Local Natural Capital Accounting: does it deliver useful management information?

A case study of Dartmoor and Exmoor National Parks

EXTENDED SUMMARY

November 2019

Report to Exmoor National Park Authority and Dartmoor National Park Authority

Michela Faccioli
Sara Zonneveld
Charles Tyler
Brett Day

This is an extended summary of the report titled "Local Natural Capital Accounting: does it deliver useful management information? A case study of Dartmoor and Exmoor National Parks".

Acknowledgements:

The research in this report was funded by the Natural Environment Research Council (NERC) through the SWEEP project [grant number NE/P011217/1].

Introduction

The 25 Year Environment Plan represents an important step towards placing the protection of Natural Capital at the top of the political agenda. Natural Capital (or natural assets) - the habitats and ecosystems that underpin our natural environment - provide a wide variety of ecosystem goods and services (e.g. clean air and water, food and timber, recreation opportunities) that people appreciate. In most cases, though, the benefits provided by nature are 'invisible' and are not adequately accounted for in decision-making processes, which leads, for example, to environmental degradation. Many environmental goods and services are 'invisible' mostly because they don't have a given price. This way, natural resources are assumed to be exploitable at no or little cost, where in fact depleting the environment has a wider social cost and preserving nature generates social welfare benefits that have an economic value.

Natural Capital Accounting can be used as a tool to make the costs of environmental degradation and the benefits of environmental protection visible. Natural Capital Accounts record changes in the extent and condition of natural assets over time, measure the resulting variation in the flow of ecosystem goods and services provided and, through economic valuation techniques, allow the quantification of the costs and benefits of such changes in service flows. These costs and benefits are frequently measured in monetary terms to consider a common metric that policy-makers can use to compare the costs and benefits of environmental degradation and conservation with other types of costs and benefits.

Within the field of natural capital accounting, most efforts to date have focused on the development of *national* accounts. Only recently, the Natural Capital Committee has emphasised the need for more efforts into developing natural capital accounting *at organisational* scale – at the level of businesses, NGOs or governmental departments, i.e. those who own and/or manage land on a more local or regional scale. The role of such businesses and organisations is crucial for the successful preservation of the natural environment and the delivery of ecosystem goods and services. This is particularly true in the case of environmentally-facing organisations, such as National Park Authorities.

Natural Capital accounting at organisational level can fulfil many purposes. For example, it can *"document an organisation's ownership, liability and assets related to natural capital"* (EFTEC 2015)[1] and it can help in balancing competing priorities and identifying opportunities to enhance ecosystem functioning. It can also help in promoting awareness about the importance of Natural Capital and the interdependencies between the environment and people. It can be useful to identify trade-offs between different land uses and/or ecosystem services and be employed to provide evidence about the importance and value of given natural assets or ecosystem services to influence legislative and funding decisions.

[1] Eftec (2015). Developing Corporate Natural Capital Accounts. Final Report for the Natural Capital Committee. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/516968/ncc-research-cnca-final-report.pdf

Whilst being increasingly encouraged to produce Natural Capital Accounts, many organisations often struggle with the task. They frequently lack the data, expertise and/or resources to comprehensively monitor all their Natural Capital, identify the ecosystem goods and services, and quantify the wider benefits in economic terms, which can make the development of Natural Capital Accounts challenging.

Several organisations have attempted the development of Natural Capital Accounts at a local and/or regional scale. In the absence of any clear methodological guidance and in-house expertise, those efforts have sought to adapt methods of Natural Capital accounting developed for application in international and national accounting exercises. One concerns is that such methods may not necessarily be appropriate or suitable for accounting at the local or organisational scale.

In this report we critically assess the advantages and disadvantages (potential limitations) of the currently used methodologies in natural capital accounting at a local, organisational scale. To this aim, we review recent efforts, scoping and pilot case studies of Natural Capital Accounts developed with or for UK organisations which are heavily involved in the conservation or management of the environment. We replicate their approaches to produce Natural Capital accounts for two National Park Authorities. We also test the sensitivity of the accounts to the use of different data sources and methodologies, and explore potential ways in which organisations can incorporate additional data and expertise to improve the overall accuracy and usefulness of the accounts. For this project, which is part of the NERC-funded programme SWEEP (South West Partnership for Environmental and Economic Prosperity), we focused on Dartmoor and Exmoor National Parks as our case study areas.

Natural Capital Accounting explained

Natural Capital accounting represents a much-needed addition to the System of National Accounts (SNA), as it provides a more complete picture of the economic wealth of a nation by including the value generated by the environment to people.

The framework underlying Natural Capital Accounting is based on the Natural Capital approach (Figure 1) - a way of thinking about nature as a production system that provides humans with flows of valuable goods and services.

