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ECOSYTEM SERVICES: A RAPID ASSESSMENT METHOD TESTED AT 35 SITES OF THE LTER-EUROPE NETWORK

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Abstract

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The identification of parameters to monitor the ecosystem services delivered at a site is fundamental to the concept's adoption as a useful policy instrument at local, national and international scales. In this paper we (i) describe the process of developing a rapid comprehensive ecosystem service assessment methodology and (ii) test the applicability of the protocol at 35 long-term research (LTER) sites across 14 countries in the LTER-Europe network (www.lter-europe.net) including marine, urban, agricultural, forest, desert and conservation sites. An assessment of probability of occurrence with estimated confidence score using 83 ecosystem service parameters was tested. The parameters were either specific services like food production or proxies such as human activities which were considered surrogates for cultural diversity and economic activity. This initial test of the ecosystem service parameter list revealed that the parameters tested were relatively easy to score by site managers with a high level of certainty (92% scored as either occurring or not occurring at the site with certainty of over 90%). Based on this assessment, we concluded that (i) this approach to operationalise the concept of ecosystem services is practical and applicable by many sectors of civil society as a first screen of the ecosystem services present at a site, (ii) this study has direct relevance to land management and policy decision makers as a transparent vehicle to focus testing scenarios and target data gathering, but (iii) further work beyond the scale investigated here is required to ensure global applicability.

Key words: ecosystem service assessment, natural resource management, environmental values, natural capital, land-use assessment, Long-Term Ecosystem Research (LTER).

Introduction

The link between the study of ecosystem services and policy formulation is now well established (Constanza et al., 1997; Millennium Ecosystem Assessment (MA), 2005; Daily et al., 2009; Ring et al., 2010; Zhang et al., 2010; Moldan et al., 2012). The EU biodiversity strategy explicitly calls (action 5) for the mapping of ecosystem services (Maes et al., 2013).

Reviews of the scientific literature on the benefits of ecosystems services to human society have reported an exponential growth in research effort (Cornell, 2010; Vihervaara et al., 2010; Dick et al., 2011a; Seppelt et al., 2011). Currently a special emphasis has been put on mapping ecosystem services (Maes et al., 2012; Reyers et al., 2009), with particular interest on the possibilities to link services with remote information on land use types (Burkhard et al., 2009; Metzger, 2006), and on management challenges related to tradeoffs between services that may cause unintentional decline of some services when the others are promoted by specific policy interventions (DEFRA, 2007; Hanson et al., 2008) that can result in substantial economic loses (de Groot, 2010; Troy, Wilson, 2006). From this perspective it seems to be particularly important to develop a quick and simple system allowing an overview of the ecosystem services delivered by areas of different land use types.

Currently there are significant differences in assessment indicators, calculation and modelling approaches to report the ecosystem services of an area, which makes comparisons and knowledge transfer between studies difficult. In order to utilise the concept, a standard protocol for the assessment of ecosystem services have been called for (Anton et al., 2010; Keene, Pullin, 2011). Generic lists of ecosystem services have been published (e.g. MA, 2005; Haines-Young, Potschin, 2010) and these have been used as the basis for a specific list of ecosystem services created and tested by the UK long-term monitoring network the Environmental Change Network (Dick et al., 2011b,c). Expanding and testing the practicality of such a list in the European long-term monitoring community (LTER Europe) is the focus of this paper.

The European sites, by virtue of their long-term site-based research, provide information over multiple temporal and spatial scales (Mirtl et al., 2010). In this study we explore the possibility of assessing ecosystem services provided by sites based on the minimum possible information available from all sites. This was defined as the likelihood of the service occurring at the site, with an associated confidence value. Such rapid assessment methods based on minimum data have been widely developed in the field of agriculture, economics, sociology, anthropology and epidemiology (Brooke, Knuthk, 2002; Rifkin, 1996; Torrico, Janssens, 2010). A simple methodology of biodiversity assessment based on presence/absence of species is frequently used in ecology and habitat management practice (see e.g. Elith et al., 2006) and rapid assessment methods have been shown to be sensitive tools to assess anthropogenic impacts to wetland ecosystems (Fennessy et al., 1998; van Dam et al., 1998; Bartoldus, 1999; Mack et al., 2000). In this study we test the applicability of a simple rapid protocol for the assessment of ecosystem service at 35 sites from 14 countries of the LTER-Europe network.

Methods

This study arose out of an ongoing collaboration among the LTER-Europe community; consequently the researchers and sites studied are part of that network (http://www.lter-europe.net/). Participants at an Alter-Net sponsored participatory workshop in Vienna, November 2010, agreed on a data matrix for the quantification of ecosystem services. The data matrix was identified by considering each category and indicator presented by Dick et al. (2011b) and discussing additional indicators suggested by the participants. The study was limited to the participants of the workshop for practical purposes.

