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BIOservicES

Linking soil biodiversity and ecosystem functions and services in different land uses: from the identification of drivers, pressures, and climate change resilience to their economic valuation

Title: Integrated framework and research methodology protocol for the economic valuation of ES

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Report

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Contents

Executive summary

BIOservicES Work Package 4 will be undertaking valuation of the ecosystem services attributed to soil management across the 8 land uses in 25 experimental sites (summarised in Figure 1). This will include application of market and non-market valuation methods and will feed into a valuation toolkit to inform wider valuation by stakeholders beyond the BIOservicES project.

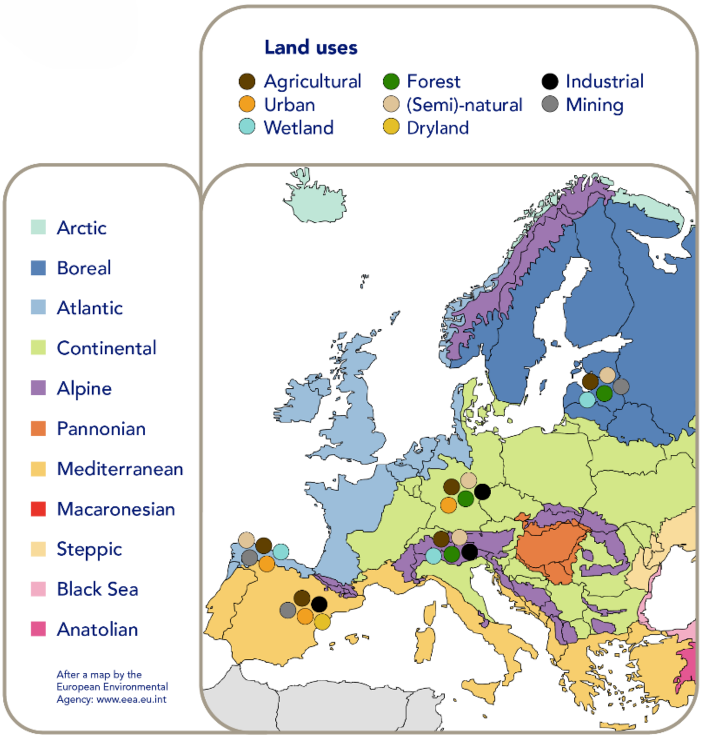

Fig. 1. Summary map of experimental site locations and land uses

The experimental sites represent a large variety of land use and management intensities and time and resources available for valuation studies are necessarily constrained. However, there is commonality across the ecosystem services, both within and across land use, allowing us to adopt a common valuation framework. This report describes our initial development of that framework. Project partners were invited to an online workshop which sought to identify the ecosystem services associated with each land use and the indicators that could be used to measure or value those services. Analysis of soil related ecosystem services suggested by the literature and during the workshop also allowed us to refine the scope of the valuation, for example removing services that are abiotic in nature or not moderated by soil biodiversity. Jointly provided ecosystem services were also identified suggesting common indicators.

Market values are mainly associated with provisioning services, but may also be relevant for some regulating services, e.g. using cost-based approaches or where ecosystem markets exist, and cultural services where their entry fees or visitor expenditure can be identified. Non-market valuation is more flexible but is mainly applicable to services where there are public good or societal value motivations. An important early task in undertaking any valuations will be to develop thorough profiles of the socio-economic and biophysical contexts for each case study site as these will confirm the degree of ecosystem service delivery and potential benefits. Developing a common data pro-forma for these profiles will be the next step for the work package. We will work with regional partners to identify the relevant data sources. Ideally these will be existing published and commonly available data. This is an important element in developing a valuation toolkit that can used widely across different European regions and land uses as it will allow easier identification of relevant data. But primary data collection may be necessary for some land uses or regions where data gaps exist whether in respect to the benefits of the ecosystem services, or the benefitting populations.

1. Introduction

BIOservicES will be undertaking soil sampling and analysis over 25 experimental sites across 8 land uses[1] in 5 European regions[2]. Each site will have a range of associated ecosystem services with differing levels of supply according to the land use intensities (3 per experimental site). The benefits, and consequent values of those ecosystem services will vary according to both the biophysical and local socio-economic contexts.