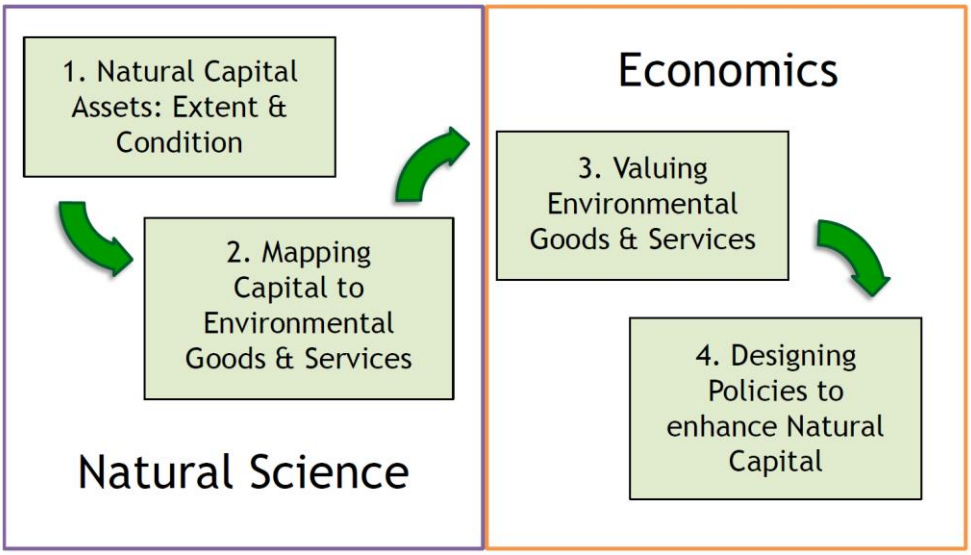


Figure 1. The steps of the Natural Capital approach

The first step in the Natural Capital approach involves establishing the extent and condition of Natural Capital assets or stocks. The second step focuses on mapping the pathways through which Natural Capital provides flows of ecosystem goods and services. The next step in the approach is to apply methods developed by economists to establish the economic value of those flows (step 3). The last step in the Natural Capital approach consists of using the information from step 1 to 3 to inform decision-making, e.g. to design policies and management practices to enhance Natural Capital and maximise the delivery of Ecosystem Goods and Services.

Natural Capital Accounting uses the steps outlined above to produce a structured account to record information about the stocks, Ecosystem Goods and Services, and their monetary value for a given area of interest (such as the area of land managed by an environmental organisation). Currently, practitioners producing Natural Capital Accounts typically rely on the use of readily available datasets to measure natural assets (e.g. land cover maps) and ecosystem services (e.g. ecological literature on Carbon storage by habitat type). Once goods and services are quantified, this information is generally multiplied by per unit values (based on a range of valuation figures and approaches available from the literature) to compute the total economic value. More information on the principles underlying Natural Capital Accounting and the economic techniques used to value Ecosystem Goods and Services, can be found in the full report.

Methodology

The methodology followed to produce Natural Capital accounts for Dartmoor and Exmoor national Parks is based on a review of a selection of publicly available Natural Capital accounting scoping studies/reports and of ecological and environmental economics literature, supplemented with information collected from consultations with management and technical staff from both National Parks.

After identifying Dartmoor and Exmoor National Park Authorities' aspirations regarding the use of Natural Capital Accounts to inform their decision-making, we reviewed the methodologies adopted by the selected (scoping) studies and replicated them to build Natural Capital Accounts for the year 2015 for the full National Park area. The following reports were used to review current practices in natural capital accounting at local and/or organisational scale:

- White, C., Dunscombe, R., Dvarskas, A., Eves, C., Finisdore, J., Kieboom, E., Maclean, I., Obst, C., Rowcroft, P. & Silcock, P. (2015), '**Developing ecosystem accounts for protected areas in England and Scotland'**, Department for Food, Environment & Rural Affairs/The Scottish Government
- RSPB (2017). **Accounting for Nature: A Natural Capital Account of the RSPB's estate in England**
- Rouquette, J.R. (2016). **Mapping Natural Capital and Ecosystem Services in the Nene Valley.** Report for the Nene Valley NIA Project.
- Cryle, P., Krisht, S., Tinch, R., Provins, A., Dickie, I., Fairhead, A. (2015**). Developing UK natural capital accounts: woodland ecosystem accounts.** Economics for the Environment Consultancy Ltd (Eftec) in association with Cascade Consulting for the Department for Environment, Food and Rural Affairs (Defra)
- Office for National Statistics scoping studies:
    - Jones, L., Vieno, M., Morton, D., Cryle, P., Holland, M., Carnell, E., Nemitz, E., Hall, J., Beck, R., Reis, S., Pritchard, N., Hayes, F., Mills, G., Koshy, A., Dickie, I. (2017). **Developing Estimates for the Valuation of Air Pollution Removal in Ecosystem Accounts.** Final report for Office of National Statistics, July 2017
    - Richard Smithers, Outi Korkeala, Guy Whiteley, Shaun Brace, Bex Holmes (2016). **Valuing flood-regulation services for inclusion in the UK ecosystem accounts.** Ricardo Energy & Environment for the UK Office for National Statistics
    - Office for National Statistics (ONS) (2016) **Scoping the UK coastal margin ecosystem accounts**

We closely replicated the reviewed approaches to Natural Capital accounting (or the closest approximation possible) when measuring the extent of the various Natural Capital assets (using Land Cover Map data, adapted for DNPA – see full report for details), the amount of Ecosystem Good and Service flows and their value. We next tested and discussed the sensitivity of the account results to different assumptions available from the reviewed studies regarding quantifications of the natural assets, flows of ecosystem services and goods and values. In this process, we also highlighted limitations of the reviewed and replicated methodologies, and suggest potential ways to improve the accounts. We concluded by

critically discussing the usefulness of Natural Capital Accounts to meet management aspirations and inform decisions, by referring to the consultations held with and feedback received from National Park Authority staff at the various stages of the project.

Results and discussion

NATURAL CAPITAL ACCOUNTS FOR DARTMOOR AND EXMOOR

Through replicating the methodologies that practitioners have employed in the reviewed Natural Capital Accounts, we drafted a Natural Capital flow account for the year 2015 for Dartmoor and Exmoor National Parks. In Table 2 and 3, benefits are reported by ecosystem good and service (each column) and, where possible and applicable, also by the different Natural Capital asset classes (each row) (e.g. "woodland") - please refer to the full report for a breakdown by habitat sub-classes (e.g. coniferous vs. broadleaved woodland). Values are also presented in aggregate form: The total benefits associated with each given ecosystem service across the different natural assets supplying it, are presented in the bottom row. The total values for each Natural Capital stock (right-hand column) are also displayed as the sum of the values associated with all ecosystem services provided by that stock. A colour coded-approach is employed in each table. Green boxes show instances where ecosystem services could be valued successfully (albeit with limitations to the valuation technique in several instances), red boxes reflect those cases where ecosystem services could not be valued successfully. Orange boxes indicate a partial valuation (not all habitat-subtypes could be included), and grey boxes indicate situations where a given ecosystem service is not provided by a given habitat. Blue boxes show the totals for each ecosystem service across all habitat types.