The participants further agreed to perform an initial test scoring the probability of occurrence of the ecosystem service parameter along with an estimate of the confidence provided by the assessor (Table 1). A simple scoring template was circulated to ensure all participants scored the services using unified criteria. The probability of an ecosystem service occurring at the site and confidence of the assessor in their answer was scored on a 0–1 scale, i.e. the service scored 1 for probability and 1 for confidence if the assessor was 100% sure that the service occurred at that site and scored 0 for probability and 1 for confidence if the assessor was 100% sure that the service did not occurred at that site.

T a b l e 1. Definitions of ecosystem service and disservice parameters utilising Millennium Assessment typology scored for occurrence at each of 35 sites LTER Europe sites.

Service	Category	Ecosystem service #
Provisioning		
Food	Farming produce: meat (1) , milk/diary (2) & fish (3)	1–3
	Non-farmed (wild) meat (4) or fish (5) utilised at site	4–5
	Grown or picked for human consumption on site: vegetables (6), fruit (7), mushrooms(8), honey (9), eggs (10), crops (11)	6–11
	Crops/plants harvested for non-human consumption on the site	12
Fibre	Fibre produced by animals from the site	13
	Fibre produced by crops from the site	14
	Wood produce (not fire wood) harvested on the site (e.g. pulp/paper/sawn timber)	15
Fuel	Wood harvested for fuel from the site	16
	Hydropower electricity produced at the site	17
	Biomass grown at the site for energy needs	18
Genetic Resources	Animal species within site held for use as a genetic stock.	19
	Plant species within site held for use as a genetic stock.	20
Biochemicals & pharmaceuticals	Species or breeds grown or raised on the site for use in biochemical &/or pharmaceutical industries/research.	21
Ornamental resources	Site resources used in producing ornaments, arts, crafts etc.	22
Fresh Water	Fresh water extracted for human consumption from within site	23
Regulating		
Climate regulation	Site is considered to be a net sink (reduction) of greenhouse gas emissions	24
Water regulation	Dams/Reservoirs present within the site boundary	25
	Flood events (water going outside normal bounds) occurs on site	26
	Water storage on site	27

T a b l e 1. Definitions of ecosystem service and disservice parameters utilising Millennium Assessment typology scored for occurrence at each of 35 sites LTER Europe sites - continued.

Service	Category	Ecosystem service #
Provisioning		
Water quality regulation	Removal of nutrients from water occurs on site	28
	Removal of heavy metals from water occurs on site	29
Regulation of human diseases	Reduction of water born diseases and/or algal blooms (e.g. presence of wetlands for reduction of bacterial and virus pollution)	30
Erosion regulation	Minimal erosion to areas within site boundaries.	31
	Significant landscape erosion to areas within site boundaries*.	32
Regulation of human diseases	Minimal risk of human disease from ecosystem within site boundaries.	33
	Significant risk of human disease within site boundaries*.	34
Pollination	Nectar plants exist on site	35
Natural hazard regulation	Fire occurs on site	36
	Land used for fire prevention	37
Other hazard regulation	The site regulates noise pollution (e.g. woodland reduces sound of busy road)?	38
Cultural		
Cultural diversity	Does the site contain landscape, biodiversity or habitat features which are used by (or in) amateur botanists (39), recreational anglers (40), bird watchers (41), climbers (42), cyclists (43), farmers (44), foresters (45), fungal forays (46), green weddings (47), horse riding (48), lepidopteron enthusiasts (49), model/kite enthusiasts (50), mountain bikers (51), research (52), hunting (53), special needs groups (54), walkers (55), yoga practitioners (56) skiing (57), military or emergency training (58), film making (59), education (60), picnicking or general recreation (61), bathers (62), motorised water sports (63), ice based sports (64), snow based sports (65)?	39–65
Spiritual and religious values	Are there natural features in the ecosystem of spiritual/religious value to either the local or larger population (e.g. significant mountain summits, fairy pools etc…)?	66
	Are there manmade features in the ecosystem of spiritual/religious value (e.g. churches, chapels, standing stones)?	67
Educational values	Is the site used in part for formal education purposes (e.g. school visits)?	68
	Is the site used for informal education?	69
Aesthetic values	Are there species of the following taxa on site: Butterflies (70), ground beetles (71), moths (72), bats (73), birds (74), vascular plants (75), bryophytes (76), and lichens (77).	70–77
	Are there interstitial elements from the following list occurring within site boundaries? (Ditch, path/track, road, hedgerow, fence, stone wall, waterway).	78
	Are there statutory designations governing areas within the site (e.g Natura 2000, SSSI, SAC)?	79
Social relations	Is there easy access to the site e.g. via metalled road, rail link etc…?	80
Cultural heritage values	Are there special features present within the site boundaries? e.g. historic, Argyll stone in Cairngorms.	81
Recreation and ecotourism	Are there tourist visitors to the site each year?	82
	Is there accommodation for tourist visitors at the site?	83

