TREES OUTSIDE FORESTS – VALUES AND SERVICES (TREEVES)

Review and Perspective for Switzerland

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Chapter 1: Introduction and Study Framework

1.1 Background and objective

The Forest Ecosystem Services and Silviculture Section, Forest Division, Swiss Federal Office for the Environment FOEN assigned this research study on tree values and services (TREEVES in short) – with focus on the values (including those related to worldviews and perceptions), services, potential, markets of trees outside forests in both Switzerland and (as a reference framework) Western Europe.

Recent years have seen a broadening of the perspective on tree benefits and values, instigated among other by the work of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). Prior to this, the focus had very much been on what IPBES calls 'nature's benefits to people', which comprises an anthropocentric perspective emphasising the instrumental benefits of trees and other nature. Typically, this also includes an ecosystem service perspective. This approach became criticised due to its strongly anthropocentric focus. During the past few years, and most recently in its "Methodological assessment regarding the diverse conceptualization of multiple values of nature and its benefits, including biodiversity and ecosystem functions and services", IPBES (2021) has therefore taken a more comprehensive perspective on the multiple values of nature, distinguishing e.g., worldviews, broad values, and specific values, but also integrating the values of nature for nature itself. A more detailed presentation of this comprehensive perspective is provided below, as it guides the present study.

The present study looked both at the extent, values, and services of trees outside forests (TOF). These have usually been less studied today than the values and services of trees within forests (e.g., FAO, 2013; Thomas et al., 2021). However, trees often play an important role in non-forest landscaped as well. Examples of these are urban and peri-urban areas (e.g., in the form of trees along streets, in parks and gardens), natural areas (e.g., coastal and mountain landscapes), and in rural landscapes (e.g., as part of agricultural systems).

This applied research project was exploratory and focused on existing data and information (e.g., regional or country-level assessments, other studies), complemented by targeted expert interviews. Focus was on Switzerland, as the project provides inputs towards a potential Swiss approach / strategy for assessing the values of trees outside forests, but it also looks at relevant practices and approaches in other European countries as inspiration and frame of reference. Germany, Netherlands, Sweden, the United Kingdom (and England in particular) and Spain served as selected reference countries, partly because of the researchers' prior knowledge of relevant TOF programs and research in these countries.

The research project was composed of both a methodological and international analysis section, as well as a national analysis of the existing values (including perceptions and worldviews) of tree ecosystem services, their quantitative and qualitative benefits potential according to selected services, and finally of existing or likely marketing pathways and public or private PES-schemes for these services. The innovative part of the research project lies in its methodological development in view of an open and country-level exploration of the various values (and perceptions, thus possible acceptation and support) of trees, tree expansion (planting and maintenance) through the lens of the ecosystem services they can deliver.

The first part of the work, summarised in this first chapter, aimed to develop an initial framework of values of trees outside forests based on key documents and policies, and especially recent IPBES work, and an empirical method to assess various values and stakeholder groups is framed. An initial

list TREEVES (for trees outside forests) and approaches to assessing these was developed to guide the international and Swiss review of relevant initiatives and methods.

1.2 Trees outside forests

In simple terms, TOF include all trees that are not part of forests. Obviously, there are some 'grey zones' in this distinction. For example, how do we define forests? Here we follow national forest legislation, considering as forests all those areas that are legally defined as forests. In urban areas, for example, groups of trees can have forest-like properties, and they are considered part of a wider urban forest (comprising of all trees and associated vegetation in a defined urban area) – but they are often not part of legally defined forest areas. Similarly, in the pre-alps, agricultural land can become overgrown by trees (which in some cases will turn it into forest) or many agroforestry systems are not submitted under forest law. Two examples from Switzerland show how fluid the transitions are: In Ticino, chestnut groves ('Kastanienselven') are generally to be understood as forests according to the Forest Act, whereas wooded pastures ('Wytweiden') may also be subject to the Forest Act (depending on cantonal legislation and extension), leaving some room for interpretation.

The Food and Agriculture Organization of the United Nations (FAO) has recognised the importance of TOF for livelihoods for many years, and it has developed a series of program activities focusing on ToF in urban, peri-urban, and especially in rural areas. FAO (2000) has defined TOF as:

"Trees outside the forest are defined by default, as all trees excluded from the definition of forest and other wooded lands (..). Trees outside the forest are located on "other lands", mostly on farmlands and built-up areas, both in rural and urban areas. A large number of TOF consist of planted or domesticated trees. TOF include trees in agroforestry systems, orchards and small woodlots. They may grow in meadows, pastoral areas and on farms, or along rivers, canals and roadsides, or in towns, gardens and parks. Some of the land use systems include alley cropping and shifting cultivation, permanent tree cover crops (e.g., coffee, cocoa), windbreaks, hedgerows, home gardens and fruit-tree plantations."

1.3 Tree values and ecosystem services

According to the work of IPBES (see e.g., IPBES, 2015, but also later documents), values can refer to:

- Principles or core beliefs
- A preference (for something or for a particular state of the world)
- The importance (of something for itself or for other things)
- A measure (for example the number of species).

In relation to nature and ecosystems, IPBES conceptual framework proposes that these dimensions should be focused on:

1. *Nature ('Nature for Nature')*. This category refers to the value that nature or natural entities have in, of and/or for themselves (*intrinsic* values). It can include their functional value within a broader ecological state. It can also involve attributing them a moral value, e.g., that species should not be driven to extinction regardless of human interests. The target of value may be: individual organisms such as a particular gorilla or oak tree; bio-physical assemblages

such as a population of polar bears or a river basin; biophysical processes such as evolution or ecological resilience; or biodiversity on a genetic, organismal, species or holistic basis. The orientation in this category is non-anthropocentric.

2. *Nature's benefits to people ('Nature for Society')*. This category refers to the benefits (in the broadest sense) that people draw from nature or ecosystem functions (instrumental values). These benefits can be realized as physical outputs, such as water or food. They can also include cultural, recreational and/or spiritual interactions that are directly or indirectly influential for human endeavour. One of the conceptualizations of nature's benefits is 'ecosystems services'. The orientation in this category is anthropocentric, and includes both biophysical and *instrumental* values with a normative goal of human well-being.
3. *Good quality of life ('Nature as Culture')*. This category concerns the contribution of nature and ecosystem processes to a good quality of life, or a fulfilled human life. This refers to the way in which different elements of nature and BES support human well-being. It also includes the principles of living in harmony with nature and living well in balance with Mother Earth. This can involve the development of desirable communities and societies, for example the way landscape conservation can contribute to a sense of place and community. The orientation in this category is anthropocentric and *relational*.

As mentioned above, as part of the ecosystem service discourse (e.g., Jax and Heink, 2015; Matthies et al., 2016) focus during the past decades has often been on the second type of values, which are anthropocentric and instruments, and focus on what humans obtain from nature. This links to the often-used ecosystem service categories of especially provisioning (food, energy, water), regulating (cooling, air pollution reduction), and cultural (recreation, tourism) ecosystem services. IPBES thus suggests a much broader value framework, where the intrinsic values of nature are recognised ('nature for nature itself'), as are the wider relational values between humans and nature.

Table 1.1, derived from the IPBES guide, provides an overview of the definitions of the main types of values used in the framework.

IPBES then also suggests that assessments of nature – in the form of ecosystems and their components, should address these different values, rather than taking a narrower focus (e.g., on specific sets of ecosystem services). Obviously, this is complex, also because of values referring to anything from principles and core beliefs to specific measures. To add to this complexity, values are individual or shared, context and scale sensitive, influenced by personal experiences, by social and norms the socio-cultural and political environment (collectively called institutions in the IPBES conceptual framework) and by the biophysical environment itself.

Fig 1.1, also derived the IPBES guidance documents (IPBES, 2015), offers a good overview of the nature value assessment process with its key components. This framework is also relevant for this study specifically on trees outside forests.

As can be seen in Figure 1.1, the different categories of values are recognised: non-anthropocentric, instrumental, and relational. Not shown in the figure, but also of importance are the perceptions different people and different groups have of the values of nature.

Next, different ways of assessment and valuation need to be applied. These include biophysical assessments (e.g., how many trees are there, of what species, what is the canopy cover?); social and cultural assessments (e.g., recreational studies, social surveys of e.g., perceptions and preferences, ethnographic studies); economic valuation (e.g., market-based approaches, hedonic pricing, etc.); health assessments comprising methods valuing the effects of ecosystem services on human health; and more holistic approaches. Social and cultural assessments are defined broadly, looking into the

psychological, historical, cultural, social, ecological, and political contexts and conditions (the broader social context), as well as the worldviews and social perceptions that shape individually held or commonly shared values (Chan et al., 2012). Health assessments should take a broad view, looking e.g., at nutrition, infectious disease, non-communicable disease, and mental health. The last category comprises of holistic, indigenous, and local knowledge-based methods aim to capture holistic values about peoples and nature whilst internalizing principles and ethical values about Mother Earth and 'Living-well' of indigenous and local knowledge systems.

Table 1.1. Definitions of main types of values (IPBES, 2015).

Box 2.2. Definitions of the main types of values used in this document

Instrumental Value: An instrumental value is the value attributed to something as a means to achieve a particular end.

Non-Instrumental Value: A non-instrumental value is the value attributed to something as an end in itself, regardless of its utility for other ends.

Anthropogenic: Anthropogenic means 'human-generated' and is a term often used to refer to the way in which value is a concept and construct generated by humans. While it can be argued that all principles and preferences are anthropogenic (human-generated), it is important to note that this does not mean they are all anthropocentric (human-centred).

Anthropocentric: Anthropocentric means 'human-centred' so an anthropocentric value is a value that something has for human beings and human purposes.

Non-anthropocentric: A non-anthropocentric value is a value centered on something other than human beings. These values can be non-instrumental (e.g. a value ascribed to the existence of specific species for their own sake) or instrumental to non-human ends (e.g. the instrumental value a habitat has for the existence of a specific species).

Relational value: Values relative to the meaningfulness of relationships, including the relationships between individuals or societies and other animals and aspects of the lifeworld (all of whom may be understood as conscious persons), as well as those among individuals and articulated by formal and informal institutions. Another type of relational values, *eudaimonistic* values are associated with a good life, which include considerations of principles and virtues, and value the actions and habits that are conducive to a meaningful and satisfying life.

Intrinsic value: This concept can refer to inherent value, i.e. the value something has independent of any human experience or evaluation. Such a value is viewed as an inherent property of the entity (e.g. an organism) and not ascribed or generated by external valuing agents (such as human beings). This is the meaning of intrinsic value that has been adopted in the IPBES Conceptual Framework (Díaz et al., 2015): "*Intrinsic value* [is] *the value inherent to nature, independent of human experience and evaluation and thus beyond the scope of anthropocentric valuation approaches*".

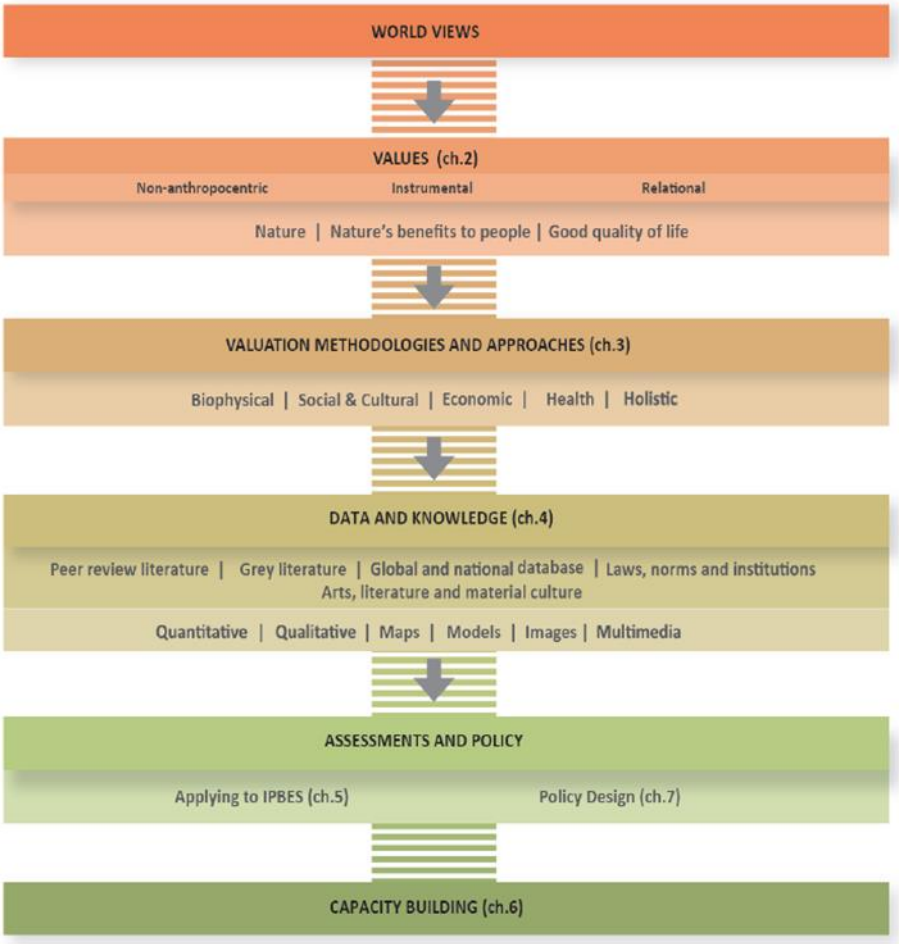
Biophysical values: A biophysical value is a measure of the importance of components of nature (living being or non-living element), of the processes that are derived from the interactions among these components, or those of particular properties of those components and processes.

Economic values: Economists group values in terms of their "use" or "non-use", each of which is associated with a selection of valuation methods. Use values can be both direct and indirect, and relate to the current or future (option) uses. Direct use values may be 'consumptive' (e.g. drinking water) or 'non-consumptive' (e.g. nature-based recreational activities). Indirect use values capture the ways that people benefit from something without necessarily seeking it out (e.g. flood protection). Non-use values are based on the preference for nature's existence without the valuer using it, and are of three types: existence value, altruistic value, and bequest value. Such values can be mediated through market, pseudo-market or non-market mechanisms.

Socio-cultural values: Values shared by people in groups and/or those that inform shared identity of a particular group.

The IPBES guide also mentions methods of integrating, bridging and upscaling valuation results, such as narratives (including scenario storylines, using artistic impressions), deliberation, integrated modelling, and multi-criteria analysis.

Fig 1.1. Overview of the nature value assessment process according to IPBES (IPBES, 2015).



The present project followed the above-mentioned logic and distinguished the following levels:

- Values (chapter 2 of the IPBES guidance (IPBES, 2015)): non-anthropocentric, instrumental, relational; nature, NCP, good quality of life
- Valuation methodologies and approaches (chapter 3): biophysical, social & cultural, economic, health, holistic methods/approaches
- Data and knowledge (chapter 4)
- Assessments (chapter 5), including focus of values
- Policy (chapter 7 of the IPBES guidance)

Please note that capacity building (chapter 6 in the IPBES guidance document) was not part of the present review.

Although the comprehensive IPBES values of nature framework has been guiding for this study, extending its scope beyond ecosystem services to include e.g., intrinsic values of nature, relational values, as well as perceptions and worldviews related to nature, it became clear from the start that the framework is complex and boundaries between different value categories (e.g., cultural values under the 'Nature for People' dimension vs. relational values).

