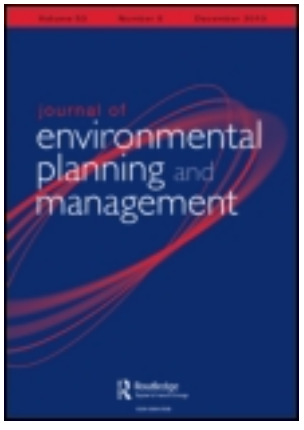

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Environmental Impact Assessment, ecosystems services and the case of energy crops in England

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Environmental Impact Assessment, ecosystems services and the case of energy crops in England

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A consequence of the increased requirements for renewable energy is likely to be allocation of more land to bio-energy crop production. Recent regulatory changes in England, as in other parts of the UK, mean that changes in land-use are increasingly subject to screening through Environmental Impact Assessment (EIA). This paper reviews these regulatory changes and explores the potential benefits of incorporating a fuller examination of ecosystem services within EIA procedures. The authors argue that such an approach could help achieve sustainability by identifying the best options within an area, rather than concentrating on the negative effects of selected proposed projects. It could also help highlight the benefits provided by existing and proposed agricultural, forestry, peri-urban and urban systems. However, successful implementation of an ecosystem services approach would also require a greater understanding of the societal preferences for the full range of ecosystem services at a landscape scale, as well as the trade-offs and synergies between uses of specific services.

Keywords: ecosystem services; environmental assessment; agriculture; land-use planning, biomass; stakeholders

1. Introduction

The UK Government set ambitious renewable energy targets to be achieved by 2020 (House of Lords EU Committee 2008). These targets have led to proposed new developments such as wind turbines, hydro-electric plants and increased use of biomass energy. In the case of biomass energy, potential sources include: organic waste products; use of existing agricultural and forestry by-products; and the establishment and harvest of biomass from dedicated energy crops. The latter grouping includes perennial crops such as short rotation coppiced (SRC) trees such as willow and poplar and high yielding grasses such as miscanthus.

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Whilst most land-use decisions, including the establishment of biomass energy crops, are primarily financially driven, many decisions result in external costs and benefits that are felt, not by the landowner or site developer, but by society at large. Hence the UK Government, as elsewhere, has developed a planning permission system to address such externalities and the wider concerns of society.

The interaction between bioenergy crops and environmental costs and benefits is especially relevant because renewable energy targets, particularly for transport fuel, may require very large areas of land nationally and/or globally to be planted. Moreover, large-scale planting of new energy crops (e.g. short rotation coppice willow and miscanthus energy grasses) could result in substantial hydrological, biodiversity and visual changes (Smeets *et al*. 2008, Bellamy *et al*. 2009, Rowe *et al*. 2009). The consequences of planting new energy crops is not restricted solely to the agricultural land on which they are planted. There is a need to consider such developments in the wider context of full life-cycle assessments (e.g. do such crop production life-cycles offer real greenhouse gas emission benefits?) and in relation to this, their infrastructure provision and use (e.g. additional road transport, biomass power-plant development and emissions).

At present the environmental impacts of new renewable energy projects are largely addressed in the planning process through the use of Environmental Impact Assessments (EIA). These evaluate the environmental consequences of major development projects *in situ*. However, an additional framework for assessing the impact of land-use change is the ecosystem services (ES) framework. ES is a collective term used to describe the various production resources and processes that humanity obtains from land, air and water, and the associated ecosystems (Haines-Young 2009). These include the provision of food, fibre, fuel, the regulation of pollination, nutrients, water supply and water quality, alongside cultural benefits such as recreation and education. Their importance to human well-being and to nature conservation itself has been highlighted by the 2005 Millennium Ecosystem Assessment (IISD 2007), and others (e.g. de Groot *et al*. 2002, de Groot 2006, Haines-Young 2009). A detailed definition of ES with examples is provided in Section 5 and Table 2 of this paper.

This paper examines the development, use, strengths and weaknesses of EIA in the context of biomass energy crops, and discusses the subsequent necessity of integrating ES concepts into the current EIA process. In May 2011, in response to the UK National Ecosystem Assessment (UK NEA 2011) and the Parliamentary White Paper on Ecosystem Service Valuation (UK Parliament 2011), the UK Government called for more integrated approaches to ecosystem management beyond (the current EIA) conventional sectoral approaches (DEFRA 2011a).

