Journal of Environmental Planning and Management

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/cjep20

The role of choice experiments in natural capital accounting approaches: fast track versus simulated exchange value in the Deben Estuary saltmarshes

Gaetano Grilli, Silvia Ferrini, Tiziana Luisetti & R. Kerry Turner

To cite this article: Gaetano Grilli, Silvia Ferrini, Tiziana Luisetti & R. Kerry Turner (2021): The role of choice experiments in natural capital accounting approaches: fast track versus simulated exchange value in the Deben Estuary saltmarshes, Journal of Environmental Planning and Management, DOI: 10.1080/09640568.2021.1957794

To link to this article: https://doi.org/10.1080/09640568.2021.1957794

Published online: 28 Sep 2021.

Journal of Environmental Planning and Management, 2021
https://doi.org/10.1080/09640568.2021.1957794

Routledge
Taylor & Francis Group

OPEN ACCESS Check for updates

The role of choice experiments in natural capital accounting approaches: fast track versus simulated exchange value in the Deben Estuary saltmarshes

Gaetano Grilli[a]*, Silvia Ferrini[a,b], Tiziana Luisetti[c] and R. Kerry Turner[a]

[a]*Centre for Social and Economic Research on the Global Environment, School of Environmental Sciences, University of East Anglia, Norwich, UK;* [b]*Department of Political and International Sciences, University of Siena, Siena, Italy;* [c]*Centre for Environment Fisheries and Aquaculture Science, Lowestoft, UK*

(*Received 8 August 2020; revised 29 March 2021; final version received 13 July 2021*)

Natural capital accounting requires exchange rather than welfare values, but lack of data and standards have encouraged practitioners to use different approaches (e.g. simple lookup table vs spatial modeling approaches). In this paper, we demonstrate how choice modeling data can provide simulated exchange values which are more robust than simple (fast track) valuation approaches for natural capital accounting. A survey of East of England residents collected the preferences for saltmarsh management and simulated exchange values, coherently linked with the ecosystem conditions. This approach is more informative for environmental local planning purposes. We claim that expanding the set of tools available for natural capital accounting can enhance management of ecosystem services and policy decision making.

Keywords: natural capital accounting; choice experiment; simulated exchange value; local environmental policy; saltmarsh management

1. Introduction

The UK Natural Capital Committee defines natural capital as the “part of nature which directly or indirectly underpins value to people, including ecosystems, species, freshwater, soils, minerals, the air, and oceans, as well as natural processes and functions. In combination with other types of capital, natural capital forms part of our wealth; that is, our ability to produce actual or potential goods and services into the future to support our wellbeing” (Natural Capital Committee 2019, 3). In other words, natural capital can be seen as the economy’s endowment of natural resources providing ecosystem services for human wellbeing (Barbier 2019).

In the last two decades, natural capital and ecosystem services have become increasingly recognized in policy circles (MEA 2005; TEEB 2010; UK NEA 2011, 2014) as significant contributors to national wealth and individual wellbeing. This contribution requires augmentation through combination with other forms of capital stocks and flows such as financial, manufactured, social and human (Barbier 2019; Mace

*Corresponding author. Email: G.Grilli@uea.ac.uk

2019). This representation of the environment as a form of capital is appealing from a policy perspective because it fosters the management, valuation and accounting of natural capital in line with the treatment of other forms of capital (Milligan *et al.* 2014).

Natural capital and ecosystem services accounting (NCA) has therefore emerged as a valuable tool to analyze natural capital and trace contributions to the productive system over time and space. Indeed, NCA provides a comprehensive and integrated framework for structuring information on ecosystems condition and use, and directly links it to the System of National Accounts (SNA) (Edens and Hein 2013; Obst and Vardon 2014; Hein *et al.* 2015; Obst, Hein, and Edens 2016). In this way, the contribution of nature to wealth and economic productivity, which is only partially recorded in SNA, can be made more explicit and tradeoffs can be better understood (Obst, Hein, and Edens 2016). Therefore, NCA frameworks have been proposed during the last decade, and argued to be effective and efficient in informing environmental policy and management (Guerry *et al.* 2015; Vardon, Burnett, and Dovers 2016; Vardon *et al.* 2017, Ruijs and van Egmond 2017; Virto, Weber, and Jeantil 2018). Frameworks such as the System of Environmental-Economic Accounting (UN *et al.* 2014a, 2014b) are increasingly used in practical applications at national (e.g. EC, FAO, and OECD 2014; EC 2016; ONS 2019; Obst and Vardon 2017; Smith 2014), local (e.g. ABS 2017; Clark 2017; Dvarskas 2019) and business level (NCC 2016).

Nevertheless, the inclusion of NCA in real world policy decision making remains limited, complex and overlooked (Ruijs and van Egmond 2017; Virto, Weber, and Jeantil 2018). The debate around the development of a set of internationally shared NCA rules and frameworks has become mired in technical issues (in particular, the extent to which exchange values can encompass the diversity of ecosystem service benefits) and has lost track of the potential policy use benefit. As Vardon, Burnett, and Dovers (2016) have argued, the "accounting push" has not been matched by a "policy pull". NCA is perceived in isolation from other policy tools and not integrated in wider government action (Guerry *et al.* 2015). In addition, data limitation and proliferation of different experimentations of the international frameworks (e.g. the valuation methods employed) undermine the robustness and the credibility of the accounts, decreasing their uptake in real world policy decisions (Virto, Weber, and Jeantil 2018; Vardon, Burnett, and Dovers 2016; Schaefer *et al.* 2015; Turner, Badura, and Ferrini 2019a).

This is particularly true at the local government level, where many environmental management decisions overlook the complex interrelationships between nature, society and economy. An improved NCA system could facilitate local decision-making and jointly promote the three pillars of sustainable development. At the same time, the lack of data and the use of quick valuation strategies, i.e. fast track approaches, can obscure the causal nexus between natural assets, ecosystem services provision and economic values.

The objective of this paper is to consider how ecosystem services provided by a saltmarsh area could be included in an NCA framework using fast track strategies (e.g. using country-wide secondary information for local level applications) and contrast this with simulated exchange value results derived from a primary choice valuation study. In particular, the simulated exchange value approach is proposed as a valuable and more informative alternative to fast track strategies in accounting for cultural ecosystem services at the local level and in line with the ecosystem conditions. We argue that observational data and valuation methods based on biophysical information can help to improve the reliability of NCA. In turn, increased robustness and sound methodological approaches would provide policy makers with more stable and solid evidence for decision making, particularly at the local government level. This would also inform the technical discussion around the use of valuation methods and the scalability of economic values in NCA.

2. Natural capital accounts and the policy needs

The ability of NCA to support policy and decision making has been widely advocated in terms of producing a more comprehensive and inclusive measure of wealth (Guerry *et al.* 2015; Obst 2015; Hein *et al.* 2015). The NCA is organized in physical and monetary accounts that identify the contribution of nature to production systems (Obst and Vardon 2014; Edens and Hein 2013). From a policy perspective, the NCA formally records and monitors the link between the environment and the economy. NCA is seen as a relevant additional tool for informing sustainable development as it can i) spotlight the costs of natural capital depletion and degradation, ii) measure ecosystem conditions and functions, iii) help to target environmental policies toward sensitive natural resources (Hein *et al.* 2015; Mäler, Aniyar, and Jansson 2008). The alignment of concepts and measurements with the SNA allows NCA to be potentially used as an operational tool for setting policy objectives and monitoring results (Dalmazzone and La Notte 2013). Moreover, because of the spatially explicit approach taken, NCA could play a significant role in local level environmental management: for example, in informing land use planning, in characterizing opportunity costs and tradeoffs between projects and investments, in designing compensation mechanisms and payment for ecosystem services schemes (Hein *et al.* 2015). Ultimately, the integrated, comprehensive, and detailed information encompassed by the NCA can help reduce the uncertainty in policy decision making, the asymmetry between economic and environmental considerations and the tensions between different sectoral policies (Vardon *et al.* 2018; Guerry *et al.* 2015).