It is our intention to use the valuations undertaken during the project to develop a tool to allow the valuation of soil ecosystem services (as moderated by biodiversity) across those combinations of land uses and services more broadly. This requires a common approach, for example through estimating a set of value transfer adjustments or functions.

The time and resources available for us to undertake the valuation exercises are also constrained in that bespoke approaches across either each site or land use will not be possible. This means that common approaches are needed where possible, although the different characteristics of the land uses may require specific data collection to better qualify socio-economic features in each context. Commonality also allows us to better understand the effect of local context on the estimated values, i.e. allowing us to identify where values for otherwise similar services vary across regions or land uses.

2. Experimental sites summary

Table 1 summarises the experimental sites across each region and land use. This illustrates the variety within each land use. For example, the industrial land use includes recreational sites (ski slopes) and areas associated with commercial industry use. Mining covers different intensities of extractive activity from open-cast coal/lignite mining (Germany and Spain (Aragon)), gravel quarrying (Spain (Galicia)), and peat extraction (Latvia), these involve different degrees of rehabilitation. Semi-natural varies between permanent grassland used for fodder production with varying levels of nutrient input and frequency of cutting (Switzerland and Germany) and land that has returned to woodland (Spain (Galicia) and Latvia). Forest land also varies from different intensities of grazing (Switzerland), forest management (Germany) and nutrient balance (Latvia).

These variations across similarly labelled land use means that there will very likely be a corresponding variance in the types and degrees of ecosystem services provided in each site.

[1] Agriculture (5 regions), Dryland (1 region), Forest (3 regions), Industrial (2 regions), Mining (4 regions), Semi-natural (4 regions), Urban (3 regions), and Wetland (3 regions)
[2] Alpine (Switzerland), Atlantic (Galicia, Spain), Boreal (Latvia), Continental (Germany), and Mediterranean (Aragon, Spain)

3. Ecosystem services and indicators

Soils directly and indirectly contribute to the provision of a range of ecosystem services. These are related to the land uses or habitats that the soil underpins, and the degree of service provision will reflect both the land use type and intensity of management. Consequently, although there is a common set of ecosystem services, the extent to which they provide benefits will vary across land uses and locations, also reflecting socio-economic and biophysical contexts.

Baveye et al. (2016) identify the main categories of ecosystem services associated with soils, these are summarised in Figure 2. These services will form the basis for those to be considered in this project. An initial task is therefore to assess which land uses and experimental sites are likely to provide these services and to identify any additional services. To achieve this a workshop was held with BIOservicES project partners representing the different regions[3]. Partners were asked to identify which of the ecosystem services listed by Baveye et al. (2016) were associated with the land use types of the experimental sites and make suggestions for additional ecosystem services.

This exercise was then followed up with tasks aimed at identifying the indicators that could be used to measure and value those ecosystem services. These tasks were separated in line with the planned valuation tasks for work package 4. Specifically, we are considering market-based and non-market valuations separately.

We can characterise market-based values as being associated predominantly with provisioning ecosystem services. But there are some overlaps into regulating and cultural services. Some regulating services can be valued using cost-based approaches (e.g. the cost of replacing the service with man-made infrastructure), whereas cultural services such as recreation may have associated entry fees (e.g. ski pass revenue). Non-market values will be associated with those services that are not obviously traded in particular those with public good characteristics (i.e. non-rival and non-excludable).

[3] In total there were 12 workshop participants. The workshop was held online in May 2024.