1.4 Reviewing the current state of assessment of TOF values and services

In this project, the current state of tree value and service assessment (for TOF) was assessed in Switzerland as well as five selected, European reference countries (Germany, Spain, Sweden, The Netherlands, and the United Kingdom). The IPBES nature values framework was applied, i.e., the three different types of values will be considered, as well as examples of the five types of value assessment methods (see above).

Questions to be answered in both the international and Swiss reviews were:

Values

- What type of values are considered?
- How are values associated with nature, nature's benefits to people and a good quality of life relevant for the assessment?
- What worldviews and perceptions are involved, and what issues are at stake, in the mandate of the assessment?

Valuation methodologies and approaches

- What methodologies and approaches are in place for the values and services of trees outside forests in the set of countries studied?
- How are the five different types of valuation methodologies and approaches represented?

Data and knowledge

- What data and knowledge are needed?
- What is the scale at which the methodologies and approaches are applied? (In the context of this study, focus on the country level, but e.g., regional assessments could be of interest.)
- In what setting does the study/assessment take place?

Assessments

- What is the primary focus of these methodologies/approaches, and how do trees outside forests feature in a wider nature and ecosystem perspective? Or: how do ToF (urban, peri-urban, rural) feature in ecosystem and biodiversity assessments?
- What are some of the findings of these assessments, and what values and services are highlighted?
- How are different valuation and assessment methods combined, if at all?
- Who is assigning and implementing the valuations?

Policy

- How are valuation and assessment methods informing policy and decision making?
- What gaps are there currently in terms of assessment and valuation of TREEVES?
- Which assessment and valuation approaches are particularly promising for Switzerland?

The IPBES guidance document (IPBES, 2015) provides detailed suggestions for how to identify different types of assessment methods, as well as for what key questions to ask when reviewing (and implementing) these.

For this review it has been important to distinguish between different types of values, including worldviews, preferences, importance, and measurements. An example of this: trees that are part of agroforestry systems could be seen from a production and instrumental perspective, based on a Western worldview. However, different farmers will have different preferences in terms of using different species of trees. Trees can be of different importance (also to different people), from essential (e.g., protection of soil productivity) to mostly playing a more secondary role. Finally, the value of trees in these systems can be measured, for example in terms of the biomass produced, the increased production of other crops, and soil loss avoided.

The review and research work comprised of the following components:

a) Review of relevant literature and documents for both the international and Swiss context. For the international review, focus was on the five mentioned countries, but additional studies and reports were considered were especially relevant.
b) Semi-focused interviews with experts in both the five selected European countries and Switzerland, with focus on the questions and topics outlined above.
c) Two workshops with both selected international and Swiss experts, to discuss the study framework, (initial) findings, promising examples / good practices of TOF assessment and valuation, and possible recommendations for the Swiss context.

The project period for the above activities was September-December 2021. The expert interviews were largely held during October and November. The workshops were hosted online on October 25th and on December 7th, with 12-15 participants each.

Tables 1.2, 1.3, 1.4 and 1.5 are part of the framework used internally for analysing existing research, programs, methods, and approaches. In the next chapters, findings are presented in a narrative form, as well as through different tables.

Table 1.2. Values, methodologies and approaches.

Study/Assessment	Author	Perspective	Values (chapter 2)						Approaches (ch. 3)				
			NA	I	R	N	NBP	Q	B	SC	E	H	HM
Tree Inventory TG	Künzler / TG	Tree Protection	○		●				○	●			
Tree Strategy St. Gallen	Stadtgrün SG	Tree Protection	●					●	●	○			○

Value: *NA: non-anthropocentric; I: instrumental; R: relational; N: nature, NBP: Natures Benefits to People; Q: good quality of life.*
Approaches: *B: biophysical; SC: social & cultural; E: economic; H: health; HM: holistic methods/approaches*

In Table 2, NA values refer to 'nature for nature's sake' and the intrinsic values of e.g., individual species. Note that values will also be studied in terms of prevailing worldviews and perceptions among different segments of the population.

Table 1.3. Data and knowledge.

Study/Assessment	Database				Form of data						Scale				Setting		
	L	D	G	O	Qt	Ql	Ma	Mo	I	M	I	N	C	L	U	P	R
Tree Inventory TG		●			●	○	●		●				●		●	●	●
Tree Strategy St. Gallen			●			●								●	●		

Database: *L: Literature; D: Database; G: Governance (Laws, norms, institutions); O: other (art, literature, cultural material).*
Form of data: *Qt: Quantitative; Ql: Qualitative; Ma: Maps; Mo: Models; I: Images; M: Multimedia.*
Scale: *I: International; N: National; C: Cantonal/Regional; L: Local.*
Setting: *U: Urban; P: Peri-urban; R: Rural.*

Table 1.4. Assessment categories.

Study/Assessment	Nature				NBP				Good Quality of Life									
	I	BA	BP	B	R	P	C	H	SL	SR	DO	L	H	E	I	GR	A	S	GJ
Tree Inventory TG	●						●								●	●		●	
Tree Strategy St. Gallen	●				●	●	●	●	●	●	●								

Nature (intrinsic value): *I: Individual Organisms; BA: Biophysical Assemblage; BP: Biophysical Process; B: Biodiversity*
Natures Benefits to People: *R: Regulating Services; P: Provisioning Services; C: Cultural Services; H: Habitat Services (sometimes also called Supporting Services)*
Good Quality of Life: *SL: Security & Livelihoods; SR: Sustainability & Resilience; DO: Diversity & Options; L: Living well in Harmony with nature and mother earth; H: Health & Wellbeing; E: Education & Knowledge; I: Identity & Autonomy; GR: Good social relations; A: Art & cultural heritage; S: Spirituality & Religion; GJ: Governance & Justice.*

Table 1.5. Policy implications.

Study/Assessment	Policy (ch. 6)				Major strengths and gaps
	B	P	N	O	
Tree Inventory TG	●				Systematic overview (whole canton); spec. tree-valuation not shown in report.
Tree Strategy St. Gallen			●		The strategy describes outline and major principles for guidance.

Policy implications: *B: Basis for plans; P: Plans; N: Norms; O: Other implications*

The review also included an analysis and assessment of the suitability of methodologies and approaches for valuation of the values of trees outside forests for a Swiss context, in collaboration with key stakeholders and based on expert advice, looking at criteria such as feasibility, usability, data availability, effectiveness, efficiency, and equity. The questions provided above provided key information in support of this process.

For the Swiss context, a comprehensive review was made of relevant valuations of TOF. For the international part of the study, valuation approaches and methodologies were identified that are particularly promising for Switzerland. The international review thus had a different emphasis for the different countries, but a good coverage was be ensured of the different value types as well as the different assessment approaches (from biophysical to holistic; and from tree inventories to valuation through storytelling and deliberative approaches; and including consideration of worldviews and perceptions of TOF).

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Chapter 2: International Scoping Review

2.1 Introduction and review methodology

As outlined in Chapter 1, this international scoping review focused on trees outside forests (TOF), their values, ways of assessing and valuation these, and the attention given to these in policies and strategies. In 2001, FAO (2001) defined TOF as referring to "trees on land not defined as forest and other wooded land. This may include agricultural land, including meadows and pasture, built-on land (including settlements and infrastructure), and barren land (including sand dunes and rocky outcroppings)." Here we follow this definition, although it is sometimes difficult to separate TOFs and 'other wooded land', especially in urban areas where both single trees, groups of trees, and small woodlands are included in the 'urban forest' concept (Konijnendijk et al., 2006). Please note that in Switzerland, the situation is quite clear: TOF can be defined as all those trees that do not grow on areas subject to the Forest Act. In settlement areas, forest boundaries have been clearly defined (fixed boundaries for the forest subject to forest law). The understanding of 'urban forest' in Switzerland is such that the urban forest includes all trees in the catchment area of settlements, that means both forest trees (subject to the Forest Act) and TOF (cf. Pütz et al., 2015; Pütz and Bernasconi, 2017).

The review focused on five European countries: Germany, Sweden, Spain, Switzerland, and the United Kingdom (with focus on England). These countries were selected to provide a good range of experiences relevant to the Swiss context, while also highlighting some respective areas of focus and strength. The review was specifically focused on identifying promising approaches to recognising and assessing the values of trees outside forests in different contexts with possible relevance to the Swiss context. The review also addressed the current state of these values of TOF and the ways in which they (and their assessment) are integrated in policy and practice.

Throughout this report, the different settings in which TOF are found are identified, from the rural via the exurban, peri-urban, suburban, and the urban context. These parts of the rural-urban continuum also include a wide range of specific landscape types – often differing between countries. Specific focus areas included, but were not limited to, urban areas, agricultural landscapes, and non-forested natural areas.

The review comprised of literature and policy review, expert interviews (see Table 2.1), as well as information obtained from additional experts and policy makers via email. The expert interviews were semi-focused, using a general script that looked at different aspects of the values of trees outside forests and ways of assessing them in their respective countries. An overview of questions asked and topics addressed is provided in Appendix 1. Several of the international expert interviewees also participated in one or both of the project workshops and thus were able to contribute further to the discussions and identification of promising approaches and practices.

Table 2.1. Overview of international expert interviews

Country	Name and affiliation of interviewee	Expertise	Date of interview
Germany	*Prof. Dr. Tobias Plieninger* Universities of Kassel and Göttingen, Social-Ecological Interactions in Agricultural Systems	Cultural ecosystem services, agricultural landscapes, wooded pastures	17 September 2021
Germany	*Prof. Dr. Stephan Pauleit ** Technical University of Munich, Chair for Strategic Landscape Planning and Management	Urban green infrastructure, ecosystem services, landscape planning	24 September 2021
The Netherlands	*Dr. Arjen Buijs ** Wageningen University, Chair of Forest and Nature Policy	Cultural ecosystem services, urban nature, perceptions and values of nature	27 September 2021
Spain	*Dr. Ana Macias Palomo ** Arbocity and Universidad Politécnica de Madrid	Urban Forestry, ecosystem service assessment	21 October 2021
Spain	*Dr. Inazio Martinez de Arano* European Forest Institute, Barcelona Office	Forest policy, forest ecosystem services, environmental economics	13 October 2021
Spain	*Dr. Fernando Santos Martín* Universidad Rey Juan Carlos, Department of Chemical and Environmental Technology	Ecosystem and ecosystem service assessments	23 September 2021
Sweden	*Dr. Marcus Hedblom ** Swedish University of Agricultural Sciences, Department of Urban and Rural Development	Landscape assessment, urban forestry, ecosystem services	27 September 2021
United Kingdom	*Dr. Kieron Doick ** Forest Research	Urban forestry, assessment of urban ecosystem services, urban forest inventory	14 October 2021
United Kingdom	*Prof. em. Alan Simson ** The White Rose Forest and formerly Leeds Beckett University	Urban forestry, community forestry, landscape design, values of nature	28 September 2021

*also participated in one or both of the project workshops.

This work comprises a scoping review rather than a full, systematic assessment of TOF values and assessment approaches due to the objectives of the study and the time limitations. It was carried out in parallel with a more comprehensive of TOF, their values, ways of assessment them, and consideration in policies and programs in Switzerland.

2.2 Results

2.2.1 Introduction

This chapter summarises the findings of the international review, with focus on the five selected reference countries. Appendix 2 provides a tabular overview of selected relevant studies and assessments.

2.2.2 Values of TOF

In general, there has been a broadening of the perspective on values of nature over the years. The ecosystem service concept has become the most widely used way of identifying and categorising values of nature, and TOF in particular. Often the categorisation by the Millennium Ecosystem Assessment (2005) is used or at least serves as inspiration, with the following categories of ecosystem services: supporting, provisioning, regulating, and cultural. Sometimes variations on this categorisation are used. An example of this is the Common International Classification of Ecosystem Services (CICES) by the European Environment Agency (2021). CICES distinguishes between provisioning services, regulating and maintenance services, and cultural services, but also makes an explicit distinction between biotic and abiotic services within each of these categories. Most studies reviewed for this project used a classification based on either MEA or CICES. One of the interviewees mentioned, for example, that they used the CICES framework for their assessment of urban forest ecosystem services in Madrid, Spain (Macias Palomo, pers. comm.). In urban contexts, assessment tools such as i-Tree (see below) also focus on ecosystem services, and regulating services in particular.

At the global level, TOF have been given attention for quite some time by organisations like the Food and Agriculture Organization of the United Nations (see e.g., FAO, 2001, 2002), often in a Global South context and with focus on e.g., contributions to people's livelihoods. An illustration of the increasing attention for TOF is the article by Skole et al. (2021) on trees outside forests as natural climate solutions. The authors state: "Trees outside of forests are numerous and can be important carbon sinks, while also providing ecosystem services and benefits to livelihoods. New monitoring tools highlight the crucial contribution they can make to strategies for both mitigation and adaptation." In the article they e.g., refer to a recent, nation-wide assessment of trees in Rwanda and of trees in savannah ecosystems in Senegal, linking these to estimates of carbon storage.

The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) has further broadened the perspective, recognising as three value categories those of Nature for Nature (the intrinsic values of nature), Nature for Society (instrumental or use values of nature, most closely related to the ecosystem service concept), and Nature as Culture (the relations values of nature) (Fig. 1.1). Most of the expert interviewees stated that they were familiar with the IPBES framework, but they had not yet seen it widely implemented in their respective countries. The ecosystem service framework was still more prevalent in most cases.

The following overview looks at the three main IPBES value categories in relation to TOF. It also considers the aspect of different worldviews and perceptions, as values will differ between different socio-demographic groups.

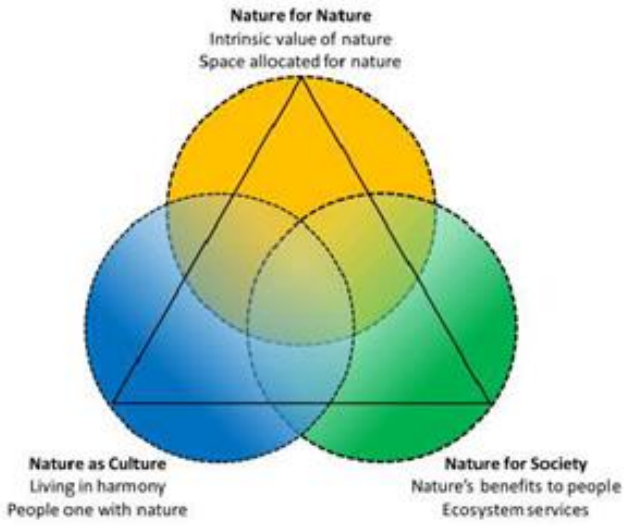

Fig. 1.1. IPBES Pluralistic Nature Futures Framework to capture the multiplicity of relationships between people and nature: Nature as Culture (blue) where society lives in harmony with nature; Nature for Society (green) where utilitarian values for nature dominate; and Nature for Nature (orange) where intrinsic values for nature, its species, habitats, and ecosystems, are given a higher value than benefits to humans.

Nature for Nature

The intrinsic values of nature have often been considered, e.g., in well-established nature conservation policies and programs in European countries, but these values are typically addressed via biodiversity assessments at different scales (from the local to the European), which in many cases are not directly linked to ecosystem services. Moreover, there are not many examples of biodiversity assessments that specifically address TOF. One global meta-analysis of the biodiversity values of 'scattered trees' in the landscape did show the importance of TOF for ecosystems (Prevedello et al., 2017). The authors write: "Scattered trees are thought to be keystone structures in landscapes based on the recognition that they occupy a small part of the landscape but may have disproportionately high ecological importance". The authors also write that these trees, as part of both natural and human-dominated landscapes, have been largely neglected by researchers and their importance for biodiversity remains unclear. More usual is that TOF are part of wider ecosystems or landscapes, with perhaps urban forestry and to some extent agroforestry landscapes being the exceptions. Moreover, in countries like the UK, ancient trees in urban, rural, and natural settings are given specific attention in policy, legislation, and monitoring.