However, Virto, Weber, and Jeantil (2018) found that the actual use of NCA in real world policy and decision making is very limited. The European Commission supports the KIP-INCA initiative to promote the experimental natural capital accounting strategies (EC 2016; Badura *et al.* 2017), but policy applications of accounting results are still limited. According to Ruijs and van Egmond (2017) and Mckenzie *et al.* (2014), one of the main reasons for this is the lack of understanding on how NCA can inform the policy decision-making process, fueled by the lack of solid and fully developed accounts available for policy exploitation.

The lack of demand from policy decision makers may initially be best tackled at the local scale of ecosystems, basins, catchment areas, marine planning areas, provinces or urban agglomerates. At this granular level, the biophysical, economic and social changes can be easily perceived by local decision makers and adopting a consistent instrument to identify tradeoffs can promote policy demand for NCA. Ultimately, many environmental and natural resource policies are designed, implemented and monitored at local levels rather than centrally (Dalmazzone and La Notte 2013). Natural capital conditions, ecosystem services provision and valuation are highly context dependent (Fisher, Turner, and Morling 2009; Petersen and Gocheva 2015) so a broader uptake of NCA for informing land use and regional scale environmental and economic management decisions would be key. But the adoption of NCA at this level requires solid evidence stemming from coherent and robust methodologies. While it is the case that the low policy uptake of NCA can be generally attributed to structural, institutional, and political obstacles (Virto, Weber, and Jeantil 2018), three other intertwined elements particularly undermine the policy perception of credibility, robustness and trustworthiness of NCA applications at the local scale.

The first element relates to data limitations. The collection, arrangement and availability of data is key to evidence-based public policy (Head 2010). The compilation of national scale NCA benefits from the availability of data collected for other purposes (e.g. environmental indicators, sectoral input-output analysis, land use maps, etc.) and the higher level of aggregation needed (Hecht 2000). In the case of local level NCA, granular data are often unavailable or only sporadically collected. This limitation has direct effects on increasing the uncertainty of information and the failure to record and account for several elements of NCA (e.g. not including the whole set of services, not recording ecosystem conditions, etc.). The secondary data employed to circumvent this issue often require many assumptions to match specific local applications and to secure the transferability of data. In practice, this might result in information and the estimated values that do not reflect local ecosystem characteristics, and the nexus between environmental condition, services and values is lost.

Closely related to the previous point is the difference in valuation approaches used. The SEEA guidelines are clear in requiring that only exchange-type values are acceptable when compiling NCA in order to ensure integration with SNA. Much has been written about the use of exchange and welfare values for accounting purposes and discussions are ongoing (e.g. Obst, Hein, and Edens 2016; Turner, Badura, and Ferrini 2019a). What is important to consider here is the way exchange value can be applied when non-monetary transactions are involved at a local scale. The restriction over usable methods, the lack of clear guidelines for local level NCA and the discussed data limitations imply that a wide range of different valuation techniques and information is employed to account for the same services in different empirical applications. This fast track approach risks undermining a crucial element of NCA that is consideration of specific links between biophysical conditions and estimated monetary values, for example by using country-wide exchange values for local level ecosystem services. In contrast, the use of more sophisticated and case-sensitive methods which are coherent with NCA frameworks, such as the simulated exchange value approach would help to i) account for a wider set of values and services, therefore improving the local NCA quality, ii) better mirror local environmental conditions and characteristics, and iii) better capture local communities' connections to and preferences for environmental management.

Finally, the discussion so far has drawn attention to an important aspect of developing local level NCA, namely the scalability issue. NCA frameworks have been designed for application at a national level, the most notable example being the SEEA. It is more challenging to apply at the level of ecosystems, basins, catchment areas, marine planning areas, provinces or urban agglomerates (Hein *et al.* 2015). Nonetheless, consistency across geographical scales should be maintained to allow for integration with SNA. The use of fast track approaches does not help because they risk compromising the consistency of information and methods used, reducing the scalability and aggregation of locally developed NCA.

3. Materials and methods

The case study concerns a practical policy application within the context of the Marine Pioneer programme, a UK wide pilot project aimed at informing the delivery of the

Table 1. Ecosystem services and benefits to human wellbeing from saltmarsh areas.

Service group	Final ecosystem services	Benefits
Provisioning	Raw materials and food	Agricultural production (cattle and sheep) Wild food
Regulating	Climate regulation	Carbon sequestration
	Hazard regulation	Sea and flood defence
		Erosion control
	Waste breakdown	Immobilisation of pollutants
	Water purification	Surface water filtration
	Species diversity	Fish nursery grounds
		Birds' breeding, over-wintering, and feeding grounds
Cultural	Recreation and tourism	Walking, birdwatching, cycling, recreational fishing, sailing, etc.
	Cultural and spiritual	Sense of place, heritage sites, clocal cultural significance
	Education and knowledge	Formal and informal learning, research
	Aesthetic and inspirational	

Government's 25 Years Environmental Plan (Defra 2018). Among the other objectives, the programme called for empirical investigation of the suitability of using a natural capital approach. In particular, the present study makes use of observational data from a choice experiment (CE) developed to gather public preferences for the recreational use of the Deben Estuary saltmarsh in Suffolk, to feed into local environmental planning.

3.1. Study area: the Deben Estuary

The Deben Estuary is located on the Suffolk coast. It is an important ecosystem that supports approximately 40% of Suffolk's area of saltmarsh (Natural England 1991). As summarized in Table 1, several valuable benefits to humans in terms of ecosystems services are associated with saltmarsh areas. These include protection from storms and sea level rise, reduction of risks associated with flooding, sequestration and storage of carbon, provision of recreation opportunities and amenity benefits, and maintenance of biodiversity through provision of nutrients and critical habitat (Jones *et al.* 2011; Barbier *et al.* 2011).

Ecosystem services and benefits of particular relevance in the Deben Estuary saltmarsh are biodiversity maintenance and recreational benefits. Indeed, the area contains multiple environmental designations, is a sanctuary for wintering birds, and represents an attraction for locals and tourists, receiving approximately 160,000 visitors per year with a turnover of roughly £30 m per year. Due to the large area covered by the saltmarsh, carbon sequestration and storage and natural sea and flood defence can also be considered as highly relevant ecosystem services and benefits in the Deben. However, similar to other coastal and estuarine ecosystems, the Deben saltmarsh is currently under a number of anthropogenic and natural pressures causing ecosystem loss and degradation. The total saltmarsh area was estimated to be between 175 ha (JNCC 2016) and 230 ha (EA 2011). Earlier reports claimed that the Deben Estuary saltmarsh reduced in size by 22.8% between 1971 and 1998 (Cooper and Cooper 2000), with further losses in extent observed between 2000 and 2007 (Boyes and Thomson 2010). Coastal squeeze is considered to be the dominant threat to saltmarsh habitats within the Estuary, leading to increased rates of erosion along its seaward boundary and fragmentation of the marsh interior (Reid 2013). For this reason, several management options have been proposed from small-scale restorations to wider managed realignment schemes.

3.2. Fast track approaches

The objective of NCA use in local areas is to assess the contribution of ecosystem services to local economy and wellbeing and facilitate planning and restoration actions. Fast track approaches rely on secondary data availability to measure the main ecosystem services. In the case of the recreational value for coastal and marine ecosystems, secondary data feeding into fast track NCA approaches are commonly the number of visits and proxies of the costs of visiting coastal and marine sites for recreation purposes. Results are then usually reported in terms of value per visit or per hectare.