The scoring matrix was distributed to individuals who had expressed interest in contributing to this study within the LTER Europe community and those who delivered data by the beginning of 2011 were included in the present analysis (Table 2). Following compilation and initial quality control of received data, the combined dataset was redistributed to all authors to ensure consistency and data quality. This quality control step ensured no misunderstanding between authors/surveyors.

T a b l e 2. Site and surveyor information for the 35 LTER sites included in the study (affiliations reported for non-authors).

Site Code	Map number	Country	Site name	Area assessed (ha)	Site Surveyor
EIS_AT	1	Austria	LTSER Platform Eisenwurzen	577600	Mirtl Michael
ZOE_AT	2	Austria	Zoebelboden LTER and ICP IM	89	Mirtl Michael
LAM_FI	3	Finland	Lammi LTER, Southern Boreal Aquatic and Terrestrial Long Term Ecological Research Area	10580	Petteri Vihervaara
ORG_HU	4	Hungary	Orgovány Meadows of Kiskunság National Park - KISKUN LTER	3948	Miklós Kertész
SAM_IS	5	Israel	Samar Sand Dunes	300	Daniel Orenstein & Elli Groner
ALP_IT	6	Italy	Western Alps (high elevation)	100	Michele Freppaz, Univ. of Turin
APP_IT	7	Italy	Apennines (High elevation) LTER 01	500000	Angela Stanisci, Univ. of Molise
COL_IT	8	Italy	Collelongo - Selva Piana	250	Giorgio Matteucci
DPO_IT	9	Italy	Delta del Po	13730	Michele Mistri, Univ. of Ferrara
FON_IT	10	Italy	Riserva Naturale Statale Bosco della Fontana	233	Alessandro Campanaro & Franco Mason, National Forest Service
MAR_IT	11	Italy	Portofino Marine Protected Area	374	Riccardo Cattaneo Vietti, Univ. of Genoa
RUF_IT	12	Italy	Monte Rufeno Regional Reserve	3000	Cristiana Cocciufa, National Forest Service
VAL_IT	13	Italy	Valbona Forest Reserve	123	Renzo Motta, Univ. of Turin
ARA_JO	14	Jordan	Wadi Araba	340000	Amani Al Assaf & Fares Khoury
ENG_LV	15	Latvia	Lake Engure Nature Park	18000	Viesturs Melecis
LOD_PO	16	Poland	Lodz	29300	Kinga Krauze
PIL_PO	17	Poland	Pilica LTSER	102400	Kinga Krauze
MON_PT	18	Portugal	Grândola cork oak forest - site LTER Montado	221	Margarida Santos-Reis
BRA_RO	19	Romania	Small Island of Braila (Braila Islands LTSER site)	24555	Angheluta Vadineanu & Elena Preda
FRU_SB	20	Serbia	Fruška gora	34711	SanjaVselić
KOV_SB	21	Serbia	Koviljsko-petrovaradinski rit	5895	Dušanka Krašić
TRA_SK	22	Slovakia	Trnava	74100	Zita Izakovicova
DON_ES	23	Spain	LTER-Doñana National Park	53639	Ricardo Díaz-Delgado
ALI_UK	24	UK	Alice Holt	850	Sue Bentham, Forest Research
CAI_UK	25	UK	Cairngorm	1000	Jan Dick & Chris Andrews
DRA_UK	26	UK	Drayton	190	Simon McMillan, ADAS
GLE_UK	27	UK	Glensaugh	1125	Helen Watson, James Hutton Institute
MOO_UK	28	UK	Moorhouse	7500	Rob Rose, CEH
NOR_UK	29	UK	North Wyke	250	Deborah Beaumont, Rothamsted Research
POR_UK	30	UK	Porton Down	1227	Stuart Corbett, DSTL
ROT_UK	31	UK	Rothamstead	330	Tony Scott, Rothamsted Research
SNO_UK	32	UK	Snowdon	700	Alex Turner, CCW
SOU_UK	33	UK	Sourhope	1119	Carol Taylor, James Hutton Institute
WYT_UK	34	UK	Wytham	770	Michelle Taylor, CEH
CNP_UK	35	UK	Cairngorm National Park	452800	Hamish Trench, CNPA

Study sites

A total of 35 sites from 14 countries tested the protocol (Fig. 1). These sites were defined by each site surveyor(s) according to the Millennium Ecosystem Assessment Reporting Categories (MA, 2005) (Table 3). The MA recognised that each of these categories may contain a number of ecosystems. In this study eight of the ten categories were represented (only polar and island were not represented). Eight sites comprised four or more categories and fourteen sites contained only one MA land category.

