Supporting information
Assessing the evidence of ecosystem services studies: a framework and its application

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We applied the evidence-based concept to 12 case studies, three of them already mentioned in the main document. The details about the question, the outcome and the level of evidence after the critical appraisal are given in Table S1. We further present the quality checklist used to determine the study quality in all 12 case studies (Table S2). We covered a broad range of case studies, providing an example for all disciplinary foci (quantification, valuation, management and governance) and all different study designs.

In the main document, we state that each ecosystem service should be investigated from the perspective of all facets and that questions can be answered on all levels of evidence. Carbon sequestration was a prominent topic over the previous years (Oren *et al.*, 2001; Fernández-Martínez *et al.*, 2014) and we found studies about carbon sequestration following different study designs (Table S3). The studies vary in their geographical region and the focus of the question. They may also investigate a broader range, e.g. the value of all ecosystem services, and we extracted only the question related to carbon sequestration. No critical appraisal was performed, but this example still highlights the use of the evidence-based concept.

Table S1: Studies ranked according to the evidence-based approach. The key columns (grey section) are the question, the outcome and the final level of evidence (LoE). They are supported by context, facet and the evidence assessment with study design and quality assessment (critical appraisal)

	1. Question, outcome and the context				2. Evidence Assessment				
Reference	Context: Ecosystem services; Ecosystem(s); Location	Facet	**Question/Purpose investigated**	**Outcome**	2a. Study design ->	Level of evidence	2b. Quality points (see checklist S2) ->	Quality score	Final level of evidence
Bowler et al. 2010	Air conditioning in urban space; cities; global	Management	Can human exposure to heat be mitigated by greening urban spaces?	Green space in an urban area is on average 1°C cooler, than a built-up site.	Systematic review	LoE1a	30/31	0.97	LoE1a
Lindhjem 2007	Non-timber forest ecosystem services, mainly recreation; forests; Norway, Sweden, Finland	Valuation	Review of people's willingness to pay for non-timber forest ecosystem services	Willingness to pay (WTP) is insensitive to forest size; WTP is higher if people are asked as individuals than on behalf of their households	Conventional review	LoE1b	21/27	0.78	LoE2
Ayanu et al 2012	Crops and biomass production, above ground carbon storage, amount of pollutants removed from the air, soil retained, water purification, storm mitigation, pest control; all; global	Quantification	Analysing advantages and disadvantages of several remote sensing procedures to map ecosystem services	Description of various remote sensing techniques. Claim for more studies assessing validity, reliability and uncertainty of remote sensing procedures in quantifying and mapping ecosystem services	Conventional review	LoE1b	11/18	0.61	LoE2b
Liu et al. 2008	Timber, soil erosion, carbon sequestration, recreation through wildlife observing; forests; China	Governance	What is the socioeconomical and ecological impact of two payments-for-ecosystem-services programs in China?	Socioeconomical impact: income increased, but revenues declined for local governments. Ecological impact: Timber harvest decreased locally but import increased. Carbon sequestration increased and soil erosion declined.	Conventional review	LoE1b	8/23	0.35	LoE3b
Millar et al. 2010	Soil erosion protection; grassland; USA	Quantification	What is the effect of sod farming on soil loss.	Net loss of productive soil under sod farming is larger than the tolerable soil loss.	Case-control	LoE2a	18/28	0.64	LoE3a
Acuna et al. 2013	Food (fish), retention of organic and inorganic matter; river, forests; Iberian Peninsula	Management	How does adding dead wood to stream channels affect the provision of ecosystem services?	Restoration of natural wood loading in streams greatly increases the ecosystem services they provide.	Before-after control-impact	LoE2a	19/29	0.66	LoE3a
Lara et al. 2009	Food (fish); marine; mediterranean	Quantification	Developping an index that estimates fish density, biomass and production in dependance of environmental variables	Index etimating fish density, biomass and production in dependance of surface area/volume ratio, water volume with sufficient oxygen, conductivity, cholorphyll a concentration perimeter	Inferential study	LoE3a	9/21	0.43	LoE4
Barkmann et al. 2008	Fibre, water, recreation/biodiversity, cacao; agroforestry; Indonesia	Valuation	What is the value of ecosystem services provided by a hydrological ecosystem?	Willingness to pay for improving water availability equals about 1% of mean cash income of households.	Inferential study	LoE3a	11/21	0.52	LoE4
Xie et al. 2011	Improved air quality; city; China	Quantification	Quantification of carbon sequestration, O_2 production and dust removal of different plant species	Absolute numbers for carbon sequestration, O_2 production and dust removal and the differences between plant species	Descriptive study	LoE3b	10/20	0.50	LoE4
Karimzadegan et al. 2007	Gas regulation, pollination, pest control and others; forests; Iran	Valuation	What is the value of Iran's forest and rangeland ecosystem services?	A value [$] for Iran's forests and rangelands	Descriptive study	LoE3b	8/21	0.38	LoE4
Entenmann and Schmitt 2013	Biodiversity; forests; Peru	Governance	Do stakeholders relate REDD+ to biodiversity conservation?	Yes, synergies between REDD+ and biodiversity conservation were assumed.	Descriptive study	LoE3b	11/22	0.50	LoE4
Desanker 2005	Climate stabilisation; all; Africa	Governance	How can the Clean Development Mechanism be better engaged in Africa?	Projects should be initiated by locals rather than external groups, and we need fund for all forest products and services.	Expert opinion	LoE4	not required - already on lowest level of evidence		LoE4

