Forestry Commission

Research Note

Valuing the social and environmental contribution of woodlands and trees in England, Scotland and Wales

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This Research Note is based on a review by the University of Exeter that evaluated existing knowledge on valuing the social and environmental contributions of British trees and woodlands. It starts by bringing together different (but related) economic terms and concepts in a single framework for understanding how trees and woodlands contribute to economic well-being, then sets out some guiding principles that distinguish this area of study. Tables are used to categorise and to summarise the evidence base of the social and environmental contributions (including consideration of decision support tools and a separate assessment for urban trees). A further table summarises priorities for future research, both to fill gaps in understanding and to develop more advanced techniques and models. The Note concludes that much work has been done on valuing the flows of social and environmental goods and services from trees and woodlands in Britain. A substantial evidence base has developed, particularly in relation to open-access recreation and climate change mitigation. However, major gaps remain in other areas including the role of woodlands in flood alleviation, water quality, physical and mental health, and biodiversity. The Note highlights the need for sound underpinning science and the need for more integrated approaches to valuation, assessment and decision-making tools. Future research efforts should focus on areas where significant additions to existing evidence are realistic and where effort will provide the greatest benefits for policy and operational decision-making.

Introduction

In a world of limited resources, choices are inevitable. Although nature underpins our health and well-being, we often do not consider all of the values that nature provides when making decisions on how best to use our resources. Economic valuation can help to correct for this failure; for example, by supporting cost-benefit analyses or by providing information to advise land management policies. Economics is just one of many perspectives available to guide such work; other types of evidence and analysis – including social and equity issues – are often critical but they are not the focus of this Research Note.

Trees and woodlands deliver many goods and services (Figure1). Those goods and services which are traded in markets, notably timber, are valued according to their prices and contribute to established economic measures of value such as gross domestic product (GDP). However, many of the social and environmental benefits are wholly (or partly)

Figure 1 Trees and woodlands are a vital part of our biodiversity, they remove carbon dioxide from the atmosphere, help to alleviate flooding and provide recreational and health benefits for visitors and local communities. Valuing these benefits demonstrates the impacts they have on economic well-being.

unvalued in markets (and associated calculations of GDP). This does not mean that such benefits are worthless. Economists recognise their importance and use terms such as public goods and externalities to describe them. In fact, there is strong evidence to show that nature plays a major role in generating economic activity and well-being, and awareness is increasing of the environmental and economic risks of undervaluing this role.

This Note explains how the social and environmental outputs of trees and woodlands contribute to economic well-being, and summarises the current state of evidence in England, Scotland and Wales on the value of such benefits. It is based largely on a recent review by the University of Exeter (Binner *et al*., 2016). Specifically, the Note:

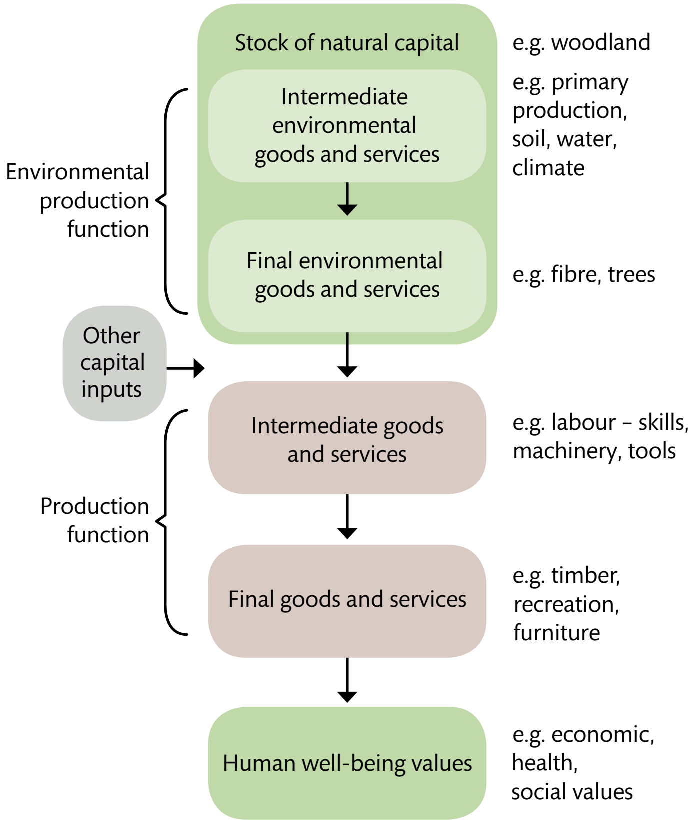
- brings together different (but related) economic terms and concepts in a single framework for understanding how trees and woodlands contribute to economic well-being;
- sets out some guiding principles which distinguish this area of study;
- evaluates the scope and rigour of existing knowledge;
- identifies priorities for future research, both to fill gaps in understanding and to develop more advanced techniques and models.