Not only species diversity is assessed, as there has also been attention for e.g., habitats, biotopes, and landscapes. One of the interesting approaches that recognised the values of nature for nature, and also carries out regular assessments to monitor change, is the *National Inventory of Landscapes in Sweden* (NILS) program (SLU, 2021). NILS is mainly funded by the Swedish Environmental Protection Agency and an important objective is to provide information for follow-up of the Swedish national environmental objectives and the Natura 2000 network. NILS also contributes data to environmental research and international reporting. It has put focus on selected landscapes of high value, namely seashores, deciduous forests, grasslands, and mountain areas, but trees outside forests have not been specifically addressed in the assessment. The NILS program takes a rather broad, national-level approach and the Swedish County Boards developed a spin-off (called LillNILS, or 'small NILS´) to focus more on regional monitoring of landscapes, nature and biotopes

(Länsstyrelsen, 2021). This program neither has specific focus on trees outside forests, but it looks at small biotopes, grassland, beaches, and ants.

Nature for Society

In the countries studied, when it comes to TOF (and in fact many other forms of nature), the instrumental values of nature (that is, ecosystems services) are still the primary focus – both of research, policy, and practice. Among these, recent years have seen a rise in recognition of the regulatory ecosystem services of trees, such as their role in (storm)water regulation, carbon sequestration, cooling, air pollution reduction, and wind and noise reduction. Often explicit links are made between trees and climate action, e.g., in terms of trees and urban tree canopy cooling cities with one or more degrees Celsius during hot summers (see Marando et al., 2022 for a recent example). Most of the tree-related work has been done in urban areas, in relation to urban forestry programs, and using assessment tools such as i-Tree (see the following sections). The relative focus will often shift depending on the context considered, e.g., more emphasis on wind reduction in rural landscapes, on drinking water protection in peri-urban landscapes, and on cooling in urban areas.

In urban areas, the socio-cultural benefits of TOF have often been in focus, thus linking to the cultural ecosystem service perspective (e.g., Veerkamp et al., 2021). Urban trees and the green spaces they help shape are recognised for their essential contributions to recreation and tourism, high-quality living environments, social cohesion, education, and with that also the wider health and well-being benefits. During the Covid-19 pandemic, the cultural services provided by especially urban and peri-urban forests became even more prominent, as the example from Germany by Beckmann-Wübbelt et al. (2021) shows. Using a participatory map-based questionnaire survey, the study demonstrated that residents prefer nearby locations for all studied cultural ecosystem services but place a higher value on peri-urban forests regardless of their frequency of use. The survey results showed an increase in visits to urban and peri-urban forests during the COVID-19 pandemic.

There is a wealth of research on the different socio-cultural benefits of urban trees. For just some guidance and examples, refer to UK Government (2021), Vibrant Cities Lab (2021; mostly based on US research), and various chapters in Ferrini et al. (2017).

In a review of 850 studies by Veerkamp et al. (2021), most ecosystem service assessments for blue and green infrastructure focused on unspecified green space (30% of the studies) or parks (26%). TOF were not recognised as a specific category of green and blue infrastructure, but trees were mentioned as components of categories like parks and (semi-)natural green spaces and building green. A Swedish study estimated that at least about 50% of green infrastructure comprises of trees in Swedish cities (Deak Sjöman and Östberg, 2020).

In rural areas, the amount of research specifically on TOF values / ecosystem services is generally more limited. The work by experts like Tobias Plieninger and collaborators to map and assess the cultural values also in rural landscapes, such as wooded pastures, deserves specific mentioning here (e.g., Plieninger et al., 2013, 2015; Torralba et al., 2016). In some of these studies, cultural services are linked to provisioning services of the productive agricultural landscape. More about these studies and the promise they hold for the Swiss context will be discussed later in this report. There is more focus on the provisioning services of e.g., fruit and nut trees. Countries like Spain are world-leaving exporters of olives, lemons, oranges, and other fruit, mostly grown in orchards.

Nature as Culture

If one sees the relational values of TOF as also including at least some of the cultural ecosystem services than some of these values have become recognised and studied. However, most interviewees mentioned that the relational values were probably the least studied and recognised to date in their respective countries. These values are framed by IPBES are related to humans being part of nature, and ideally living in harmony with nature (see also Kok et al., 2016). That the 'Nature as Culture' dimension and relational values are still somewhat difficult to operationalise is also discussed by Stålhammar and Thorén (2019) who write "We show how the concept can be seen as solving the problem of narrow conceptualizations of intrinsic and instrumental value in ecosystem services valuation and suggest that RV can be conceived of as an epistemological framing rather than a values concept." The authors relate relational values to the fields of ethics, (cultural) ecosystem service valuation, and environmental psychology.

A recent paper by Pramova et al. (2021) builds, among other, on the relational values concept in an effort to better frame and explore the sensory, affective, and cognitive dimensions of human–nature interactions, as well as the settings and activities that frame them. The authors mention how human–nature connections are produced through an interactivity of mind, body, and environment. Raymond et al. (2018) refer to 'embodied ecosystems' that are constituted by a web of relations between environment, culture, body and mind, which are situational and dynamical.

Worldviews and perceptions

Most, if not all of the countries studied, have recognised the need to understand and regularly assess different worldviews and especially perceptions of nature. This does not often specifically relate to TOF, but often to nature and landscapes more general, for example through surveys to assess how different socio-demographic groups looks at nature, biodiversity, and nature conservation. These surveys have often asked for preferences, most preferred benefits and for different types of nature (e.g., forests, coastal areas, agricultural land), showing differences between e.g., gender, age groups, and income levels. Some specific studies have also looked at differences between people of varying cultural backgrounds, including studies in The Netherlands of how immigrant groups use and look at different types of urban and rural nature (see for example Buijs et al., 2009; Kloek, 2015). This work has shown that ethnic identities play an important role in outdoor recreation, with distinct differences between different ethnic groups as well. The work by Kloek (2015) also looked specifically at young adults of different ethnic decent, finding that personal identities alongside collective identities (particularly being a youngster and ethnic background) were perceived as important for outdoor recreation. Recently there has been more focus on vulnerable groups and their use and perception of nature (e.g., Raymond et al., 2021), linked to the field of environmental justice and fair access to nature for all (Calderón-Argelich et al., 2021 for a recent review).

A new study in the UK by Forest Research on the public perceptions of urban trees, with a representative sample of the UK urban population, can also be mentioned here (Forest Research, 2021). The research has investigated individual and community level understanding of and support for, planting, management, and maintenance of urban trees. It also compared the value of urban trees with other urban habitats, including managing or removing trees for other biodiversity or societal benefits. Study findings showed that urban trees in all settings were appreciated, but those in urban parks and similar settings were seen as the most beneficial. About 50% of people felt more connected to urban trees since the COVID19 lockdowns, and many felt attached to trees through folk stories and sayings and personal childhood memories of interaction with particular trees. There were differences by age, gender, and ethnicity, and by region or country, for some of the questions asked, but the statistical significance of these was very small in most cases.

Sometimes a distinction has been made between urban and rural populations. In the Spanish national ecosystem service assessment (Gobierno de España, 2014), for example, cultural services are assessed separately for urban and rural people, as the review team considered these to be fundamentally different (Santon Martín, personal communication). An example of how this distinction is reflected in the assessment is provided in Fig. 2.2.

Nature awareness / appreciation / perception studies, often done at the national level (both urban and rural). An example is the national, representative so-called Nature Awareness Study (BfN, 2019) in Germany. In the 2019 edition, for example, there is a lot of focus on biodiversity, protected areas on changing preferences for 'wilder' nature, but trees also feature. They are mentioned in the top 5 of which species the population would like to know more about, for example, following birds and flowering plants in general (BfN, 2019). Important generational differences were noted. For example, the youngest surveyed segment of those under 30 did not differ from the general population with regard to their basic interest in species knowledge but does ascribe itself a significantly lower level of knowledge about animals and plants.

Studies typically distinguish between different segments of the population (e.g., based on age, gender, income, education, cultural background, urban versus rural) and they dig into perceptions and to some extent different worldviews. TOF are not often distinguished as a separate type of nature, although the UK study explicitly focused on urban trees and one of the German studies focused on urban nature.

Considering perceptions, worldviews, and experiences of TOF is important, for example within the context of what has been coined 'the extinction of experience'. A review by Soga and Gaston (2016) illustrates that the loss of interaction with nature not only diminishes a wide range of benefits relating to health and well-being, but also discourages positive emotions, attitudes, and behaviour with regard to the environment, implying a cycle of disaffection toward nature.

Comprehensive perspectives on values

Although, as mentioned earlier, a more comprehensive perspective of the values of nature in line with e.g., the IPBES plural values framework is still not very common, some countries have started to implement it. PBL The Netherlands Assessment Agency, an official government body, writes on its website: "The goods and services provided by nature are important, or even indispensable, for human survival on earth. Consider, for example, the production of wood or the dunes offering protection against flooding. These are what we call ecosystem services. Nature and biodiversity are also considered to have their own, intrinsic value, apart from their usefulness to humankind." (PBL, 2021).

Another example of more comprehensive consideration of the multiple values of trees (and woodland) is the England Trees Action Plan 2021-2024 (UK Government, 2021). Textbox 2.1 gives an overview of the types of values and benefits identified and prioritised. Most of these relate to ecosystem services, but there are also links to 'Nature as Culture' and aspects such as living in treed landscapes and sense of place.

It is also important to note that the value categories are not mutually exclusive, but rather intricately connected and can mutually reinforce each other (Stålhammar and Thorén, 2019).

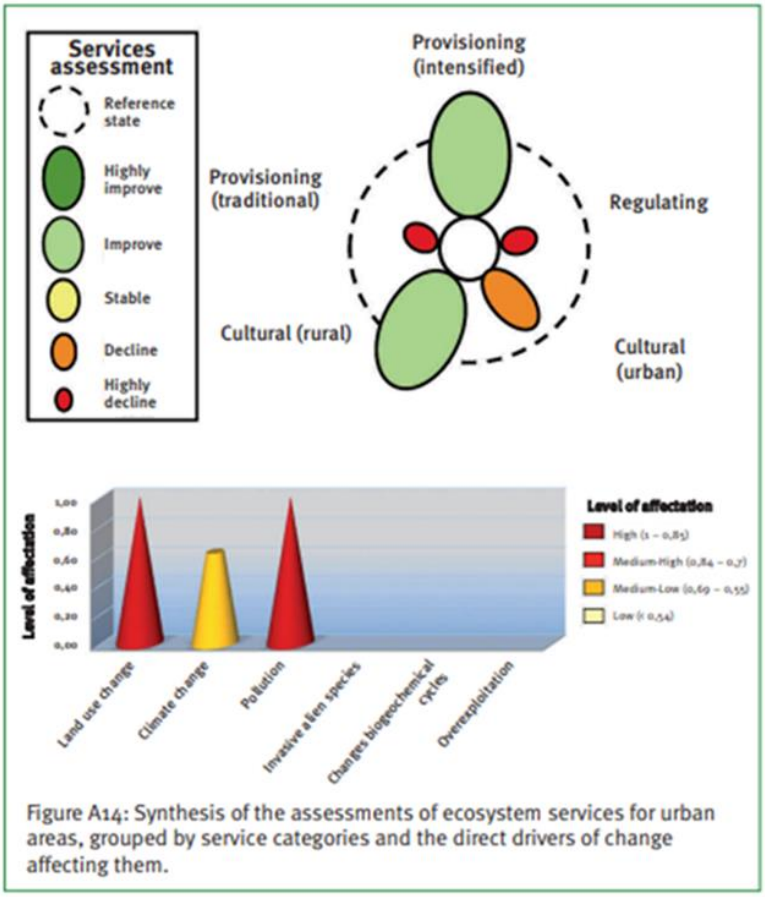

Figure A14: Synthesis of the assessments of ecosystem services for urban areas, grouped by service categories and the direct drivers of change affecting them.

Fig. 2.2. Distinction made between cultural services for urban and rural populations in the Spanish National Ecosystem Assessment (Gobierno de España, 2014).

2.2.3 Valuation and assessment methodologies and approaches

Following the IPBES framework, there are five overall types of assessment approaches, with their respective focus on biophysical, sociocultural, health, economic, and holistic assessments. In general, more comprehensive assessments of the values of nature in general, and those of TOF in particular, are still rare, although e.g., national ecosystem (service) assessments in countries like the UK and Spain, and national landscape assessments in e.g., Sweden are attempts at this type of effort (see below). The UK seems to be one of the few countries that has given specific attention to 'trees outside woodland'. It has become clear, however, that trees outside forests are not very often specifically covered. Assessments and valuations have often taken a broader perspective, e.g., looking at ecosystem and landscape types without specifically distinguishing the tree component.

Biophysical valuation and assessment

Very few valuations and assessments of the biophysical TOF resource have taken place beyond the local or site level. An exception in Europe is the UK, where 'tree cover outside woodlands' has been assessed once as part of the UK National Forest Inventory (Forest Research, 2017). This report provides estimates of the amount of tree cover outside National Forest Inventory (NFI) woodland areas in the form of small woods, groups of trees and lone trees, as of January 2016. It includes estimates for England, Scotland, and Wales, broken down by NFI Regions and by urban and rural land categories. The assessment of tree cover outside woodland used the National Tree Map produced by Bluesky International Limited and a NFI programme of field surveys and hand mapping of non-

woodland tree cover, used for calibrating and correcting areas derived from the National Tree Map. See Textbox 2.2 for some key findings.

Textbox 2.1. Benefits of trees and woodlands - England Trees Action Plan 2021-2024.

The plan lists the following priorities in terms of benefits:

- Nature recovery
- Trees and woodlands for climate change mitigation
- Levelling up of thriving forest economy
- Trees and woodlands for water and soils
- Trees and woodlands for people in towns and country
- Heritage and landscape
- Trees outside woodlands
- Healthy, resilient trees and woodlands

The item 'trees and woodlands for people in towns and country' specifies the multiple benefits of trees for people, including e.g., wellbeing and mental health (with the importance of these having been highlighted during the Covid-19 pandemic), improving air quality, and contributing to social cohesion and sense of place. For 'trees outside woodlands' is mentioned: "Trees throughout the environment such as wood pastures, ancient and veteran trees, scrub, scattered and hedgerow trees contribute to England's natural beauty and are important spaces for nature. We must continue to protect and enhance these features. Agroforestry will also play an important role in delivering more trees on farms and in our landscape, improving climate resilience and encouraging more wildlife and biodiversity in our farming systems." (p. 8).

Source: UK Government (2021)

Although not part of the countries included in this review, the United States should be mentioned as another country that has attempted to assess the TOF resource, and trees in urban areas in particular. It has developed an extensive Urban Forest Inventory Assessment program, under the umbrella of the US Forest Service, for the about 2.7% of land area in the conterminous United States (US Forest Service, 2021).

Specific components of the TOF resource have been given more attention in biophysical assessments, including orchards. Under the umbrella of the European Commission and Eurostat, for example, assessments of orchards are carried out every five years (Eurostat, 2021). The UK government (Defra, 2007) has provided a handbook for the survey of hedgerows at the local level. Also in the UK, studies have assessed hedgerows, for example in terms of their length and pattern characteristics (Barr and Gillespie, 2000; Carrey et al., 2009). A survey from 2007 (published in 2008) estimated that there are 402,000 km of "managed" hedgerows in England. There are a further 145,000km of linear features such as relict hedges and lines of trees. Between 1998 and 2007 the total length of managed hedgerow decreased by 6.1% (26,000km). A large proportion of this decrease was managed hedges turning into lines of trees and relict hedges (which increased by 13.2%), reflecting a reduction in management intensity (Carey et al., 2009).

