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Land use and the state of the natural environment☆

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ABSTRACT

Land use and land cover are important determinants of the state of the natural environment. As a result, measures of land use and land cover change have been widely used as indicators of environmental condition and quality. This review explores the range of measures that have been applied in the UK at national, regional and local scales, and their sensitivity to particular drivers of change. The extent to which these indicators are important properties in themselves or are surrogates for wider environmental qualities is considered.

The discussion focuses on the evolving frameworks used to analyse the relationships between land use and the state of the natural environment. The limitations and strengths of the DPSIR reporting and analytical framework are explored. Recent approaches to the assessment of the impacts of future land use change on the natural environment using model-based scenario methods are examined, and the need to develop new types of aggregate measure of land use function is identified. There is also a pressing need to link assessments of trends to the analysis of sustainability thresholds or limits. It is concluded that the concept of a socio-ecological system offers a more fruitful approach to the analysis of the relationships between land use and the state of the natural environment than the simplistic cause–effect models that have been used in the past.

Introduction

Indicators based on land use have been widely employed as a way of characterising the state of the natural environment. Land use is sometimes used as a measure of the state of the environment in its own right, for example, when tracking the area of farmland of high conservation value. Alternatively, it can also be used as a surrogate for some wider environmental pressure, such as the conversion of land to arable use and the implications this might have for sediment loss, or as a measure of the effectiveness of a particular policy. As a result, land use emerges as one of the core concepts used to represent sustainable development issues and to measure progress towards this important goal.

Numerous studies underpin the assertion that land use is an important determinant of the state of the natural environment. The Millennium Ecosystem Assessment (MA, 2005), for example, has shown that at global scales the conversion of ecosystems through human activities has adversely affected not only biodiversity but a range of ecosystem services. These include the regulation of climate, air and water quality, soil formation, and the regulation of flooding and other natural hazards. At more local scales, land use has been employed to predict the output of ecosystem services and to value different types of land parcel in relation to both its market and its non-market products (Troy and Wilson, 2006). Furthermore, there are a number of reviews that focus specifically on the relationships between particular land cover and land use types, and the way in which their condition and management impact upon different aspects of the natural environment. For example: in the UK Calder et al. (2008) have reviewed the woodland actions for both biodiversity and water management; Petit et al. (2001) and Petit and Elbersen (2006) have reviewed the impact of agricultural intensification on ecologically valuable habitats in Europe through the MIRABEL project, and the EEA has published a range of more empirically based measures describing the impact of agriculture on the environment through the IRENA initiative (EEA, 2005); finally, the impacts of land cover and land use change on carbon storage in soils has been described by Bradley et al. (2005). Thus it is clear that a range of specific indicators describing the impact of land use on the state of the natural environment could be constructed.

If measures based on land use are to be employed as indicators of the state of the natural environment, then it is important that their conceptual basis is sound and that the messages they provide can be communicated easily. There is always a danger that indicators may over-simplify issues. And as some have argued, such indicators may not always be as neutral as they seem (e.g. Svarstad et al., 2008). The selection of indicators to represent a system or issue may

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reflect the concerns, assumptions and priorities of those undertaking the analysis. The aim of this review is to examine the different ways in which land use indicators are being used to inform environmental management and policy. It will consider the role of land use indicators in reporting the state of the environment and progress towards the goal of sustainable development, and what part they play in allowing new methods of integrated environmental assessment to be developed. Although biodiversity is clearly an important topic area, this paper seeks to deal with natural resources more generally. Its purpose is therefore to complement and broaden the discussion provided by Haines-Young (this issue) which is focused more specifically on biodiversity issues. 'Land use' is defined here in the same way as in this other study, in terms of the purposes of either active or passive management of land by people and the material and non-material benefits they derive from it. In looking at 'natural resources', we focus only on those benefits that depend on the biophysical characteristics of land.

Tracking land use change and its implications

The problem with tracing the relationships between land use and the state of the natural environment is that while monitoring data exist, surveillance systems rarely link the two components. Issues of 'land use' and 'environmental quality' tend to be owned by different communities, and so integrated understandings are often difficult to make. In Europe, for example, extensive land use and land cover data are available through the CORINE initiative (EEA, 2006). While change in land cover and land use between 1990 and 2000 can now be analysed effectively, the consequences of such change for the wider environment in terms of, say, the impacts on biodiversity or water quality remain a matter of speculation. Thus indicators that can be developed using the land accounts constructed around these monitoring data can only give an approximate picture of what might be happening on the ground at broad spatial scales. This situation arises despite the considerable efforts made by other groups to develop indicators of biodiversity change and to understand the impacts of the different drivers upon ecological systems (Haines-Young, this issue).