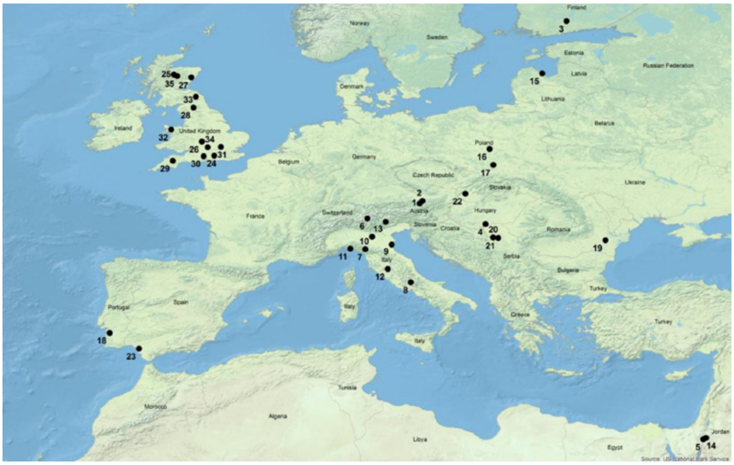

Fig. 1. Location of 35 LTER Europe sites in 14 countries included in this study (see Table 2 for full details of sites).

T a b l e 3. Millennium Ecosystem Assessment Reporting Categories of 35 LTER Europe sites (see Table 1 for full description of ES code).

Site Code	Marine	Costal	Inland Water	Forest	Dry-land	Island	Moun-tain	Polar	Cultiva-ted	Urban	Total
EIS_AT	0	0	1	1	0	0	1	0	1	1	5
ZOE_AT	0	0	0	1	0	0	1	0	0	0	2
LAM_FI	0	0	1	1	0	0	0	0	0	0	2
ORG_HU	0	0	1	1	1	0	0	0	1	0	4
SAM_IS	0	0	0	0	1	0	0	0	0	0	1
ALP_IT	0	0	0	1	0	0	1	0	0	0	2
FON_IT	0	0	0	1	0	0	0	0	0	0	1
DPO_IT	0	1	1	0	0	0	0	0	0	0	2
VAL_IT	0	0	0	1	0	0	1	0	0	0	2
COL_IT	0	0	0	1	0	0	1	0	0	0	2
APP_IT	0	0	0	0	0	0	1	0	0	0	1
RUF_IT	0	0	0	1	0	0	1	0	0	0	2
MAR_IT	1	0	0	0	0	0	0	0	0	0	1
ARA_JO	0	0	0	0	1	0	0	0	0	0	1
ENG_LV	0	1	1	1	0	0	0	0	1	0	4
LOD_PO	0	0	1	1	0	0	0	0	1	1	4
PIL_PO	0	0	1	1	0	0	0	0	1	1	4
MON_PT	0	0	0	1	0	0	0	0	1	0	2
BRA_RO	0	0	1	0	0	0	0	0	0	0	1
FRU_SB	0	0	0	1	0	0	1	0	1	0	3
KOV_SB	0	0	1	1	0	0	0	0	1	0	3
TRN_SK	0	0	1	1	0	0	1	0	1	1	5
DON_ES	0	1	1	1	1	0	0	0	0	0	4
ALI_UK	0	0	0	1	0	0	0	0	0	0	1
WYT_UK	0	0	0	1	0	0	0	0	1	0	2
GLE_UK	0	0	0	0	0	0	0	0	1	0	1
SOU_UK	0	0	0	0	0	0	0	0	1	0	1
NOR_UK	0	0	0	1	0	0	0	0	1	0	2
CAI_UK	0	0	0	1	0	0	1	0	0	0	2
MOO_UK	0	0	0	0	0	0	1	0	0	0	1
SNO_UK	0	0	0	0	0	0	1	0	0	0	1
DRA_UK	0	0	0	0	0	0	0	0	1	0	1
ROT_UK	0	0	0	0	0	0	0	0	1	0	1
POR_UK	0	0	0	0	0	0	0	0	1	0	1
CNP_UK	0	0	1	1	0	0	1	0	1	0	4

Statistical analysis

A generalised linear model with logit link and binomial error (using Genstat 5 software; Payne et al., 1987) was used to determine whether the differences between the confidence of the observers depend on the ecosystem service category (provision, regulating and cultural).