Ancient or remarkable trees are another TOF component for which some inventories exist, for example in countries like the UK (Woodland Trust, 2021) and Spain (Observatori del Paisatge, 2021). As of December 2021, the UK inventory already included 160,000 trees, but the work was ongoing. A searchable database is available online. The national register in Spain does not advertise the location

of individual specimen trees out of fear that trees will suffer from too many visitors and associated soil compaction and other damages (Macias Palomo, pers. comm.).

As for example demonstrated by Skole et al. (2021) rapid advances in geospatial technologies and data will make it easier to assess TOF resources, also at the national level. Measurement capabilities are emerging across a wide spectrum of remote-sensing platforms, from medium (10–30 m) to high (~3 m) and very-high-resolution (<1 m) products.

When TOF and their values are specifically recognised and included in assessments, this is mostly done in urban areas. Urban forest and urban tree inventories, assessment, and monitoring using a wide range of approaches and tools (see below) has become more common, also helped by the advancement in geospatial methods. The emergence of assessment tools such as i-Tree have resulted in some form of standardisation that will also make national and international comparison and benchmarking possible. However, many cities have their own ways of assessing their urban trees and their values, using their own specific tools and database. In many cases, only publicly owned trees are included in assessments. The specific framework conditions, objectives and methods are set at city level; thus no or only very limited national data are available.

Trees also feature in biophysical assessments that have a wider scope – and are sometimes more directly tied to urban planning. An example of this is the Green Space Factor tool developed by the City of Malmo, and now used also by other cities in Sweden and elsewhere (Kruuse, 2017). The system comprises of a point system that determines how green a certain existing area of new development is. This given municipalities a tool to secure a minimum standard for local green space. Trees, and especially larger trees, as well as tree diversity all generate high scores in the Factor.

The biodiversity values of TOF have also been the subject of study. A meta-analysis of 62 studies, including several in the five countries that are the focus of this report, on the biodiversity values of ‘scattered trees’ by Prevedello et al. (2017) found that the local abundance of arthropods, vertebrates and woody plants was 60%–430% greater and overall species richness was 50%–100% higher in areas with scattered trees than in open areas.

Sociocultural assessments

Social values can broadly be described as those values that people express regarding the environment (see Stålhammar and Thorén, 2019). Social (and cultural) values, like many of those values encompassed by ES valuation methods, are subjective values in a methodological sense, in that they build on social perceptions of environments.

Studies and assessments have looked at cultural ecosystem services through the lens of e.g., recreation, sometimes also including a perception, preference, and sense of place perspective. Other studies focus mainly on uses and activities. This type of work has been done in various settings, from the urban to the rural context. A wide range of assessment methods has been used, including a combination of social surveys / interviews and GIS-based for assessing and mapping cultural (and other) cultural ecosystem services (often done in rural areas, but also in urban ones). The work by scholars such as Dr Tobias Plieninger tries to find ways of capturing ecosystem services at the level of individuals, and then aggregating these at the level of a specific landscape or area (e.g., Plieninger et al., 2013).

Textbox 2.2. Tree cover outside woodland in Great Britain – a national inventory.

Some of the key findings from this 2016 inventory (for England, Scotland, and Wales) include:

- There are 742 thousand hectares of tree cover outside areas of NFI woodland in Britain; 565 thousand hectares in England, 84 thousand hectares in Scotland and 93 thousand hectares in Wales.
- 546 thousand hectares (74%) of tree cover outside woodland are found in rural areas and 196 thousand hectares (26%) in urban areas. Non-woodland tree cover amounts to 11% of land area in urban areas and 3% in rural areas.
- Total tree cover, including both woodland tree cover and tree cover outside woodland is 16.5% in urban areas and 16.7% in rural areas.
- Small woods of over 0.1 hectare in extent cover 390 thousand hectares in Britain; 295 thousand hectares in England, 46 thousand hectares in Scotland and 49 thousand hectares in Wales.
- Groups of trees of less than 0.1 hectare in extent cover 255 thousand hectares in Britain; 193 thousand hectares in England, 29 thousand hectares in Scotland and 33 thousand hectares in Wales.
- There is estimated to be a total canopy cover of 97 thousand hectares associated with lone trees2 in Britain. The country breakdown of this total is 78 thousand hectares in England, 9 thousand hectares in Scotland and 10 thousand hectares in Wales.

Forest Research (2017)

Pramova et al. (2021) mention how cultural ecosystem services research and practice has mostly focused on cognitive ways of constructing and expressing intangible values of, and relationships with, nature. But the authors stress that our non-material relationships with nature are not exclusively cognitive: sensory and affective processes are fundamental to how we build, enact, and experience these relationships. Building on the relational values concept, embodied experiences and connectedness with nature, a simple framework is presented and tested through interviews with people inhabiting a series of local landscapes in the Peruvian Andes (see Fig. 2.3) to explore the sensory, affective, and cognitive dimensions of human–nature interactions, as well as the settings and activities that frame them. Approaches like this also hold promise in relation to TOF.

More recently, assessment have also looked at people's perceptions, preferences, and behaviours, distinguishing between different socio-demographic and even socio-cultural groups. Kim et al. (2021) stress the importance of these types of assessments, as drawing on rich plurality of people's values and preferences on nature from diverse places is key to improved decision-making, ensuring equitable sharing of benefits and responsibilities.

Recent research projects such as VIVA-PLAN, led by Swedish partners, explored the links between vulnerable groups and urban green space, as part of developing a multi-method approach for engaging diverse groups in the planning of green spaces and meeting spots (Raymond et al., 2021). As illustrated in Fig. 2.4, they used a series of different approaches, including e.g., ethnographic ones, to better understand how different (vulnerable and other) groups are using urban green spaces. The researchers recognise that this multi-method approach is time- and resource consuming, with for example the ethnographic study taking an estimated six months (Buijs, pers. comm.), but this type of approach is very important for getting a more comprehensive overview of the views and perceptions of all segments of a local community. In the section about holistic assessments we also refer to the

use of storytelling as a way of gaining deeper understanding of the cultural values of landscapes to residents (Bieling, 2014).

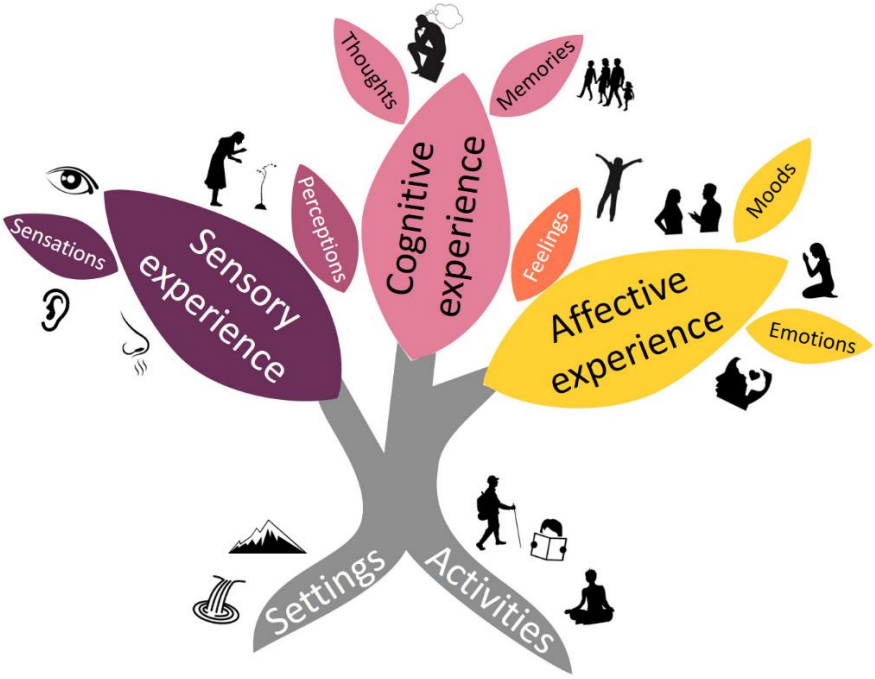

Fig. 2.3. Framework for analysing experiences with non-human natures (Pramova et al., 2021).

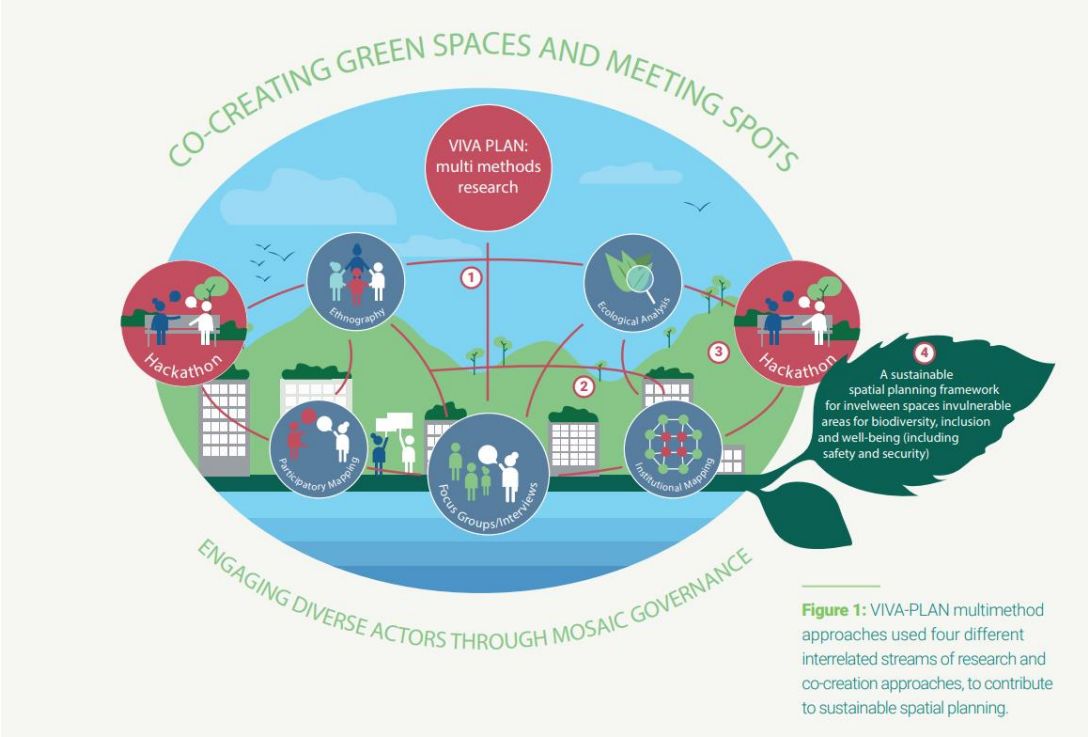

Fig. 2.4. The VIVA-PLAN multimethod approach for understanding how different groups use and perceive green spaces, as a way of starting to engage them in governance and management of these spaces (from Raymond et al., 2021).

As highlighted by Kok et al. (2016), implementation of the IPBES plural values of nature framework requires assessing and identifying effective participatory tools and processes that can bridge diverse knowledge systems in scenario processes. An interesting example of the use participatory GIS tools is the study by Bijker en Sijtsma (2017) on mapping people's favourite places at different scales (for the case of Berlin and Germany). Once again, TOF do not feature separately, but they are part of landscapes and favourite places, and assessment approaches like this hold promise.

Health assessments

Research on the relations between nature and public health has increased rapidly during recent years (see for an overview Van den Bosch and Bird, 2018). The links between trees, and especially urban trees, and human health have also become well studied (e.g., Wolf et al., 2020). Some ongoing work by Forest Research and others looks at the health benefits of street trees in particularly, including determining the economic values of these (Doick, personal communication).

In general, health impact assessments have become more widely implemented, for example to assess the health impacts of new developments and projects. Green space, especially in urban contexts, is sometimes considered in these, including tree canopy. One of the few examples that specifically looks at the health impact of a change in urban tree canopy is the work by Kondo et al. (2020) for Philadelphia, USA. The researchers aimed to assess whether an increase in tree canopy or greenspace in Philadelphia could decrease mortality. They estimated that 403 premature deaths overall, including 244 premature deaths in areas of lower socioeconomic status, could be prevented annually in Philadelphia if the city were able to meet its goal of increasing tree canopy cover to 30%.

For the five countries studied, work in Spain in particular stands out, and a city like Barcelona in particular. In a study of potential health impacts of the so-called Barcelona Superblock program, which involves the removing of traffic, partially closing off streets, and establishment of new public spaces and tree planting, some major impacts were identified (Mueller et al., 2020). If the full program would be implemented, the researchers find, as many as 667 premature deaths could be prevented annually. Although the greatest proportion of these could be attributed to reductions in NO2 levels, road traffic noise, and health, green space would result in 60 less premature deaths. In another, pan-European study of over 1000 cities, it was estimated that 43,000 deaths annually could be avoided if citizens would have proper access to urban green space (Pereira Barboza et al., 2021).

Economic assessments

Since the wider implementation of the ecosystem service framework starting from the early 1990s, more emphasis has been put on economic assessment of the values of nature. New research and environmental economic approaches have assisted with this, and many studies initially took a very large-scale perspective (e.g., at the global or national level). Economic valuation has become part of national ecosystem service assessments such as those in Spain and the UK. The UK assessment comprises of many different components and work packages (UK National Ecosystem Assessment, 2021). A summary report highlights findings such as the contribution of pollination services to UK agriculture being estimated to be 400 million GBP per year based on the economic value of the crops produced. In Wales, natural environment-related activities contributed 9% of the national GDP; one in six jobs and 10% of all wage and salary income (UNEP et al., 2014). It is also stressed the economic value estimates for different services cannot be aggregated.

A meta-study by Quintas-Soriano et al. (2016) of economic valuation of ecosystem services in Spain based on the national ecosystem service assessment found an increase in the number of scientific studies on the economic valuation of ecosystem services. Cultural ecosystem services (and especially nature recreation and tourism) received the most attention, and coastal systems and forested areas were the most studied ecosystem types. TOF were not given specific attention, but they are part of

ecosystems such as mountains, urban areas, arid areas, and agroecosystems. The authors also provide some overall valuation of different categories of ecosystem services, aggregated for all types of ecosystems, with provisioning services eliciting the highest economic values (284.04 EUR/ha/yr), followed by regulating services (131.40 EUR/ha/year) and cultural services (100.83 EUR/ha/year). Out of all services, food was the most valued (371.04 EUR/ha/year), followed by regulation against hazards, primarily forest fires (262.83 EUR/ha/year; SD = 435.38), and nature tourism and recreation (186.36 EUR/ha/year). Although spiritual values ranked lowest, they still accounted for 6.22 EUR/ha/yr.

The Netherlands became one of the first countries in the world to officially implement ecosystem accounting and the monetary valuation of ecosystem services (Horlings et al., 2020). A recent report presented a monetary supply and use account and the ecosystem asset account measure the flow of services from ecosystems to society (using the framework developed by the UN, the so-called SEEA EEA). The study estimated the value of ten ecosystem services, including provisioning, regulating and cultural services. The results are spatially explicit and presented per province and on national scale. TOF were not specifically covered. The ten ecosystem services covered were crop production, fodder production; timber production; air filtration; carbon sequestration in biomass; water filtration; pollination; nature recreation; nature tourism; and amenity services. For each ecosystem service valuation methods were selected that are conceptually valid. Monetary values were calculated using the Net Present Value method. The researchers also conclude that, from a conceptual and practical point of view, the best valuation techniques to apply are: rent-based methods (e.g., stumpage prices, rent prices for agricultural land) for provisioning services; replacement cost or avoided damage costs methods for regulating services; and consumer expenditure and hedonic pricing for cultural services.