Considering only applications developed in the United Kingdom, several examples can be found. At the national level, the Office for National Statistics uses a simplified travel cost method (ONS 2016, 2019; Ricardo Energy and Environment 2016). The method estimates the monetary amount that a person is willing to spend to visit the natural environment (costs on travel, parking and admission), and derives an aggregate value for recreation services through the total number of visits. A slightly different version (Ricardo Energy and Environment 2016) includes an estimation of the value of time taken to travel to the natural environment. The method was originally devised for use on the Monitor of Engagement with the Natural Environment (MENE) Survey (Natural England 2019). Similarly, Thornton *et al.* (2019) estimate a travel cost function specifically for local coastal areas. This methodology is consistent with accounting principles as it draws on a market-based proxy; however the method underestimates and overlooks the crucial biophysical features of coastal areas. Moreover, if a fast track NCA was to be developed for the Deben Estuary, the use of these values would be suspect as they use national scale information and aggregate across different habitats. Another approach employed in accounting for recreational services provided by coastal and marine habitats is found in White *et al.* (2015) and Eftec (2015). The accounting values are derived from a meta-analysis developed by Sen *et al.* (2014). The same values are also employed in developing NCA for the national natural reserves (Sunderland *et al.* 2019). The aggregate value is calculated by using the number of visits to natural reserves. The method is also used for NCA of natural reserves by the Royal Society for the Protection of Birds (RSPB 2017). Whilst the methodology in Sen *et al.* (2014) is more robust than the simple travel cost approach, the figures obtained are welfare-type values therefore in principle not consistent with NCA. Moreover, as for the simple travel cost, the method aggregates different habitats types and diverse valuation information and therefore cannot capture specific features typical in local level applications.

Compilation of NCA at a local level for saltmarshes, and in general coastal and marine ecosystems, are scant. Clark (2017) tests the development of NCAs for selected natural reserves in England, including the Bure marshes in the East of England, by averaging admission fees charged in a small set of other managed reserves. In another application, the Environmental Agency (2018) reports the estimation of recreational benefits for the Oare Marshes. The accounting-type value employed is derived from the Multi-colored Handbook for economic appraisal (EA 2013).

Table 2. Attributes and levels of the choice experiment.

Attribute	Levels
Extent new saltmarsh created	10 ha, 30 ha, 50 ha, 70 ha
Number endangered bird species reaching safe limits	2 species, 3 species, 4 species, 5 species
Location new saltmarsh (distance from home)	Four levels between 10-80 miles depending on residence area
Access new saltmarsh	No, Yes
One-off council tax increase	£3, £6, £9, £12

Finally, it is worth noting that accounting methods for cultural and recreational services are subject to continuing improvement, with particular attention being paid to the need for consistency with NCA requirements and scalability at the local level, but further work is still required (Eftec, SQW, CEH, and ABPmer 2019).

3.3. Choice experiment and simulated exchange value

The approach we propose in this paper is based on observational data from a CE used to simulate an accounting consistent value for recreational services of the Deben estuary saltmarsh. The CE survey was administered online between January and March 2019 to a representative stratified sample of residents in the East of England (Essex, Suffolk, Norfolk, and Peterborough areas). The final sample consisted of 417 complete and usable questionnaires. The CE (Champ, Boyle, and Brown 2017; Bateman *et al.* 2003), which represented the bulk of the questionnaire, was developed specifically with the aim of testing the use of estimates within an NCA framework. Therefore, particular attention was devoted to the selection and definition of attributes and levels. In particular, the aim was to explicitly capture the linkage between changes in biophysical characteristics, direct use of the saltmarsh and valuation estimates. Attributes and levels used in the CE are summarized in Table 2.

The area of new saltmarsh and the number of bird species convey information on the condition of the saltmarsh and the provision of recreational services. The distance from respondents' residence area and the possibility to access the saltmarsh characterize the use of the services. The attribute related to bird species within safe population limits is used as a proxy for biodiversity levels and general health of the saltmarsh habitat. Birds tend to be at higher levels of the food chain (Gregory *et al.* 2005) especially in estuarine and coastal habitats such as saltmarshes where they represent, together with fish, the major groups of invertebrates (Boorman 2003). Therefore, birds are particularly sensitive to environmental and land use changes, providing a good indicator of general ecosystem quality and biodiversity (Fraixedas *et al.* 2020). Moreover, bird species richness and diversity are used in the literature on valuation and management of recreational ecosystem services because of the clear link with the welfare benefits they provide (e.g. Luisetti *et al.* 2011; Faccioli, Font, and Figuerola 2015; Boeri *et al.* 2020). Considering that birds' conservation is often instrumental to the protection of saltmarsh habitats (Foster *et al.* 2013) and that the Deben Estuary is a critical habitat for wintering and migratory species[1], birds' richness was judged to be an appropriate proxy for biodiversity and environmental quality.

A D-efficient Bayesian design (Ferrini and Scarpa 2007; Rose and Bliemer 2009) with sequential update of priors was used to select 24 choice situations. Each respondent was asked to make six repeated choices between two possible alternative saltmarsh restoration projects and a status quo. Data were analyzed with a Multinomial Logit model (MNL) (McFadden 1974; Hensher, Rose, and Greene 2005) and estimates subsequently used to derive simulated exchange values[2]. An example choice card and the results from the MNL model are reported in the Appendix.

The simulated exchange value (SEV) (Caparrós, Campos, and Montero 2003, Caparrós *et al.* 2017) represents a flexible and informative approach to derive account-consistent monetary estimates for non-marketed ecosystem services and can be particularly useful when applied at the local scale. The application of the SEV in this research consists of using demand functions estimated using the CE results to simulate the entire recreation market for the Deben Estuary saltmarsh (demand, supply and competitive environment), and an exchange-type value. In other words, an account-consistent price for the recreation ecosystem service is derived that would be realistically implemented if a market existed for recreation in the Deben Estuary saltmarsh. This is achieved considering that the CE ultimately estimates the probability that an individual n chooses the alternative i (Hensher, Rose, and Greene 2005), that is the probability that individual n is willing to pay a given amount of money for the provision of ecosystem services (in this case recreational service from saltmarsh) with given characteristics. For the MNL model this can be written as:

$$\mathrm{P}_{ni} = \frac{\mathrm{e}^{\beta x_{ni}}}{\sum_{\mathrm{i}} \mathrm{e}^{\beta x_{ni}}} \tag{1}$$

given the utility function:

$$\mathrm{U}_{ni} = \beta x_{ni} + \varepsilon_{ni} = \beta x_{ni} + \beta_p p_{ni} + \varepsilon_{ni} \tag{2}$$

where x_{ni} are the levels of attributes presented, p_{ni} the levels of payment vehicle, β and β_p the corresponding coefficients, and ε_{ni} the error term.

The MNL probability can be used to derive the demand function for the extent of saltmarsh at given price levels $a(p)$:

$$a(p) = \mathrm{A} \sum_j \frac{\mathrm{e}^{\hat{\beta} x_{nj}}}{\sum_{\mathrm{i}} \mathrm{e}^{\hat{\beta} x_{ni}}} \tag{3}$$

Therefore, $a(p)$ depends on the current extent of saltmarsh in the Deben Estuary A and the probability of choosing one of the alternatives proposed in the CE calculated using estimated coefficients $\hat{\beta}_x$.

Assuming that each individual faces the same price (which can be a realistic assumption considering that entrance fees are usually of fixed amount) and that the market is in perfect competition (a realistic assumption considering the relevant number of other saltmarshes with similar characteristics in the same area), the demand can be evaluated at the average value and/or current situation value of attribute levels $\bar{x}$. Equation (3) can be rearranged as:

$$\ln\left(\frac{\mathrm{a}}{\mathrm{m}(\mathrm{A} - \mathrm{a})}\right) = \hat{\beta}_{\mathrm{x}} \bar{x} + \hat{\beta}_p p \tag{4}$$

and the inverse demand function can be defined as:

$$P(a) = p = \frac{\ln\big(a/m(A-a)\big)}{\hat{\beta}_p} - \frac{\hat{\beta}_x\bar{x}}{\hat{\beta}_p} \quad (5)$$

where m is the number of alternatives offered to respondents in the choice cards.