2. Environmental Impact Assessment (EIA)

Environmental Impact Assessments (EIA, also known as Environmental Assessments, EA) were first undertaken in the USA in 1969 under the National Environmental Policy Act as a means of spatially identifying probable environmental and social outcomes of human actions (US Environmental Protection Agency 2011). The 1969 Act came into being following extensive lobbying by environmental stakeholders seeking the protection of sites of ecological importance both in terms of the services provided by conservation and by their aesthetics. In the European Union, the planning policies of member states were predicated on the

European EIA Directive in 1985 (85/337/EEC) and its subsequent amendments in 1997, 2003 and 2009 (EC 2009). Importantly, the EIA framework now provides a process for assessing and predicting the effects of human interventions on affected stakeholders and ecosystems (Slootweg and Kolhoff 2003, Slootweg *et al.* 2006, 2009).

Within the UK, the initial European EIA Directive (85/337/EEC) was incorporated into existing legislation via the 1999 Town and Country Planning (Environmental Impact Assessment) Regulations (UK Government 1999a) in England, with the other parts of the UK enacting equivalent versions. The regulations initially defined two schedules (classes) of projects for EIA: those in Schedule 1 such as infrastructure projects for which EIA is mandatory; and those in Schedule 2 where planning authorities are required to consider whether the project may have a significant environmental impact. Most small biomass energy generation projects (with a heat output of less than 300 MW) fall under schedule 2, and are only subject to an EIA if they are considered to have "significant effects on the environment by virtue of factors such as its nature, size or location" (the Town and Country Planning (Environmental Impact Assessment) Regulations 1999, UK Government 1999a). The applicable thresholds and criteria specified for Schedule 2 energy installations are those where areas of development exceed 0.5 ha. Sensitive locations include Sites of Special Scientific Interest, areas of nature conservation, National Parks, World Heritage Sites, Scheduled Ancient Monuments, Areas of Outstanding Natural Beauty, and habitats protected by European directives. In practice, however, smaller projects outside such locations may voluntarily provide an EIA in order to gain planning approval. Projects burning more than 100 t d^{-1} of biomass 'wastes' are also deemed to be Schedule 1 activities, which in the case of biomass wood waste equates to an electrical generation capacity of only 5–10 MW.

The operational facilities of bioenergy projects are regulated under the Environmental Permitting Regime (UK Government 2007), previously the Pollution Prevention and Control Regulations enacted in 2000 (UK Government 2000), as Part 1 activities where the thermal input is >50 MW (>3 MW for waste) or Part 2 activities if 20-50 MW (or burn waste generating <3 MW). The Clean Air Act (UK Government 1993) and the 1994 Habitats Regulations (UK Government 1994) also apply.

3. Increasing scope to screen projects for EIA

Until recently, most changes in types of production on agricultural land in England have been outside the scope of the EIA regulations. As a general rule this includes the transition to energy crops even though they pose specific environmental impacts related to the type of species, height, appearance and monoculture. For example, reduced recharge and runoff of water from areas used for these crops could exacerbate over-exploitation of local aquifers (Smeets *et al.* 2008). Such impacts, however, can be minimised by careful assessment of land use and selecting suitable locations and harvesting regimes alongside limiting the size of plantations.

Although conventional arable crops do provide certain habitats for wildlife, the impacts of energy crops on biodiversity are generally favourable when compared to conventional intensive arable plantations (Bellamy *et al.* 2009, Sage *et al.* 2010). Research by Bellamy *et al.* (2009) found that fields of the energy crop miscanthus had a greater abundance and diversity of birds than did wheat in both winter and in summer. In winter, the greater numbers of birds in miscanthus fields were thought to

have been attracted by the shelter provided by the crop and by the abundance of non-crop plants. During the bird breeding season, the provisioning ecosystem services provided included an abundance of non-crop plants in the miscanthus fields, and greater numbers of insects associated with the plants provided food resources. However, miscanthus crop plants provided less insect food than wheat crop plants. Changes in crop structure during the breeding season also influenced breeding birds.