Table 1. Summary of experimental sites and land use intensities

Region	Land use	Intensity 1	Intensity 2	Intensity 3
Alpine (Switzerland)	Forest	Forest pasture - high grazing intensity - young trees rejuvenation, but may be subject to pressures	Forest pasture area with low grazing intensity, old trees, natural rejuvenation	No grazing - dense old stand alpine forest on a steep slope
	Agricultural	High intensity Strawberry and Raspberry production in a crop rotation	Strawberry and Raspberry produced under the Swiss Integrated Production requirements	Strawberry and Raspberry produced under the Swiss Integrated Production, no tillage
	Industrial	Areas outside of the skiing runway	Skiing runway without terrain changes + artificial snow	Skiing runway with terrain changes + artificial snow
	Semi-natural	Grassland - up to 4 times mowing - slurry after each cut	Grassland - moderate mowing and slurry application rate	Unfertilized meadow 1 cut per year
	Wetland	Rarely saturated to the top - grass removal	Water saturated to the top level - biomass removal	Nature protected area - permanently under water - biomass removal to reduce the risk of eutrophication
Atlantic (Galicia, Spain)	Urban	Human pressure (pedestrians, children's, university parties), pet animals, potential rubbish from papers and plastics. Near to heavy traffic and urban contaminants from residential areas	Less human pressure and less pet animals. More far from heavy traffic	Urban river walk along the River Lonia in Ourense city. Far from traffic or industrial areas. The selected area was a vineyard before 1950s. Since then, it was cover by riparian forest. Now, it's used by pedestrians and pet animals.
	Agricultural	Herbicide and fungicide application. Vegetation clearing	Vegetation clearing between rows and herbicide in the rows.	Agroecological weed management. Fungicide application (occasional)
	Mining (gravel extraction)	Stone quarry tailing. No restoration measures. Different rubbish mixed with stones	Stone quarry tailing. Partially restored area with soil substrate (topsoil removing).	Forest area.

Region	Land use	Intensity 1	Intensity 2	Intensity 3
		derived from quarrying operations (plastics, cans, etc.)	Now, it has a moderate forest formation in the upper area	
	Semi-natural	Alien species invasion (Acacia dealbata). Previously to the current use, it was an agricultural field but abandoned since 1970s	Pinus pinaster afforestation	Atlantic Riparian forest (Quercus robur). Previously to the current use, it was an agricultural field but abandoned since 1970s.
	Wetland	Crops in summer (vegetables)	Frequently cleared areas	Semi-natural area
Boreal (Latvia)	Forest	Forest nutrient imbalance - Eutrophication (91E0*-Black alder alluvial forest).	Forest Acidification, nutrient disbalance (9050- Spruce-caulescent plant biodiverse forests).	Oligotroph, normal to low density forest (9010* Pine- Old native boreal forest).
	Agricultural	Annual cropping system (Arable land)	Perennial cropping system (Grassland)	Woody/Perennial cropping system (Woody pasture).
	Mining (peat extraction)	Recultivation after peat extraction was not carried out (Set aside area)	Recultivation after peat extraction was carried out 20 years after disturbance – planting and fertilization (Recultivation by afforestation)	Recultivation after peat extraction was carried out immediately after the end of peat extraction naturally (naturally recultivated former peat mining area)
	Semi-natural	High soil compaction with low primary productivity, OM loss (Seminatural forest- drained spruce stand	Soil compaction, medium productivity. Sparse, uneven-aged forest (Semi natural planted drained spruce forest thinning in different time and intensities)	Seminatural mix forest stand, selective clear cuttings, re-naturalization (Seminatural spruce/birch forest)
	Wetland	Wetland where amelioration done and forest stand thinned – disturbed water level (Wetland- drained, renovated ditch system, thinning)	Groundwater is high, but water movement is limited, the forest productivity is medium (Drained wetland no renovated amelioration system)	Groundwater level is high undisturbed wetland (wetland - mire naturally overgrowing by trees)
Continental (Germany)	Urban	Playground next to railway line (frequency and scope of green space maintenance: high)	Lawn area with a few trees in front of detached houses	Green strip with more shrubs and trees next to sports field