The use of a natural capital accounting approach has also been applied in countries like the UK. The Office for National Statistics and Department for Environment, Food and Rural Affairs have been working on a natural capital project (Office for National Statistics, 2021). The project website states that accounting for natural capital is important as many of the most valuable services it provides are intangible, so they are often overlooked; therefore, prior to creating natural capital accounts, decisions can frequently be made without best representing the environment. So-called dedicated habitat accounts have included, among other, those for woodland, marine areas, and urban areas, while cross-cutting accounts have looked into e.g., carbon stock and outdoor tourism and leisure.

More specifically relevant for TOF valuation is the research done by Binner et al. (2017) on valuing the social and environmental contribution of woodlands and trees in England, Scotland and Wales. The report is mostly a review of exciting ecosystem service valuations of woodland and trees, but it also provides a comprehensive overview of different assessment and valuation approaches. The report has special emphasis for both urban trees and trees (and woodlands) on farms. For the latter it looks at e.g., fuelwood, water management, and crop pollination services of trees. The report also highlight the potential of trees and woodlands on farms to reduce and capture ammonia emissions.

Specific types of TOF have been given some attention economically, also at the national level. From national economic statistics in The Netherlands can be derived, for example, that fruit production in the country has a value of 1.3 billion EUR, with a large part of this coming from fruit trees (CBS, 2020). Not from the five countries studied in this review, but an Israeli study estimated the annual value of old growth trees in Israel using a Contingent Valuation (CV) study. Included in the category of old growth trees were single trees in urban settings generally on private property, single trees or small groupings observed on both private and public lands, located in rural areas, and single trees or small groupings located in national parks, reserves, groves, and forests. It was found that the annual value can range between 2.35 and 19.9 million Euros depending on the assumption with respect to who are the beneficiaries of the project (Becker and Freeman, 2009).

At the local level, especially in urban forestry, quite some emphasis has been put on economic valuation of (regulatory) ecosystem services, although this is still less the case than in North America where e.g., i-Tree has become widely used for urban forest assessment (i-Tree, 2021). Recently the assessment approach was even used to carry out a national assessment of urban forest benefits. A study by the University of Nebraska for the Arbor Day Foundation found that urban trees contribute 73 billion USD in community-wide environmental benefits each year. Out this, 65 billion USD are related to carbon sequestration, 5 billion USD to air pollution reduction, and 3 billion USD to stormwater management (Arbor Day Foundation, 2021). The urban tree resource in the US also added 31.5 billion USD added annually to property values across the country.

In all countries included in the scoping review, the i-Tree assessment tool developed by the United States Forest Service have been applied in at least some cities. i-Tree consists of a suite of software tools (including e.g., i-Tree Eco, i-Tree Landscape) that combine geospatial information and on-site (sample) inventories to assess the structure of a local urban or community forest. Based on information on canopy cover, species distribution, and other information, the ecosystem services provided for individual trees, tree sites, or a community's entire urban forest are modelled and assessed. Moreover, a monetary value can be linked to these services. i-Tree currently has a strong focus on regulatory ecosystem services, such as carbon sequestration, air pollution reduction, cooling, stormwater regular, and energy saving. To be used properly, national-level data (e.g., for climate and tree species) needs to be uploaded. Recently i-Tree adaptations have been made for countries like the UK, The Netherlands, and Sweden. A high-profile example is the London i-Tree assessment (see Textbox 2.3) which shows that the annual economic value of the urban forest, based on a set of regulatory ecosystem service, is close to 156 million EUR. The London study also assessed the amenity value of London's 8+ million trees using the CAVAT method, giving a total value of 44.3 billion GBP (about 52 billion EUR), which equals about 6,175 EUR value per tree.

Table 2.1 provides a comparative view of i-Tree assessments and the economic value of the urban forest in selected Dutch, Swedish, and UK cities. The assessment in Utrecht, The Netherlands found that trees in the urban core had the highest values, while the city as a whole gave an average economic value of 16.75 EUR. In London, the equivalent annual value per tree is 18.51 EUR. It should be noted, once again, that i-Tree only allows for assessing a select group of (regulatory) ecosystem services. The Swedish i-Tree estimated that carbon stored in all Swedish urban forests is the equivalent of the annual emission of more than 5.5 million cars. The carbon stock stored in London's trees represents a value of 20.5 EUR per tree.

Other economic assessment tools have been developed for urban trees, often to calculate replacement cost or determine the appropriate fine level when trees are damaged or removed. In the UK, the so-called CAVAT assessment model is widely used for individual trees and small groups of trees (The London Tree Officers Association, 2017; Doick et al., 2018), sometimes also in rural areas. This method sets out to value amenity trees as public assets. It includes two methods: the Full Method, which is used to provide a compensation replacement value for single trees; and the Quick Method, which is used to determine the value of a population of trees as an asset, for asset management purposes. CAVAT is widely adopt-ed across the UK within local authority tree departments, and by major landholding and transport organisations. Countries like Sweden and Spain have developed their own tree valuation and replacement cost methods, such as the Norma Granada in Spain (AEPJP, 2020).

Textbox 2.3. i-Tree assessment of London's urban forest.

In 2019, i-Tree was used to assess the ecosystem services and values provided by the urban forest of London, UK. The study estimated that there are approximately 8.4 million trees in London's urban forest. Some selected benefits:

- 2.4 million tonnes of carbon stored valued at GBP 146.9 million
- 77,000 tonnes of carbon sequestered annually valued at GBP 4.79 million per year.
- 2241 tonnes of pollution removed annually valued at GBP 126.1 million per year.
- 3.5 million cubic meters of avoided storm water runoff valued at GBP 2.8 million per year.
- GBP 260,600.0 per year of energy savings attributed to trees in relation to buildings.

The London urban forest assessment was one of the largest scale i-Tree projects completed with over 700 plots surveyed throughout inner and outer London. It involved professional assessors as well as a large number of volunteers.

Treeconomics (2015)

Table 2.1. Comparison of the economic value of urban forests in selected European cities based on i-Tree assessments.

City	Number of trees	Air pollution reduction value (EUR)	Water regulation value (EUR)	Annual carbon storage value (EUR)	Total carbon stored value (EUR)	Total *annual* value of urban forest (EUR)[2]
Utrecht (NET)	148,908[1]				5,429,649	1,500,000
Gothenburg (SWE)	10,230,045	103,268,166			680,464,504	
Helsingborg (SWE)	319,370	1,756,925			36,013,718	
Stockholm (SWE)	969,464	9,663,089			107,145,751	
Bristol (UK)	600,000	1,879,613	164,466	1,080,777	27,019,440	3,171,847
Glasgow (UK)	2,000,000	1,644,661	1,292,234	1,644,661	46,990,331	7,812,143
London (UK)	8,421,000	148,137,021	3,289,323	5,627,092	172,571,993	155,890,425

NET = The Netherlands; SWE = Sweden; UK = United Kingdom. [1]Municipal trees only. [2]Only for a select number of regulatory ecosystem services assessable by i-Tree. Sources: Deak Sjöman and Östberg (2020) for Sweden; Platform i-Tree Nederland (s.a.) for The Netherlands; Treeconomics (2015) for London; i-Tree Bristol (2019) for Bristol; Rumble et al. (2015) for Glasgow.

Provisioning services such as those related to the provision of food, water have sometimes also been part of assessments, while supporting services are not often covered aside from more conventional biodiversity assessments. In contrast to the forest management timber production plays a rather subordinate role in the TOF.

The cultural services of TOF have also been assessed in monetary terms, as mentioned in some of the examples above. In a study in a Dutch municipality that has an attractive landscape, a survey was conducted with tourists in the municipality of Winterswijk (Van Berkel and Verburg, 2014). The survey collected data on landscape preferences for individual landscape features, including tree lines

and hedgerows as important element, and the structure and composition of the landscape as a whole. This was linked to respondent appreciation of the landscape functions of recreation, aesthetic beauty, cultural heritage, spirituality and inspiration. A willingness to pay (WTP) and travel cost exercise was conducted using photo manipulations depicting likely landscape changes to obtain a monetary estimate of cultural ecosystem services of the landscape, finding a monetary value of the cultural services is placed between €86 (WTP) and €23 (travel cost) per tourist/year.

Holistic assessments

Assessment of ecosystem services and the values of nature is slowly broadening and diversifying as well, building in more community-based and non-monetary valuation approaches. In The Netherlands, for example, the societal cost-benefit assessment (MKBA) approach has become widely implemented to evaluate the impact of projects and developments at the societal level (Rijksoverheid, 2021). This approach includes attention for ecosystems and values of nature. TOFs are mostly not specifically covered, but they are part of some of the habitats/ecosystems considered.

Veerkamp et al. (2021) recently reviewed 850 studies assessing ecosystem services provided by urban green and blue infrastructure. The majority of ecosystem service assessments focused on local temperature regulation (36%) and recreation and aesthetic appreciation (23%). Assessments used a wide variety of indicators. Most assessments quantified ecosystem properties (59%), while a minority assessed actual benefits to people, recognized values or societal demands.

As also mentioned in the Veerkamp et al. (2021) review, it has become recognised that assessment of the multiple values of nature requires a suite of assessment approaches, and e.g., surveys and interviews have become more common especially at the local and landscape level. Interesting work has been done in Germany, for example, and agroforestry and wooded pasture landscapes. This work has also started looking at e.g., scenario studies and the use of people's stories (Plieninger, pers.com.). An example of using storytelling as an ecosystem service assessment tool is the study by Bieling (2014). Fourteen residents of the Swabian Alp region of Germany revealed important cultural ecosystem landscapes of their landscape through stories. The author concludes that the stories revealed rich evidence regarding connections to identity, heritage values, inspiration, esthetic values and recreation. They underline that nonmaterial benefits are actively created by people.

It should also be emphasised here that the topic of TOF is dealt with in different disciplines and sectors, and that - depending on the sector - different approaches and methods are used. The objectives and purpose of the studies also vary greatly depending on the addressees and the perspective.

2.2.4 Data and knowledge – as well as knowledge gaps

Although some information about TOF and their values, as well as approaches and methods for assessing these is available, there are also some very clear gaps.

Only some types of TOF have been assessed more comprehensively, such as urban trees, trees in smaller woodlands, and orchards, although some of these assessments have been mostly local. The UK inventory of trees outside woodland seems to be the only comprehensive national assessment to date of TOF, and it has only been done once (and has not been fully integrated in the National Forest Inventory). Thus there are obvious data and knowledge gaps when it comes to a basic understanding of the extent of the TOF resource.

In terms of values, both the intrinsic values and instruments values (ecosystem services) have been partly covered, with some progress having been made during recent years on e.g., some regulatory services (especially of trees in urban contexts) and economic valuation (especially of regulatory services). New, more comprehensive assessment methods have emerged, such as i-Tree and various tree value calculation methods (mostly for urban trees). For rural trees that feature in production systems (e.g., orchards), information on provisioning services, also in economic terms, is sometimes available. Health benefits have also been given more attention in research lately, but health impact assessments that specifically address TOF are still limited. Some promising methods have emerged for assessing sociocultural values, but these have mostly been at a pilot and local level. There is also a lack of more holistic assessment approaches of TOF and their values. To date, there is no comprehensive overview of TOF values, and this also relates to the gaps in information about the TOF resource itself.

A major gap is also the fragmentation of data and knowledge, as also highlighted by several of the interviewees. There is a lack of comprehensive datasets, coordination of data and knowledge compilation, and accessibility to data and knowledge.

With the growing policy attention for e.g., green infrastructure and the role of trees in climate action, it can be expected that more work on the assessment of TOF and their values will be undertaken during the coming years.

2.2.5 Implementation – including opportunities and barriers

Finding from this review shows that consideration and assessment of TOF and their values is still rare and fragmented, at least in the five European countries studied. Only some of the TOFs and some of their values are considered and assessed, and proper integration in policy and programs is still lacking.

In the review, we asked the expert interviewees to identify some of the key barriers and opportunities behind the current situation. Obviously some of their responses are more country specific, such as the highly decentralised governance and policy structure in countries like Germany and Spain that makes it difficult to have TOF integration coordinated. However, some more common themes also emerged.

Barriers

- Lack of specific policies, policy frameworks, legislation, and programs that consider TOF and their values. As good as all interviewees mentioned this barrier as an important roadblock for advancing the role of TOF. Policies and programs are often very fragmented, if they exist at all. An example is that of urban areas and the municipal level, where cities are often left to develop their own urban forestry programs and inventories/assessments.
- At the local level, TOF and green space at large are often not a statutory task for municipalities, and no standards are in place for the proper protection and management of these resources.
- There are political barriers to the better consideration (and protection) of TOF, for example in relation to prevailing views on free access to land and resources.
- Land use conflicts and e.g., change of land ownership can pose major threats to TOF. An example is the removal of urban trees on private property under ownership change or redevelopment.
- Cultural views can be a barrier as well, for example more traditional views of agricultural production systems among farmers.
- Often there is still a lack of awareness about the role and potential of trees, for example among important professions such as engineers, planners, and architects. Related to this, there is a

tendency to focus on small- and medium-sized trees in new plantings, as there are misconceptions and fears around the use of large trees. It's the latter that provide most values and ecosystem services in the longer term.

- Consideration and assessment of TOF is often very much 'siloed', with a lack of coordination and collaboration between different government departments (horizontal integration) as well as between different levels of government (vertical integration).
- In current policies, assessments, valuations, TOF are seldom distinguished from wider landscape types and ecosystems. This is especially the case in rural (and natural) areas.
- There is not often a good overview of the TOF resource at national, regional, but also at the local level. This makes it difficult to assess the values of TOF as well as their economic contributions. It also makes it difficult to develop clear policies and management plans.
- Not all of the values of TOF have been assessed in more comprehensive and quantitative ways. Focus has e.g., been on 'Nature for People' values, and then more quantitative information is only available for some of the ecosystem services provided. In urban areas, focus has very much been on regulatory ecosystems services, while in rural areas provisioning services (food, biomass) have also been in focus. Cultural services are partly addressed, but in-depth understanding and assessment is still lacking. In line with this, there is still a lack of holistic and comprehensive assessments of TOF values and ecosystem services.
- More work should be done on the economic assessment and cost-benefit analysis of TOF and their values. Here the pros and cons of different valuation methods need to be discussed, and combinations of assessment and valuation methods will be needed.
- Valuation methods should not only consider quantitative and monetary aspects, but also provide insight in e.g., cultural values and different perceptions and worldviews. This calls for the expansion of valuation and assessment methods.
- There is a lack of dedicated funding for TOF, although some initiatives have emerged, also in relation to piloting Payments for Ecosystem Services.
- Specific guidance and standards for consideration and assessment of TOF are still lacking.
- Upscaling and wider implementation of TOF-related pilot and demonstration projects has been difficult to date.