Results from the Bellamy *et al*. (2009) study suggested that an increase in miscanthus areas grown in the UK could temporarily benefit farmland bird populations during establishment. However, these benefits are likely to diminish with the age of crop and as crop management is intensified, with impacts including increased water extraction and reductions in biodiversity. Therefore, management of *in situ* ecosystem services is required to maintain the diversity of features attractive to birds because many features will be lost if miscanthus is managed solely to maximise crop yields, (Bellamy *et al*. 2009). Overall, however, perennial energy crops such as reed canary grass and short rotation coppice are considered to exert lower environmental pressures than most annual crops, since they reduce soil compaction and erosion, and have reduced cultivation, nutrient and pesticide inputs (European Environment Agency 2006).

An important inconsistency in the EIA Regulations is the way they are applied to different sectors, in that agriculture is scarcely covered while EIA does apply to forestry. This has implications that can influence land-use decisions. At present the Environmental Impact Assessment (Forestry) Regulations of 1999, make EIA necessary for changes such as afforestation (including SRC willow) in cases where the area planted is greater than 5 ha and deforestation is more than 1 ha (UK Government 1999b, 2006a, Forestry Commission 2009). An EIA is always required for work in sensitive environmental areas such as National Parks and designated Areas of Outstanding Natural Beauty, whereby the areas triggering an EIA are reduced to 2 ha and 0.5 ha, respectively. The imperfection in the current EIA system is that it includes changes in forestry but not in agriculture, which suggests it is now appropriate to review the current approach to environmental assessment.

EIA is applicable to agricultural management only where it involves the intensification of management of previously uncultivated land (defined as land that has not been physically cultivated or fertilised for the past 15 years (Natural England 2007)). In situations where the Environmental Impact Assessment (Uncultivated Land and Semi-natural Areas) (England) Regulations 2001 (UK Government 2001) look like they could apply then landowners' are required to contact the statutory body, Natural England, to determine if any intended use of uncultivated land or semi-natural areas is considered as a change to intensive farming. In 2006 the scope was further expanded in the EIA (Agriculture) 2006 regulations, which potentially cover any form of productivity increase on uncultivated land or semi-natural area and physical restructuring rural land holdings above a certain level (defined in EIA Schedule 1 as Thresholds of 2, 4, and 50-100 hectares respectively), (UK Government 2006b). Furthermore, the guidance indicates that an EIA screening decision should be sought for land-use change greater than 2 ha or involving more than 4 km of field boundaries.

Thus, between 1999 and 2006, there was a steady increase in environmental regulation in EIA associated with changes in the use of agricultural and forestry land, although not applicable to changes in agriculture itself. However, even where a particular land-use change does not require screening, for example, planting

miscanthus on arable land, when seeking financial support from the UK Government's energy crops scheme, owners have been required to undertake an EIA screening (Natural England 2007). It can be argued then that, if certain farming activities are required to carry out an EIA, then the same rules should apply to all agriculture in order to assess its effects on the rural environment.

4. Implementation of EIA

When a land-use change project is screened and the need for an EIA is identified, an EIA is required to address both the direct and indirect effects of the proposed development (BERR 2009). It must examine the implications for the natural (flora and fauna), the social (human population) and the physical (soil, air, water, climatic factors, landscape and archaeology) environments. In the case of establishing a miscanthus plantation, an EIA screening decision should consider the visual effects on the landscape as wells as its impacts on local biodiversity such a birds and insects (Agriculture, Food and Development Authority 2010).

Prior to 2008, the purpose of an EIA was to consider the impacts of a proposal on the surrounding ecology, hydrology and landscape (EIA Regulations 1999 Schedule 4 section 4(c) and Annex A2). Hence the focus was primarily to mitigate undesirable impacts of proposed changes, rather than to identify pro-actively the best ways forward in a particular environment (Table 1). Although EIA legislation has been successful in promoting early consideration of environmental issues in the decision-making process (EC 2009), it has been primarily a reactive tool. Subsequently, making EIAs proactive, rather than just re-active, was called for in the 2008 Planning Act (UK Government 2008) and in 2011 via the NEA call for proactive ES management (DEFRA 2011a).