It is important to note that the used methodologies are subject to several limitations, as we will discuss in the rest of this extended summary and in more detail in the full report. These limitations cause part of the estimates provided in tables 2 and 3 to be incomplete or inaccurate. The figures and findings from these tables should therefore not be used without reference to the wider context of this study.

Table 2. Natural Capital account for Exmoor National Park for 2015 (in 2015 GBP).

	PUBLIC BENEFITS			PRIVATE BENEFITS					
	Recreation	Climate regulation	Air quality	Timber	Livestock	Crops	Volunteering	Pollination	**TOTALS**
Woodland	731k	8953k	2175k	427k			X		***12285k***
Open water	8k	-62k					X		-54k
Mountain/heath/bog	333k	685k	23k				X		1042k
Improved grassland	1022k	X	133k				X		1155k
Semi-natural grassland	517k	1732k	129k				X		***2378k***
Arable	82k	-3183k	12k			1613k	X	7k	-1469k
Coastal	68k	31k	1k				X		100k
TOTALS	**2763k**	**8157k**	**2472k**	427k	**7258k**	1613k	199k	7k	**22897k**

Table 3. Natural Capital account for Dartmoor National Park for 2015 (in 2015 GBP).

	PUBLIC BENEFITS			PRIVATE BENEFITS				
	Recreation	Climate regulation	Air quality	Timber	Livestock	Crops	Pollination	**TOTALS**
Woodland	3035k	9741k	2356k	456k				***15588k***
Open water	29k	-73k						-44k
Mountain/heath/ bog	4380k	540k	18k					*4939k*
Improved grassland	3337k	X	113k					*3450k*
Semi-natural grassland	4484k	3916k	291k					***8691k***
Arable	251k	-2539k	10k			1287k	6k	-986k
TOTALS	**15516k**	**11585k**	2788k	456k	**8194k**	**1287k**	6k	**39832k**

A number of goods and services of interest (namely game, drinking water, biodiversity, flood protection, plants & seeds and minerals) could not be estimated through replicating the approaches from the reviewed studies (and therefore are missing from Tables 2 and 3). This is either because of insufficient availability of information on the quantity (flow) of Ecosystem Goods and Services produced and/or a lack of monetised estimates of the corresponding benefits.

Based on the results displayed in tables 2 and 3, it is possible to show that Dartmoor and Exmoor National Parks provide a mixture of both public benefits (accruing to multiple individuals representing the entirety or some groups within society) and private benefits (accruing to single individuals or organisations). Whilst volunteering and pollination provide benefits to the public, they are here classed as private benefits due to the fact that they are valued using approaches that capture only the private benefits of these ecosystem services (namely proportion of farm gross margins dependent on pollination and reduced costs for organisations working with volunteers).

In terms of the most valuable ecosystem goods and services provided (based on the results of the Natural Capital Accounts in Tables 2 and 3), similar conclusions can be drawn for both National Parks. In both cases, the most valuable goods and services supplied include two

ecosystem goods and services with a public good nature (recreation and carbon sequestration) and one private good (livestock – although see discussion on the limitation of the livestock analysis later in this report).

Both in Dartmoor and Exmoor, woodland habitats provide the highest measured benefits, followed by semi-natural grasslands – in both cases mostly due to the high values associated with carbon sequestration in those habitats. The magnitude of these figures, calculated using a Price x Quantity multiplication, is also driven by the amount of these habitats found within the National Parks (i.e. greater habitat extent contributes to increasing the total value associated with a given ecosystems). Negative values (driven by carbon emissions) are seen for arable land and open water.

LIMITATIONS AND SENSITIVITY TO ALTERNATIVE ESTIMATES

In this section, we discuss some examples of the limitations of the produced Natural Capital Accounts for Exmoor and Dartmoor. We discuss issues around measuring stock extent and quantifying and valuing ecosystem service flows. We test the sensitivity of the results to using alternative estimates, and suggest potential alterations of, and additions to, currently used Natural Capital Accounting approaches to improve account results. For further examples and a wider discussion, see the full report.

Measuring stock extent

A core requirement of any natural capital accounting undertaking is to establish a physical measure of the extents and qualities of the different natural capitals within the region, forming the focus of the account. In nearly all applications, that we reviewed, the practice has been to quantify those assets in unit of areas of habitat and land use. A significant difficulty in those applications is that data on habitat extent and quality is not available or not collected in the consistent and repeated manner required to construct and update an account. Lacking access to locally collected data, a standard alternative has been to use national, often satellite-derived, land cover data, such as the land cover map products generated by CEH.

Level of detail

In our application to Dartmoor and Exmoor National Parks, the CEH national land cover map 2015 data was used to produce the results displayed in Tables 2 and 3. The habitats identifiable from that data are mapped into relatively broad classes, meaning that some habitat variables with local ecological and management relevance (e.g. ancient woodland, Rhos pasture, Bracken) are overlooked. As a result, we sought local datasets, capturing such specific habitat types of interest. Whilst some data were available, these generally did not provide the full spatial coverage or temporal repeatability necessary to produce Natural Capital Accounts.

Classification accuracy

National land cover map data can also be subject to limited classification accuracy when it comes to the identification of Natural Capital stocks at finer spatial resolutions. Based on our produced Natural Capital accounts for Dartmoor and Exmoor, for example, Exmoor's open moors were erroneously classified as acid grassland by the 2015 Land Cover Map data. In order to test whether this misclassification affects account results, we tested what would happen if all acid grassland extent was instead considered to be "heather" (a generalisation used only for testing purposes). Results of this test of re-classification of the stocks, showed that habitat classification inaccuracies can substantially affect the valuation estimates in the Natural Capital Accounts. In fact, the total Natural Capital Account value changes from £22.9 million in the original account to £26.0 million after updating the stock classification assumptions.

Repeatability issues

If the ambition is to produce Natural Capital Accounts over multiple years, to detect variations in natural capital stocks, ecosystem goods/services and value over time, data need to be collected using a repeatable and consistent methodology. Land Cover Map data are available for multiple years (1990, 2000, 2007 and 2015). However, due to changes in the protocol of satellite data imagery classification and modelling, they do not offer consistent methodologies for change detection (see box below).