Opportunities

- There is increasing awareness about TOF and their values, for example in terms of their contributions to climate change mitigation and adaptation, public health, and maintaining liveable and attractive rural landscapes. This increased awareness can be found both among decision makers, experts, and people in general. The importance of trees has become more widely known, and citizen action has also emerged in relation to this, placing more pressure on decision makers to take action and prioritise trees.
- The IPBES framework represents a more comprehensive approach to the values of nature, although it is still not always easy to implement e.g., due to unclear boundaries between value categories.
- The knowledge base about TOF and their values has steadily increased, and we also have a better range of approaches and methods to assess these. The latter also include economic valuation methods, although not all TOF values are covered by existing methods. New research is emerging all the time, and work has intensified with the initiation of national and regional ecosystem assessments and accounting.
- As there are more opportunities to assess TOF values and benefits also economically, their importance has become even more clear.
- Although quite some knowledge and information is available, these are often rather fragmented and not easy to access. Even at the local level, different and sometimes partially overlapping datasets exists. Opportunities exist in terms of better streamlining of this information.

- New policy and legislative initiative have emerged that hold promise for TOF, including initiatives at the EU-level (such as the green infrastructure framework, Common Agricultural Policy reforms, new strategies for biodiversity and forestry) as well as the national level (new Spanish green infrastructure law, new England Tree Strategy, new Dutch Forests Strategy). These top-down initiatives offer opportunities for better policy coordination, streamlining of local actions, standardising of e.g., TOF assessments.
- Municipalities in most countries (for example Spain) hold quite a lot of power, for example over land use. While this can be a barrier to TOF promotion, it can also become a tool for TOF protection and development.
- Better guidance, incentives, and standards are being developed and provide opportunities for wider adoption and upscaling, especially if national governments get involved.
- There has been increasing attention for TOF in national forest inventories, as demonstrated by the example of the UK. Organisations like FAO have also started calling for inclusion of TOF in forest resource assessments.
- Market opportunities and opportunities for PES-schemes are emerging, also for TOF, for example in relation to carbon sequestration, water management, and public health promotion.
- Promising valuation and assessment methods have been developed and (partially) tested, including methods such as participatory GIS and scenario-based models that can look into cultural values, relational values, perceptions and worldviews, and the like.

2.2.6 Policy integration

As also confirmed by the interviewees, it is often difficult to identify a direct link between TOF and value assessments with policy and strategy changes. However, at the local level assessments with e.g., i-Tree assessments have informed policy and been part of the development of urban forest strategies (Macias Paloma, Doick, pers. comm.)

National ecosystem (service) assessments have become more common, as shown by the examples of Spain and the UK, but according to the interviewees also here it is difficult to identify direct policy impacts. In Spain, for example, the assessment has so far not been followed up with a new one and thus provides more of a 'snapshot'. Ecosystem (service) assessments have in some cases been followed up by ecosystem service accounting.

A suite of promising new policies has been adopted in the UK as of late, including a new Environment Act (UK Parliament, 2021). This new Act makes, among other, "provision about targets, plans and policies for improving the natural environment". It includes the principle of net biodiversity gain for development projects, setting a minimum of 10% more biodiversity at a site after development. For this a specific scoring system has been developed, in which e.g., the presence of trees plays a role.

In some cases, forest policies and programs have started to give consideration to TOF. One example is the new *Dutch Forest Strategy 2030* (Bossenstrategie voor 2030; Ministerie van Landbouw, Natuur en Voedselkwaliteit, 2020), which has a specific section for 'trees outside forest' ('bomen buiten bos' in Dutch). The strategy highlights the benefits provided by TOF both in rural and urban areas. Policy priorities are the expansion of woody elements (such as hedgerows, shrubs, individual trees) in rural areas and the planting of more trees in urban areas (with an ambition of 1% increase of tree cover per year). TOFs are seen as important contributors to enhancing landscape quality, and especially their contributions to carbon sequestration, climate adaptation, biodiversity, health and liveability are highlighted. Agroforestry is specifically mentioned as well. For the expansion and protection of woody elements in landscapes, tree planting in urban areas, and the support of agroforestry a series of specific policy tools (including funding) are mentioned in the strategy.

In the UK, the *England Trees Action Plan 2021-2024* was launched in May 2021 (UK Government, 2021). It sets out our long-term plan for the whole 'treescape' - trees, woodlands and forests. It includes our vision for trees in 2050 and the economic, environmental, and social benefits that are to be realised through our new trees and woodlands. Tree planting in England is to be increased with 30,000 ha and funding comes for example, from the government's Nature for Climate funding program. Climate change mitigation and adaptation, as well as biodiversity benefits are highlighted.

A very promising example is that of Spain, where a new strategy, titled 'Estrategia Nacional de Infraestructura Verde y de la Conectividad y Restauración Ecológicas´(National Strategy of Green Infrastructure and Ecological Connectivity and Restoration) was formally and legally adopted in summer 2021 (Miteco, 2021). The strategy sets out to implement the European Union framework for green infrastructure. It holds the requirements for lower-level authorities to make comprehensive assessments of their green infrastructure and ecosystems, and to prepare plans for maintaining and developing these. The document is a accompanied by guidance on e.g., how to assess different types of ecosystems and vegetation. According to the Spanish interviewees, this could be a major step forward, also in terms of standardisation of consideration and assessment of TOF, bridging across the decentralised Spanish governance system.

Private businesses can play an important role in PES-schemes, also for TOF. The study by Davies et al. (2018) in Southampton, UK specifically for PES for urban forests showed that representatives of businesses saw opportunities for PES, especially in terms of air purification, pollution reduction, and aesthetic enhancement. They did prefer voluntary payments towards location-specific, costed projects.

2.2.7 Payments for Ecosystem Services

Payments for Ecosystem Services (PES) are of interest to the governments and other actors in the five countries included in this review. Payments for ecosystem services (PES) is a specialist term used to describe a range of innovative schemes in which the beneficiaries, or users, of nature's services pay or fund the stewards, or providers of those services. Wunder et al. (2017) analysed opportunities for PES relates to forests in Europe. They stated, among other that PES are direct, flexible, and potentially effective. In Europe, there are good possibilities for PES due to well-defined property rights. However, PES economic functioning is largely dependent on their design and implementation.

The European SINCERE project (Spurring INnovations for forest eCosystem sERvices in Europe) also looked at PES schemes and opportunities (SINCERE, 2021). The project had its focus on forests, but some of the case studies in which PES and other business models were assessed included urban and peri-urban forests. Moreover, a Swiss case study looked at spiritual forests and forest kindergartens. PES approaches looked at e.g., recreation, learning, human health promotion, water management, and game management.

In the UK, the government carried out several PES pilot projects during 2012-2015 (Defra, 2016). So-called catchment-based projects have shown the most potential for PES applications, for example by delivering cost-effective water quality improvements, and can be considered closer to 'market'. The pilot projects included projects to reduce urban flooding, improve (runoff) water quality, and biomass production for energy, among other. Not much specific information is provided about the role of TOF, but the role of trees as riparian buffers between agriculture and rivers and of trees and shrubs in wetland areas (for biomass) can be highlighted. The pilot projects also tested a wide range of valuation methods, including multi-criteria analysis, cost-effective analysis, direct market research,

and ecosystem service assessment, but also e.g., stakeholder engagement. Also in The Netherlands has water been a key driver of the exploration of PES schemes. When contributing to local water quality, e.g., by changing agricultural practices but also by environmental improvement such as planting trees and establishing woodland, farmers could be paid for the provision of this ecosystem service (see e.g., Linderhof et al., 2009).

Apart from water quality and the provision of drinking water, carbon sequestration provides another avenue for PES through carbon markets. But this requires a detailed assessment of the TOF resource, something which only few countries have done so far. Biomass production for biofuels is another example where PES can come in.

As i-Tree and other assessment tools have made it much easier to determine several of the (especially regulatory) ecosystem services provided by TOF in urban areas, and even place a monetary value on some of these services, opportunities for PES also emerge here. Davies et al. (2018) explored business attitudes towards funding ecosystem services provided by urban forests in the UK. Findings show that businesses supported the idea of private sector investment in urban forests. They would fund air purification, flood alleviation and aesthetic enhancement, and preferred voluntary payments towards local-specific, costed projects.

2.3 Conclusions and perspective

The ecosystem services framework has become well integrated in most of the countries studied, also at the national governmental level. A broadening of the values of nature perspective is happening but is still in its early stages. The IPBES process has started to make an impact, but e.g., the relational values of nature still seem difficult to grasp, and with that also to assess.

TOF and their values are to some extent recognised. This is especially the case for some types of TOF, such as urban trees (as part of the urban forest) and trees that are part of orchards. Some attention has also been given to ancient trees (especially in the UK), trees that are part of hedgerows, and in general trees that are part of farming systems. A more coordinated and comprehensive approach to TOF and their values is still lacking in the five countries. Among the countries studied, the UK has perhaps paid most attention specifically to TOF, for example in its first-ever national assessment of trees outside of woodland (although this has so far been a one off), but also through its ancient tree register and recent studies that look at the perceptions and health impacts of urban trees.

There is usually not a clear picture yet of the extent of the biophysical TOF resource. Even in cities, where inventories of trees have become more common, focus has often been only on part of the TOF resource (i.e. trees in public ownership). Information is often fragmented and not easily available.

There are, however, some signs that TOF and their values are being given more consideration. With the emergence of new geospatial tools, for example, assessment of the TOF resource has become easier and less expensive. A stronger research base and range of assessment and valuation methods, including economic valuation, has resulted in an increasing number of assessments of TOF values. This is often mostly still done at the local and perhaps landscape level, and urban areas have often been in focus. Assessments and valuations of regulatory ecosystem services have been especially strong, most likely due to current climate action and nature-based solutions discourses. A wider range of cultural services of TOF are being assessed, and the same holds true for different perceptions and worldviews.

A few particularly promising approaches and opportunities emerge for the Swiss context:

- The importance of national-level consideration of TOF and their values, which will also require cross-departmental collaboration as well as collaboration between different levels of government.
- Opportunities to include TOF in the National Forest Inventory, based on e.g., the UK experience.
- Mobilising TOF and their values as delivery tools for global commitments, e.g., within climate change and biodiversity agendas.
- Lessons learnt from ecosystem service accounting that can possibly also be transferred to a Swiss context. On a more local level, the current testing of i-Tree in Swiss cities can be supported by experiences in other countries.
- The development of promising assessment and valuation tools, also for e.g., assessing cultural and possibly relational values. Examples of these include, among other, approaches that use participatory GIS, scenarios, storytelling, and community-based assessments.

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Chapter 3: Swiss Scoping Review

3.1 Introduction

3.1.1 Method and resources

The following is a summary of results of a scoping review on TOF and their values in Switzerland. This review was undertaken in autumn 2021. The results presented here are based on desk research, interviews with selected experts and workshops (see Table 3.1).

There are different classification schemes for areas and landscapes outside forests. In the international part, the rural-urban continuum was discussed; this is basically also applicable to Switzerland. With regard to subsequent implementation of TOF-related initiatives and the target groups envisaged, the spatial planning system appears to be the appropriate platform for action; the Swiss Spatial Concept formulates an orientation framework and a decision-making aid for the future spatial development of Switzerland. It distinguishes between three pillars where action is needed, i.e., in metropolitan areas, so-called small and medium-sized areas, and alpine areas (Federal Council 2012). The topic is very broad and there is a lot of knowledge in very different fields of action and areas of knowledge. The following summary serves the purpose of showing the breadth and diversity of instruments and principles of relevance of TOF in Switzerland that exist. In accordance with the chosen search process, the compiled knowledge is grouped into a total of five thematic clusters (in alphabetical order): agriculture (section 3.2), nature and landscape conservation (section 3.3), recreation & leisure (section 3.4), spatial development and landscape research (section 3.5), and urban forestry (section 3.6).

3.1.2 Summary of findings

Consideration of TOF as an independent subject or field of action has so far been the exception rather than the rule. At the national level, there are reports and surveys on TOF, especially in the fields of agriculture and nature and landscape (Table 3.2). Based on remote sensing data, a survey of the tree population outside the forest was carried out for all of Switzerland (Malkov et al, 2021). The type, distribution, and extent of occurrence of TOF was analysed. Six percent of the country's surface is covered with TOF, with the degree of tree cover being the highest in settlement areas at around 21%.

Furthermore, an inventory of mighty, old, and special trees and large shrubs in Switzerland is maintained by “Pro Arbore” on a project basis (www.proarbore.com). The project draws attention to the importance of trees as natural monuments and cultural assets worthy of protection. Thanks to nationwide appeals and the evaluation of archival material, over 3,000 trees have been mapped, measured, documented, and photographed to date (Brunner, 2021; Pro Arbore). Also to be mentioned in this context is the LFI logbook of the highest trees in Switzerland. Individual trees can be entered in this logbook, and these can be not only trees in the forest but - depending on the location - also trees outside forests.

Substantial data exists in connection with agricultural biodiversity promotion (e.g., statistics on orchards, BLW 2020). There are studies on specific questions such as the occurrence of special species (such as Maple trees (see Kiebacher et al., 2018) or Giant chestnut) or on specific forms of use. Many inventories focus on the occurrence, type, and distribution of TOF, but their specific values or ecosystem services are usually not recorded or assessed.

Table 3.1. Overview of contacted Swiss experts (interviews and workshop participation)

Name and affiliation of expert	Expertise	Interview	WS I	WS II
Raushan Bokusheva, ZHAW Life Sciences und Facility Management, Institut für Umwelt und Natürliche Ressourcen, Wädenswil, Switzerland	Valuation of ecosystem services; project ValPar		●	
Martina Bozzola, ZHAW Life Sciences und Facility Management, Institut für Umwelt und Natürliche Ressourcen, Wädenswil, Switzerland	Valuation of ecosystem services; project ValPar		●	
Reto Camenzind, Federal Office for Spatial Planning, Ittigen, Switzerland	Spatial planning			●
Andreas Friedli, Cantonal Office for Spatial Planning, Switzerland	Cantonal planning; regional parks and regional development	●		
Christian Ginzler, WSL, Birmensdorf, Switzerland	Remote sensing for ecological issues; remote sensing & forest inventories	●		
Hansueli Gujer, FOEN, Biodiversity Division, Bern, Switzerland	Biodiversity in agricultural land		●	
Tessa Hegetschweiler, WSL, Birmensdorf, Switzerland	Landscape research			●
Jérémy Huber, municipality of Porrentruy	Urban development	●		
Gerda Jimmy, FOEN, Forestry Division, Bern, Switzerland	Forest knowledge transfer		●	
Sonja Kay, Agroscope, Switzerland	Agriculture; agroforestry	●	●	●
Felix Kienast, WSL, Birmensdorf, Switzerland	Landscape research	●	●	
Aurelia Passaseo, Federal Office for Agriculture, Bern, Switzerland	Agriculture			●

A wide range of different approaches and perspectives are reflected in the studies on TOF. At the national level (see Table 3.2), natural science-oriented studies dominate. These are usually focused on ecosystem services. National studies on the intrinsic values of TOF are not known to date. In the interviews conducted for this study it was expressed that - for pragmatic reasons - only a part of the wider TOF value perspective is taken into account in the planning processes. For example, the emotional values many residents attach to the trees are not addressed in the plans, or only in general terms.

Table 3.2. Selected information about TOF on the Swiss national level (extract).