With perfect competition, the saltmarsh extent and the corresponding price in equilibrium will implicitly be given by the intersection between the inverse demand curve in Equation (5) and the marginal cost of saltmarsh provision:

$$\frac{\ln\big(a/m(A-a)\big)}{\hat{\beta}_p} - \frac{\hat{\beta}_x\bar{x}}{\hat{\beta}_p} = c_1 + c_2 a \quad (6)$$

If the cost of provision is fixed per unit of saltmarsh, or marginal costs are negligible, or there is insufficient information to construct a reliable marginal cost curve, Equation (6) reduces to:

$$a^*(p) = A\sum\nolimits_{Alt}\left(\frac{e^{\hat{\beta}_x\bar{x}_{Alt}}}{\sum_i e^{\hat{\beta}_x\bar{x}_i}}\right) \quad (7)$$

where only the predicted probabilities of choosing one of the alternatives offering new saltmarsh provision are considered.

The SEV is, therefore, obtained by following sequential steps in the development and analysis of the CE. First, the choice of attributes and levels was informed by the linking of saltmarsh condition, provision of recreational services and subsequent valuation. After collecting CE observational data, appropriate models were employed (in this case MNL) to estimate the coefficients of each attribute (the $\hat{\beta}_x$ in Equations (3)–(7)). Based on the estimated coefficients, predicted choice probabilities were simulated for each alternative at different levels of the council tax increase while keeping fixed the values of other attributes to predefined (policy) scenarios. For example, in a policy scenario where the current extent of saltmarsh is preserved without additional improvements, attributes for newly created area and bird species were set to be zero whilst keeping the possibility to access the saltmarsh. This step allowed the simulation of the demand curve for saltmarsh area in the Deben. The same process was followed to identify the equilibrium quantity of saltmarsh for recreational use purposes in Equation (7). In this case, considering the assumption of zero marginal costs for providing additional saltmarsh area and the current situation where no increase in council tax is required, a single equilibrium quantity of the area demanded was determined and the corresponding SEV could be derived by substituting it into the demand function in Equation (6).

4. Results

4.1. Fast track approaches in the Deben estuary

In this Section, fast track approaches identified in Section 3.2 are used to derive accounting values for the Deben Estuary saltmarsh. To allow for increased comparability, only applications developed in the United Kingdom are considered in our fast track measurement of the Deben Estuary.

Starting with national scale applications, the simple travel cost approach found in ONS (2019, 2016) results in a value per visit estimated to be £1.60 in 2017, whilst the value in Thornton *et al.* (2019) is equal to £3.70 per visit to the marine environment. The meta-analysis function in Sen *et al.* (2014) is based on revealed and stated

Table 3. A comparison of applications on accounting for saltmarsh recreational value.

Application	Method	Scale	Value	Value Deben Estuary
ONS, 2016, 2019; Ricardo Energy and Environment 2016	Simple travel cost	National	1.60 £/visit	£256,000
Thornton *et al.* 2019	Simple travel cost	National	3.70 £/visit	£592,000
Sen *et al.* 2014 (White et al. 2015; Eftec 2015)	Meta-analysis	National	3.00 £/visit	£480,000
Sunderland *et al.* 2019 (from Sen *et al.* 2014)	Meta-analysis	National/ Local	329.00 £/ha	£49,350
Clark 2017	Entrance fees	Local	65.00 £/ha	£9,750
EA 2018	Avoided cost	Local	110.00 £/ha	£16,500

preferences studies and provides a value of roughly £3 per visit for recreation associated with coastal and marine habitats. This is used in Sunderland *et al.* (2019) to derive an accounting value for recreational services of national natural reserves, including coastal reserves, equal to £329 per hectare/year. In local level applications, the approach in Clark (2017) of averaging entrance fees data from other managed reserves results in a value of £3.40 per visit and an annual accounting recreational value of £65 per hectare for the East of England marshes. Finally, the estimation of recreational services from the Oare saltmarsh (EA 2013) equals to £110 per hectare.

Table 3 summarizes the recreational values found in fast track NCA applications and the annual value that would be obtained if those values were used for the Deben Estuary. Where values are per visit, an estimation of 160,000 annual recreational visits to the Deben is used in calculating the annual value; where values are expressed per hectare, a conservative estimate of 150 hectares of saltmarsh in the Deben is used.

It is clear from Table 3 that the variety of approaches used in valuing the recreational benefits of saltmarshes results in substantial variability in the values estimated across studies. This variability persists even across applications adopting the same valuation methodology. Moreover, the estimated values appear to be sensitive with respect to the number of visits and the extent of the saltmarsh; therefore propagating uncertainty if robust local information is lacking, as in the case of the Deben Estuary.

4.2. Simulated exchange value in the deben estuary

Figure 1 shows the simulated demand function and the equilibrium saltmarsh extent demanded in the Deben Estuary with the corresponding simulated value. The values obtained mirror the current situation of the Deben saltmarsh in the absence of restoration policies aimed at increasing its extent. In other words, Figure 1 is related to the base-case policy of maintaining and restoring the current extent of saltmarsh and can be viewed as a hold-the-line scenario. The simulated value of one marginal hectare of saltmarsh in the Deben Estuary is equal to £24.8. In equilibrium, the extent of saltmarsh demanded is 59.2 ha. Given the uncertainty of the current extent of saltmarsh in the Deben, these values are based on the assumption that the total hectares are 150. Moreover, the values obtained consider the possibility that the restored saltmarsh can be accessed, attempting to isolate the direct use value attached by respondents. The estimated value also explicitly considers the different distances between the saltmarsh and the location where respondents live.

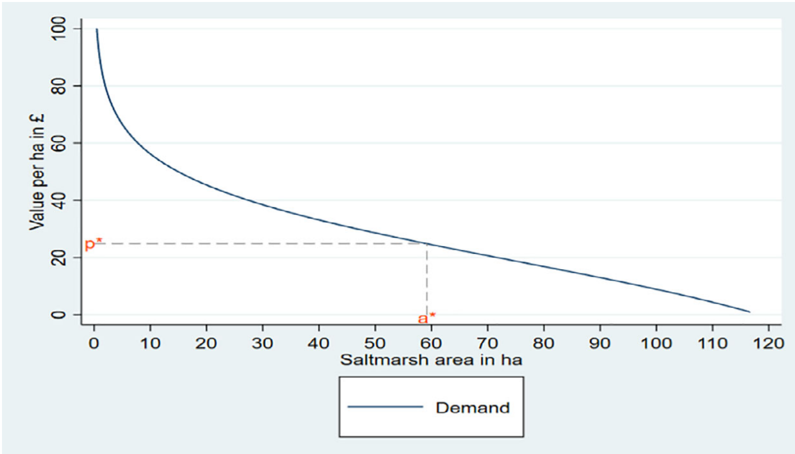

Figure 1. Simulated demand function and equilibrium values for the Deben Estuary saltmarsh.

An important point is related to the capacity of SEV to consider the specific biophysical characterization of the saltmarsh under scrutiny. In the base-case scenario presented, this characterization is defined by the accessibility, the distance, and the current extent. The flexibility of CEs, and the combined use of the SEV approach, allows the analysis to deepen the characterization of the linkage between biophysical characteristics and monetary values. At the same time, this explicitly considers different policy scenarios and how they impact the monetary values. The approach proposed can therefore capture local features linking ecosystem biophysical characteristics, monetary valuation and socio-demographic context. This integration is, ultimately, what NCA frameworks advocate and is lost when fast track approaches are employed.

To clarify this point further, two other possible policy scenarios are considered. The first relates to the implementation of a restoration project that would result in an increase of the saltmarsh area compared to current extent. This is summarized in Figure 2, where the SEV is estimated for three different restoration scenarios.

The simulated value of one marginal hectare of saltmarsh in the Deben Estuary under the policy decision to implement a more structured restoration action (e.g. a managed realignment or a beneficial use of dredged material) is equal to £26.0 if the policy target is to restore an additional 20 ha, £27.9 if 50 ha are restored, and to £31.8 if 100 ha are restored.