The similarity of sites to each other, derived from the ecosystem services they shared, was calculated and analysed graphically using principal coordinate analysis, with the plot enhanced by scaling the diameter of the symbols to reflect the different areas of the sites (on a log scale) and colour coded to denote the number of MA Reporting Categories present at a site.

Results

Of the 83 ecosystem services parameters assessed for probability of occurrence (Fig. 2) across the 35 sites, the vast majority (93%) were scored as either occurring (53%) or not occurring at the site (40%). The surveyors were very confident about their assessment, scoring the occurrence of services with 92% certainty and non-occurrence with 90% certainty (Fig. 3).

There were a total of 46 ecosystem services that at least one surveyor was unable to conclude did or did not occur at their site. The regulating ecosystem services were found to be more difficult to assess (Fig. 4), with the ecosystems' ability to remove metals or nutrients from the water (services #28, 29) and to reduce water born diseases and/or algal blooms (service #30) proving particularly difficult for site surveyors. In total, 9.5% of the 15 regulating services across the 35 sites were scored as 'don't knows' compared with 3.2% and 1.5% for the 26 provisioning and 45 cultural services respectively. The confidence score associated with the probability of occurrence for each ecosystem service parameter by each site surveyor also reflected the uncertainty associated with assessing the regulating services (Fig. 3). Averaged across all sites there was a significant difference ($p < 0.001$) in the confidence

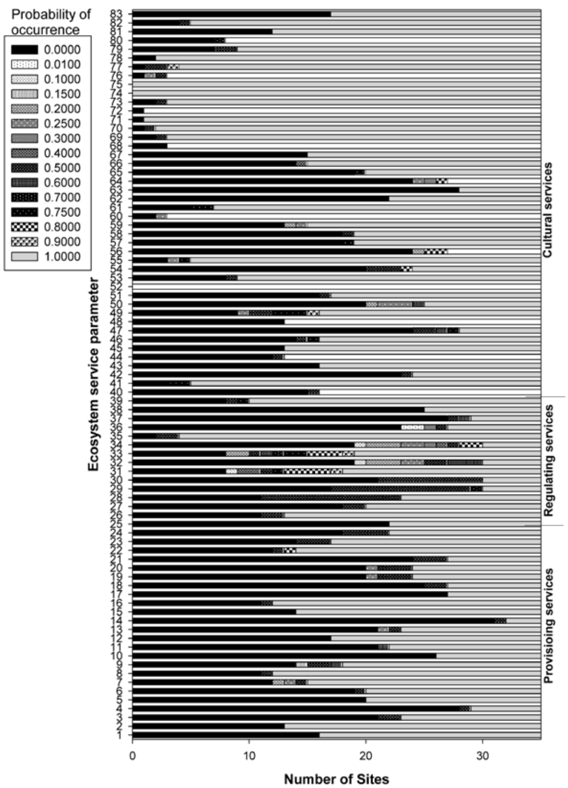

Fig. 2. Probability of occurrence of 83 ecosystem service parameters at 35 LTER Europe sites (see Table 1 for full details of ecosystem service).

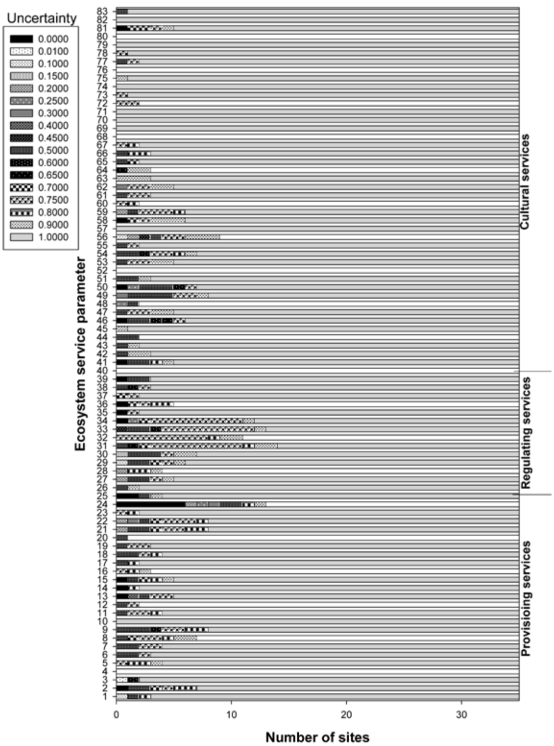

Fig. 3. Estimated confidence score of each 83 ecosystem service parameters assessed at 35 LTER-Europe sites (see Table 1 for full details of ecosystem service parameter).

score of the three types of services with surveyors estimating a confidence score of 80% (±2%) for the regulating services but 89% (±1%) and 92% (±1%) for the provisioning and cultural services, respectively.