Case study: increase in broadleaved woodland on Exmoor

LCM data appear to show that broadleaved woodlands on Exmoor have changed in extent from 5,764 ha (2007) to 7,821 ha (2015), suggesting an increase by 2,057 ha in less than 10 years. No evidence could be found of such changes in stocks happening on the ground. A plausible reason for such differences between the two years could therefore be linked to variations in the methodological approach adopted in the Land Cover Map data classification. We therefore visually compare land cover classification based on Land Cover Map data with Google Earth's imageries. Land Cover Map 2007 data seem to better classify broadleaved woodlands (purple dots in image B) compared to Land Cover Map 2015 data (image C). As image C shows, in the LCM 2015 data, habitats other than broadleaved woodlands tend to be classified as broadleaved woodland (yellow dots). This is likely one of the reasons why broadleaved woodland figures in 2015 are so high relative to 2007. In 2015 LCM data, there is also a higher tendency to classify broadleaved or mixed woodlands as coniferous woodland (red dots), which suggests low accuracy in woodland classification routines for this area.

2007 2015

An immediate and significant conclusion is that enabling the development and maintenance of local Natural Capital Accounts requires the development of a targeted programme of repeated habitat extent and quality monitoring. Such data is currently not readily available.

Measuring flows of goods and services

In this section, we discuss examples of factors relating to the methods for the quantification of ecosystem services, which may limit the completeness and/or reliability of Natural Capital Accounts.

Missing data

Missing data is a major limitation when building Natural Capital Accounts following current approaches and methods. For some ecosystem services (i.e. Minerals, Plants and Seeds; Wildlife), no information on the biophysical flows and valuation is readily available from the literature or publicly available datasets. Wildlife is a particular challenge in Natural Capital accounting, an issue which is discussed in more detail in the box below. Game, Drinking Water and Flood Protection are context-specific goods and services and therefore they are not always incorporated into natural capital accounting approaches due to lack of local information. Suitable data on game, deer and fish numbers extracted annually was not available from either of the National Parks. For Flood Risk Regulation no suitable methodology could be identified based on the reviewed reports. Flood risk mitigation is a complex ecosystem service, and the extent of flood risk mitigation depends on the local land use, hydrology, geomorphology and wider ecology, meaning that generalisable methodologies, which can be employed across different case study areas, for quantifying this ecosystem service do not exist. To fill the gaps in the quantification of the flow of these ecosystem goods and services, and thereby improve the account completeness, local data need to be systematically collected to supplement publicly available datasets. For example, no publicly available data on volunteering numbers could be found for Dartmoor. This information gap was however later filled with data held within the National Park Authority (see full report).

Case study. Incorporating wildlife

Incorporating wildlife and biodiversity is a major challenge in the field of Natural Capital Accounting. From an ecological perspective, the first step is to determine which component of wildlife should be captured; it could for example be measured as the abundance or conservation status of a wide range of individual species, or the diversity of selected species or species groups. The next step is then to determine how such information links to ecosystem services enjoyed by humans and, subsequently, how such benefits can be valued (see full report). Even when a suitable measure of biodiversity can be identified, data gaps remain a problem, with ecological survey records often patchy across time and space.

Currently, many organisations simply omit an estimate of wildlife from their accounts, or only quantify certain aspects of the wildlife "stock" (e.g. extent of areas under designation as a proxy for capturing biodiversity), without attempting valuation. One solution could be to monitor changes in abundance and status of key species year-on-year towards the target of "net gain". This information can represent a helpful addition to Natural Capital Accounts to improve the usefulness of the accounts for management decision-making.

Whilst selecting locally relevant wildlife species for monitoring could be preferred for management purposes, such an approach introduces limitations in terms of the comparability across different areas. To ensure that information can be compared between areas of organisations, using biodiversity indicators obtained from national data can be desirable. Publicly available online tools can be used to aid this process. For example, the online tool NEVO developed by the LEEP institute at the University of Exeter uses JNCC species distribution data to estimate species richness for a selected area of interest, using a set list of 100 species from a wide variety of species groups.

Whilst species richness can be a clear indicator for management purposes, other key indicators (such as the status of key species of interest), should also be incorporated into Natural Capital Accounts. This is due to the fact that some key habitats may provide a lower diversity of species, but have great conservation value.

Alternative assumptions

In many cases, a range of alternative biophysical assumptions are available when building Natural Capital Accounts. Different Natural Capital Accounting projects often consider different datasets and underpinning methodologies, which can produce multiple alternative estimates. This is the case, for example, with carbon sequestration and recreation.

Depending on the approach and data considered to measure how many tonnes of carbon are sequestered every year per hectare of broadleaved woodland, carbon sequestration benefit estimates for this habitat type on Exmoor ranged from £2.3 million to £5.3 million.

Multiple methods are also available to estimate visitor numbers. To measure the number of recreationists on Dartmoor, we compared the figures proceeding from two visitor models: STEAM, which has been used in multiple previous accounting studies, and ORVal. STEAM provided an estimate of 21 visits per hectare, resulting in a recreation value of £13.7 million (we will discuss more on the estimates of recreational values later in this extended summary). Using the same valuation methodology, but different figures for the number of visitors per hectare based on the ORVal model, leading to an estimate of 69 visitors per hectare, we obtain a recreational value of £16 million. The two models rely on different methods to estimate the number of visitors to a given area. STEAM only focuses on visits of over four hours, whereas ORVal considers all day visits, including shorter visits as well. It is therefore deemed that

ORVal provides a more accurate picture of the total number of recreationists. However, the estimates derived from STEAM can be used to compare the number of visitors in Dartmoor with those in other National Parks and protected areas which also use STEAM.

More broadly, alternative local and context-specific information on the quantity of given Ecosystem Goods and Services is occasionally available, in addition to national averages. In such circumstances, accounts can be improved by replacing national estimates with local information. We illustrate this point (and the associated implications) in the box below, for the case of crop production.