The second policy scenario relates to the protection of biodiversity in the Estuary. This case is particularly enlightening when comparing a fast track and a more structured approach in developing NCA at the local level. Indeed, in a fast track approach the monetary value of recreational use of saltmarsh (therefore, the account-consistent value for cultural services) cannot internalize the quality and condition of the ecosystem, in this case the level of biodiversity of the saltmarsh in the Deben, as the value employed would likely be transferred from the national level or other area accounts. A SEV approach allows this internalization, as shown in Figure 3. In this case, the scenario considers a policy action aimed at preserving the number of wintering birds in the Deben.

The simulated value of one marginal hectare of saltmarsh in the Deben Estuary under the policy decision to preserve biodiversity, in this case wintering bird species, is equal to £28.3 if the policy target is to protect three species and to £30.8 in case of

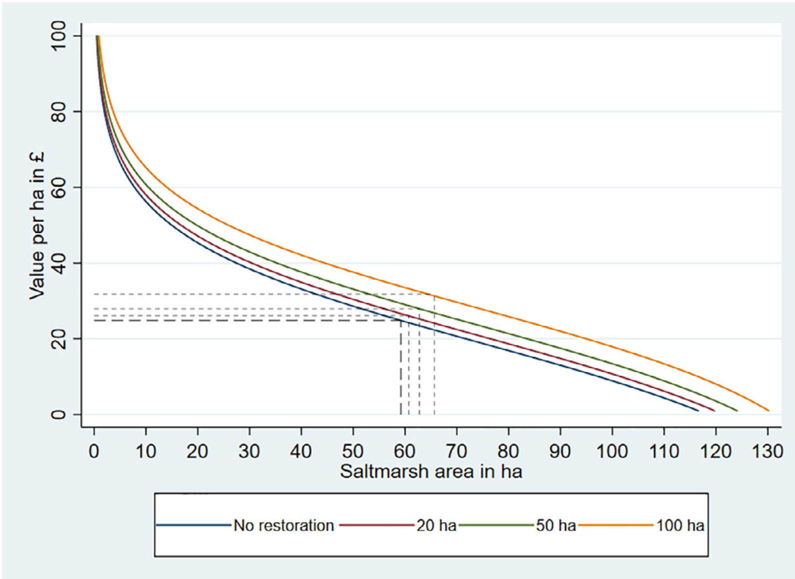

Figure 2. Simulated demand and equilibrium values for restoration scenarios.

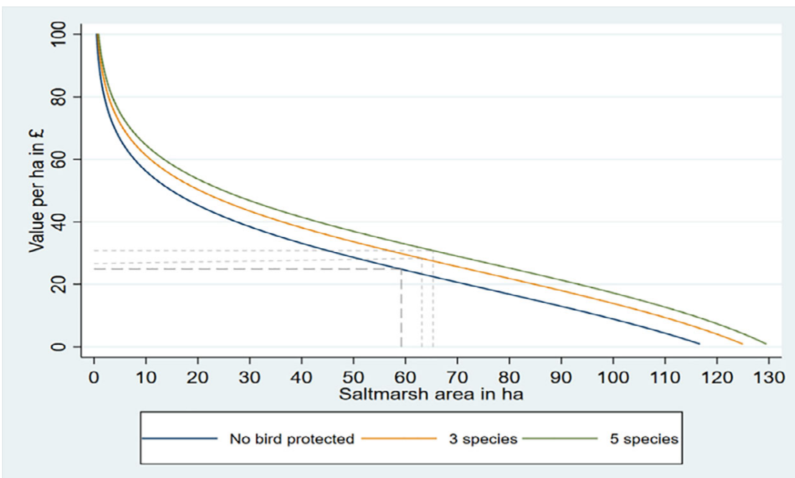

Figure 3. Simulated demand and equilibrium values for bird protection scenarios.

five species protected. Several other policy options and their combinations based on the attributes included in the CE could be assessed by using the same approach.

5. Policy implications, discussion and conclusions

This research aims to explore the use of a SEV approach to estimate ecosystem services values consistent with accounting frameworks, and its advantages over currently used approaches in the context of local level applications, with a particular focus on recreational benefits provided by saltmarshes. Results outlined in the previous section highlight how several different approaches are used in ecosystem services accounting. Some of the approaches, defined here as fast track, suffer from critical limitations when used in local level applications. Therefore, alternative and more targeted approaches such as the SEV can lead to an improvement in NCA development. Without considering the inherent complexity of valuing and accounting for recreational services (Fish *et al.* 2016; Barton *et al.* 2019), some considerations can be drawn more generally on the development of local-level NCAs. The main issue with currently used approaches relates to the inability to characterize the linkages between specific small-scale level ecosystem conditions, provision of ecosystem services and monetary valuation. In other words, the use of a top-down approach with averaged country wide figures for economic valuation and accounting, even when consistent with exchange value interpretations, does not represent a robust scaling down because it does not reflect local circumstances. This inevitably reflects on the robustness of NCAs and, in turn, on their credibility for use in decision making. A SEV approach overcomes this problem due to its capacity to include biophysical characteristics of the asset providing ecosystem services, thus directly conveying specific local ecosystem features into a valuation method coherent with exchange value interpretation. Moreover, expanding the suite of methodological approaches that is possible to use for NCA allows for the possibility to record a wider range of non-marketed ecosystem transactions, broadening the scope of NCA through improved precision and completeness.

This has several policy implications and advantages over fast track approaches, particularly at the local scale. Local land use planning can benefit from better and more comprehensive information contained in NCA, in order to inform the adoption of restoration and conservation policies by assessing the tradeoffs between environmental priorities and other socio-economic activities. For example, in the case of the Deben Estuary, it would be possible to compare the value attached to alternative management scenarios by considering tradeoffs between restoration of saltmarsh areas and loss of grazing or agricultural land. Also, it would be possible to assess tradeoffs between the specific attributes of a restoration policy, for example increasing the extent of saltmarsh versus preserving biodiversity of bird species. Moreover, estimates from the SEV are exchange values akin to and directly comparable with, for example, capital costs of implementing a restoration policy, revenues from agriculture, tourism expenditure, etc., thus allowing more structured cross-sectoral local policy decision making. In the context of local government NCA development, a relevant advantage of the SEV approach relates to internalizing ecosystem characteristics and conditions. In the case study presented in this research, the characteristics internalized are the level of biodiversity, the saltmarsh extent, the possibility to access the area and the spatial relationship with the wider region. The characteristics and conditions that can be internalized are varied and depend on the specific context. This has at least two main implications for local policy makers. Firstly, more targeted NCAs that encompass local circumstances and policy needs would inform policy makers in a more reliable, consistent and credible manner. Secondly, changes in ecosystem conditions could be promptly translated into monetary valuation and NCAs, allowing for more rapid policy response and fine-tuning.

A better-informed local policy through approaches such as the SEV can, in turn, foster environmental and social gains. In the case of the Deben Estuary, accounting-consistent measures of the value of recreational services which consider local specificities and can be directly compared with the costs of alternative management options, would serve as solid evidence for cost-benefit analyses and prospective funding models that are integral to the implementation of the Deben maintenance and restoration plan (Allam *et al.* 2015). This would primarily help to support the preservation of a habitat of high ecological value for endangered biodiversity, representing a substantial return to nature. Maintained or improved provision of ecosystem services crucial for the area, such as natural flood protection and recreational services, would ensure the sustained development of local economic activities (agriculture, marine industries, fisheries and tourism) while conserving the heritage and cultural value for the local population. A comprehensive assessment of the plural (monetary and non-monetary) values stemming from the sustainable management of the Deben saltmarsh, toward which the SEV would contribute, could be achieved using natural capital accounting approaches such as the Complementary Accounts Network (CAN, Turner, Badura, and Ferrini 2019b). A CAN-type approach, indeed, represents a flexible tool to address specific policy options which takes into account monetary as well as non-monetary values and accommodates diverse data and methods.

Other advantages of the SEV approach at the local level stem from the data collection process. Indeed, SEV makes efficient use of data from stated preference surveys expanding the set of information and values obtained, thus widening the available policy relevant evidence. Furthermore, the underlying stated preference study can be administered on targeted residents in the area who are the main beneficiaries of ecosystem services provision. The estimated values reflect local stakeholders' preferences and have the potential to reconcile service supply and use. Finally, the coherence of SEV-derived exchange values and the different geographical scales it can cover have implications for the scalability of NCAs, at least for some selected ecosystem services.