Conceptual framework – 'the natural factory'

Before attempting to value the social and environmental outputs of trees and woodlands, it is helpful to have a clear understanding of the process through which nature contributes to the economy. The 2005 Millennium Ecosystem Assessment classified ecosystem services as provisioning, regulating, supporting and cultural. This is a comprehensive categorisation, but not one that helps particularly in understanding how to approach the task of valuation.

The work of Binner *et al*. (2016) recognises the ecosystem services approach[1], but characterises nature as a natural factory which contributes to the economy's productive processes (or production functions). Natural resources (e.g. water, soil or trees) are seen as forms of capital that enter production processes, along with human capital (e.g. labour) and man-made capital (e.g. machinery), to produce goods and services that society enjoys (Figure 2 and Box 1). The role of nature in the economy can therefore be captured explicitly by identifying the many production processes to which it contributes and measuring its contribution to each process. This approach reveals the complexity of nature's role.

Figure 2 The natural factory.



Box 1 The economic production process

Each part of the economic production process is represented by what economists call production functions in which different resources combine to produce something. Thus, natural processes combine to produce environmental goods and services which are then combined with labour and man-made inputs (e.g. machinery) to produce the final goods and services that society enjoys (Figure 1). This approach allows the specific contribution of nature to be captured in a more accurate and comprehensive way. To take an example, a combination of natural processes in soils and the atmosphere results in the growth of trees. The subsequent addition of a forestry workforce, harvesting and processing machinery results in the final output of wood products. In a similar way, the addition of visitor facilities results in recreation activities.

[1] The ecosystem services approach is a framework for looking at whole ecosystems in decision-making, and for valuing the ecosystem services they provide, to ensure that society can maintain a healthy and resilient natural environment now and for future generations.

Within the natural factory, it is important to value not just flows of goods and services but also the stocks of assets that generate them (although different methods are needed to value stocks and flows). This is because valuing flows of social and environmental benefits alone will not reveal any impacts on the scale and quality of the underlying assets that generate them[2]. Failure to value such assets can prevent recognition that they are being depleted, which can have potentially devastating consequences for the provision of goods and services that society enjoys.

The stocks of assets provided by nature have become known as natural capital (Box 2). For example, a country's stock of woodland is a natural capital asset. This asset generates flows of social and environmental goods (e.g. timber) (Figure 3) and services (e.g. carbon sequestration, recreation and tourism).

Box 2 Natural capital

The concept of natural capital adds considerable weight to our understanding of how nature benefits the economy and society although the increasing popularity of the term is attracting a range of inconsistent definitions, such that it is sometimes used as a 'catch all' for all things green. The use of the term natural capital (rather than, say, the environment) identifies it as **capital** (alongside other forms of capital) with implications for valuing capital stocks and the flows of goods and services that it generates.

Figure 3 In the natural factory, natural processes are combined with labour and man-made inputs to produce goods and services that society enjoys.

[2] In this regard, a common criticism of GDP as a measure of welfare is that it does not account for the depreciation of capital resources including natural capital.

Guiding principles in valuing nature

Environmental economists have devoted much effort in recent decades to devising methods for valuing goods and services that are not traded in markets. More recently, this work has examined how to value natural capital (stocks) as well as environmental goods and services (flows), and how to incorporate such values into accounting frameworks that are used to monitor economic performance (Box 3).