Region	Land use	Intensity 1	Intensity 2	Intensity 3
			(frequency and scope of green space maintenance: medium)	(frequency and scope of green space maintenance: low)
	Agricultural	Conventional crop rotation with 2 times maize cultivation within 5 years	Conventional crop rotation with 1 time maize cultivation within 5 years	Conventional crop rotation without maize cultivation within 5 years
	Mining (open cast lignite)	Recultivation after mining: 2018	Recultivation after mining: 2013	Recultivation after mining: 2009
	Semi-natural	Permanent grassland with intensive fertilization and 3 cuts per year	Permanent grassland with only solid manure fertilization and 2 cuts per year	Calcareous grassland without fertilization and 1 cut per year
	Forest	Clear felling in 2018 followed by reforestation (high forest management intensity)	Thinning every 10 years (last time: 2019/2020) (medium forest management intensity)	Managed succession (sick/broken trees felled for traffic safety but remain on site as dead wood) (low forest management intensity)
Mediterranean (Aragon, Spain)	Urban	Well-kept urban park with managed grass	Urban park with low maintenance	Unmanaged urban area, neglected urban plot
	Agricultural	Rainfed agricultural plot under conventional tillage	Rainfed agricultural plot under reduced tillage	Agricultural plot under no-tillage and irrigation
	Mining (open cast coal)	Bare soil with minimal degree of restoration	Restored soil with cereal cropping 3 years ago.	Restored soil with forest species 15 years ago.
	Industrial	Clay stockage industry	Plot in company that manufactures cardboard articles	Bare plot in industrial area without any use
	Dryland	Herbaceous and shrub vegetation	Shrub vegetation	Wood tree forest

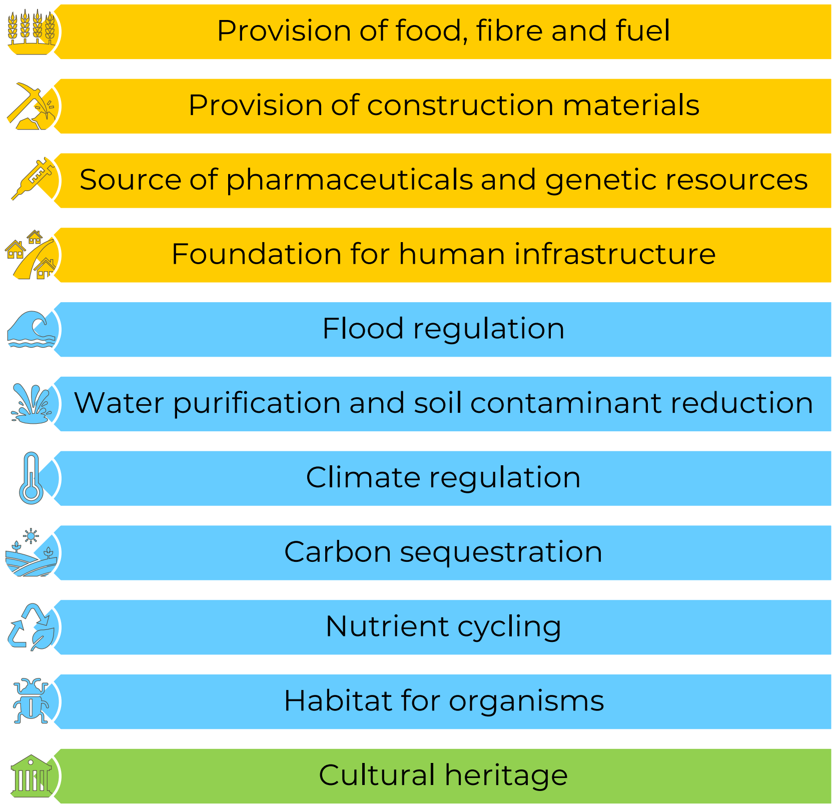

Fig. 2. Soil related ecosystem services (adapted from Baveye et al., 2016)

An alternative conceptualisation is that we can consider economic indicators as relating either to the supply or demand-side of the ecosystem services. On the supply side these would include ecosystem services that are traded or observable in market transactions. Examples include the quantities and prices of provisioning services (e.g. crops, livestock, timber), revenues associated with recreational uses (where these are marketed, e.g. ski-slope lift pass revenues) or impacts on property values. We might also consider cost-based values for regulating services within the supply side realm.

The demand side indicators could include data on the numbers of beneficiaries and the degrees of benefit they receive. These would be of particular use for non-marketed ecosystem services including some regulating services and cultural services.