Despite these issues, the advantages of developing integrated approaches to monitoring land use change and its consequences for the natural environment are considerable. They can be illustrated by reference to the outputs of Countryside Survey in the UK,[1] which now provides time series data for a range of land-related characteristics extending back to 1978 (Carey et al., 2008; Haines-Young et al., 2000, 2003a,b). The initiative has been based on a stratified random sample of 1 km × 1 km squares distributed across Great Britain. These have been surveyed repeatedly for their land cover, the state and condition of associated landscape features such as hedgerows, their vegetation characteristics, soil conditions, and water quality. As a result it is possible to build up a more complete picture of how changes in land use and land management might be impacting on wider aspects of the natural environment.

For example, a series of policy measures have been used since the late 1990s to encourage farmers in the UK to create arable margins sown with mixtures of grasses and wild flowers species. Countryside Survey 2007 reports that these arable margins have now improved the level of plant diversity in arable landscapes, which were found to have twice as many species as crops and a much higher percentage cover of plants. It was concluded that these changes in vegetation are likely to benefit farmland birds, butterflies and other animal species in these landscapes.

The result of policy change in relation to hedgerows is also detectable through successive Countryside Surveys. Since 1997, the Hedgerow Regulations have restricted the removal of hedgerows in England and Wales and this is reflected in the reduced rate of loss of hedge length recorded in the survey squares between 1984 and 1990. The most recent survey suggests that although the stock of hedgerows is now stable, the most serious threat is the neglect and over-management of these features, which are important to the character of the British countryside.

Broad-scale monitoring systems such as Countryside Survey can never eliminate the need for more controlled experimental investigations of the cause–effect relationships between land use and the state of the natural environment. However, more integrated monitoring approaches are possible. They can go some way to tracing the impacts of different pressures on the characteristics of land, and the links between land management actions, policy interventions and environmental outcomes. In the future it is likely that we will see monitoring systems such as Countryside Survey evolving further. We can also foresee attempts to develop a wider range of indicators that will also enable us to track change in the ecosystem services associated with different kinds of landscape. For example, as part of Countryside Survey 2007, an integrated assessment of ecosystem services is now underway,[2] and the UK National Ecosystem Assessment is also considering how spatially explicit approaches can be used to describe change at a range of scales.[3] In addition, Natural England are exploring how methods previously used to assess change in landscape quality can be extended to assess the broader functional integrity of the National Character Areas of England through the CQuEL Project.[4] However, the design of these new indicator frameworks is complex and represents a considerable research challenge.

Indicator frameworks and the place of land use

Although a number of indicator frameworks are available, the OECD 'DPSIR' model is perhaps the most widely used, and it is useful to reflect on its ability to meet future needs. The acronym stands for Driving forces, Pressures, State, Impacts and Responses. They are linked in the conceptual framework as a causal loop running from the pressures and events that trigger environmental change through to the responses and interventions that might be tried in order to mitigate the problem. The model is illustrated in Fig. 1, using examples of different types of measure employed to track land use change, the influences upon it and the way in which specific changes can be used to monitor the effectiveness of different policy interventions.

Segnestam (2002) has given a useful summary of the development of the DPSIR model, which was refined from an earlier framework proposed by the OECD in 1994 that recognised only pressures, states and responses. Many commentators felt that the early 'PSR' idea was limited, in that it only flagged up the immediate factors that led to environmental change and not the wider social, economic and institutional aspects that triggered these pressures. This led to the notion of 'drivers' being introduced. Similarly, many felt that the representing the environment merely in terms of its current state was too limited, because this did not suggest the sorts of issues that may prompt society to act. Thus the idea of 'impacts' was added to better capture these types of concern.

[1] http://www.countrysidesurvey.org.uk/.

[2] http://www.countrysidesurvey.org.uk/work_packages_6.html.

[3] http://www.unep-wcmc.org/eap/ukNationalEA.aspx.

[4] Character and Quality of England's Landscapes (A. Baker, personal communication).