Detailed technical guidance on how to carry out economic valuation exercises is available elsewhere (HM Treasury, 2003), but it is helpful here to note some important guiding principles, which are summarised in Table 1. These principles help to determine where weaknesses in the current evidence base may lie and where future research should be focused. They highlight both the underpinning role of science (Box 4) in economic valuation and the variation of social and

Box 3 Natural capital accounting

Natural capital has required new thinking in relation to accounting standards and to economic valuation methods. National accounts have traditionally been governed by the globally recognised System of National Accounts (SNA), which generates well-known measures such as GDP. However, the SNA's 'production boundary', which determines what is included and what is excluded from the national accounts, introduces two major challenges for natural capital accounting. First, it excludes many natural capital assets that are not privately owned and exchanged in markets. Second, because there is no environmental sector in the national accounts, any market contributions from the natural environment are attributed to other sectors.

New guidance and standards have been developed in recent years on how natural capital can be incorporated into accounting processes. Foremost is the 2012 System of Environmental-Economic Accounting – Central Framework (SEEA-CF), a UN statistical standard, and its accompanying guidance on Experimental Ecosystem Accounting (SEEA-EEA). In the UK, the Office for National Statistics and the Natural Capital Committee have provided guidance and developed initial accounts, at both a national and corporate level. A set of Great Britain woodland ecosystem accounts, consistent with the SEEA-EEA, has been produced by EFTEC (2015). Forest Enterprise England published its first set of corporate natural capital accounts in July 2016 (Forest Enterprise England, 2016). These initiatives are enabling the economic value of natural capital to be explicitly recognised and understood.

Table 1 Guiding principles in valuing nature.

Sound science	Scientific understanding is the basis for estimating many economic values. Scientists must determine the impact of an intervention on the production of the good or service before economists can attempt to value it (Box 4). This underlines the need for interdisciplinary and/or systems-based research and analysis.
Attribution	The value of nature should be attributed carefully. For example, natural capital is one among a range of capital inputs in economic production processes. To avoid overestimating their role, values for natural capital should not include elements of value from other forms of man-made capital.
Condition and location	Value is determined by characteristics (e.g. type of recreation activity), the context (e.g. whether substitutes exist) and the number of users (and where they live). Values can vary greatly between localities. Biophysical accounting and mapping are often required.
Timing	Woodlands grow and mature over long time periods. This has important implications for valuing natural capital due to the need to apply discount rates and future prices, and to assess long-term technological change.
Losses and gains	Nature can generate both benefits and costs and these must be identified and valued. For example, losses can occur through forest fires, damage to buildings and pavements, and pests and disease. Individuals tend to value losses more highly than equivalent an amount of gains. This is explained by psychology as loss aversion (Box 5).
Scale	Most valuation methods are designed to estimate small (marginal) changes in flows (i.e. within a particular range of supply) rather than large changes, which may have significant effects on overall stocks. Marginal values are point estimates and cannot simply be multiplied by the size of the stock to get the stock value. Marginal values may not reveal the effects of scarcity or of ecosystem 'tipping points' which result from large-scale changes in stocks.
Renewability	Unlike some other forms of capital, much natural capital is capable of repair and regeneration without human intervention. However, unsustainable use can deplete natural capital to levels where it loses its capacity to renew (e.g. overexploitation of forests leading to permanent soil damage). Understanding such 'tipping points' is vital.

environmental values across different locations. Table 1 also notes the importance of thresholds and 'tipping points' in understanding how values change as natural capital increases or decreases.

Box 4 Economics needs sound science

The science may be simple where an intervention directly reduces or increases the flow of a final good or service. A more complex situation arises where an intervention affects intermediate goods and services; in this case, economists can only estimate values once scientists have traced the impacts of the intervention through the natural factory to changes in the supply of final goods and services. Take as an example a project that establishes continuous cover forestry in place of clearfelling. Assuming the change directly improves visual amenity, it may be relatively straightforward to value this impact through economic valuation techniques such as contingent valuation. However, identifying other impacts such as those on soil stability, which is an intermediate service, requires scientists to link continuous cover forestry to changes in soil erosion. Impacts on intermediate goods and services can be followed through to impacts on final goods and services; for example, changes in sediment in rivers can be valued by considering reductions in costs to water companies associated with dredging.