Table 1: **Quality checklist** applied to 12 case studies to obtain the quality points (2b in Table S1)

	Reference:	Bowler et al. 2010	Lindhjem 2007	Ayanu et al. 2012	Liu et al. 2008	Millar et al. 2010	Acuna et al. 2013	Lara et al. 2009	Barkm. et al. 2008	Xie et al. 2011	Karimz. et al. 2007	Entenm. and Schmitt 2013	Desanker 2005
General aspects													
1	Does the question match the answer?	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	
2	Are the assumptions used in the study reasonable?	yes	yes	yes	/	yes	yes	no	yes	yes	yes	no	
3	Internal validity: Do design and implementation avoid a high risk of bias?	yes	yes	no	no	yes	yes	no	yes	no	no	no	
4	External validity/relevance: Is the result transferable to similar scenarios?	yes	no	yes	yes	yes	yes	yes	no	yes	yes	yes	
Data collection													
5	Was the target population/area defined in space, time and size?	yes	yes	no	yes	yes	no	yes	no	no	yes	yes	
6	Was a sampling population/area defined?	yes	yes	no	no	yes	yes	yes	yes	yes	yes	yes	

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7	Were potential differences between the target population and the sampling population considered?	yes	no	/	/	no	/	no	/	/	no	no	
8	Were the methods described in sufficient detail to permit replication?	yes	yes	/	no	yes	yes	no	no	yes	yes	yes	
9	Was the sample size appropriate?	yes	yes	yes	no	yes	yes	no	yes	no	no	yes	
10	Was probability sampling used for constructing the sample?	/	/	/	/	no	no	no	no	no	no	no	
11	If secondary data are used, did an evaluation of the original data take place?	yes	yes	yes	no	/	/	/	/	/	no	/	
Analysis													

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12	Is the choice of statistical/analytical methods justified and comprehensively explained?	yes	yes	/	/	yes	yes	no	yes	no	/	yes	
13	Are variables and statistical measures given?	yes	yes	/	/	yes	no	yes	yes	yes	no	yes	
14	Was accuracy/uncertainty assessed and reported?	yes	yes	/	no	no	yes	no	no	no	no	no	
Results													
15	Are results consistent and homogeneous?	yes	yes	/	yes	yes	no	yes	yes	yes	yes	yes	
16	Magnitude of effect: Is the effect large (and without large uncertainty)?	no	no	/		yes	no	no	/	no	no	no	

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17	Is the outcome report complete and no information is missing?	yes	yes	/	no	yes	yes	yes	yes	yes	no	yes	
18	Attrition bias: Are non-response/drop-outs given and is their impact discussed?	yes	/	no	no	/	/	/	no	/	/	no	
Design-specific aspects													
Review													
19	Is there a low probability of publication bias? E.g. results reporting a negative relationship were probably not included	yes	yes	no	no	/	/	/	/	/	/	/	

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20	Is the review based on high evidence individual studies?	yes	no	yes	no	/	/	/	/	/	/	/	
21	Do the studies included respond to the same question?	yes	yes	yes	/	/	/	/	/	/	/	/	
22	Was the literature searched in a systematic way?	yes	no	yes	no	/	/	/	/	/	/	/	
23	Was a meta-analysis (in the strict sense: see Vetter et al. 2013) included?	yes	yes	no	no	/	/	/	/	/	/	/	
24	Were appropriate study inclusion/exclusion criteria defined?	yes	yes	yes	no	/	/	/	/	/	/	/	
Study with a reference													

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25	Selection bias: Was the assignment of case-control groups randomized?	/	/	/	/	no	no	/	/	/	/	/	
26	Were groups designed equally, aside from the investigated point of interest?	/	/	/	/	no	yes	/	/	/	/	/	
27	Performance bias: Was the sampling blinded, e.g. researchers taking samples of a specific area wouldn't know the differences between these areas?	/	/	/	/	no	no	/	/	/	/	/	