Three ecosystem service parameters were scored by all site surveyors as occurring at their sites (Fig. 2), including (i) landscape, biodiversity or habitat features used by researchers (#52), (ii) landscape, biodiversity or habitat features used by bird watchers (#74) and (iii) presence of vascular plant species (#75). Ranking the ecosystem service parameters by their power to discriminate between the sites reveals that 12 were scored the same for over 90% of the 35 sites indicating little discriminating power to distinguish the sites assessed in this study (Table 4). The majority of these ecosystem service parameters could be classed as biodiversity, i.e. presence of birds, vascular plants, beetles, moths, butterflies, bats and bryophytes. The use of the site for education purposes was also found to have little discriminating power with only three sites indicating the site was not used for educational purposes.

Comparative analysis between sites was conducted to test the discriminating power of the protocol. Principal coordinate analysis of the similarity between sites in the ecosystem services they provided (Fig. 5) reveals good discriminating power; generally sites which encompassed the largest area and had a greater number of Millennium Ecosystem Assessment Reporting Categories clustered to the top of the two dimensional plot (y-axis accounted for 16% of the variance). The dryland site in Jordan is an obvious exception to the general pattern. The x-axis (7% variance) split the sites on land-use such that sites providing mainly provisioning services associated with the farmed land clustered to the left and sites associated with a wider range of ecosystem services were located to the right. Two countries, Italy and UK, tested the protocol in multiple sites (8 and 12 sites, respectively). These sites were well distributed in the plot demonstrating that the protocol can discriminate within countries as well as between countries.

Discussion

In this study, we introduce and test a simple and transparent protocol to perform a rapid initial assessment of the ecosystem services delivered by a landscape. It was found to be robust and can be applied by a diverse range of people (academic researchers, land managers and national park staff) across a broad range of ecosystem types and spatial scales. This protocol is practical and sits squarely across the philosophical divide between assessing ecosystem services in terms of ecological and non-monetary indicators or only economic indicators as elucidated by Sagoff (2011). This method scores the ecosystem service used/provided in a landscape considering both market activities and ecological processes and, although not quantified or economically valued directly, could form a common platform for future studies to numerate the services.

We are not arguing that studies should numerate all services in an area. Rather, we advocate that the occurrence of all services should be reported and then in-depth analysis can be conducted for the services that are considered most important depending on the focus of the study. We believe this would give a more transparent and accurate assessment of the ecosystem services of an area and aid inter-site comparisons, management planning, off-setting and/or policy scenario assessments. The protocol tested in this study is the first international trial of this method and has illuminated some advantages and limitations of this approach to operationalise the concept

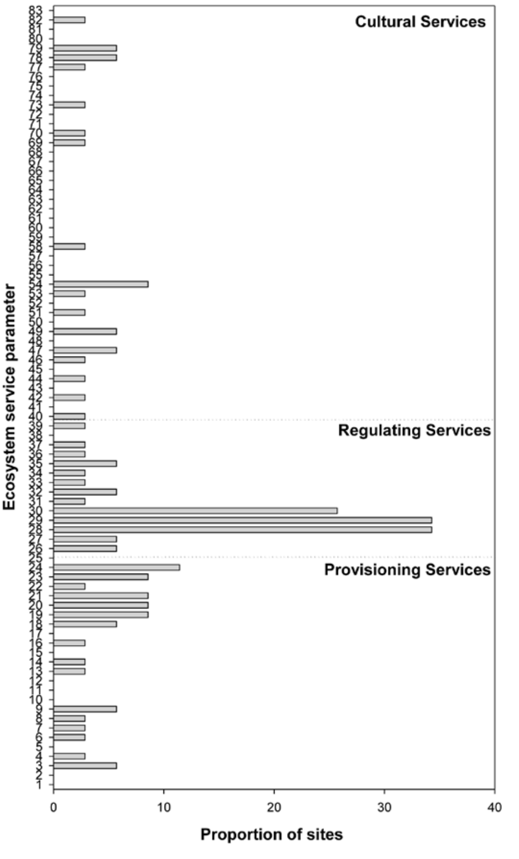

Fig. 4. Occurrence of ecosystem service parameters scored as unknown by site surveyors at 35 LTER-Europe sites (see Table 1 for full details of ecosystem service parameters).

T a b l e 4. Ecosystem service parameters which were scored the same for over 90% of the 35 LTER-Europe sites assessed (see Table 1 for full description of ES code).