Existing knowledge of the values of the social and environmental contribution of trees and woodlands

The review by Exeter University (Binner *et al.*, 2016) found a sizeable body of research and case studies on how to value flows of environmental goods and services from woodlands. Analysis by Willis *et al.* (2003) and the UK National Ecosystem Assessment (2011) of the non-market social and environmental outputs of forests across Great Britain estimated their value to be in excess of two billion pounds annually. Further analysis for the UK National Ecosystem Assessment Follow-on and for the Natural Capital Committee have shown how investments in woodland creation could deliver major increases in economic welfare (UK National Ecosystem Assessment, 2014; EFTEC, 2015).

The natural factory concept described above suggests that nature plays a greater role in many production processes (or functions) than is often recognised. Table 2 (which is based on Tables 1.1 of Binner *et al.* (2016)) categorises production functions and their relationships with final environmental goods and services. This categorisation provides structure, assists completeness and avoids double-counting. The widely used classification of provisioning, regulating, supporting and cultural ecosystem services (although in part recognisable in Table 2) would not methodically identify the myriad ways in which nature contributes to the economy.

Table 2 Categorising the social and environmental benefits of trees and woodlands.

Final environmental goods and Services*	Description	Production functions*															
		Timber products	Food (agriculture and subsistence)	Industrial production	Pharmaceuticals	Hydropower	Drinking water	Transportation	Flood alleviation	Housing	Physical health	Mental health	Recreation	Artistic	Learning	Spiritual and cultural	Non-use value
Water quality	The condition of water in terms of its chemical, physical, biological, radiological and/or aesthetic characteristics.		✘	✘		✘	✘	✘		✘	✘		✘	✘	✘	✘	✘
Water quantity	The volume and flow of water.		✘	✘		✘	✘	✘	✘	✘			✘	✘	✘	✘	✘
Air quality	The condition of the air including chemical composition, e.g. greenhouse gas emissions, and scent.			✘													
Flora, fauna and fungi	Plant and animal life.	✘	✘		✘					✘	✘	✘	✘		✘	✘	✘
Environmental amenity	Characteristics of the surroundings and/or conditions in which a beneficiary lives, works or recreates.									✘	✘	✘	✘	✘	✘	✘	✘
Sound and scent	Sources of sounds and scents as well as the magnitude of the emission.									✘	✘	✘	✘	✘	✘	✘	✘
Views	Visible characteristics in which a beneficiary lives, works or recreates.			✘						✘		✘	✘	✘	✘	✘	✘
Soil	Measures of the condition of the soil including soil type (e.g. clay, loam, sand), acidity (pH), moisture.		✘	✘						✘			✘		✘	✘	✘
Timber and fibre	Measures of the direct timber and fibre produced by trees and woodlands.	✘	✘	✘	✘					✘			✘	✘	✘	✘	

* A full description of production function categories can be found in Table 1.2 and 1.3 of Binner *et al*. (2016).

Using the categorisation provided in Table 2, Binner *et al*. (2016) carried out a thorough review of the current state of evidence of the values of the social and environmental contribution of trees and woodlands. They grouped their findings under seven main headings, and a summary of their review of the evidence base is given in Table 3. A traffic light colour key indicates the strength of underpinning scientific and economic evidence. The table also includes an assessment of the current state of development of decision support tools into which such evidence can be fed and a separate assessment is given for urban trees.

Table 3 shows that existing evidence on economic values of trees and woodland is strongest for recreation and for their role in addressing climate change. A firmer evidence base is also emerging for the contribution made to improving air quality. In other areas – notably water availability and flood alleviation, water quality and human (physical and mental) health – major gaps remain. Significant improvements are also needed to improve the valuation of woodland biodiversity, an area that is fraught with complexity.

There are also important cross-cutting issues in considering future research and evidence needs:

- Trees and woodlands on farms. Trees offer a range of services that benefit agriculture including shelter, soil stabilisation and pollinator habitat. However, relatively few valuation studies have examined and quantified the value of woodlands to agriculture. Biophysical data are lacking on the impacts of woodlands on agricultural production, including the role of different tree species and management practices.