Case study. Crop proportions and agriculture

Before crop yield and values can be estimated, the total extent of arable land needs to be broken down into different crop types. National figures on agricultural land use can be employed in order to divide the total arable land into crop types, using a proportional allocation based on national averages. However, such an approach is not necessarily accurate for Dartmoor and Exmoor, due to the existence of regional variations in crop distribution. An alternative source of information on crop production is the Farm Business Survey which is used, for instance, in a map-based decision-support tool (NEVO), developed by the university of Exeter. We converted the extent of crop types (as provided in NEVO) into percentages and compared these with those derived based on the reviewed approaches. The results of this comparison are outlined in the table below. The two datasets consider different crops, but when comparing the estimates of production and value for the five crops which were included in both the reviewed studies and NEVO (i.e. wheat, spring barley, winter barley, oilseed rape and sugar beet), substantial differences emerge.

	Dartmoor			
Crop type	**Total production (tonnes) – national crop type proportions**	**Total production (tonnes) – NEVO crop type proportions**	**Value – national crop type proportions**	**Value – NEVO proportions**
Wheat	7804	4719	£1,555,106	£940,310
spring barley	1168	1608	£208,782	£287,580
winter barley	1519	1333	£271,686	£238,310
oilseed rape	1287	1365	£457,778	£485,515
sugar beet	3109	0	£100,393	0

When building natural capital accounts for Dartmoor and Exmoor by following the approaches used in the reviewed studies, the quantification of the amount of livestock present within the National Parks, proved challenging. An additional test that was therefore performed is related to the consideration of alternative approaches for the quantification of livestock production for Natural Capital accounting purposes (see box below).

Case study. Testing for alternative quantifications of livestock

We attempted to replicate the methodology adopted by the reviewed natural capital accounts to quantify the flow of livestock. However, replicating the existing approaches was not possible due to insufficient information provided in the reviewed accounts regarding the adopted methodology for estimating livestock yield. In our exercise, we initially assumed that the annual flow of benefits linked to livestock corresponded to the value (measured in terms of farm gross margins) provided by the sale of the total number of livestock present in a given year on Dartmoor and Exmoor. This is, however, a poor assumption, given that some livestock takes multiple years to mature and other adult animals are kept solely for breeding purposes. We therefore tested for the effect of excluding breeding animals from the livestock count – assuming that these are not slaughtered and sold on the market on the same year and instead kept for future sales once maturity is achieved. Considering approaches used in previous studies, we included the following type of livestock, for which valuation information was also available: dairy herd, beef herd, calves, lambs and fowl. The quantification of the livestock relied on the DEFRA June survey data.

	based on total numbers present		**excluding livestock for (likely) breeding purposes**	
National Park	**Total animals**	**Value**	**Total animals**	**Value**
Dartmoor National Park	282,088	£8,193,537.42	168,788	£5,093,923.29
Exmoor National Park	362,840	£7,257,878.66	231,523	£3,401,148.79

Excluding the breeding livestock understandably decreased the total number of livestock and led to a lower value of livestock production. This may be an improvement on the original account values, as it is no longer assumed that all animals produce value each year. We believe that excluding breeding livestock is a more credible and conservative approach, compared to the one initially adopted, which assumes that all livestock on Dartmoor or Exmoor are sold or slaughtered on a yearly basis. However, in the absence of data on the exact number of livestock produced and sold on the market for the year of interest, only including non-breeding livestock, may still lead to an over-estimate of annual production. This is because some animals take longer than one year to mature and some lambs and young cattle may be retained for future breeding rather than marketed.

Incomplete ecological information

In previous Natural Capital Accounting studies, a wide range of ecologically complex, but nonetheless crucial, interactions between the natural environment and the provision of ecosystem services are often entirely overlooked. For example, our draft accounts included only one estimate of air quality (PM_{10}), but other indicators of air pollution could be included to improve completeness. In addition, to model flood protection, land use and other geographical factors in the affected area of interest also need to be considered. Another example of complex but nonetheless crucial ecological interactions is between parasitic wasp species and other environmental goods. These species often act as crop pests, but at the same time also support ecosystem service provision through links with a wide range of other organisms.

Overlooking ecosystem condition

When developing a Natural Capital Account, ecosystem condition is often partly or completely overlooked in current approaches. This can be a substantial limitation given that the production of Ecosystem Goods and Services depends on the condition of the underlying natural capital. For example, carbon sequestration in peatlands depends on the ecological

condition of peat habitats. Depending on peat condition, peatlands can range from net carbon emission (when in poor condition) to net carbon sequestration (when in good condition). In our case study area, the Climate regulation services provided by bogs/peatlands could not be estimated due to the absence of relevant information (at the scale of interest) regarding the condition of peatlands.

Accounting for aspects related to temporal dynamics

When building Natural Capital Accounts, temporal aspects should be taken into consideration. In most cases, the current methodology just focuses on the amount of goods and services that natural assets provide over the period of one year (flow account). Alternatively, if the desire is to produce an asset account, it is necessary to look into the quantity of goods and services that Natural Capital supplies into the future. The amount of ecosystem service flows and beneficiaries can vary over time, not only due to variations in the stock of Natural Capital, but also because of other factors, such as the change in the number of beneficiaries and users of the good (e.g. due to population growth). Often, an average or outdated figure is used across years, which may misrepresent the actual ecosystem service flows or number of beneficiaries.

A good illustrative example is recreation. The total number of visitors may change over time due to local housing developments and population growth and this can lead to an increase in the total recreation values, even when the habitat extent (natural capital assets) and valuation estimates are kept the same. Not updating the estimates of the number of visitors over the different accounting years considered, would lead to an underestimation of the recreational values. This example illustrates that not only the habitat extents and per-unit values need to be reviewed on an annual basis, but any changes in the quantification of service flows (e.g. numbers of visitors) also need to be updated in the account.

Measuring economic values of goods and services

In the following sub-sections, we discuss a series of factors that have to date been overlooked or insufficiently accounted for in the economic valuation of ecosystem goods and services by the reviewed approaches in Natural Capital accounting.