ES number	ES_code	No sites
52	Used by researchers	35
74	Birds on site	35
76	Vascular plants on site	35
71	Beetles on site	34
72	Moths	34
70	Butterflies on site	33
75	Interstitial feature	33
60	Landscape used by educationists	32
68	Formal education provided	32
69	Informal education provided	32
73	Bats on site	32
77	Bryophytes on site	32

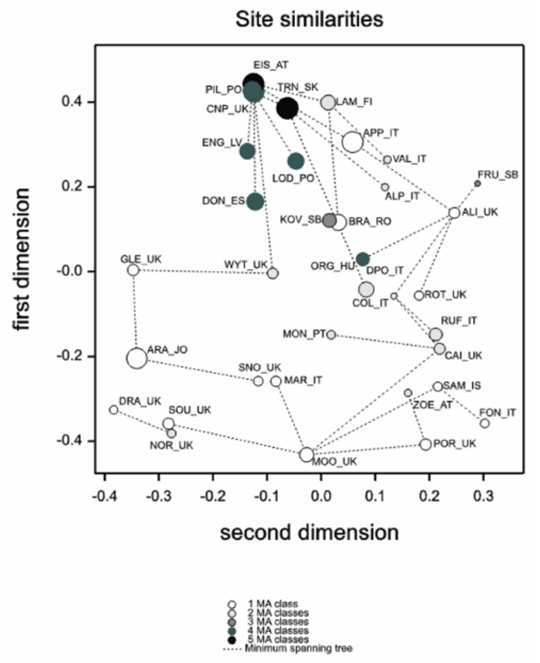

Fig. 5. First two dimensions of the principal coordinate analysis of the similarity matrix for 35 LTER-Europe sites. Size of circle is proportional to the area of each site.

of ecosystem services which are discussed in the following sections. We consider below the list of ecosystem services, the scoring system, assessment of biodiversity and the discrimination power of this protocol.

Identification of parameters to assess ecosystem services

In this study the identification of ecosystem service parameters was accomplished building upon the framework set out by Dick et al. (2011b), which drew its inspiration in part from the Millennium Ecosystem Assessment protocol (MA, 2005). The MA provides a useful classification of ecosystem services: supporting, provisioning, regulating and cultural. Supporting services were recognised for the production of all other ecosystem services and included services like biomass production, soil formation, retention and provisioning of habitat. However, as recognised by several studies utilising the MA typology, humans usually obtain the benefits of supporting services in the form of the other three services, and consequently the inclusion of supporting services has been suggested as 'double accounting' (Boyd, Banzhaf, 2007; TEEB, 2010). In addition, the supporting services were not considered in this study to be useful to score on a probability of occurrence scale as they generally occur in all ecosystems. Consequently supporting ecosystem services were not considered explicitly in this study.

The actual ecosystem services inventory list was refined through iterative consultations with the LTER-Europe site or network managers participating in this study. We recognise however that it would benefit from testing in polar, tropical and island ecosystems which were not included in this study which might result in the addition of more parameters. Interestingly, in contrast to extending the list, some project participants felt the list could and should be shortened, for instance, by combining categories to shorten the list of 45 cultural activities (Table 1, Fig. 2). Depending on the purpose of conducting the assessment there maybe merit in hieratical structure. For example if there is snow at a site, an extended list of activities may help focus on economic assessment but such a list is redundant when there is no or limited snow at a site. It is self-evident that each assessor has a unique set of values and priorities that will be reflected in their choice of ecosystem service parameters for inclusion in an assessment list, as demonstrated by Orenstein et al. (2012), who adopted the methodology for an arid ecosystem and found it necessary to modify the list according to local specifications. But, as this study shows, even with a diverse, international team, a consensus list can be produced and utilized, and disagreements noted within the transparent assessment and scoring process.

The list of ecosystem service parameters identified in this study included both positive (e.g. food production) and negative services, (e.g. soil erosion). It is considered strength of this tested protocol to include both types of service although it is recognised that this issue requires further attention. It has been suggested that higher occurrence of biological disservices may be directly linked to disturbed ecosystems (Dunn, 2010) and perhaps a reflection of reduced supporting ecosystem services. Dunn notes that valuing tropical forests for the low level of ecosystem disservices may be more important than for the ecosystem services they deliver. Similarly, Zhang and colleagues argue in favour of including ecosystem disservices in assessment protocol (Zhang et al., 2007). They emphasize that agricultural ecosystems are both threatened by and can deliver ecosystem dis-services that can greatly affect the profitability and sustainability of agricultural production (e.g. crop pests). These studies have profound policy implications and we therefore recommend that more attention be focused on the inclusion of ecosystem disservices in this rapid ecosystem service methodology.