Whilst the SEV is considered more appropriate than fast track approaches in this case study and, in general, in situations where recreational services from open access ecosystems are examined, its application might be limited in other cases. The SEV is based on assumptions about the institutional market setting (e.g. perfect competition) that might be inappropriate when dealing with the provision of other ecosystem services. In our case, the assumption of a competitive setting in the provision of recreational services from saltmarshes is based on the existence of several, similar saltmarshes close to the Deben. This assumption might not be justifiable in other cases. Strictly related is the assumption on the marginal costs determining the shape of the supply curve. In many instances, including this case study, it can be reasonable to assume that the cost of providing the service is fixed and that marginal costs are negligible, for example when the ecosystem providing recreational services is open access with low or null management and maintenance costs. This assumption, again, might not hold for other services. In those cases, it might not be possible to simulate a supply curve. Also, ideally if the full set of ecosystems services management costs are known, the accounting tables could directly use those costs to proxy a market value. Finally, the quality of the underlying CE data is relevant for SEV, which could limit its generalized application in particular for ecosystem services with scientific uncertainty around links between biophysical condition of the asset and service provision.

In conclusion, this paper demonstrates that more spatially targeted approaches to valuation for ecosystem accounting at the local level present several advantages over currently used approaches for informing policy makers. Approaches able to consider specific local environmental features and conditions have the potential to make accounts more reliable and robust, with subsequent increased uptake from policy makers in real-world decisions. More research is needed to broaden simulated exchange value applicability within accounting frameworks, but the SEV offers a promising approach for bridging accounts at different scales and expanding the set of ecosystem values to be included in natural capital accounts.

Notes

1. The Deben Estuary contains a Special Protection Area (SPA), Sites of Special Scientific Interest (SSSI) (Deben Estuary, Ferry Cliff and Ramsholt Cliff) and a Ramsar site. The Deben Estuary SPA, SSSI and Ramsar designations have been assigned to protect a number of bird species, including, but not limited to, overwintering Avocet (*Recurvirostra avosetta*) and Dark-bellied Brent Geese (*Branta bernicla bernicla*), as well as other important migratory bird species that includes 8 species classified as endangered by the Wetland Bird Survey (i.e. have a Birds of Conservation Concern status of amber or red, primarily due to historic declines in population numbers) (Mason, Excell, and Meyer 2013).
2. The analysis was performed using R software (R Core Team 2020) and the R package *apollo* (Hess and Palma 2019b).

Disclosure statement

No potential conflict of interest was reported by the authors.

ORCID

Silvia Ferrini http://orcid.org/0000-0003-1861-5604

References

Allam, S., T. Astley-Reid, C. Block, G. Henderson, A. Judge, S. Read, K. Thomas, M. Thomas, R. Whittle, and P. Youngs. 2015. *The Deben Estuary Plan: April 2015*. Woodbridge, Suffolk: Deben Estuary Partnership.

Australian Bureau of Statistics. 2017. *Experimental Environmental-Economic Accounts for the Great Barrier Reef*. Australian Bureau of Statistics Cat. No. 4680.0.55.001. Canberra, Australia: ABS.

Badura, T., S. Ferrini, M. Agarwala, and K. Turner. 2017. *Valuation for Natural Capital and Ecosystem Accounting. Synthesis Report for the European Commission*. Norwich: Centre for Social and Economic Research on the Global Environment, University of East Anglia.

Barbier, E. B. 2019. "The Concept of Natural Capital." *Oxford Review of Economic Policy* 35 (1): 14–36. doi:10.1093/oxrep/gry028.

Barbier, E., S. Hacker, C. Kennedy, E. Koch, A. Stier, and B. Silliman. 2011. "The Value of Estuarine and Coastal Ecosystem Services." Ecological Monographs 81 (2): 169–193. doi:10.1890/10-1510.1.

Barton, DN., C. Obst, B. Day, A. Caparrós, P. Dadvand, E. Fenichel, I. Havinga, et al. 2019. "Discussion Paper 10: Recreation Services from Ecosystems." Paper submitted to the Expert Meeting on Advancing the Measurement of Ecosystem Services for Ecosystem Accounting, New York, January 22–24 and subsequently revised. Version of 25 March 2019.

Bateman, I. J., R. T. Carson, B. Day, W. M. Hanemann, N. Hanley, T. Hett, M. J. Lee., *et al.* 2003., *Economic Valuation with Stated Preference Techniques: A Manual*. Cheltenham: Edward Elgar.

Boeri, M., T. A. Stojanovic, L. J. Wright, N. H. K. Burton, N. Hockley, and R. B. Bradbury. 2020. "Public Preferences for Multiple Dimensions of Bird Biodiversity at the Coast: Insights for the Cultural Ecosystem Services Framework." *Estuarine, Coastal and Shelf Science* 235: 106571. doi:10.1016/j.ecss.2019.106571.

Boorman, L. A. 2003. *Saltmarsh Review. An Overview of Coastal Saltmarshes, Their Dynamic and Sensitivity Characteristics for Conservation and Management*. JNCC Report, No. 334. Peterborough: JNCC.

Boyes, S., and S. Thomson. 2010. *Suffolk Estuarine SSSIs – Assessment of Changes in Extent of Saltmarsh over the Period 1999/2000 to 2006/2007*. Volumes I & II. Report YBB155-F2010. Prepared for Natural England. UK: Institute of Estuarine and Coastal Studies, University of Hull.

Caparrós, A., P. Campos, and G. Montero. 2003. "An Operative Framework for Total Hicksian Income Measurement: Application to a Multiple Use Forest." *Environmental and Resource Economics* 26 (2): 173–198. doi:10.1023/A:1026306832349.

Caparrós, A., J. L. Oviedo, A. Alvarez, and P. Campos. 2017. "Simulated Exchange Values and Ecosystem Accounting: Theory and Application to Free Access Recreation." *Ecological Economics* 139: 140–149. doi:10.1016/j.ecolecon.2017.04.011.

Champ, P. A., K. J. Boyle, and T. C. Brown. 2017. *A Primer on Nonmarket Valuation*. 2nd ed. Dordrecht: Springer.

Clark, R. 2017. *Is Corporate Natural Capital Accounting Appropriate for Monitoring Nature Reserves? An assessment for National Nature Reserves managed by Natural England*. Natural England Research Reports, Number 072. York, UK: Natural England.

Cooper, N., and T. Cooper. 2000. *Saltmarsh Change within the Suffolk Estuaries between 1971, 1986 and 1998*. Report to the Environment Agency Anglian Region. Peterborough, UK: Environmental Agency.

Dalmazzone, S., and A. La Notte. 2013. "Multi-Scale Environmental Accounting: Methodological Lessons from the Application of NAMEA at Sub-National Levels." *Journal of Environmental Management* 130: 405–416. doi:10.1016/j.jenvman.2013.09.008.

Department for Environment, Food & Rural Affairs. 2018. *A Green Future: Our 25 Year Plan to Improve the Environment*. London, UK: Defra.

Dvarskas, A. 2019. "Experimental Ecosystem Accounting for Coastal and Marine Areas: A Pilot Application of the SEEA-EEA in Long Island Coastal Bays." *Marine Policy* 100: 141–151. doi:10.1016/j.marpol.2018.11.017.

Edens, B., and L. Hein. 2013. "Towards a Consistent Approach for Ecosystem Accounting." *Ecological Economics* 90: 41–52. doi:10.1016/j.ecolecon.2013.03.003.

Eftec, SQW, CEH, ABPmer. 2019. *The Ecosystem Contribution to Tourism and Outdoor Leisure*. Report prepared for the Department for Environment, Food and Rural Affairs. London, UK: Eftec.