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28	Were there sufficient replicates of treatment and reference units?	/	/	/	/	yes	yes	/	/	/	/	/	
29	Detection bias: Were outcomes measured identically between groups?	/	/	/	/	yes	yes	/	/	/	/	/	
	Focus-specific aspects:												
	Quantification												
30	Is the unit of the quantification measurement appropriate?	/	/	/	/	yes	/	yes	/	yes	/	/	

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31	Was temporal change of ecosystem services' quantities (e.g. annual or long-term) discussed?	/	/	no	/	yes	/	no	/	no	/	/	
Valuation													
32	Were future values of ecosystem services considered?	/	yes	/	/	/	/	/	no	/	no	/	
33	If future values were considered, were they discounted with a well-motivated discount rate?	/	yes	/	/	/	/	/	/	/	/	/	

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34	If aggregate economic values for a population were estimated, was this estimation consistent with the sampling and the definition of the population?	/	/	/	/	/	/	/	no	/	no	/	
35	If valuation took place in form of a questionnaire, was the study pre-tested and piloted?	/	/	/	/	/	/	/	yes	/	/	/	
Management													
36	Was the aim of the management intervention clearly defined?	yes	/	/	/	/	yes	/	/	/	/	/	

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37	Were both long-term and short-term effects discussed?	yes	/	/	/	/	yes	/	/	/	/	/	
38	Did monitoring take place for an appropriate time period?	yes	/	/	/	/	yes	/	/	/	/	/	
39	Were stakeholders included?	yes	/	/	/	/	no	/	/	/	/	/	
40	Was the role of stakeholders described in detail?	yes	/	/	/	/	/	/	/	/	/	/	
Governance													
41	Were long-term effects assessed?	/	/	/	yes	/	/	/	/	/	/	no	
42	Was the policy instrument that was used described and well chosen?	/	/	/	yes	/	/	/	/	/	/	/	

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43	Was the influence of the policy instrument (incentive/law) on society discussed?	/	/	/	yes	/	/	/	/	/	/	no	
		0.97 30/31	0.78 21/27	0.61 11/18	0.35 8/23	0.64 18/28	0.66 19/29	0.43 9/21	0.52 11/21	0.50 10/20	0.38 8/21	0.50 11/22	

Table S2: Studies on carbon sequestration (CS) in forests. Examples are given for each facet (quantification, valuation, management, governance) and all levels of evidence

	Quantification	**Valuation**	**Management**	**Governance**
Question:	**How much carbon can be captured and stored by a forest?**	**What is the value of carbon sequestration in a forest?**	**How can we manage a forest to maximize carbon sequestration?**	**What are the best governance measures to manage a forest to maximize carbon sequestration?**
Review (LoE1 if there are no qualtiy shortcomings)	Does nutrient availability determine CS in forests? (Fernandez-Martinez et al. 2014)	What is the monetary value of CS provided by urban trees in Lisbon? (Roy, Byrne & Pickering 2012)	What is the effect of forest management on CS in soils? (Jandl et al. 2007)	How can we overcome critical challenges to scale up carbon investments in carbon sequestration projects in Africa? (Jindal, Swallow & Kerr 2008)
Referenced study (LoE2 if there are no quality shortcomings)	Does CS in forests depend on soil fertility? (Oren et al. 2001)	What is the non-market value from an afforested area in Spain? - Comparing results with contingent valuation and choice modelling (Mogas, Riera, Bennett 2006)	Impact of prescribed fire and small clear-cut tree harvesting on carbon dynamics in a mixed-conifer forest in Sierra Nevada? (Stephens et al. 2013)	What are barriers in implementing forest carbon trading? A comparison between the Clean Development Mechanism and a State-run carbon forestry program. (Corbera & Brown 2008)
Observational study (LoE3 if there are no quality shortcomings)	What is the reason for an increased CS in boreal deciduous forests in Canada between 1994 and 1998? (Black et al. 2000)	What is the value of CS provided by Canberra's urban forests? (Brack 2002)	Does carbon fixation increase with different forest managment strategies (e.g. fertilization, thinning)? (Hoen 1994)	What are the effects of carbon taxes and subsidies on the supply of carbon services in West-Canada? (Van Kooten, Binkley & Delcourt 1995)
Based on no data (LoE4)	No study	No study	Does proper design and management of agroforestry result in effective carbon sinks? (Montagnini & Nair 2012)	What governance conditions have to be met to succesfully put in practice small-scale forest carbon projects? (Boyd, Gutierrez & Chang 2007)

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