A criticism of existing EIAs is that they often take a narrow view of what is sustainable, neglecting social and economic factors in favour of environmental ones. Currently, an EIA is only an aid to the decision-making process, providing information to make a more transparent and evidence based process, but it is not

Table 1. Three perceived challenges associated with implementation of EIA in terms of renewable energy, and descriptions of their potential solution.

Challenge	Potential solution
1. A focus on mitigating the environmental effects of proposed projects, rather than identifying and encouraging sustainable best practice in an area/region.	The 2008 Planning Act indicates that planners should identify suitable sites for renewable energy development. The new challenge is find a framework to do this re: the 2011 NEA.
2. A low appreciation of ecosystem benefits of agricultural, forestry, peri-urban and urban land because the origins of EIA were conservation orientated.	Greater efforts to map and value ALL the ecosystem benefits of agricultural, forestry, peri-urban and urban land.
3. At present the planning system encourages local stakeholders to focus on resisting aesthetic change, rather than ways to enhance the full range of ecosystem services within an area.	The incorporation of an ecosystem services approach within the EIA could help focus local stakeholders away from simply resisting change to identifying best options and an increased focus on enhancement of the natural environment.

a decision-making tool in itself and does not guarantee environmentally sustainable outcomes. One particular shortfall is that because of a focus on habitat conservation regulations, EIA often underestimates the environmental value of existing agricultural, forestry, and indeed peri-urban and urban environments.

For example, the conversion value of changing agricultural land from food production to biomass energy production is not considered by regulators to have a significant environmental impact (see UK Government, EIA Regs 2001, 2005). This is even though such changes have implications (positive or negative) for carbon sequestration and biodiversity. A critical socio-economic impact may also be to increase food prices (Sherrington *et al.* 2008, Spiertz and Ewert 2009), although disputed by some (Bond *et al.* 2011), and increase the intensity of food production elsewhere that could in turn have significant negative effects on ecosystem services and biodiversity.

Another key aspect of any EIA is the involvement of stakeholders. The planning system defines these as members of the public who, alongside statutory environmental consultees, must be given the opportunity to comment on an EIA's findings through its Environmental Statement. This describes the options and consequences of any proposed development, and is submitted alongside the Project Plan. The Environmental Statement should be systematic and objective, include the necessary technical details, with a summary that can be understood by laypeople (EC 2001, UK Government 2001). The explicit incorporation of locally known ecosystem services via stakeholder engagement into the EIA would further help to deliver its objectives, namely to identify the full environmental implications of proposed changes in the use of site specific natural resources.

The challenge, as always in EIA and land use, particularly with regard to agriculture, lies in how the criteria in planning regulations that specify which changes in land-use require assessment are in practice defined, assessed and interpreted. In England differences of opinion between farmers and environmental regulators have at times led to conflict between these two key stakeholders on how the land should be managed. In one case in 2005 the UK Department of the Environment, Food and Rural Affairs (DEFRA) used the Environmental Impact Assessment (Uncultivated Land and Semi-natural Areas) (England) Regulations 2001 (UK Government 2001), to prosecute a farmer for fertilising moorland fields, arguing that there was an implied intention of bringing land that had not recently been used for farming into intensive use without first carrying out an EIA (Queen's Bench Division, 2005). In this case the farmer's decision had implications for the ecosystem services provided by the meadow flora and fauna that exceeded the simple provisioning of food. The moorland also not only offered support and regulatory services, including grazing moorland and natural habitat for *in situ* pollinating insects and birds, but also cultural services such as scenic benefits to local walkers and residents. Whilst this example did not involve energy crops, it did highlight why any significant change in agricultural land-use should be subject to an EIA that recognises locally important ecosystem services (ES).