Study/Assessment	Source	ES			
		P	R	C	H
Agriculture/Agroforestry					
Statistik Obstanlagen	BLW (2020)	•			
Agrarbericht	BLW (2021)		•		•
Agroforestry in Switzerland – current research and policy developments	Schoop (2021) (EURAF2020)	•			
Assessment of ecosystem services provided by agroforestry systems at the landscape scale	Kay (2018)	•	•		•
Evaluation Landschaftsqualitätsbeiträge	Steiger et al. (2016)	•	•	•	
Nature and landscape					
The ValPar.CH Project	Reynard et al. (2021)	•	•	•	•
Bestand und Bedeutung von Alleen und Alleenlandschaften in der Schweiz	Tartaro and Kunz (2008)	•	•	•	•
Potential impacts of changing agricultural activities on scenic beauty	Hunziker and Kienast (1999)			•	
Katalog der charakteristischen Kulturlandschaften der Schweiz	Rodewald et al. (2014)			•	
Pro Arbore (Schweizer Baumarchiv)	Brunner (2021); Pro Arbore			•	
Bergahornweiden im Alpenraum	Kiebacher et al. 2018			•	•
Spatial planning					
Programm Landschaftsbeobachtung Schweiz (LABES)	Wartmann et al. (2021)			•	
Schweizerisches Landesforstinventar - Gehölze ausserhalb des Waldareals (LFI)	Brändli et al. (2020)				
Die Baumbedeckung in der Schweiz	Ginzler et al. (2011)				
Countrywide mapping of TOFs based on remote sensing data in Switzerland	Malkoç et al. (2021)				
Tree biomass in the Swiss landscape	Price et al. (2017)	•			

ES Ecosystem Services: *R: Regulating Services; P: Provisioning Services; C: Cultural Services; H: Habitat Services*

3.2 Agriculture

3.2.1 Statistics and data on national level

In Swiss agriculture, various types of reporting are done in connection with landscape quality contributions (see BLW, 2020). Of particular note are orchards (high stem fruit trees), hedges and riparian woods, avenues and individual trees, as well as wooded pastures (insofar as these are not subject to the Forest Act respectively not considered (part of) forests) (Table 3.3).

Table 3.3. Swiss national statistics and data collection, Agriculture.

Theme	Criterion	Indicator / methods	Source
Obstanlagen	Dauerkulturen Obst	Fläche der Anlagen von Obst-Dauerkulturen mit minimaler Fläche (Bäume/ha) und Mindestfläche (0.2ha) pro Betrieb	BLW (2020)
Hochstamm-Feldobstbäume (mit Nussbäumen)	Dauerkulturen Obst	Minimal Stammhöhe für Steinobst 1,2 m; für Kernobst, Nuss u. Edelkastanien 1,6m	BLW (Agrarbericht)
Waldweiden	Bestockte Weiden	Fläche des Weideanteil von nachweislich extensiv genutzten Waldweiden, mind. 1x Beweiden ohne Zufütterung und keine N-Mineraldünger; zwei Qualitätsstufen	BLW (Agrarbericht); Zurbrügg et al. (2020)
Hecken, Feld- und Ufergehölzen	Gehölzstreifen, Sträucher mit oder ohne Bäume	Nieder-, Hoch- oder Baumhecke, Windschutzstreifen, Baumgruppen, bestockte Böschung, heckenartiges Ufergehölz	BLW (Agrarbericht)
Einzelbäume und Alleen	Einheimische u. standortgerechte Bäume	Eichen, Ulmen, Linden, Weiden, Obstbäume, Nadelbäume u. andere mit mindestens 10m Abstand, pro Baum wird 1 Are angerechnet	BLW (Agrarbericht)

3.2.2 Examples on different scales

At the cantonal level, according to the specific cantonal requirements and reporting mechanisms, further and more detailed knowledge exists on tree occurrence in the agricultural sector (Table 3.4). At the other levels (regional, local, and object level), mostly case studies or specific research projects deal with TOF or with other topics taking TOF into account. Landscape development concepts (Landschaftsentwicklungskonzepte, LEK) are located at the interface between agriculture, recreation, and biodiversity. Herein trees, groups of trees, and hedges play a special role and should be highlighted.

Table 3.4. Selected examples from the knowledge base for each spatial scale in the area of agriculture.

Scale	Ideal-typical examples	Comments
Nation	Statistics fruit orchards	Area-wide recording of fruit production with min. of trees per area.
Canton	Management contracts agriculture (biodiversity); Labiola (2017)	Specific measures to promote biodiversity are agreed in the management contracts, e.g. promotion of wild shrubs (Labiola, 2017).
Region	Whole system valuation of arable, agroforestry and tree-only systems at three case study sites in Europe	Three case studies on the economic profitability of agricultural areas, those with trees and tree stands. For Switzerland, the study was conducted in Schwarzbubenland.
Municipality	Godfather tree – fruit garden Altendorf - A sponsorship for high-stem fruit trees	Sponsorship of high-stem fruit trees as part of the LEK (landscape development concept) of the municipality of Altendorf.
Objects/ Projects	Agroforestry with fruit trees in Switzerland (AGFORWARD)	Study on the dynamics of organic carbon in soil.

3.2.3 Results: Agroforestry of growing importance

The range of topics covered by the literature review is very broad. In addition to studies on the impact of landscape quality contributions, it stands out that agroforestry has become much more important in recent years and that the concept of ecosystem services is increasingly being taken up (Table 3.5).

Table 3.5. Knowledge base on the subject area of agriculture (extract).

Study/Assessment	Source	ES				Scale			
		P	R	C	H	I	N	C	L
Statistik Obstanlagen	BLW (2020)	•					•	•	
Biodiversitätsförderung auf dem Landwirtschaftsbetrieb – Wegleitung	AGRIDEA (2021)				•		•		
Agro4esterie; Projektkonzept	Schoop et al. (2020)	•						•	•
H20202 AGROMIX; AGROMIX: Transforming landscapes (Swiss project partners: Agroscope and ZHAW)	Barange (2021)	•	•		•	•			
Agrarbericht	BLW, www.agrarbericht.ch		•		•		•	•	
Weiterentwicklung der Biodiversitätsbeiträge in der AP22+	Zurbrügg et al. (2020)		•		•		•		
Agroforestry with fruit trees in Switzerland (AGFORWARD)	Jäger (2017)	•				•			•
Erhöhte Humusvorräte in einem siebenjährigen Agroforstsystem	Seitz et al. (2017)		•						•
Moderne Agroforstwirtschaft in der Schweiz	Kay et al. (2019c)	•	•				•		
5th European Agroforestry Conference	EURAF2020 (2021)	•	•	•	•	•			
Agroforestry in Switzerland – current research focus and policy developments	Schoop et al. (2021) (EURAF2020)	•					•		
Mixtures of forest and agroforestry alleviate trade-offs between ecosystem	Rolo et al. (2021)	•	•	•	•	•			•
Assessment of ecosystem services provided by agroforestry systems at the landscape scale	Kay et al. (2018)	•	•		•		•		
Spatial similarities between European agroforestry systems and ecosystem services at the landscape scale	Kay et al. (2017)	•	•		•	•			
Landscape-scale modelling of agroforestry ecosystems services in Swiss orchards	Kay et al. (2018)	•	•		•				•
Agroforestry is paying off	Kay et al. (2019a)	•	•		•	•			•
Ressourcenschutz durch Agroforstsysteme – standortangepasste Lösungen	Kay et al. (2019b)	•	•	•	•		•		
Agroforestry can enhance foraging and nesting resources for pollinators with focus on solitary bees at the landscape scale	Kay et al. (2020)				•				•
Programm Labiola	Agrofutura (2021)		•	•	•			•	
Schweizer Christbaummarkt/ IG Suisse Christbaum	WaldSchweiz (2021) Ingold (2021)	•					•		
Sortenerhalter	Pro specie rara (2021)		•				•		
Politique Cantonale des pâturages boisés	Kanton Jura (2018)			•				•	
Evaluation Landschaftsqualitätsbeiträge	Steiger et al. (2016)	•	•	•			•		
Kleinstrukturen-Praxismerkblatt 5 Kopfweiden	BirdLife (2019)	•		•			•		

Study/Assessment	Source	ES				Scale			
		P	R	C	H	I	N	C	L
H2020 MIXED Multi-actor and transdisciplinary development of efficient and resilient MIXED farming and agroforestry-systems (Swiss project partner FIBL)	FiBL (2021)	•	•	•		•			
Whole system valuation of arable, agroforestry and tree-only systems at three case study sites in Europe	Giannitsopoulos et al. (2020)	•	•			•			•
Verband der Aargauer Obstproduzenten	https://www.vaop.ch/	•			•			•	
Göttibaum-Obstgarten Altendorf – Eine Patenschaft für Hochstamm-Obstbäume	suisseplan (2019)	•			•				•

Scale: *I: International; N: National; C: Cantonal/Regional; L: Local.*
ES Ecosystem Services: *R: Regulating Services; P: Provisioning Services; C: Cultural Services; H: Habitat Services*

3.3 Nature and landscape protection

3.3.1 Statistics and data on national level

Trees and tree-dominated ecosystems are at the heart of many conservation inventories (Table 3.6). An inventory-based survey was carried out for tree alleys (Tartaro and Kunz, 2008). In addition, special trees are being recorded and documented in a national project (Tree Archive; Brunner, 2021).

In the context of the Swiss Biodiversity Strategy, the development of a functioning ecological infrastructure is one of the Confederation's priority goals in the field of environmental protection. The aim is to create a network of natural and near-natural habitats consisting of core areas (protected areas) and high-quality connectivity areas. In this context, trees and tree-dominated ecosystems outside the forest represent important elements. The ValPar.CH research project, which examines the value of ecological infrastructure from a social, economic, and ecological perspective, should be highlighted here.

Table 3.6. National statistics and data collection, Nature and landscape protection.

Theme	Criterion	Indicator / method	Source
Baumalleen	Alleen als schutzwürdige Objekte	Bestandesaufnahme von Allen und Baumbestände aus Inventaren (z.B. ISOS, BLN)	Tartaro and Kunz (2008)
Bemerkenswerte Baumindividuen	«mächtige, alte und kuriose Bäume und Grosssträucher»	Landesweite Aufrufe und Auswertung von Archiven zur Identifizierung und anschliessend kartieren, vermessen, dokumentieren und fotografieren.	Brunner (2021)
Kulturlandschaften	Charakteristischen Kulturlandschaften der Schweiz	Es werden in sechs Gruppen und anhand von vier massgebenden Landschaftsleistungen zugeordnet	Rodewald et al. (2014)
ValPar.CH Project	Ökologischen Infrastruktur	-	Reynard et al. (2021)

3.3.2 Examples on different scales

In the so-called tree archive “pro arbore” – which is set up at the national scale - more than 3,000 trees have been mapped and documented by now. The selection of the special specimens was based on the trunk circumference and cultural aspects. The platform “Monumental Trees” represents a

similar collection (see also the section on Recreation). There are also several cantonal tree inventories and many municipal tree cadastres and tree inventories. In addition, numerous studies have been undertaken on the conservation and cultural-historical values of trees and groups of trees (Table 3.7).

Table 3.7. Selected examples from the knowledge base for each level of spatial scale for the area of nature and landscape protection.

Scale	Ideal-typical examples	Comments
Nation	The Swiss Tree Archive (Pro Arbore)	Collection of big and special trees throughout Switzerland.
Canton	40 years – 40 oaks for tomorrow (canton du Jura, 2019)	Initiative of the Canton of Jura with the aim of motivating municipalities to plant 40 trees each - especially oaks.
Region	The chestnut forests of Italian-speaking Switzerland (Moretti et al, 2021)	Documentation on the history and different aspects of the restoration of Chestnut forests.
Municipality	Tree Inventory 2020 Municipality of Freienbach (suisseplan, 2020)	Detailed records of all trees in the municipality of Freienbach.
Objects/Projects	Eichenhaft (Bonfils und Willi, 2015)	Communication and education project to promote the oaks in the "Bovel" above the town of Maienfeld (GR).

3.3.3 Results: numerous studies and inventories on all levels

On the one hand, numerous inventories (at all levels and with different thematic thresholds) stand out, be it inventories of trees above a certain diameter (all species) or inventories of rare species or very specific inventories of individual tree species (e.g., Oak, Sycamore). There are studies that focus on habitats and biodiversity services, as well as studies dedicated to the history of use and cultural-historical topics (Table 3.8).

Table 3.8. Knowledge base on the subject area of nature and landscape conservation.

Study/Assessment	Source	ES				Scale			
		P	R	C	H	I	N	C	L
Der Baumarchivar (pro arbore)	Iraoui (2021)			•		•	•		
Geschützte botanische Objekte	Kanton Bern (2021)			•				•	
Bestand und Bedeutung von Alleen und Alleenlandschaften in der Schweiz	Tartaro and Kunz (2008)	•	•	•	•		•		
Potential impacts of changing agricultural activities on scenic beauty	Hunziker and Kienast (1999)			•			•		
Katalog der charakteristischen Kulturlandschaften der Schweiz	Rodewald et al. (2014)			•			•		
Eichenhaft	Bonfils and Willi (2015)			•					•
40 ans – 40 chênes pour demain	canton du Jura (2019)			•	•			•	
Le selve castanili della Svizzera italiana	Moretti et al. (2021)	•		•	•		•		
Bauminventar 2020 Gemeinde Freienbach	suisseplan (2020)			•					•
Nutzungsgeschichte von Bergahornweiden im Alpenraum	Gosteli (2016)			•			•		

Study/Assessment	Source	ES				Scale			
		P	R	C	H	I	N	C	L
Bergahornweiden im Alpenraum	Kiebacher et al. (2018)			•	•		•		
Projekt zur Förderung der Bergahornlandschaften	Naturpark Diemtigtal (2021)			•	•				
Projekt Landschaftsqualität Limmattal (LQL)	Brossard and Häusler (2012)			•	•			•	
Grundlagenbericht Wildtierkorridore	Müri et al. (2010)				•			•	
BirdLife-Projekt Obstgarten Farnsberg	Schuck (2020)				•				•
Hochstammlandschaften/Früchte, Geschichte, Bedeutung und Biodiversität	Hochstamm Suisse (2018)	•		•	•		•		
Flecht-, Binde- und Imkerweiden	Pro specie rara (2019)			•	•		•		
Regionales Naturschutzkonzept Brig – Salgesch	PRONAT (2015)			•	•				•
SORBUS: Förderung von Speierling und Elsbeere	Pro Natura Schaffhausen (2021)			•	•				
The ValPar.CH Project	Reynard et al. (2021)	•	•	•	•		•		

Scale: *I: International; N: National; C: Cantonal/Regional; L: Local.*

ES Ecosystem Services: *R: Regulating Services; P: Provisioning Services; C: Cultural Services; H: Habitat Services*

3.4 Recreation and leisure

3.4.1 Statistics and data on national level

Prominent trees and other landscape-defining elements are very important for recreation. Accordingly, TOF are often the subject of open space and recreation planning. There are also specific walking routes to prominent trees or tree books combined with walking suggestions. Furthermore, people are often invited to record particularly conspicuous or especially popular trees. An example of this is the (international) platform Monumentaltrees, where individual trees can be photographed and entered with their location (open source database). Since the trees are visualised in a geoportal, they also have a significance for recreational use at the same time. Moreover, this type of recording system is an example of citizen science activity.

Table 3.9: Statistics and data collection, Recreation and leisure.

Theme	Criterion	Indicator / method	Period of recording	Source
Monumental trees	Monumental tree	Open-source database where everyone around the world can register a monumental tree	Continuously updated	Monumentaltrees.com (2021)
Baum des Jahres	Baumart	Hervorhebung einer lokalen Baumart pro Jahr	Annually	Dr. Silvius Wodarz Stiftung (2021)
Inventar der Riesenkastanien im Tessin und Misox	Riesenkastanien (Umfang >7m)	komplettes Inventar aller Riesenkastanien des Kantons Tessins und des Misox, die einen Umfang von mehr als 7 m auf Brusthöhendurchmesser aufweisen	Unknown	WSL (2021)

3.4.2 Examples on different scales

At practically all levels, there are recreational hiking routes that lead to particularly striking and rare trees. These offers are often combined with cultural-historical information on the trees and their former use or with information on biodiversity. Overnight accommodation in trees (tree hotels or tree bivouacs) is a special offer (for which there are two or three opportunities in Switzerland) (Table 3.10).