Table 2 summarises the outcomes of the first workshop task which was to match ecosystem services categories to land uses. This illustrates that there is a large degree of commonality across the land uses. However, the exercise did not make a deeper dive into the directionality of those services where they may be negatively impacted by land use, or the effects of different management intensities. We have not included some suggested additional disservices, specifically the release of allergens (e.g. pollen) as these are unlikely to be even indirectly related to the functioning of soils. This reflects a further issue of the extent to which the soil is directly or indirectly providing the services. For example, should we take a narrow view of ‘provision of construction materials’ to include only the direct use of the soil itself, or more broadly the supporting of the growth of construction materials (e.g. timber)? Arguably the narrow view is appropriate given that growth of timber is captured within ‘provision of food, fibre and fuel’. We also need to consider whether the ‘provision of construction materials’ is within the scope of the BIOservicES project as we are not generally considering extractive uses of soil as a material. Our focus on the contribution of soil biodiversity in ecosystem services also indicates that services with a purely abiotic basis are out of scope. Conversely, the associated loss of other ecosystem services due to soil removal could be inferred directly from the valuation of those services, but that would require us to consider counterfactual land uses, i.e. what would service provision be in the absence of extraction of the abiotic resource given some alternative land use. This argument could also be applied to soil as the ‘foundation for human infrastructure’ as being outside the scope of the project due to its abiotic basis. However, some of our land uses such as industrial (e.g. skiing pistes) may rely on soils to provide such a foundation. It may be difficult to value the supporting role of the soil, instead the trade-offs with respect to other ecosystem services across the land use intensities could be evaluated. In this respect we would not value the service of ‘foundation for human infrastructure’, but the loss of other services due to that role being provided (e.g. loss of water retention due to compaction).

The addition of ‘Protection from rockslides’ could be broadened out to a more general ‘regulation of mass flows’ (i.e. soil erosion) which could be related to soil structure and probably applied across a wider set of the land uses.

Two further cultural services were added by participants ‘Family heritage (working on a farm)’ to agricultural land, and ‘Religious traditions’ added to forest. These are important services for those involved in the associated activities but are difficult to apply monetary values to. This reflects the potential to include of non-monetary or qualitative values as part of this project where monetary or quantitative valuation is difficult.

Table 2. Matching of ecosystem services to land uses by workshop participants

Ecosystem service	Agriculture	Dryland	Forest	Industrial	Mining (restoration)	Mining (peat extraction)	Semi-natural	Urban	Wetland
Provision of food, fibre and fuel	●	●	●			●		●	
Source of pharmaceuticals and genetic resources	●	●	●		●	●	●	●	●
Provision of construction materials*			●	●	●	●	●		●
Foundation for infrastructure*	●				●			●	
Water purification and soil contaminate reduction				●			●		
Flood regulation		●	●	●		●	●	●	●
Protection from rockslides[†]			●						
Habitat for organisms	●	●	●	●	●	●	●	●	●
Seed and genetic storage	●	●	●		●		●		●
Nutrient cycling	●	●	●		●	●	●	●	●
Pest control and disease suppression	●	●	●		●		●	●	
Climate regulation	●	●	●	●	●	●	●	●	●
Carbon sequestration	●	●	●		●		●	●	●
Rare species abundance									●
Cultural heritage	●	●	●	●	●	●	●	●	●
Family heritage (working on a farm)[‡]	●								
Recreation	●	●	●	●	●		●	●	●
Religious traditions[‡]			●						

* Services are outside the scope of the project.
[†] Broaden to regulation of mass flows/soil erosion and apply across more land uses.
[‡] Difficult to monetise, could be included in non-monetary/qualitative value assessment.

4. Indicators

The 12 participants in the online workshop were asked to identify potential indicators for each of the identified ecosystem services. This used a Mural board[4] which was pre-prepared with a diagram of ecosystem services and participants were asked to create sticky notes with suggested indicators. This task was repeated with separate diagrams for market-based and non-marketed indicators.

