) 475-485
- Balmford A, Rodrigues A S L, Walpole M, ten Brink P, Kettunen M, Braat L, de Groot R, 2008, *The economics of ecosystems and biodiversity: Scoping the science* (European Commission, Cambridge, UK)
- Black R, 2011, "Nature 'is worth billions' to UK" *BBC News Online* 2 June, <http://www.bbc.co.uk/news/science-environment-13616543>
- Bornmann L, 2012, "Measuring the societal impact of research" *EMBO Reports* **13**(8) 673-676
- Briggs S V, 2006, "Integrating policy and science in natural resources: Why so difficult?" *Ecological Management & Restoration* **7**(1) 37-39
- Cash D W, Clark W C, Alcock F, Dickson N M, Eckley N, Guston D H, Jäger J, Mitchell R B, 2003, "Knowledge systems for sustainable development" *Proceedings of the National Academy of Sciences* **100**(14) 8086-8091
- Costanza R, D'Arge R, De Groot R S, Farber S, Grasso M, Hannon B, Limburg K, Naeem S, V O N R, Paruelo J, Raskin R G, Sutton P, van den Belt M, 1997, "The value of the world's ecosystem services and natural capital" *Nature* **387** 253-260
- Court J, Hovland I, Young J, 2004 *Bridging research and policy in development: evidence and the change process* (ITDG, London)
- Cowell R, Lennon M, XXXX
- Dahler-Larsen P, 1998, "Beyond non-utilization of evaluations: An institutional perspective" *Knowledge, Technology & Policy* **11**(1) 64-90
- DEFRA, 2011 *The Natural Choice: Securing the value of nature* Cm 8082, Department for Environment, Food and Rural Affairs (The Stationery Office, London)
- Díaz S, Fargione J, Chapin F S, III, Tilman D, 2006, "Biodiversity loss threatens human well-being" *PLoS Biology* **4**(8) e277

Dunlop C, XXXX

Engels A, Hisschemöller M, von Moltke K, 2006, "When supply meets demand, yet no market emerges: The contribution of integrated environmental assessment to the rationalisation of EU environmental policy-making" *Science and Public Policy* **33**(7) 519-528

Environmental Audit Committee, 2006 *The UN Millennium Ecosystem Assessment: report, together with formal minutes, oral and written evidence* First Report of Session 2006-2007, HC 77 (The Stationery Office, London)

Environmental Audit Committee, 2007 *Government Response to the Committee's First Report of Session 2006-07: The UN Millennium Ecosystem Assessment* HC 848 (The Stationery Office, London)

Government Office for Science, 2010 *The Government Chief Scientific Adviser's Guidelines on the Use of Scientific and Engineering Advice in Policy Making*, Department for Business, Innovation and Skills, <http://www.bis.gov.uk/assets/goscience/docs/g/10-669-gcsa-guidelines-scientific-engineering-advice-policy-making>

Greenberg D H, Mandell M B, 1991, "Research utilization in policymaking: A tale of two series (of social experiments)" *Journal of Policy Analysis and Management* **10**(4) 633-656

Gudmundsson H, 2003, "The policy use of environmental indicators—learning from evaluation research" *The Journal of Transdisciplinary Environmental Studies* **2**(2) 1-12

Haines-Young R, Potschin M, XXXX

Hemsley-Brown J, 2004, "Facilitating research utilisation: A cross-sector review of research evidence" *International Journal of Public Sector Management* **17**(6) 534-552

Herkenrath P, Harrison J, 2011, "The 10th meeting of the Conference of the Parties to the Convention on Biological Diversity—a breakthrough for biodiversity?" *Oryx* **45**(01) 1-2

Hockley N, XXXX

Holmes J, Clark R, 2008, "Enhancing the use of science in environmental policy-making and regulation" *Environmental Science & Policy* **11**(8) 702-711

- Hoppe R, 2005, "Rethinking the science-policy nexus: from knowledge utilization and science technology studies to types of boundary arrangements" *Poiesis & Praxis* **3**(3) 199-215
- Huberman M, 1994, "Research utilization: The state of the art" *Knowledge and Policy* **7**(4) 13-33
- Jasanoff S, Wynne B, 1998, "Science and decision making", in *Human Choice and Climate Change* Eds H S Rayner, E L Malone (Battelle Press, Columbus, OH) pp 1-87
- Jordan A, Russel D, XXXX
- Kaiser J, 2000, "Advocacy - Taking a stand - Ecologists on a mission to save the world" *Science* **287**(5456) 1188-1192
- Landry R, Amara N, Lamari M, 2001, "Utilization of social science research knowledge in Canada" *Research Policy* **30**(2) 333-349
- Larigauderie A, Mooney H A, 2010, "The Intergovernmental science-policy Platform on Biodiversity and Ecosystem Services: moving a step closer to an IPCC-like mechanism for biodiversity" *Current Opinion in Environmental Sustainability* **2**(1-2) 9-14
- Lemos M C, Kirchhoff C J, Ramprasad V, 2012, "Narrowing the climate information usability gap" *Nature Climate Change* **2**(11) 789-794
- Lemos M C, Morehouse B J, 2005, "The co-production of science and policy in integrated climate assessments" *Global Environmental Change* **15**(1) 57-68
- McKenzie E, Posner S, Tillmann P, Bernhardt J R, Howard K, Rosenthal A, XXXX
- Millennium Ecosystem Assessment, 2005 *Ecosystems and Human Well-being: Synthesis* (Island Press, Washington, DC)
- Miller C A, Dublin H, 2003 *Millennium Ecosystem Assessment (UNEP/GEF/UNFIP PROJECT - MP/FP/1010-04) Mid-term evaluation* (Evaluation and Oversight Unit, United Nations Environment Programme, Nairobi)
- Monaghan M, 2011 *Evidence Versus Politics: Exploiting Research in UK Drug Policy Making?* (The Policy Press, Bristol)