It has been suggested that because ecosystems are so diverse (e.g. artificial and natural ecosystems), the creation of a single classification for all ecosystems is not possible (Zhang et al., 2010). However, the ecosystem service parameter list tested in this study proved to be remarkably versatile across a range of sites including urban, crop land, forest, mountain, desert and marine sites. While the list of ecosystem service parameters should be expanded (as discussed above), the approach used in this study has proven to be useful in providing insights regarding the distribution and abundance of ecosystem services across regions, but also in exposing major gaps in our local and global knowledge of ecosystem service identification.

Scoring occurrence and uncertainty of ecosystem service parameters

In this study, the probability of occurrence of an ecosystem service parameter was generally found to be known. In practice, the full 0-1 scale for occurrence of the ecosystem service parameter was seldom utilised because surveyors were well acquainted with their sites. This has led to the suggestion that a simple three-point scale (present-1, absent-0 and don't know) would be more pragmatic with the associated confidence score; such that if the respondent believes that a service is probably present but is not sure, they will enter value '1' and express the degree of uncertainty in the associated confidence score, similarly if the ecosystem service parameter is considered not to occur.

The purpose of many ecosystem service evaluations is to estimate the marginal change on the provision of ecosystem services following a change in management and in terms of trade-offs against other ecosystem service that people value (Collins et al., 2010). We believe that the methodology tested in this study could be used for this purpose by guiding more detailed studies to quantify the ecosystem services identified as being the subject of change, while presenting a clear picture of the full suite of ecosystem services provided by the site.

Insights into biodiversity and ecosystem services

The relationship between biodiversity and ecosystem services is poorly understood but widely discussed in current scientific literature (e.g. Anderson et al., 2009; Benayas et al., 2009; Feld et al., 2009; Luck et al., 2009) and consequently warrants further consideration. In this study, which had its roots in the UK Environmental Change Network (Dick et al., 2011b), biodiversity was primarily assessed by the suite of ecosystem services #70-77 (i.e. *Are there species of the following taxa on site: butterflies, ground beetles, moths, bats, birds, vascular plants, bryophytes, and lichens*), which are core measurements in the UK network. The quantification of these biodiversity groups was found by Dick et al. (2011b) to discriminate between sites showing that the upland sites generally had lower numbers in most biodiversity groups. The simple probability of occurrence of these groups has not proved a useful discriminating approach in this study and perhaps a check list of functional types may be a better way forward rather than taxonomic groups. Over the past decades it has been recognised that what matters most for ecosystem services is not the taxonomic group so much as the traits species possess (e.g. nitrogen-fixers, pollinators, nutrient recyclers; Perrings et al., 2010). The occurrence of keystone or umbrella species might also be a useful ecosystem service parameter in this context rather than broad taxonomic groups.

Discriminating power and use of rapid ecosystem service assessment

The focus of this study was the creation and testing of a single list of ecosystem services or proxies for services that could be used globally. The concept being that a simple check list would allow comparison of ecosystem services across diverse sites or at the one site that was the subject of suggested change. The ecosystem service occurrence check list would then form the basis for more focused in-depth studies as appropriate. The purpose was not to compare sites directly in this study but to determine if the ecosystem service parameter list developed in this study could be used across a wide range of sites. Separation of the sites in multi-dimensional space (Fig. 5) shows this methodology can also discriminate between sites. This can be important in planning situations when there is a choice of sites for development.

We recognise that the simple probability of occurrence of an ecosystem service parameter advocated here does not consider ecological function and processes explicitly; rather they are assumed by the occurrence of the end product, i.e. the occurrence of the service. Zhang and colleagues (2010) in their review of ecosystem service research in China noted that in the past 20 years 90% of research papers have focused on the ecosystem service valuation rather than analysing the relationship between ecosystem structure, processes, function and ecosystem service delivery directly. They suggest that a lack of knowledge about the relationship between ecosystem structure and function often impairs the credibility of the evaluations. Sagoff (2011) on the other hand questions if such a biophysical understanding is necessary. He argues that the market implicitly recognise ecosystem services. The protocol tested and further developed in this study is utilitarian, focusing on the occurrence or not of ecosystem services in a specified area and as such offers a rapid initial assessment of ecosystem services.

Conclusion

Following extensive consultation with stakeholders at local, regional and global levels the MA recognised five over-arching questions to be addressed when assessing ecosystem services; the first of these was 'What are the current conditions and trends of ecosystem services?' (MA, 2005). The protocol developed in this study has shown promise to be simple, transparent, cost-effective and policy relevant to assess the ecosystem services of a landscape. Site managers assessed the protocol as useful to identify the ecosystem services delivered by a site and a transparent means of focusing more detailed quantified studies.

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