4.1. Provisioning services

In the second and third tasks for the workshop we asked participants to identify potential indicators for the ecosystem services (to keep this task manageable we did not divide services across land uses). Water supply was added as a service, adjacent to the regulating services 'Water purification and contaminant reduction' and 'Flood regulation', although these are linked it is strictly speaking a provisioning service.

4.1.1. Provision of food, fibre and fuel

The 'supply-side' indicators for 'provision of food, fibre and fuel' focused on yields and gross margins (i.e. revenue less variable costs)[5]. One comment noted the 'high environmental load' of high yields. This would be something to explore in relevant experimental sites to compare yield, management intensity, and soil indicators, i.e. are these interactions synergistic or are there inherent trade-offs? The extent to which we can assess this would depend on the availability of yield and farm economic data specific to the experimental sites managed in each cases studies (land-uses) identified in table 2 (the relationship could be characterised as lower yields but with lower costs which positively impact on margins).

'Demand-side' indicators focused on considerations such as food security, self-sufficiency (at European or national level), relocating supply chains in Europe and industry sustainability and growth. These were not defined in detail, but included the use of indices. Indices are used by a number of countries to track issues such as food security and sustainability. They typically track multiple indicators based on aggregate (i.e. country-level) data. This suggests that the experimental sites data may be too granular to integrate into such indices, or would require assumptions to be made about scaling up such data. That is, how would the indices respond if the different land use intensities of the experimental sites were replicated across the wider sectors at regional, national or EU levels.

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[4] https://www.mural.co/

[5] Gross margins do not measure profit precisely as that would require apportionment of fixed costs (e.g. farm machinery and buildings to determine net margins). Gross margins are appropriate for the comparisons of different cropping or livestock enterprises and management intensities relevant to BIOservicES.

4.1.2. Source of pharmaceuticals and genetic resources

This category of the ecosystem services is problematic to evaluate without specific examples of the service being delivered. Workshop responses included the number of non-timber forest products and the increasingly healthy and nutritious food. However, these examples relate more to 'provision of food, fibre and fuel'. The latter of these indicators is interesting as it suggests a direct role for soil properties in the quality of food and could warrant further investigation as to whether the soil indicators being collected in BIOservicES can be informative including the extent to which they are impacted by different land use intensities.

4.1.3. Water supply

Indicators for this service included measures of security of supply for different users including agriculture and drinking water. A measure of supply potential could be the frequency of low flows in rivers which could be important for process water supply (i.e. short-term water extraction for purposes such as cooling which is then returned to the source). There was also the rate of groundwater recharge, this could be linked to the benefits of water retention that also include flood regulation.

4.2. Regulating services

4.2.1. Water purification and contaminant reduction

Suggested 'supply-side' indicators for this service focus on different categories of associated cost in the absence of the service being provided. These include water treatment costs, costs due to human illness and damage due to nitrates (or other nutrients, e.g. phosphates). The trade-off between nitrate leaching and crop yield was mentioned, this raises an interesting possibility of whether provision of this service can be demonstrated to reduce leaching of higher nutrient inputs and associated yields. 'Demand-side' indicators included social value of nitrate pollution reduction and the level of water-based recreation (illustrating the joint provision of different ecosystem services). However, water-based recreation is less directly related to soil management as it relies on other contextual factors such as location and water body morphology, i.e. the contribution of soil management may be relatively minor and difficult to robustly apportion.

4.2.2. Flood regulation

'Supply-side' indicators include the water retention capacity of the soil, this could be identified from comparing measures such as bulk density across management intensities. In economic terms the replacement cost of providing an equivalent amount of flood storage or engineered flood defences could be used.

'Demand-side' indicators focus on the degree of risk such as the population of the catchment and number of properties at risk of flooding. These could then be linked to the avoided damage costs or the cost or savings in insurance premiums.

4.2.3. Habitats for organisms

Suggested indicators include the abundance (quantity and type) of both charismatic and uncharismatic species, and the habitat suitability for pollinators in particular. Inherent trade-offs were also identified with respect to high intensity monocultures versus diversified cropping systems, and the expectation of less wild fauna close to humans.