With energy crop production set to drive the most extensive changes in land-use in Britain since the 1950s it is crucial to have in place an effective method of assessing the consequences. The changes will not simply be in the vegetation cover and productivity of individual parcels of land that are directly implicated, but also in the knock-on effects of both supporting infrastructure and neighbouring land parcels (Holzschuh *et al.* 2011). There may also be displacement of the services that were

provided prior to the change that will impact secondary systems, often distant, such as animal feed and food crops through indirect land-use change (Thyø and Wenzel 2007, Searchinger *et al*. 2008). These major indirect impacts tend to be dominated by provisioning services, as traditionally they have been the major component of the valued we place on the environment. Examples include where market forces have led to food production being shifted to agriculturally marginal land to meet demand. However, with European legislation in the form of the Habitats Directive, ecosystems of equivalent value must be created or restored to balance habitat loss, meaning that all ecosystem services are included in this approach. Potential changes must be assessed in terms of their ability to deliver the objectives of the developer balanced against possible compromise of services currently delivered and valued by all other stakeholders. The production of energy crops can contribute to both securing our energy supply and reducing greenhouse gas emissions. These must also be balanced against compromises with existing uses of the land that may already sequester emissions such as natural grasslands and forests and deliver other services. Therefore, to address this, what is needed is the formal incorporation of the ES concept into EIA methodology. As it stands the European EIA directives and the Habitats Directive (EC 2001, 2007, 2009) that drive EIA regulations in England implicitly call upon spatial planners to protect ecosystems and their habitat functions, i.e. provisioning services.

5. Ecosystem services and the scope for their inclusion in environmental assessment

As noted above, in 2011 following the publication of the National Ecosystem Assessment (UK NEA 2011) and a White Paper on Ecosystem Service Valuation (UK Parliament 2011), DEFRA has sought a more integrated ecosystem management approach to environmental planning (DEFRA 2011a). This in turn had followed DEFRA's highlighting in 2007 of the need for a more strategic framework for policy making and delivery on the natural environment (DEFRA 2007a). They pushed for the use of an ecosystem approach building on de Groot's (2006) categorisation of ecosystem services into: production; regulation; habitat; cultural; and carrier functions (Table 2). However, DEFRA (2007a) used the ecosystem services (ES) approach popularised by the Millennium Ecosystem Assessment (MEA) (2005) which classified ecosystem services into four categories namely:

Table 2. Categorisation of ecosystem services by the MEA (2005) and de Groot (2006).

Millennium Ecosystem Assessment (2005)	de Groot (2006)
Provisioning services: food, wood, fibre, fuel and water	Provisioning services: the production of biomass
Regulating services: regulation of water supply and quality, and diseases	Regulation services: the regulation of bio-geochemical cycles
Cultural services: opportunities for recreation, spiritual, aesthetic or educational development	Cultural services: the opportunity for recreation, aesthetic or cognitive development
Supporting services: such as soil formation, nutrient cycling and primary production	Habitat services: the spatial conditions needed to maintain biological diversity
	Carrier service, providing a suitable substrate for human activity and infrastructure

production; regulation; cultural; and supporting services. For more detail on these definitions and some examples see Table 2.

Since the 2005 MEA the recognition and use of ecosystem services has been the subject of much debate between traditional land-use commentators and environmental assessors seeking to incorporate ecosystem services into EIA. However, debating the ES framework across a wider range of stakeholders, alongside the associated publicity, is extremely useful in getting different parties to see their specific requirements as part of the broader requirements within a landscape (van der Horst 2007, Coleby *et al*. 2008, Howard *et al*. 2009, Hubacek *et al*. 2009, Upham 2009). Notably this approach could also be undertaken within the context of other intergovernmental initiatives on such issues as energy security, biological diversity or climate change.

However, at present, the EIA regulations, as established in 1999 (UK Government 1999a), do not recognise the provision of ecosystem services as formal criteria for conducting an EIA. Likewise, although the 2008 UK Planning Act (Chapter 29, UK Government 2008) directed planners to identify suitable sites for renewable energy development, it did not highlight ecosystem services. Therefore, the planning system needs to become proactive in recognising important ecosystem services and understand the potential impacts that may arise through land-use change. Furthermore, in order to achieve the 'global sustainability' to which the 2008 Planning Act aspired, there is a need for the planning process to cover ecosystem services effectively and in a way that all stakeholders can recognise.