- Mooney H, Mace G, 2009, "Biodiversity Policy Challenges" *Science* **325**(5947) 1474
- Morrison S, 2011, "What price nature? Report puts financial value on UK's ecology" The Independent Online Edition, 2 June, <http://www.independent.co.uk/environment/nature/what-price-nature-report-puts-financial-value-on-uks-ecology-2292043.html>
- NERC, 2011, "Science Plan: Challenges Underpinning the Call for Proposals Project Funding" A NERC Interdisciplinary Network for Valuing Biodiversity, Ecosystem Services and Natural Resource Use, Natural Environment Research Council, Swindon, http://www.valuing-nature.net/sites/default/files/Science Plan - Challenges Underpinning the Call_2.pdf
- Ney S, 2009 *Solving messy policy problems: handling conflicts in environmental, transport, health and ageing policy* (Earthscan, Bristol)
- Nutley S, Morton S, Jung T, Boaz A, 2010, "Evidence and policy in six European countries: diverse approaches and common challenges" *Evidence & Policy* **6**(2) 131-144
- Nutley S M, Walter I, Davies H T O, 2007 *Using Evidence: How Research Can Inform Public Services* (Policy Press, Bristol)
- Pahl-Wostl C, 2007, "The implications of complexity for integrated resources management" *Environmental Modelling & Software* **22**(5) 561-569
- QSR International, 2010, NVivo 9 (QSR International, Melbourne, Australia)
- Reid F, 2003 *Evidence-based policy: Where is the Evidence for it?* (School for Policy Studies, University of Bristol, Bristol)
- Reid W, 2006 "Millennium Ecosystem Assessment: Survey of Initial Impacts", Millennium Ecosystem Assessment, <http://www.watsoninstitute.org/ge/scenarios/pubs/Reid Survey of Preliminary MA Impact - 2.pdf>
- Reid W V, 2004, "Bridging the Science–Policy Divide" *PLoS Biology* **2**(2) e27
- Revell A, 2005, "Ecological modernization in the UK: rhetoric or reality?" *European Environment* **15**(6) 344-361

- Rich R, 1997, "Measuring knowledge utilization: Processes and outcomes" *Knowledge, Technology & Policy* **10**(3) 11-24
- Rothman D S, van Bers C, Bakkes J, Pahl-Wostl C, 2009, "How to make global assessments more effective: lessons from the assessment community" *Current Opinion in Environmental Sustainability* **1**(2) 214-218
- Russel D, Jordan A, 2009, "Joining up or pulling apart? The use of appraisal to coordinate policy making for sustainable development" *Environment and Planning A* **41**(5) 1201-1216
- Sanderson I, 2003, "Is it 'what works' that matters? Evaluation and evidence-based policy-making" *Research Papers in Education* **18**(4) 331-345
- Shackley S, Wynne B, 1995, "Global climate change: the mutual construction of an emergent science-policy domain" *Science and Public Policy* **22**(4) 218-230
- Shaxson L, 2005, "Is your evidence robust enough? Questions for policy makers and practitioners" *Evidence & Policy* **1**(1) 101-112
- Shaxson L, Bielack A, Ahmed I, Brien D, Conant B, Fisher C, Gwyn E, Klerkx L, Middleton A, Morton S, Pant L, 2012, "Expanding our understanding of K* (KT, KE, KTT, KMb, KB, KM, etc.). A concept paper emerging from the K* conference held in Hamilton, Ontario, Canada, April 2012" United Nations University - Institute for Water Environment and Health, Hamilton, Ontario, http://inweh.unu.edu/wp-content/uploads/2013/05/KStar_ConceptPaper_FINAL_Oct29_WEBsmaller.pdf
- Sheate W R, Partidário M R, 2010, "Strategic approaches and assessment techniques—Potential for knowledge brokerage towards sustainability" *Environmental Impact Assessment Review* **30**(4) 278-288
- Simpson L, 2010, "Understanding Nature's Value to Society in the UK" *British Ecological Society Bulletin* **41**(1) 20-22
- Slob A F L, Rijnveld M, Chapman A S, Strosser P, 2007, "Challenges of linking scientific knowledge to river basin management policy: AquaTerra as a case study" *Environmental Pollution* **148**(3) 867-874
- Strauss A L, Corbin J M, 1998 *Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory* (Sage Publications, London)