Table 3 Summary of the evidence base on the social and environmental contribution of trees and woodland.

<table>
<tr><th></th><th>Biophysical evidence</th><th>Valuation evidence</th><th>Decision support tools</th><th>Urban trees</th></tr>
<tr><td rowspan="2">Recreation</td><td>Good data on the relationship between site characteristics and recreation visits</td><td>Comprehensive methods for analysing recreation behaviour, using spatial data</td><td>Good tools, but need more on urban areas and recreation site management</td><td>Robust recreational values but not included in urban tool calculations</td></tr>
<tr><td colspan="4">There is a relatively firm evidence base on the value of rural woodland visits, and powerful tools are emerging to model visitor behaviour. A gap remains in the capacity of urban valuation tools to include recreation in their valuation calculations.</td></tr>
<tr><td rowspan="2">Climate</td><td>Good evidence on sequestration but less on climate impacts on tree growth and function</td><td>Evidence on the social cost of carbon and of abatement costs, plus DECC carbon prices</td><td>Need to account for climate impacts on woodlands, and their goods and services</td><td>The impact of trees on temperature through shading has been included in i-Tree Eco</td></tr>
<tr><td colspan="4">The evidence base for the climate-related benefits of urban trees and woodlands is relatively robust; for example, carbon models to estimate stocks and flows of CO_2 in woodlands and displacement and substitution effects from the use of woodfuel and wood products. Understanding how a changing climate affects tree growth and function is less advanced.</td></tr>
<tr><td rowspan="2">Air quality</td><td>How both rural and urban trees affect air quality is relatively well understood</td><td>More evidence needed to show how health impacts depend on population exposure</td><td>Need to account for spatial variations in air quality improvements</td><td>i-Tree Eco uses UK-wide values for removal of air pollutants (NO_2 PM_{10} and SO_2)</td></tr>
<tr><td colspan="4">Scientific work is needed on pollutant absorption and deposition in urban forests. Direct and indirect health benefits (e.g. creating cleaner outdoor spaces for recreation) should be considered. Spatial variations require greater attention including studies of local baseline pollutant concentrations and of differences in population exposure.</td></tr>
<tr><td rowspan="2">Water availability and flood alleviation</td><td>Data needed to quantify the impact of woodland measures on water flows</td><td>Lack of robust data to demonstrate values for key beneficiaries</td><td>Need to integrate water-related values and the role of woodlands</td><td>i-Tree Eco uses US hydrology models to assess storm water capture</td></tr>
<tr><td colspan="4">Evidence to link woodlands to flood alleviation, for example by reducing run-off and slowing flood peak travel times, is growing. More biophysical evidence is needed on the impacts of woodland management, location and forest design. Complex factors determine flood events. A full valuation must consider tree and woodland impacts on the timing and severity of flooding, and capture catchment-level impacts in order to quantify effects on the probability of downstream flooding. Values are also needed for different beneficiaries, such as manufacturing, agriculture and the energy sector.</td></tr>
<tr><td rowspan="2">Water quality</td><td>Need to link water quality to planting and/or managing woodland</td><td>Valuation needed of different pollutants and their removal from waterways</td><td>More evidence needed to develop tools that cover water quality</td><td>Limited information on urban trees and water quality</td></tr>
<tr><td colspan="4">The scientific and economic evidence on woodlands and water quality in both rural and urban areas requires significant improvement. Robust cost information for beneficiaries (e.g. water companies) is a priority. Evidence is needed on causality between woodland management and planting actions, identifying impacts on different pollutants.</td></tr>
<tr><td rowspan="2">Physical and mental health</td><td>Need to establish causality between woodland and mental and physical health</td><td>Lack of a suitable measure for mental health impedes valuation</td><td>Evidence needed to facilitate accessible tools that include health impacts</td><td>Key task to analyse the biophysical processes and the role of urban trees</td></tr>
<tr><td colspan="4">There is some evidence on physical health benefits; for example, linking green space to exercise and health. The key gap is to link biophysical information on the natural environment and health outcomes to the specific influence of trees and woodlands. Evidence on mental health benefits is slowly emerging but is hindered by the lack of a generic metric for measuring mental health outcomes. Existing evidence is often highly localised and difficult to interpret without a suitable control study. Care will be needed to disentangle health benefits from recreation values in order to avoid double-counting.</td></tr>
<tr><td rowspan="2">Biodiversity</td><td>Need science and data on woodland impacts on biodiversity and human health</td><td>Non-use benefits of biodiversity cannot be valued using revealed preference methods</td><td>Robust metrics, biophysical evidence and valuation methods needed</td><td>Biodiversity from urban trees is not well understood and is not valued in i-Tree Eco</td></tr>
<tr><td colspan="4">Two major gaps are identified. First, the current literature lacks adequate values for both use and non-use values of biodiversity. Existing evidence indicates that these values are substantial. Second, improvements in economic values need to be matched by better data and scientific understanding of the physical impacts of afforestation (and different species therein) on measures of biodiversity, both in rural and urban areas.</td></tr>
</table>