4.2.4. Seed and genetic storage

The number of species was also mentioned with respect to this service indicting that it could be considered jointly with habitats. Species numbers were mentioned both in terms of variety per hectare and in terms of new species observed per year. Soil samples collected from the BIOservicES experimental sites will be analysed for multiple organism types (prokaryotes, fungi, protists, nematodes, mesofauna, macrofauna, and viable bacteria (in semi-natural land uses)). Sample analysis is due to be completed by December 2025, the use of results for within and across land uses can be explored with the responsible project partners.

4.2.5. Nutrient cycling

Indicators for this service are closely related to 'provision of food, fibre and fuel' as they reflect the benefits of the service on crop yields or related reduction in nutrient inputs (as a cost saving). Soil carbon stocks were also suggested, linking this service of carbon sequestration. On the 'demand-side' this service was related to societal demand for reduced nutrient inputs including synthetic fertilisers. The use of the analysis results to develop a biodiversity indicator for use within and across land uses, can be explored with the project partners responsible for those tasks (WP2).

4.2.6. Pest control and disease suppression

Crop yield and input quantity and costs (pesticide use per hectare) were suggested for this service. Again, this indicates the potential to jointly evaluate multiple services. Conversely, this service could be constrained by the impact of pesticide application in more intensive land uses. An index of biodiversity and the abundance of pests and pathogens were also suggested as indicators for this service.

4.2.7. Climate regulation and Carbon sequestration

Although identified as two services by Baveye et al. (2016) these were treated very similarly by workshop participants in terms of indicators. These included soil carbon stocks, leaf and root biomass, and carbon values including carbon market prices and estimates of the social cost of carbon. Some studies (e.g. Christie et al., 2011) have also valued the social benefits of carbon sequestration services being provided rather than directly measuring the quantity of carbon.

4.3. Cultural services

4.3.1. Cultural heritage and Recreation

The workshop responses did not greatly differentiate between the broad service of cultural heritage and recreation more specifically. Indicators included visitor numbers, the local population and in the case of a marketed recreational activity (e.g. skiing) the direct revenues to access the activity (e.g. lift pass revenues). Indirect indicators could include numbers of shops and other businesses associated with the site and the revenues that could be attributed to the site or activity. Further indirect and qualitative indicators could include some form of indices on recreation and aesthetic beauty. Mental health benefits were also suggested.

As with some other ecosystem services, an important issue will be how service provision and associated values can be apportioned, or attributed to soil and how it is managed.

4.4. Summary

The indicators workshop outcomes highlighted that a number of soil related ecosystem services can be jointly considered due to their inherent interrelationships and common indicators. For example, the provisioning of food, fibre and fuel is reliant on the regulating services of nutrient cycling and pest control and disease suppression. The values for these are reflected both in the revenues for resulting products and the costs of production.

Services related to water supply, water purification, flood regulation and erosion control can be grouped under a common theme of water retention. This is impacted by soil properties including structure and organic matter content.

Habitat for organism and seed and genetic storage both focussed on measures of biodiversity including species numbers and abundance, and changes over time.

The identified indicators for each ecosystem service, or group of services where they are linked or jointly provided is summarised in Table 3.