Eftec. 2015. *Developing UK Natural Capital Accounts: Marine Scoping Study*. Report prepared for the Department for Environment, Food and Rural Affairs. London, UK: Eftec.

Environment Agency. 2011. *The Extent of Saltmarsh in England and Wales: 2006–2009*. Bristol, UK: Environmental Agency.

Environmental Agency. 2013. *The Multi-Coloured Manual. Flood and Coastal Erosion Risk Management – A Manual for Economic Appraisal*. London, UK: Routledge.

Environmental Agency. 2018. *Medway Estuary and Swale Flood and Erosion Management Strategy*. Bristol, UK: Environmental Agency.

European Commission, Food and Agricultural Organization of the United Nations, Organisation for Economic Co-operation and Development. 2014. *SEEA Applications and Extensions. White Cover Version*. New York: United Nations.

European Commission. 2016. *Report on Phase 1 of the Knowledge Innovation Project on an Integrated System of Natural Capital and Ecosystem Services Accounting in the EU*. Copenhagen, Denmark: European Environmental Agency.

Faccioli, M., A. R. Font, and C. M. T. Figuerola. 2015. "Valuing the Recreational Benefits of Wetland Adaptation to Climate Change: A Trade-off between Species' Abundance and Diversity." *Environmental Management* 55 (3): 550–563. doi:10.1007/s00267-014-0407-7.

Ferrini, S., and R. Scarpa. 2007. "Designs with a-Priori Information for Nonmarket Valuation with Choice-Experiments: A Monte Carlo Study." *Journal of Environmental Economics and Management* 53 (3): 342–363. doi:10.1016/j.jeem.2006.10.007.

Fish, R., A. Church, C. Willis, M. Winter, J. A. Tratalos, R. Haines-Young, and M. Potschin. 2016. "Making Space for Cultural Ecosystem Services: Insights from a Study of the UK Nature Improvement Initiative." *Ecosystem Services* 21: 329–343. doi:10.1016/j.ecoser.2016.09.017.

Fisher, B., R. K. Turner, and P. Morling. 2009. "Defining and Classifying Ecosystem Services for Decision Making." *Ecological Economics* 68 (3): 643–653. doi:10.1016/j.ecolecon.2008.09.014.

Foster, N. M., M. D. Hudson, S. Bray, and R. J. Nicholls. 2013. “Intertidal Mudflat and Saltmarsh Conservation and Sustainable Use in the UK: A Review.” *Journal of Environmental Management* 126: 96–104. doi:10.1016/j.jenvman.2013.04.015.
Fraixedas, S., A. Lindén, M. Piha, M. Cabeza, R. Gregory, and A. Lehikoinen. 2020. “A State-of-the-Art Review on Birds as Indicators of Biodiversity: Advances, Challenges, and Future Directions.” *Ecological Indicators* 118: 106728. doi:10.1016/j.ecolind.2020.106728.
Gregory, R. D., A. van Strien, P. Vorisek, A. W. Gmelig Meyling, D. G. Noble, R. P. B. Foppen, and D. W. Gibbons. 2005. “Developing Indicators for European Birds.” *Philosophical Transactions of the Royal Society B* 360 (1454): 269–288. doi:10.1098/rstb.2004.1602..
Guerry, A. D., S. Polasky, J. Lubchenco, R. Chaplin-Kramer, G. C. Daily, R. Griffin, M. Ruckelshaus., *et al.* 2015. “Natural Capital and Ecosystem Services Informing Decisions: From Promise to Practice.” *Proceedings of the National Academy of Sciences of the United States of America* 112 (24): 7348–7355. doi:10.1073/pnas.1503751112.
Head, B. W. 2010. “Reconsidering Evidence-Based Policy: Key Issues and Challenges.” *Policy and Society* 29 (2): 77–94. doi:10.1016/j.polsoc.2010.03.001.
Hecht, J. E. 2000. *Lessons Learned from Environmental Accounting: Findings from Nine Case Studies*. Washington, DC: The International Union for Conservation of Nature (IUCN)/The World Conservation Union.
Hein, L., C. Obst, B. Edens, and R. P. Remme. 2015. “Progress and Challenges in the Development of Ecosystem Accounting as a Tool to Analyse Ecosystem Capital.” *Current Opinion in Environmental Sustainability* 14: 86–92. doi:10.1016/j.cosust.2015.04.002.
Hensher, D. A., J. M. Rose, and W. H. Greene. 2005. *Applied Choice Analysis: A Primer*. Cambridge: Cambridge University Press.
Hess, S., and D. Palma. 2019a. “Apollo: A Flexible, Powerful and Customisable Freeware Package for Choice Model Estimation and Application.” *Journal of Choice Modelling* 32: 100170. doi:10.1016/j.jocm.2019.100170.
Hess, S., and D. Palma. 2019b. “Apollo version 0.0.7.” www.ApolloChoiceModelling.com.
Joint Nature Conservation Committee. 2016. *Natura 2000 Standard Data Form – Deben Estuary*.
Jones, L., S. Angus, A. Cooper, P. Doody, M. Everard, A. Garbutt, P. Gilchrist., *et al.* 2011. “Coastal Margins.” In *The UK National Ecosystem Assessment Technical Report*. Cambridge: UK National Ecosystem Assessment, UNEP-WCMC.
Luisetti, T., R. K. Turner, I. J. Bateman, S. Morse-Jones, C. Adams, and L. Fonseca. 2011. “Coastal and Marine Ecosystem Services Valuation for Policy and Management: Managed Realignment Case Studies in England.” *Ocean & Coastal Management* 54 (3): 212–224. doi:10.1016/j.ocecoaman.2010.11.003.
Mace, G. M. 2019. “The Ecology of Natural Capital Accounting.” *Oxford Review of Economic Policy* 35 (1): 54–67. doi:10.1093/oxrep/gry023.
Mäler, K. G., S. Aniyar, and A. Jansson. 2008. “Accounting for Ecosystem Services as a Way to Understand the Requirements for Sustainable Development.” *Proceedings of the National Academy of Sciences of the United States of America* 105 (28): 9501–9506. doi:10.1073/pnas.0708856105.
Mason, N., A. Excell, and J. Meyer. 2013. *The Deben Estuary and Its Hinterland: Evaluation of Key Areas for Birds, Issues and Opportunities for Enhancement*. Ashbocking, UK: Suffolk Wildlife Trust.
McFadden, D. 1974. “Conditional Logit Analysis of Qualitative Choice Analysis.” In *Frontiers in Econometrics*, edited by P. Zarembka, 105–142. New York: Academic Press.
Mckenzie, E., S. Posner, P. Tillmann, J. R. Bernhardt, K. Howard, and A. Rosenthal. 2014. “Understanding the Use of Ecosystem Service Knowledge in Decision Making: Lessons from International Experiences of Spatial Planning.” *Environment and Planning C: Government and Policy* 32 (2): 320–340. doi:10.1068/c12292j.
Millennium Ecosystem Assessment. 2005. *Ecosystems and Human Well-Being: General Synthesis*. Washington, DC: Island Press.
Milligan, B., E. Terama, R. Jiménez–Aybar, and P. Ekins. 2014. *GLOBE Natural Capital Accounting Study*. London: GLOBE International and University College London.
Natural Capital Coalition. 2016. *Natural Capital Protocol*. https://naturalcapitalcoalition.org/natural-capital-protocol.
Natural Capital Committee. 2019. *Natural Capital Terminology*. London, UK: Defra.