Key: Good evidence – some ongoing improvements needed | Partial evidence – major improvements needed in some areas | Limited evidence – major improvements needed

- **Tree health**. Understanding how tree health affects the benefits provided by woodlands is improving but there is a substantial need for better economic evidence; for example, understanding the impacts of pests and diseases on timber yield, carbon sequestration and the quality of other ecosystem services.

- **Partial gains and losses**. It is easy to conceptualise a whole tree or an entire woodland when valuing benefits. In many cases, however, what is actually being valued is a change in the quality of trees due to pests, disease or management action, or a change in woodland composition due to the loss of a species. The valuation of benefits or costs associated with these partial gains and losses is a notable gap in current evidence. Further information on valuing gains and losses is provided in Box 5.

Box 5 Valuing gains and losses

The value of a gain may not be the same as the value of a loss, even when the physical changes are of the same magnitude (i.e. the gain or loss of a single tree). Reasons for this include non-linear patterns between tree numbers/ woodland size and the benefits they provide. There are also psychological factors that lead people to value equivalent losses more than gains, such as an aversion to loss and the endowment effect (where people value something they already own more than something that they do not yet own).

- **Integrated assessment and decision-making tools**. The development of more comprehensive and robust decision support tools is receiving much attention across the land-use research and policy community. These tools include the emerging class of integrated ecosystem service mapping tools, which incorporate state-of-the-art models to capture interactions and trade-offs between multiple ecosystem services at different spatial and temporal scales (Box 6).

Box 6 Integrated modelling

The UK has played a leading role in the development of new economic valuation models, including The Integrated Model (TIM), which has been used to analyse afforestation proposals. A lack of robust values for some components of woodland ecosystem goods and services can hinder such models, although the application of non-monetary constraints (e.g. requiring that any planting that reduces bird species diversity be rejected) has been used to address this problem.

Priorities for future research

A full understanding of the economic contributions of trees and woodland must consider the quantity and quality of natural capital (stocks) as well as the flows of social and environmental benefits.

In prioritising future research needs, Binner *et al*. (2016) requested the input of forest policy advisors and analysts on the project steering group. Research gaps were determined on the basis of the availability of existing evidence and workable solutions, expectations on the scale of potential benefits (or costs) and their relevance for policy and decision-making. The resulting prioritisation of research areas is shown in Table 4. The priorities show the importance of a cross-disciplinary approach between natural scientists and economists to meet future evidence needs.

Table 4 Prioritisation of research gaps (red text = science, green text = economics).

High priority	
Water quality	Link water quality to woodland planting and management actions Extend the valuation of different pollutants at different scales
Water availability and flood alleviation	Link water quantity and flood alleviation to woodland location, design and management Generate water quantity and flood alleviation values for key beneficiaries
Air quality	Incorporate population exposure into pollution absorption values
Recreation	Estimate values for different types of recreational users Improve decision support tools, including urban planning and management of recreational sites
Physical and mental health	Develop a generic metric for mental health Establish causality (biophysical processes) between woodlands and health outcomes

Table 4 (continued) Prioritisation of research gaps (red text = science, green text = economics).