Missing economic values

Natural Capital accounting practitioners often fail to, or are unable to, include a variety of ecosystem good and services that provide important value flows to people. Based on our exercise, for instance, the benefits provided to society in relation to the existence of plants and animal species, beautiful sceneries and unique/diverse landscapes, as well as the appreciation of cultural heritage are completely missing from Natural Capital accounting case studies to date. This is a particularly significant gap especially if the goal is to develop Natural Capital Accounts for protected natural areas and National Parks, where wildlife, landscape and cultural heritage represent important components of the flows of ecosystem goods and services provided and are significant factors in land-management decision-making. The

estimation of the economic values associated with biodiversity, scenery or cultural heritage requires tailored valuation approaches, and methodologies remain largely under-developed. More research is required in the future to develop appropriate techniques to calculate the related economic values.

Partially missing economic value components

In some cases, the values considered in the accounts only provide a partial quantification of the benefits that the environment provides to people. This is the case, for instance, regarding the value of flood risk regulation (when incorporated in the accounts). Such value is often assumed to correspond with costs avoided in terms of flood-related expenditures e.g. on flood protection infrastructures. However, the costs avoided in terms of mental health distress and threats to life in the absence of flooding events is often overlooked, such that the numbers employed in analyses under-estimate the full benefits to people.

Similarly, the benefits of volunteering are often simply equated to the savings for an organisation in terms of labour costs avoided to carry out tasks that are instead done by volunteers. The mental and physical health benefits of spending time outdoors for volunteers is generally not included in the accounts, thereby underestimating the benefits of volunteering.

Accounting for spatial heterogeneity

Spatial aspects have received only limited attention in Natural Capital accounting. Some of the reviewed studies have provided maps of the spatial distribution of the different Natural Capital assets or ecosystem goods and services provided by a given area, but have generally not considered the effect of spatial aspects on the economic values. Whilst, in some cases, the value of the flow of ecosystem services is likely to be insensitive to the spatial configuration of Natural Capital, in many other cases, there may be important spatial elements to account for. For example, people might experience different recreational benefits depending on where recreational opportunities are provided, e.g. closer to or further away from home. The case study in the box below explores the effects of spatial factors on recreational values.

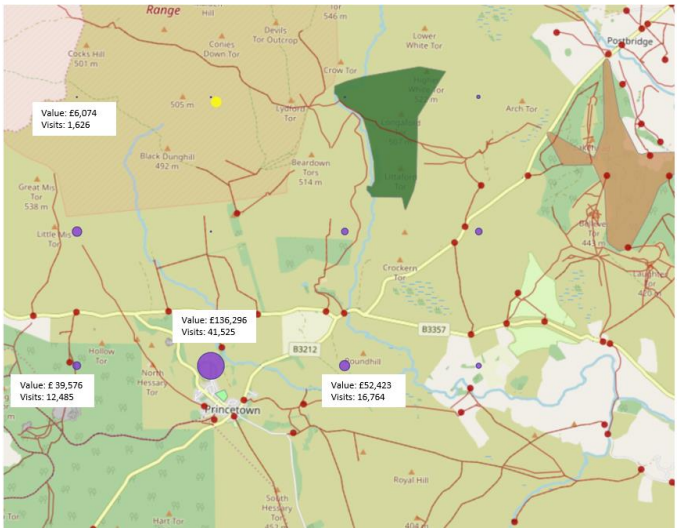
Case study. Testing the role of spatial factors on recreational values

To monetise the value of recreational visits, the reviewed Natural Capital Accounts have commonly relied on a meta-analysis by Sen et al. (2014)[1]. That study specifically controls for information on the visited habitat type, but no other spatial factor is accounted for. We compared this approach to the Outdoor Recreation Valuation (ORVal) Tool, developed by researchers at the University of Exeter. ORVal calculates of the welfare value of a recreational day visits to greenspaces in England and Wales, and incorporates spatial factors by accounting for heterogeneity in the accessibility of different sites, as well as considering the mode of transport and distance travelled by visitors. In addition to accounting for habitat-specific differences in recreational values, the ORVal model also controls for the availability of substitute sites that the individual could have considered for their visit. To illustrate the importance of accounting for spatial factors (beyond habitat-specific differences), we have calculated and compared the recreational values of Dartmoor and Exmoor National Parks using the Sen et al. (2014) and the alternative ORVal-based approaches.

	Sen et al. (2014) estimates	**ORVal estimates**
Dartmoor National Park	£15,200,000	£20,260,274
Exmoor National Park	£2,700,000	£8,023,928

From the comparison, it emerges that the Sen et al. (2014) approach undervalues the recreational values of both Dartmoor and Exmoor National Parks. Differences, though, could be driven by a variety of factors. The first difference across the two studies concerns the estimates of values per habitat. Recreational values per habitat in ORVal are estimated by assuming that the value of a visit to a given habitat site is not constant (as assumed by the Sen et al. (2014) meta-analysis), but can vary depending on the distance of the site from the recreationist and the availability of alternative sites with similar characteristics. This means that some habitats (e.g. mountains, moors and heathlands) tend to be overvalued when using the Sen et al. (2014) estimates, whilst others (e.g. freshwater ecosystems) tend to be undervalued. See the full report for a full comparison between the two approaches in the value per visit per habitat.

A second spatial aspect worth noting is that recreational values are sensitive to accessibility. Recreational values are likely higher in locations with more access points. Assuming homogeneous visitation rates, as done in a range of previously produced Natural Capital Accounts, is not realistic for Dartmoor and Exmoor (and many other recreational sites) and can substantially misrepresent the recreational values of certain portions of the National Park, with important implications in terms of spatial planning and decision-making. To understand how accessibility of sites can affect values and management decision making, we consider a hypothetical example, whereby a new woodland is created north of Princetown in Dartmoor National Park (yellow dot). ORVal then provides information on the welfare value and number of visits not only for the proposed new woodland site (yellow), but also for alternative nearby locations (purple) where the new woodland could be planted instead. As the map illustrates, the recreational benefits associated with such broadleaved woodland creation are greater the closer the site is to accessible areas (with access points and footpaths represented in red). Larger purple dots indicate a larger recreational value.