6. The challenge of incorporating ecosystem services in an EIA

Alternative methodologies and procedures to encourage ecosystem stakeholder participation in environmental planning are reflected in recent UK Government policy initiatives and European legislation (Higgs *et al*. 2008, such as the EC Directive on Public Participation (EC 2003) and the 2004 Environmental Information Regulations (UK Government 2004). However, despite such initiatives and alongside a growing literature on ecosystem services (e.g. de Groot *et al*. 2002, de Groot 2006, Haines-Young 2009), many challenges remain for the integration of ecosystem services assessment into landscape planning, management and environmental regulation (Table 3). There is a need for an Ecosystem Services framework that can be applicable to both 'natural' and highly-managed environments. Possible solutions lie in developing a framework that can include services such as 'providing space for biodiversity' as well as concepts such as 'ecosystem dis-services', for example, how particular land-use types impact on water resources.

However, the introduction of an ecosystem services framework into Environmental Impact Assessment presents a number of scientific challenges (Table 3). First, the precise nature, role and value of ecosystem services affected by any proposed land-use change needs to be adequately understood (e.g. Reed 2008, Reed *et al*. 2009). For some services, such as levels of food production, the assessment may seem straightforward, but for others, such as carbon sequestration, water quality and habitat conservation, it becomes increasingly difficult. In addition, it can also be difficult to present the information in a sufficiently understandable, detailed and holistic way. Initiatives, such as the National Ecosystem Assessment in the UK (UK NEA 2011), have sought to provide the best current assessment of the status of such services (Holt and Hattam 2009, Bateman *et al*. 2011). The availability of

Table 3. Summary of key challenges in implementing an ecosystems approach within Environmental Impact Assessments and potential solutions.

Challenge	Potential solution
1. Poor access to available and suitable integrated datasets and lack of tools to present the key information in an understandable way.	Create greater availability of and accessibility to data; encourage interdisciplinary research on EIA in theory and practice. New tools to allow the visualisation of the key ecosystem services.
2. A lack of understanding of how ecosystems services respond to natural and human interventions, including cumulative effects.	Ecosystem service research and modelling, particularly at a local and regional scale.
3. A lack of knowledge and metrics for social preferences for ecosystem benefits; for example for concepts such as 'naturalness'.	Development and use of social and economic valuation data for understanding societal preferences for ecosystem services; development of acceptable and affordable methods to collect that data; integration of natural and social science.
4. The need for an ecosystem services framework applicable to both 'natural' and highly-managed environments.	To use a framework that can include services such as 'providing space for biodiversity', and concepts such as 'ecosystem dis-service'.
5. How to design incentives for farmers to provide market and non-market benefits (such as biodiversity or landscape amenity).	Payments for providing ecosystems services, legislation for cultural values, social marketing, education and other non-financial incentives.
6. Understanding local resource issues.	Involve the full range of stakeholders both at specific sites and regionally, using deliberative analytical tools and focusing on process as much as on outcomes.

environmental information, through interactive maps through portals such as the Multi-agency Geographic Information for the Countryside (MAGIC) (DEFRA 2011b), can also help provide a platform for stakeholders to understand the current status of selected ecosystem services.

The benefits of using an ecosystem services perspective to perform EIA are that they include a framework that can act as a checklist to ensure that all issues are covered, with greater emphasis on environmental processes (Rounsevell *et al*. 2010, Metzger *et al*. 2006). However, difficulties have arisen from the independent development of the two approaches (EIA and ES) with similar but not identical aims. Thus there are clearly advantages in integrating the two. Whilst the ES approach has concentrated on conservation of biodiversity for the benefit of humanity, and EIA has concentrated on protecting the environment by mitigating impacts of development, both approaches share the same aim. The aim of both EIA and ES approaches is that both seek to ensure that the environment is protected for the benefit of both humanity and nature.

The scientific challenge, however, is greater than simply describing the current status of ecosystem services in any given location. There is also a need to understand how key ecosystem services respond to both natural change and human interventions such as changes in land-use (Dale and Polasky 2007, Metzger *et al*. 2006). Descriptions of the response of provisioning services, such as food and fibre

production, can be provided by existing models (Parry *et al*. 1996, Tuck *et al*. 2006, Graves *et al*. 2010, van der Werf *et al*. 2007, Deryng *et al*. 2011), but even here it is rare to find models that can seamlessly cover all production services within a common framework. The measurement and understanding of regulating services is needed, particularly for key services such as water quality, water supply and carbon sequestration. Whilst work has begun in these areas, in the area of cultural ecosystem services there remain few metrics for describing the non-material benefits that people gain, including reflection, spiritual enrichment and cognitive development. In addition, there remains the challenge of recognising the importance of cumulative effects (Wärnbäck and Hilding-Rydevik 2009).