High priority	
Biodiversity	Improve understanding of impacts on biodiversity of tree-planting and native/non-native species
Trees and woodlands on farms	Improve understanding of links between trees and agricultural output (e.g. impacts on soil, plant health and pollination)
Plant health	Link tree health to the value of benefits provided
Integrated modelling and valuation	Integrate natural science, economic and social science understanding of the multiple net benefits of woodland planting and management
Natural capital accounting	Spatial mapping and physical accounting of natural capital stocks and flows Ecological tipping points, resilience and functional redundancies
Medium priority	
Water quality	Identify biophysical impacts of forest management, and effects of trees generally in urban areas Transfer results across locations and time periods Apply UK hydrological models in urban areas
Water availability and flood alleviation	Estimate values for key beneficiaries (e.g. manufacturers, agriculture and energy)
Air quality	Improve understanding of pollutant absorption and deposition in urban forests
Climate regulation	Estimate effects of trees on urban heat islands (shading, evapotranspiration)
Recreation	Examine the contextual drivers of demand (including weather) Apply recreation values in urban valuation tools Decision support tools needed to support urban planning and management of recreation sites Value recreation effects from incomplete gains (losses)
Physical and mental health	Examine relationships between trees and health in urban areas Disentangle health values from other values (e.g. recreation)
Natural capital accounting	Address spatial dimensions of woodland assets Estimate marginal vs stock values
Long-term priority	
Water quality	Examine sediment impacts, acidity and turbidity Generate reliable data on treatment costs
Water availability and flood alleviation	Generate data to validate models, especially at a catchment scale
Air quality	Relate values to baseline concentrations and changes in pollution levels Examine wider impacts (e.g. direct and indirect health effects, avoided damage to infrastructure)
Climate regulation	Improved estimates of the social cost of carbon abatements Deepen understanding of urban cooling services of trees
Physical and mental health	Investigate effects related to waterborne diseases

Conclusions

The natural factory concept demonstrates the wide-ranging role that trees and woodlands play in the economy and, therefore, well-being. It also shows the relationship between natural capital stocks and the flows of benefits which they generate. The social and environmental outputs of trees and woodlands are the result of an intricate array of processes, and a full assessment of their economic value is a complex and challenging task.

Much work has been done on valuing the flows of social and environmental goods and services from trees and woodlands in England, Scotland and Wales. A substantial evidence base has developed, particularly in relation to open-access recreation and climate change mitigation. Major gaps remain in other areas including the role of trees and woodlands in flood alleviation, water quality, physical and mental health, and biodiversity.

Several main conclusions are drawn about the current state of the evidence:

- Biophysical pathways. Existing evidence is hindered by insufficient scientific evidence to link biophysical processes associated with trees and woodlands to quantifiable changes in the provision of goods and services. This reinforces the need for sound underpinning science.

- Valuation literature. Existing literature is patchy, incomplete and uses different units, years and scales. A more integrated, comprehensive and coherent approach to valuing all of the benefits and costs of trees and woodlands is needed.

- Integrated assessment and decision-making tools. There is a need to integrate knowledge and understanding in natural, economic and social sciences about the benefits provided by trees and woodlands. Current science and valuation evidence is fragmented and incomplete, and under-reports the contribution of trees and woodlands to well-being.

- Urban goods and services. These may often be based on particular biophysical relationships and require distinctive approaches to valuation.

Thinking on natural capital brings an added dimension to our understanding of the economic role of trees and woodlands but also reveals important gaps in evidence on how these assets should best be managed in the future. It shows that a focus on valuing flows of social and environmental benefits alone will fail to reveal vital information about the scale and condition of natural assets which are vital to our economy. Recent initiatives in natural capital accounting – both at a national and corporate level – are helping to address this and offer huge potential to incorporate the value of nature into mainstream economic thinking.

There is also a major opportunity for the forestry sector to have a prominent role in the development of integrated land-use models, made possible by advances in data collection and analysis, and computing technology.

A targeted research effort is needed in order to focus on areas where significant additions to existing evidence are realistic and where further effort will provide the greatest benefits for policy and operational decision-making. Such work will also help to place trees and woodlands in a stronger position to meet the many demands which land use will face in future.

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