Natural England. 1991. *Deben Estuary Site of Special Scientific Interest (SSSI) Citation*. York, UK: Natural England. https://designatedsites.naturalengland.org.uk/PDFsForWeb/Citation/1006262.pdf.
Natural England. 2019. *Monitor of Engagement with the Natural Environment: Headline Report and Technical Reports 2018 to 2019*. York, UK: Natural England.
Obst, C. G. 2015. "Reflections on Natural Capital Accounting at the National Level: Advances in the System of Environmental-Economic Accounting." *Sustainability Accounting, Management and Policy Journal* 6 (3), 315–339. doi:10.1108/SAMPJ-04-2014-0020.
Obst, C., L. Hein, and B. Edens. 2016. "National Accounting and the Valuation of Ecosystem Assets and Their Services." *Environmental and Resource Economics* 64 (1): 1–23. doi:10.1007/s10640-015-9921-1.
Obst, C., and M. Vardon. 2014. "Recording Environmental Assets in the National Accounts." *Oxford Review of Economic Policy* 30 (1): 126–144. doi:10.1093/oxrep/gru003.
Obst, C., and M. Vardon. 2017. "Recording Environmental Assets in the National Accounts and the Australian Experience." In *National Wealth: What is Missing, Why It Matters*, edited by K. Hamilton and C. Hepburn, 223–245. Oxford: Oxford University Press.
Office for National Statistics. 2016. *Scoping UK Coastal Margin Ecosystem Accounts*. Newport, UK: ONS.
Office for National Statistics. 2019. *UK Natural Capital Accounts 2019*. Newport, UK: ONS.
Petersen, J. E., and K. Gocheva. 2015. *EU Reference Document on Natural Capital Accounting*. Prepared as Part of the European Union Mapping and Assessment of Ecosystems and Their Services (MAES) Process. Accessed June 2020. http://projects.eionet.europa.eu/ecosystemcapital-accounting/library/referencedocument-natural-capital-accounting/final-revisedreferencedocument-nca-consultation-january-2015.
R Core Team. 2020. *R: A Language and Environment for Statistical Computing*. Vienna, Austria: R Foundation for Statistical Computing. https://www.R-project.org/.
Reid, C. 2013. *Possible Causes of Saltmarsh Erosion with Reference to the Deben Estuary*. Prepared for the River Deben Association and the Deben Estuary Partnership. Woodbridge, UK: River Deben Association.
Ricardo Energy and Environment. 2016. *Reviewing Cultural Services Valuation Methodology for Inclusion in Aggregate UK Natural Capital Estimates*. Report Prepared for the Office for National Statistics. Newport, UK: ONS.
Rose, J. M., and M. C. J. Bliemer. 2009. "Constructing Efficient Stated Choice Designs." *Transport Reviews* 29 (5): 587–617. doi:10.1080/01441640902827623.
Royal Society for the Protection of Birds. 2017. *Accounting for Nature: A Natural Capital account of the RSPB's Estate in England*. Sandy, UK: the RSPB.
Ruijs, A., and P. van Egmond. 2017. "Natural Capital in Practice: How to Include Its Value in Dutch Decision-Making Processes." *Ecosystem Services* 25: 106–116. doi:10.1016/j.ecoser.2017.03.025.
Schaefer, M., E. Goldman, A. M. Bartuska, A. Sutton-Grier, and J. Lubchenco. 2015. "Nature as Capital: Advancing and Incorporating Ecosystem Services in United States Federal Policies and Programs." *Proceedings of the National Academy of Sciences of the United States of America* 112 (24): 7383–7389. doi:10.1073/pnas.1420500112.
Sen, A., A. R. Harwood, I. J. Bateman, P. Munday, A. Crowe, L. Brander, J. Raychaudhuri, A. A. Lovett, J. Foden, and A. Provins. 2014. "Economic Assessment of the Recreational Value of Ecosystems: Methodological Development and National and Local Application." *Environmental and Resource Economics* 57 (2): 233–249. doi:10.1007/s10640-013-9666-7.
Smith, R. 2014. *Users and Uses of Environmental Accounts: A Review of Select Developed Countries*. Washington, DC: World Bank.
Sunderland, T., R. D. Waters, D. V. K. Marsh, C. Hudson, and J. Lusardi. 2019. *Accounting for National Nature Reserves: A Natural Capital Account of the National Nature Reserves Managed by Natural England*. Natural England Research Report, Number 078. York, UK: Natural England.
TEEB. 2010. *The Economics of Ecosystems and Biodiversity: Mainstreaming the Economics of Nature: A Synthesis of the Approach, Conclusions and Recommendations of TEEB*. Bonn, Germany: The Economics of Ecosystems and Biodiversity.
Thornton, A., T. Luisetti, G. Grilli, D. Donovan, R. Phillips, and J. Hawker. 2019. *Initial Natural Capital Accounts for the UK Marine and Coastal Environment*. Final Report.

Report prepared for the Department for Environment Food and Rural Affairs. London, UK: Defra.

Turner, K., T. Badura, and S. Ferrini. 2019a. *Valuation, Natural Capital Accounting and Decision Support Systems: Process, Tools and Methods*. Norwich: CSERGE, University of East Anglia.

Turner, K., T. Badura, and S. Ferrini. 2019b. "Natural Capital Accounting Perspectives: A Pragmatic Way Forward." *Ecosystem Health and Sustainability* 5 (1): 237–241. doi:10.1080/20964129.2019.1682470.

UK National Ecosystem Assessment. 2011. *The UK National Ecosystem Assessment: Technical Report*. Cambridge: UNEP-WCMC.

UK National Ecosystem Assessment. 2014. *The UK National Ecosystem Assessment: Synthesis of the Key Findings*. UK: UNEP-WCMC, LWEC.

UN (United Nations), European Community, International Monetary Fund, Organisation for Economic Co-operation and Development, World Bank. 2014b. *System of Environmental-Economic Accounting Experimental Ecosystem Accounting*. New York: United Nations.

United Nations, European Community, Food and Agriculture Organization, International Monetary Fund, Organisation for Economic Co-operation and Development, World Bank. 2014a. *System of Environmental-Economic Accounting Central Framework*. New York: United Nations.

Vardon, M., S. Bass, S. Ahlroth, and A. Ruijs. 2017. *Better Policy through Natural Capital Accounting: Taking Stock and Moving Forward*. Washington, DC: World Bank WAVES.

Vardon, M., P. Burnett, and S. Dovers. 2016. "The Accounting Push and the Policy Pull: Balancing Environment and Economic Decisions." *Ecological Economics* 124: 145–152. doi:10.1016/j.ecolecon.2016.01.021.

Vardon, M., J. P. Castaneda, M. Nagy, and S. Schenau. 2018. "How the System of Environmental-Economic Accounting Can Improve Environmental Information Systems and Data Quality for Decision Making." *Environmental Science & Policy* 89: 83–92. doi:10.1016/j.envsci.2018.07.007.

Virto, L. R., J. L. Weber, and M. Jeantil. 2018. "Natural Capital Accounts and Public Policy Decisions: Findings from a Survey." *Ecological Economics* 144: 244–259. doi:10.1016/j.ecolecon.2017.08.011.

White, C., R. Dunscombe, A. Dvarskas, C. Eves, J. Finisdore, E. Kieboom, I. Maclean, C. Obst, P. Rowcroft, and P. Silcock. 2015. *Developing Ecosystem Accounts for Protected Areas in England and Scotland: Main Report*. Department for Food, Environment & Rural Affairs/The Scottish Government. London, UK: Defra.

Appendix

Figure A.1 shows an example choice card presented to respondents in the choice experiment survey.

The Table A.1 summarizes the results from the MNL model that are used in the SEV approach.

	Option A	Option B	Option C
Area of new saltmarsh	25 acres (17 football pitches)	74 acres (49 football pitches)	No new saltmarshes
Number of protected bird species observable	3	4	No change
Distance from where you live	20 miles	40 miles	N/A
Public access to new saltmarsh	No Public Access	Public Access permitted	N/A
One off increase in council tax	£6	£12	No cost
Which would you choose?	◯	◯	◯

Figure A.1. Example choice card used in the choice experiment.

Table A.1. Choice experiment results.

Attribute	Coefficient	Std Err
Status Quo ASC	−0.276	0.223
Area	0.006*	0.001
Bird species - three	0.129*	0.080
Bird species - four	0.320*	0.088
Bird species - five	0.417*	0.089
Distance	−0.005*	0.002
Public access	0.838*	0.061
Council tax	−0.079*	0.009
N	417	
Log-Likelihood	−2528.17	