Table 3. Summary of suggested indicators for ecosystem services

Ecosystem service (Combined where jointly produced)	Market based indicators ('supply-side')	Non-market indicators ('demand-side' including qualitative measures)
• Provisioning of food, fibre and fuel • Nutrient cycling • Pest control and disease suppression	• Crop yields • Crop revenues/prices • Crop production costs (inputs) • Non-timber forest products • Biodiversity index • Pest species abundance	• Food security index • European supply chain • Industry sustainability • Biodiversity index • Pest species abundance
• Source of pharmaceuticals and genetic resources	• Types and abundance of micro-organisms found in soil	• Types and abundance of micro-organisms found in soil
• Water supply	• Security of water supply • River flow levels • Groundwater recharge	• Security of water supply • River flow levels • Groundwater recharge
• Water purification and contaminant reduction	• Water treatment costs • Pollution (inc. nutrient) damage costs • Crop input costs (due to more efficient nutrient use)	• Water-based recreation • Social value of water quality
• Flood regulation	• Cost of providing equivalent water storage • Cost of providing flood defences	• Local population • Number of properties at risk of flooding • Avoided flood damage costs • Insurance premiums
• Habitats for organisms • Seed and genetic storage	• Species abundance (type and quantity) per ha and change over time • Habitat suitability for pollinators	• Species abundance (type and quantity) per ha and change over time • Habitat suitability for pollinators
• Climate regulation • Carbon sequestration	• Soil organic matter levels • Leaf and root biomass • Carbon market pricing • Social cost of carbon	• Social benefit of carbon sequestration
• Cultural heritage • Recreation	• Visitor numbers • Visitor revenues • Associated business numbers and revenue	• Local population • Recreation index • Aesthetic beauty index • Health benefits

5. Recommended common valuation framework

Indicators have been identified for a comprehensive set of ecosystem services across the range of land uses in the BIOservicES experimental sites. Given the wide variety of experimental sites, these may not all be relevant or practical in all places. Therefore, an early task in implementing the valuation framework will be to more fully characterise the experimental sites and surrounding areas, to better understand the beneficiaries of the ecosystem services and which services are provided in a meaningful or measurable way. This task will be crucial both for the estimation of values for the experimental sites (tasks 4.2 and 4.4) and for the development of benefit transfer-based approach for the integrated valuation toolkit (task 4.4).

5.1. Marketed ecosystem services values

Agriculture can be linked to several soil ecosystem services which contribute to the productivity of land including the crop (or biomass) yields and the inputs required to achieve them combining both provisioning and regulating services. This presents the opportunity to use standard agricultural economics approaches such as gross margin calculations and benchmarking to determine the contribution of soil ecosystem services across the different land use intensities in the experimental sites. Similar approaches could be used with respect to other provisioning services such as timber or non-timber forest products, where these are utilised, although it is not clear if this is the case in any of experimental sites.

All of the land uses have potential to contribute to the provision of regulating services to some extent. Although these can be considered primarily non-market in nature (i.e. they are not directly related to a marketed output) there may be market-based valuation approaches including cost-based (e.g. the cost of equivalent flood defence/storage, water treatment), or they have existing policy appraisal values (e.g. carbon sequestration). There may also be the potential for ecosystem markets (payment for ecosystem services – PES) to develop in some circumstances. BIOservicES can contribute to the assessment of that potential.

Cultural ecosystem services are generally considered to have public goods characteristics, so are non-market in nature. But in some circumstances, there may be options to control access (i.e. excludability) or to observe proxy markets (e.g. travel costs) to determine cultural values. These may involve trade-offs with other ecosystem services where the cultural activities are antithetical to other ecosystem service provision.

5.2. Non-market ecosystem services values

The flexibility provided by non-market valuation approaches allows us to consider a wider range of ecosystem services and indicators than market valuation allows. This includes where there are uncertainties about the degree of service delivery including the potential for service supply beyond the range of that found in the land use types and intensities in the experimental sites. This latter property may be important for the development of the integrated valuation toolkit (task 4.4).

Our project resources allow for discrete choice experiments to be undertaken across the case study regions. The variety of land uses and intensities suggests that it would be appropriate to focus on a generic set of ecosystem services that cannot be valued using market-based methods, these most likely being predominantly regulating and cultural services, particularly where there are strong public good elements. Consequently, the non-market values will more likely reflect the social values of ecosystem services provision.

In determining the scope of the non-market valuation applications, we will also consider the option of using benefit transfer for some of the ecosystem services and land use combinations. This will utilise sources such as the Ecosystem Services Valuation Database (ESVD)[6] as described by de Groot et al. (2012) and Brander et al. (2024).

6. Next steps

The next work package task will focus on estimating the market values of ecosystem services provided by the experimental sites. This will require the collection of relevant indicator data and building socio-economic profiles of the surrounding regions. The initial step in this process will be to develop a common data pro-forma to ensure that relevant and consistent data are collected across all of the sites.

7. References

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