Accounting for aspects related to temporal dynamics

Natural Capital accounting focuses on recording Natural Capital assets, ecosystem goods/services and the related monetised values, and monitoring how these change over time. Indeed, time is a crucial dimension. The reviewed Natural Capital Accounts tend to present flow accounts, showing the value of the ecosystem goods and services provided for one year of reference, as well as stock accounts, by calculating the net present value of the flow of ecosystem goods and services that the natural assets are expected to provide over a period of time into the future. In order to calculate this, a first assumption that needs to be made concerns the length of time over which an asset is expected to provide goods and services. Another related decision that needs to be taken also concerns how much weight to place on benefits being delivered closer to the present as opposed to in the future (i.e. the discount rate for the calculation of the net present value). A positive discount rate implies that less weight is placed upon flows of benefits that are delivered further in the future (compared to the present). The higher the discount rate, the lower weight is placed on future benefits. The debate around which discount rate is most appropriate is ongoing. Indeed it is possible to argue for a range of different discount rates, and the choice of which to employ in a study can have implications on the total value calculated for given flows of ecosystem goods and services over time and affect long-term environmental decisions.

Testing for the effects of using alternative economic value estimates

For some ecosystem goods and services the reviewed Natural Capital accounting studies have employed different/alternative valuation approaches and figures. The availability of multiple valuation options raises the question of which approach is most appropriate. In most of the reviewed examples of Natural Capital Accounts the methodology employs economic values that originate from national statistics or generic literature reviews. In some cases, such national or generic values can be appropriate. However, in other circumstances this is not the case and local knowledge and expertise can be important in identifying which valuation approach or estimate is most appropriate in the development of a robust Natural Capital Account. For example, some crops (i.e. wheat and barley) may be used for different purposes (i.e. human consumption or animal feed) and different uses can be associated with different economic values.

DISCUSSION OF THE USEFULNESS OF THE ACCOUNTS

At the outset of the project, we discussed the National Park Authorities' aspirations regarding the use of Natural Capital Accounts. A list of aspirations was then compiled. This was revisited at the end of the project to discuss whether the initial expectations about Natural Capital accounting could be met using the approaches which are currently typically used.

The table below reports a list of the main aspirations expressed, at the start of the project, by the National Park Authorities. Each item is colour-coded, with colours giving an indication of the extent to which the produced Natural Capital Accounts were perceived, at the end of the project, to meet the initial aspirations and be useful to inform decision-making. Green

indicates that initial aspirations were met; orange that aspirations were only partially met and red that aspirations could not be met.

	Exmoor National Park	Dartmoor National Park	
	Provide improved information to feed into the State of the Park report	Provide improved information to feed into the State of the Park report	
	Provide input into the Environment Land Management Schemes (ELMS)/payment for farming, e.g. by putting value on provided ecosystem services	Explore the use of Natural Capital accounting for investment decision-making, e.g. when needing to prioritise between choice of two management/restoration options	
	Land ownership/land holdings: understand best use for land owned by Exmoor National Park	Leveraging funding/justifying spending. Understanding the monetary value resulting from e.g. a restoration project, and use this knowledge to leverage money for cost of project	
	Use to show where (data) gaps are in decision-making	Influencing management decision-making, e.g. increasing amounts of stocks which are shown to have high value	

As shown in the above table, in most cases, the Natural Capital Accounts could not satisfy initial expectations. Both National Park authorities perceived that Natural Capital accounting in its current state, is of only limited usefulness to inform decision-making. It was highlighted that the main usefulness of the accounts is to provide improved information to feed into the State of the Park report. The account has also been useful to illustrate current gaps in the information needed for effective decision-making. However, this ambition could only partially be met due to the lack of completeness of the accounts and the wider limitations outlined in this report.

The other listed ambitions were not delivered for a variety of reasons. For example, the work could not help decision-making about investments, as the account gaps and sensitivity to the underlying data are a constraint to robust information to guide such decisions. The accounts could also not be used to inform the use of National Park Authority-owned land. This is due to a scale issue – an account on the full National Park area cannot provide the detailed info on specific land-holdings. Local, e.g. farm-based accounts would be needed to meet this requirement. Lastly, the remaining aspirations (input into ELMS schemes, justifying spending, prioritising between management options) could not be met due to a mismatch between the perception of what Natural Capital Accounts can be used for and the actual capabilities and applications of Natural Capital Accounts. To inform investment and funding decisions and priorities in management, other tools such as cost-benefit analyses or risk registers should be considered instead of Natural Capital Accounts.

The review of a selection of accounts produced to date revealed that Natural Capital Accounts are often skewed in favour of private (or market-based) goods and only partially include public (or non-market) goods. In the case of organisations such as National Parks, whose remit is to ensure a sustainable use and appropriate conservation of the natural environment, the exclusion of important environmental public goods from the accounts is one of the biggest

limitations of Natural Capital Accounting in its present format. This is particularly true in relation to ecosystem goods and services such as biodiversity, wildlife or landscapes, upon which National Parks focus much of their management efforts.

Another topic of interest which the majority of Natural Capital Accounts fail to address, is related to a range of ecosystem services that are very specific to the local area, but of substantial cultural value. These include, for example, the role of bees and heather, contributing to local heather honey production, and Dartmoor and Exmoor ponies, as unique and charismatic species, contributing to the recreational enjoyment of the area (as well as conservation grazing).

It was clear that Natural Capital Accounting can only be as good as the underlying data employed in the process. If, as we have shown, the underlying data are subject to limitations and are inaccurate or incomplete at the spatial scale of interest, Natural Capital accounting will misrepresent the value of the natural environment. For these smaller-scale, organisational Natural Capital Accounts to be informative in the future, more support is needed to supply or collect fit-for-purpose data. In addition, ensuring consistency in the accounting methodology used by different organisations with similar characteristics is essential for comparison purposes.