A further complication to the integration of ecosystem services within Environmental Impact Assessments is that even if services can be quantified, different stakeholders can have different interpretations and valuations. There are some circumstances where the priorities of owners, government and key stakeholders may be similar, such as the development of community woodlands (Agbenyega *et al*. 2009), but this is not common, especially as people are resistant to changes in land-use. However, cultural services, physical factors such as visibility and road access are important prerequisites to allow people to visit the countryside and gain its cultural benefits. These metrics are weak surrogates for the true services, which are related to human preferences and can be diverse (between individuals and groups), unstable (changing over time) and context dependent (local) (Coleby *et al*. 2008). In other situations, and often in the case of development of renewable energy, there can be substantial disagreements (van der Horst 2007, 2008, Upham 2009). For example, existing environmental legislation and ecological quality definitions use the 'naturalness' (Schedule 3 of the UK Government 1999 EIA Regulations) of a landscape as a criterion (Paetzold *et al*. 2009). However, because all landscapes in the UK have been modified by human activity and are therefore not 'natural' in the ecological sense of the word, local communities have tended to regard naturalness in aesthetic terms (Coleby *et al*. 2008). Thus, the ecosystem services provided by the landscape as far as local community stakeholders are concerned are essentially, to them, cultural services. Whereas landowners' tend to focus on provisioning services, especially from agricultural ecosystems, conservationists concentrate on regulation and support from the more natural elements.

Even once the challenges of how ecosystems are perceived and understood by stakeholders have been resolved there still remains the technical issue over which ecosystem services should be included in Environmental Impact Assessment. The over-arching framework promoted by DEFRA (2011a, 2007b) focused on 'the natural environment' and, as noted earlier, used the categorisation popularised by the Millennium Ecosystem Assessment (2005) (Table 2). Because this framework was instigated by parties to the Convention on Biological Diversity, its starting point was that all ecosystem services arise from biodiversity and hence the value placed on habitats and species is implicit. Whilst the Millennium Ecosystem Assessment focused on natural ecosystems, the framework may be less readily applied to highly modified ecosystems such as intensive agricultural (European Environment Agency 2006, Smeets *et al*. 2008) and indeed (peri-) urban areas with their own provisioning and cultural service challenges distinct from the bio-diverse ones in rural areas. Thus there is an important difference between scientists and environmental planners making such statements on ES as 'its not working here' and 'we've applied it

successfully there, but we've still got to make it work here'. How the aims and findings of the MEA can best be incorporated into, and result in an improvement of, the EIA process, is an important question that is yet to be answered; it would require further research. The most appropriate framework will probably depend on the context of its use (Turner *et al.* 2008). It would still be desirable for a single framework to be developed for the purpose of EIAs across a comprehensive list of key ecosystem services.

To carry authority, EIA must make consistent and defensible assessments against which planning decisions can be made. A single framework is needed that will reflect the differences in the full range of ecosystem services across systems with different land-use intensities of management and modification. The authors here believe that the classification described by de Groot *et al.* (2002) and de Groot (2006) is attractive in that it recognises that heavily-managed ecological systems such as agriculture, buildings and roads can still provide space as a 'habitat' for flora and fauna, or act as a 'carrier' for other functions (e.g. the roof of a building could support a solar panel or harvest rainwater). Alongside this it is increasingly recognised that ecosystems, as well as providing services, can also provide disservices such as disease pathogens and increased risk of injury or nuisance (Agbenyega *et al.* 2009, Dunn, 2010, Dobbs *et al.* 2011). This further adds to the argument that it is important to capture these ecosystem issues in the context of an Environmental Impact Assessment.