- Turnhout E, Bloomfield B, Hulme M, Vogel J, Wynne B, 2012, "Conservation policy: Listen to the voices of experience" *Nature* **488**(7412) 454-455
- Turnhout E, Stuver M, Klostermann J, Harms B, Leeuwis C, 2013a, "New roles of science in society: Different repertoires of knowledge brokering" *Science and Public Policy* **40**(3) 354-365
- Turnhout E, Waterton C, Neves K, Buizer M, 2013b, "Rethinking biodiversity: from goods and services to "living with"" *Conservation Letters* **6**(3) 154-161
- Turnpenny J, Russel D, XXXX
- UK NEA, 2011 *The UK National Ecosystem Assessment Synthesis of Key Findings* (UNEP-WCMC, Cambridge, UK)
- UK NEA, 2012a, "Media coverage of the UK NEA and a stakeholders response (the value in environmental valuation)", UNEP-WCMC, Cambridge, UK, <http://uknea.unep-wcmc.org/Resources/Media/tabid/108/Default.aspx>
- UK NEA, 2012b, "UK National Ecosystem Assessment: Follow on phase", UNEP-WCMC, Cambridge, UK, <http://uknea.unep-wcmc.org/NEWFollowonPhase/tabid/123/Default.aspx>
- UK NEA, 2011 *The UK Natural Ecosystem Assessment Technical Report* (UNEP-WCMC, Cambridge, UK)
- UK NEA, no date, "Homepage of The UK National Ecosystem Assessment", hosted by UNEP-WCMC, Cambridge, UK, <http://uknea.unep-wcmc.org/>
- Walker S, Brower A L, Stephens R T T, Lee W G, 2009, "Why bartering biodiversity fails" *Conservation Letters* **2**(4) 149-157
- Weiss C H, 1979, "The many meanings of research utilization" *Public Administration Review* **39**(5) 426-431
- Weiss C H, 1995, "The haphazard connection: Social science and public policy" *International Journal of Educational Research* **23**(2) 137-150
- Weiss C H, 1999, "The Interface between Evaluation and Public Policy" *Evaluation* **5**(4) 468-486

Wells M P, Grossman D, Navajas H, 2006 *Terminal Evaluation of the UNEP/GEF Project "Millennium Ecosystem Assessment" Project Number MT/FP/CP/1010-01-04* (Evaluation and Oversight Unit, United Nations Environment Programme, Nairobi)

Wynne B, 2010, "Strange Weather, Again: Climate Science as Political Art" *Theory, Culture & Society* **27**(2-3) 289-305

Figure 1

A conceptual model highlighting how interventions may adopt different strategies to increase knowledge use, and how these may be expected to influence communication and uses of knowledge. This model is simple so does not represent interactions, but highlights key pathways by which interventions such as the NEA may influence use.

| Strategy used by intervention | Influence on knowledge communication | Use of knowledge |
|--|--|--|
| <p>Dissemination Tailoring content and presentation of products tailored to user needs.</p> <p>Increase interaction Establishing two-way communication and relationships</p> <p>Facilitation Increase capacities to engage in sharing and use knowledge</p> | <p>➤ Increase perceived suitability of knowledge, based on perceived relevance, credibility and legitimacy of knowledge</p> <p>↑</p> <p>➤ Build interpersonal trust which supports perceived credibility and salience of knowledge</p> <p>➤ Encourage long-term relationships to appreciate others' constraints and needs</p> <p>➤ Decrease mismatches in tacit and explicit knowledge</p> <p>↑</p> <p>Remove institutional, social, financial and technical barriers to building relationships and sharing knowledge</p> <p>→ ?</p> | <p>Direct instrumental Information allows problem-solving and decision support</p> <p>↗</p> <p>Conceptual Knowledge influences general thinking and understanding</p> <p>↖ ?</p> <p>Strategic Use of knowledge to legitimate or attack existing positions, or to delay action by commissioning new knowledge production</p> |

Table 1

Summary descriptors of individuals interviewed for this study. There are no distinct boundaries between science and policy: many working in policy or agencies have scientific training or backgrounds, and many senior scientists spend much time in advisory roles, but here we categories interviewees as either ‘producers’ or ‘users’ in relation to their expected role in the NEA process.

| NEA role | Detailed role in relation to NEA | Current professional roles | Quote reference |
|-----------------|--|--|------------------------|
| Producers | Lead authors, Contributing authors, Expert panel members, Secretariat, Co-Chairs | Academics using interdisciplinary methods, natural scientists and economists. Programme officer for iNGO, policy advisor. | P1-12 |
| Users | Members of Client group, User group, Other potential users in policy departments and public agencies related to environmental management | Advisors, senior and junior policy makers in areas relating to environment, land-use, freshwater or marine management. Agency staff relating to resource and species management. | U1-13 |