In conclusion, it became apparent in this study that there are broad perceptions and expectations regarding what a Natural Capital Account can and cannot do. In additions, it was perceived that Natural Capital Accounts, produced using the currently available methodology and datasets, do not deliver the management tool which Dartmoor and Exmoor National Park Authorities may need or hope for. From discussions with both National Park Authorities, a common theme was related to the perceived complexities and challenges associated with Natural Capital Accounting for environmental organisations. Frequent concerns raised were in relation to the limited time, resources and expertise that National Parks would have in-house to design and maintain natural capital accounts, limiting the feasibility and possibly also uptake of this approach. Based on discussions with the National Park Authorities it was felt that perhaps Natural Capital Accounting is not the most useful approach to inform decision-making. When specific management questions arise, cost-benefit analyses of alternative options or risk registers of an organisation's Natural Capital could provide a more helpful piece of information to guide decision-making and investment decisions. However, it needs to be noted these approaches can suffer from similar methodological issues and data shortages as outlined in this report, and these options are therefore likely only appropriate in specific instances, such as smaller case studies, when the management question, staff expertise and data availability allow the use of such approaches.

While it was felt that the underlying idea behind natural capital accounting could prove useful, there has been a consensus that Natural Capital Accounting at a local and/or regional scale is still in its early days, and that the methodology and framework need to be improved substantially before the approach can become useful for informing management decision-making in environmentally-facing organisations such as National Parks. Whilst developing Natural Capital Accounts at organisation level is increasingly encouraged by the Government,

there are still considerable gaps in relation to how accounts can be implemented in a way which is useful for decision-making.

LESSONS LEARNT AND RECOMMENDATIONS

1. **More clarity is needed about what a Natural Capital Account is and what it is not.** More clarity is needed on the underlying principles and methods, and there is a need for more awareness regarding the capabilities and potential applications of this approach, particularly in the context of management decision-making. It emerged that Natural Capital Accounts are often mistakenly perceived as project appraisal tools to support decisions regarding alternative investment options. This raises the question of whether alternative decision-support approaches (such as cost-benefit analyses or Natural Capital risk registers) could represent more useful tools to guide management decisions.

2. **Guidelines are needed to support the development of Natural Capital Accounts for local scales and/or environmental organisations**. Clear guidance on the methodology would prevent different organisations using different approaches and it would be beneficial for the development of a consistent and robust approach across organisations, which would be useful for comparability purposes.

3. **Tools for natural capital assessment and monitoring, ecosystem service quantification and valuation are needed to support the development of Natural Capital Accounts and collaborations with experts should be encouraged.** It was felt that the development of Natural Capital Accounts for organisations such as National Park Authorities is challenging due to the limited availability of both resources and expertise to develop and update the accounts. Developing a Natural Capital Account can be highly time-consuming and requires interdisciplinary knowledge and a range of technical and analytical skills, often not available in-house. Publicly available tools, developed by academics or other specialists, but tailored for use by non-specialists, need to be encouraged to help support the development of Natural Capital Accounts. If organisations don't have the necessary resources or skills to develop Natural Capital Account themselves, collaborations with specialists should be encouraged.

4. **Data availability is a major issue and fit-for-purpose data collection for Natural Capital Accounting should be promoted**. There is a lack of data to consistently and reliably measure natural assets over multiple years to detect change. Data on asset condition is also often not available across the entirety of the area of interest. In addition to this, data gaps also exist regarding the quantification of a range of important ecosystem goods and services. There is therefore a need to promote more fit-for-purpose data collection for Natural Capital Accounting purposes, which at its very basic, includes repeatable (multi-year) data on assets across the whole of the National Park, as well as ecosystem service measures for those goods and services which cannot typically be derived from national

data (e.g. water extraction, game harvesting and volunteer numbers).

5. **Valuation methods need to be further progressed to be fit-for-purpose for Natural Capital Accounting**. It emerged that the economic values of private goods provided by areas such as National Parks are relatively well represented, whilst some important public goods supplied are either completely or only partially included in the accounts. Importantly, no established methodology seems to be available to fully value the benefits of important services such as flood protection, cultural heritage and landscape values. More efforts are therefore needed to develop sound valuation methodologies.

6. **Uncertainties need to be made explicit**. Gaps in data and the limitations in the available methodologies need to be explicitly acknowledged when developing Natural Capital Accounting exercises, otherwise there is a risk of account results being open to misinterpretation. Sensitivity tests need to be more systematically performed in accounting exercises and the related estimates of uncertainties need to be reported.

7. **The quantification of the flow of ecosystem goods and services should be better linked to the ecological condition of natural assets.** The capability of natural assets to provide goods and services that benefit people heavily depends on the ecological condition of the stock. Wherever possible, data on asset condition, as well as evidence on the effects of condition on ecosystem service provision, should be included in the accounting process.

8. **The sustainability of extraction and/or use of natural capital stocks needs to be better considered.** Better understanding of the implications of sustainable or unsustainable uses of natural capital stocks is crucial if Natural Capital Accounting is to be used to inform decision-making in the longer term. Flow accounts which only focus on annual ecosystem service supply only provide a partial picture and are not sufficient to inform such decision-making processes. Stock accounts, which not only look at annual flow (e.g. timber extraction), but also the total stock (e.g. total standing timber) could be used to provide an improved decision-making framework.

9. **Spatial aspects need to be better incorporated into Natural Capital Accounting**. Based on the reviewed Natural Capital Accounting studies, we can conclude that only limited consideration has been given to spatial aspects. Given that for the majority of ecosystem goods and services, the location of the natural asset and the associated goods and services is important in driving economic values, spatially explicit natural capital accounting methodologies should be encouraged wherever possible, particularly if decisions about spatial planning are to be made based on the results of the Natural Capital Accounting exercise.

10. **More consideration should be given to the costs of maintaining natural capital stocks for the provision of ecosystem goods and services**. In addition to considering the benefits and values of the ecosystem goods and services provided by natural assets, the costs that

need to be incurred to support the provision of such goods and services, should also be taken into explicit consideration.