Once differences in the interests of stakeholders are identified, there needs to be methods of responding to them. For example, some land managers may choose to prioritise cultural ecosystem services (Metzger *et al.*, 2006) for aesthetic reasons; others may choose to maximise production that delivers benefits such as food, fibre and food, and so will be more influenced by market prices and government incentives (Swinton *et al.* 2007). Whilst a farmer or forester may benefit personally and directly from an increased crop yield, others may suffer from the detriment of other ecosystem services that benefit the wider population (Pearce 2005, Kroeger and Casey 2007, Purvis *et al.* 2009). In such situations, it is pertinent for land-use stakeholders to understand the trade-offs between different ecosystem services (Antle *et al.* 2003), so appropriate decisions are made. Once these trade-offs are known, the consequences of land-use change can be more accurately assessed. As the above discussion on models indicated, although land-use change models do exist at a global scale (e.g. IMAGE-GLOBIO; Leemans *et al.* 1996), they tend to focus on specific uses or sectors (e.g. agricultural production) or impacts (e.g. climate change). Once again there are fewer models that allow comprehensive assessments at a landscape scale, and few examples that link land-use with the quantity, quality and value of all ecosystem services (ICSU 2008).

The final challenge for any approach is the understanding of local issues, which are often most clearly understood by (and are often most relevant to) local stakeholders. The importance of participatory methods (noted earlier) are already highlighted in the EU and UK EIA regulations (1985/1997/2003/2009 and 1999a/2008, respectively), and their basis in the 1998 Aarhus Convention on public participation in environmental matters. Many individuals and organisations which have a 'stake' in land-use issues also have local and expert knowledge not available in top-down decision making. Collaborating with these stakeholders when identifying and modelling the potential impacts on ecosystem services of land conversion to energy crops will help to capture vital local information (Bond *et al.* 2011).

7. Conclusions

During the past 12 years (1999–2011), land-use change in England driven by the growing demand for renewable energy has come within the scope of environmental impact legislation. For example, the EIA (Agriculture) 2006 regulations potentially cover 'any form of productivity increase' on uncultivated land or semi-natural area, and the Environmental Impact Assessment (Forestry) Regulations of 1999 cover land-use changes such as afforestation (e.g. SRC willow) above a certain area. In addition, the introduction of the 2008 Planning Act means that the planning response to renewable energy development should no longer be only reactive because the Act calls on land-use planners to actively identify suitable sites for renewable energy development. An ecosystem services approach offers a useful way to take this forward. Moreover, such an approach would also include the issues such as the potential increased use of food crops for bio-energy production. Since the Environmental Impact Assessment (Uncultivated Land and Semi-natural Areas) (England) Regulations 2001 (and the amendment of 2006) have been put in place, an increased need for EIA of agricultural land use has become evident. As the authors have argued in this paper, the use of EIA to agricultural land is an important step forward, but it would be incomplete without the explicit inclusion of ecosystem services. The 2011 NEA and subsequent statements by DEFRA (2011a) and the UK Parliament (2011) show that there is indeed growing recognition at government and policy level that the environment must be managed in a holistic manner, taking into account ecosystem services.

At the time of writing, changes in the intended use of conventional food crops are not covered by EIA and there is no consideration of the wider environmental impacts, or impacts on ecosystem services. New local-level approaches are, however, being developed to use an ecosystem services approach and a common framework that describes the balance between energy and food production (Burgess *et al*. 2012). Such approaches could also be used to support a more systematic, transparent and stakeholder-inclusive decision-making process than the original EIA framework was intended to provide when it was first introduced by the EPA in 1969. Such a development could be achieved by a pragmatic, inclusive and locally adaptable approach.

To meet this challenge, the EIA community could draw on concepts discussed in the Millennium Ecosystem Assessment. For example, a rearrangement of rights and responsibilities between government and society could help to deal with the unpredictable interaction between people and ecosystems as they evolve together. This implies a decentralisation of governance, a rebalancing of reliance on formal experts alone, and a stronger focus on negotiation and agreement between stakeholders. In this respect, we are faced with the seemingly contradictory challenges of expanding the EIA community, including: lay and local knowledge; further developing our understanding of ecosystems science; and balancing conflicting interests across scales of governance, space and time. Whilst there are no easy or simple solutions to this challenge, the ability of EIA to improve decision making over the environment can only be enhanced by engagement with the rapidly growing body of literature on ES.

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