Table 3.10. Selected examples from the knowledge base for each level of spatial scale for the subject of recreation and leisure.

Scale	Ideal-typical examples	Comments
Nation	Tree hikes of Switzerland (Brunner, 2018; Roth, 2021)	Itineraries to the most impressive trees.
Canton	Spectacular trees in Canton Fribourg (Kanton Freiburg, 2021)	Interactive map.
Region	Aubonne Arboretum OR Chestnut Festival (Arboretum d'Aubonne, 2021)	Area for conservation, presentation, experimental cultivation and observation of forest, ornamental and fruit trees. OR a festival weekend to celebrate the chestnut in all its forms (with products from the region and local handicrafts).
Municipality	City parks Rheinfelden (Schweiz Tourismus, 2021a)	Discovery tour and walks through the city's parks and avenues.
Objects/Projects	Tree tents Zebuhof OR The four tree houses "Les Nids" (Les Nids, 2021)	Sleep in a tree tent OR rent a tree house.

3.4.3 Results: fascinating trees of touristic importance

Trees fascinate people, whether for purely aesthetic reasons (large, mighty trees; bizarre tree shapes) or for religious, spiritual, and mystical reasons (sacred places, religious and cultural-historical objects). In addition to the above-mentioned hiking routes, prominent trees appear in many tourist guides. Other examples include the election of favourite trees (competitions), tree-related festivities or cultural and artistic activities (such as tree museums) (Table 3.11).

Table 3.11. Knowledge base on the subject area of recreation and leisure.

Study/Assessment	Source	ES				Scale			
		P	R	C	H	I	N	C	L
Einfach knorke	Brunner (2010)			•					•
Spektakuläre Bäume im Kanton Freiburg	Kanton Freiburg (2021)			•	•			•	
Carte interactive des arbres remarquables	Kanton Genf (2020)			•	(•)			•	
PhotoArt Hanspeter Ryser	Ryser (2021)			•					•
Chêne des Bosses	Jura Tourisme (2021)			•					•
Arbres remarquables	Kanton Jura (2011)			•				•	
Baumwanderungen	Roth (2021)			•			•		
Enea Baummuseum	Enea GmbH (2021)			•					•

Study/Assessment	Source	ES				Scale			
		P	R	C	H	I	N	C	L
Bäumiges aus Glarus Nord	Müller-Wahl (2021)			•					•
Tree Inventory TG	Künzler (2006)		•	•	•			•	
Dispositifs artistiques et sensibilisation aux changements climatiques	Édhéa (2021)			•					•
Arboretum Wädenswil	Hodgson and Heinrich (2016)			•					•
Bergahornweg	myswissalp.ch 2021 (https://www.myswissalps.ch/trail/489)			•	•				•
Circuit des arbres	Belfort Tourisme (2020)			•					•
Cabane dans les arbres	Voyageons-autrement.com (2021)			•		•			
Monumental trees	Monumentaltrees.com (2021)			•		•			
Baumwipfelpfad Neckertal	Genossenschaft Baumwipfelpfad Neckertal			•					•
Stadtpärke Rheinfelden	Schweiz Tourismus (2021a)			•					•
Baumzelte Zebuhof	Schweiz Tourismus (2021b)			•					•
The four tree houses “Les Nids2	Les Nids (2021)			•					•
Arboretum du vallon de l’Aubonne	Arboretum d’Aubonne (2021)						•		
Baum des Jahres	Dr. Silvius Wodarz Stiftung (2021)			•		•			
La Fête de la Châtaigne	Fully Tourisme			•					•
Wandernroute inmitten der ältesten Lärchen Europas	Valais Promotion (2021)			•					•
Wanderungen im Blütenparadies	Thurgau Tourismus (2021)			•					•
Rundweg Wollerau-Altenbach-Becki	Bezirk Höfe (2020)			•					•
Inventar der Riesenkastanien im Tessin und Misox	WSL (2021)			•				•	

Scale: *I: International; N: National; C: Cantonal/Regional; L: Local.*
ES Ecosystem Services: *R: Regulating Services; P: Provisioning Services; C: Cultural Services; H: Habitat Services*

3.5 Spatial development and landscape research

3.5.1 Statistics and data on national level

As mentioned above, a quantification of the tree cover outside the forest area exists for Switzerland (cf. Malkov et al., 2021). As mentioned, 6% of the country’s area is covered by TOF; the data (individual trees recorded) can be viewed on the online portal geo admin. Furthermore, tree biomass was modelled based on data from the Swiss Forest Inventory. Finally, the National Forest Inventory also provides information on woody plants outside the forest area. In spatial planning, TOF is not a topic at the Swiss level (Table 3.12).

Table 3.12. Statistics and data collection on the national level, Spatial development and landscape research.

Theme	Criterion	Indicator / method	Source
Schweizweite Kartierung von TOF	Einzelbäume	Modellierung in ArcGIS auf Basis von LIDAR Daten und Luftbildern	Malkoç et al. (2021)
Biomasse	Biommasse von Bäumen in und ausserhalb des Waldes	Abschätzung durch Modell auf Basis von LIDAR Daten und Luftbildern	Price et al. (2017)
Landschaftsqualität	Wahrgenommene Qualität der Agrarlandschaft	Der Beitrag von «Einzelbäume oder Baumalleen» zur wahrgenommenen Landschaftqualität werden durch Umfragen ermittelt	Wartmann et al. (2021)
Gehölze ausserhalb des Waldareals	Hecken, Feldgehölze und Einzelbäume sowie weitere Bestockungen	Deckungsgrad und Anteile von Laub- und Nadelbäumen werden anhand von Luftbildern beurteilt	Brändli et al. (2020)
Topographisches Landschaftsmodell	Einzelbäume > als 5m	Einzelbäume werden mittels Luftbilder bei der Krone oder beim Wipfel in 3D erfasst	Swisstopo (2021)

3.5.2 Examples on different scales

Within spatial planning instruments, TOF appear only sporadically at cantonal level, for example in cantonal tree inventories or in landscape plans. Many planning frameworks and plans with direct reference to TOF exist at regional and local level, such as urban landscape plan or open space concepts (Table 3.13).

Table 3.13. Selected examples from the knowledge base for each level of spatial scale for the subject area of spatial development and landscape research.

Scale	Ideal-typical examples	Comments
Nation	Mapping trees outside forests based on remote sensing data in Switzerland (Malkoc, 2021)	Swisswide recording of TOFs based on remote sensing data.
Canton	Heat-adapted settlement development.	Various guidelines to ensure sufficient (root) space for trees.
Region	Fil Bleu - Supraregional Open space concept Glattraum (Freiraumkonzept) (Grün Stadt Zürich, 2015)	Open space design in relation to ecological revaluation measures.
Municipality	Landscape development concept (LEK) Baar (Kanton Zug, 2021)	LEK, which emphasizes the importance of trees as part of the settlement area.
Objects/Projects	Municipal Structure Plan, Municipality of Schwyz (Planpartner, 2004)	Two object sheets with TOFs: green spaces close to settlements and promotion of specific scenic landscapes.

3.5.3 Results: wide methodological range of approaches

The methodological and technical range of plans and inventories dealing with the landscape is extremely wide (Table 3.14). These focus on the protection and promotion of rare species and habitats (biodiversity) as well as aspects of recreational use and open space design. With climate

change taking place, trees and their ecosystem services have become even more important both for the creation of a microclimate conducive to health and as a sink for CO2.

Table 3.14. Knowledge base on the subject area spatial development and landscape research.

Study/Assessment	Source	ES				Scale			
		P	R	C	H	I	N	C	L
Programm Landschaftsbeobachtung Schweiz (LABES)	Wartmann et al. (2021)			•			•		
Schweizerisches Landesforstinventar - Gehölze ausserhalb des Waldareals	Brändli et al. (2020)	•	•	•	•		•		
Die Baumbedeckung in der Schweiz	Ginzler et al. (2011)	•	•	•	•		•		
An annually-resolved stem growth tool	Wagner et al. (2017)	•					•		
Countrywide mapping of TOFs based on remote sensing data in Switzerland	Malkoç et al. (2021)	•					•		
Tree biomass in the Swiss landscape	Price et al. (2017)	•					•		
Land Use Sustainability Monitoring	García-Montero et al. (2021)	•	•	•	•	•			
Baumkataster des Kanton Zug	Kanton Zug (2021)							•	
Klimaangepasste Stadtentwicklung	Stadt Sitten (2017)		•						•
Directive concernant la plantation et l'entretien des arbres	Kanton Genf (2013)							•	
Hitzeangepasste Siedlungsentwicklung Leitfaden für Gemeinden	Kanton Aargau (2021)		•					•	
Städtische Baumkataster	Stadt Bern (2021), Stadt Zürich (2021)								•
Landschaftsentwicklungskonzept (LEK) Baar	Meier (2018)			•					•
Landschaftsentwicklungskonzept (LEK) Wädenswil – Fachbericht	Stadt Wädenswil (2012)			•					•
Das Grünbuch der Stadt Zürich	Grün Stadt Zürich (2019)		•	•	•				•
Kommunaler Richtplan Gemeinde Schwyz – Objektblätter	Planpartner AG (2004)			•					•
Fil Bleu - Überregionales Freiraumkonzept Glattraum	Grün Stadt Zürich (2015)		•	•	•				
Brünnen - das neue Stadtquartier im Westen Berns	naturaqua PBK (2007)	•		•					•
Richtplan Landschaft Gemeinde Wohlen	Jaun (2010)			•	•				
Das Topografische Landschaftsmodell TLM	Swisstopo (2021)						•		
Projekt Landumlegung Region Olten (LRO)	Flurgenossenschaft LRO (2021)	•							•

Scale: *I: International; N: National; C: Cantonal/Regional; L: Local.*
ES Ecosystem Services: *R: Regulating Services; P: Provisioning Services; C: Cultural Services; H: Habitat Services*

3.6 Urban forestry

3.6.1 Statistics and data on national level

Although the importance of trees in cities and towns is already very high today and will continue to increase in the future, there is no national overview of the occurrence and distribution of trees in urban areas. The methods used to record trees vary from city to city. In connection with climate

change, however, basic instruments have been / are now being developed that can be applied throughout Switzerland (Table 3.15).

Table 3.15. Statistics and data collection, Urban forestry.

Theme	Criterion	Indicator / Method	Source
Klimaadaptierte Städteentwicklung	Klimaregulierende Eigenschaften von Stadtbäumen	Ein Index zur Beurteilung der Eignung von Baumarten für das zukünftige Klima	BAFU (2017)

3.6.2 Examples on different scales

At the federal and cantonal levels, there are mainly planning aids and supporting instruments and knowledge bases. Actual strategies, plans, and inventories exist primarily at regional and local level. The greatest density of knowledge about trees exists at the municipal level (perhaps not surprising, given that as mentioned earlier tree cover is also greatest in the settlement area at 21%; Malkov et al., 2021) (Table 3.16).

Table 3.16. Selected examples from the knowledge base for each level of spatial scale for the subject area of urban forestry.

Scale	Ideal-typical examples	Comments
Nation	The ecological value of urban trees in terms of biodiversity (Gloor and Hofbauer, 2018)	Biodiversity-focused guide for urban tree planning.
Canton	Climate Oasis Action (Naturama Aargau, 2021)	Project in Aargau for green spaces in densely constructed settlement areas.
Region	Quantifying the contributions of … trees to a city's biodiversity and ecosystem services (National Centre for Climate Services, 2018)	Comparison of non-native and native tree species in terms of biodiversity, regulating and cultural ES, and 'disservices' in the Geneva agglomeration.
Municipality	Urban tree planning guidelines (Fuchs, 2021)	Urban tree plan for the city of Zurich with a focus on health-promoting aspects and regulation of the urban climate.
Objects/Projects	Tree analysis Schwamendingen (Grün Stadt Zürich, 2010)	Tree stock analysis; all trees (>80cm circumference) in Schwamendingen are recorded; variation factors and development trends are shown.

3.6.3 Results: many tree inventories in cities

Urban trees are documented in inventories (tree inventories, ecological inventories), in concepts (e.g., tree ally concepts) as well as in specialised planning and urban tree strategies (Table 3.17). Thematically, focus is knowledge on species occurrence and distribution of trees, ecological surveys, as well as questions of recreation and open space design. Of great importance is the climate sensitivity of trees and their contribution to a healthy urban climate. The conservation of tree resources and their ecosystem services is a major challenge in the face of increasing densification and the multitude of urban stressors.

Table 3.17: Knowledge base on the subject area urban forestry.

Study/Assessment	Source	ES				Scale			
		P	R	C	H	I	N	C	L
Der ökologische Wert von Stadtbäumen bezüglich der Biodiversität	Gloor and Hofbauer (2018)				•		•		
Ökosystemleistungen von städtischen Bäumen und Wäldern klimaadaptiv managen - iTree	Saluz (2019)		•				•		
Gestaltungs-Standards Element: Vegetation	Stadt Zürich (2015)		•						•
Baumstrategie für die Stadt St.Gallen	Stadt St. Gallen (2020)		•		•				•
Plan directeur de l'arbre et de la nature en ville – instrument de gestion et de planification urbaine	National Centre for Climate Services (2018)				•				•
Evolution du patrimoine arbore	Wyler et al. (2009)								•
Fachplanung Stadtbäume	Fuchs (2021)		•						•
Allenkonzept	Stadt Zürich (2020)		•						•
Impulse für eine klimaangepasste Schweiz	BAFU (2017)		•				•		
Aktion Klimaoase	Naturama Aargau (2021)		•					•	
How wild bees find a way in European cities	Casanelles-Abella et al. (2021)				•	•			
Quantifying the contributions of trees to a city's biodiversity and ecosystem services	Schlaepfer et al. (2020)		•	•	•				•
Above-ground biomass references for urban trees from terrestrial laser scanning data	Kükenbrink et al. (2021)	•							•
Ermittlung der Kohlenstoffspeicherung von Bäumen…Stadt Bern	Gardi et al. (2016)		•						•
Urban Green & Climate Bern	Blaser et al. (2016)		•						•
Baumanalyse Schwamendingen	Grün Stadt Zürich (2010)			•	•				•
Veränderung der Grünflächenqualität aufgrund der baulichen Verdichtung in der Stadt Zürich	Wild (2013)		•	•	•				•
Projekt Siedlungsökologie	Rietmann et al. (2013)				•		•		
Citree - Gehölze für urbane Räume Planungsdatenbank	www.citree.de			•		•			
Lenkung der Baumwurzeln in Stadtbaumsubstraten	Heinrich and Saluz (2017)								

Scale: *I: International; N: National; C: Cantonal/Regional; L: Local.*
ES Ecosystem Services: *R: Regulating Services; P: Provisioning Services; C: Cultural Services; H: Habitat Services*

3.7 Economical values and Payments for Ecosystem Services

3.7.1 Knowledge about economical values of TOF

The economic dimension of tree values in Switzerland has been addressed in many studies, but there is no systematic, comprehensive study on the monetary value of TOF in general. In addition, there is no systematic assessment of all ecosystem services provided by TOFs. However, there are studies on various economic aspects, for example for landscape quality contributions, with new agroforestry models or market values of specific products (e.g., Christmas trees, fruits) (Table 3.18)

Table 3.18: Information about the economic value of TOF in Switzerland.

Study/Assessment	**Source**
Agriculture/Agroforestry	
Statistik Obstanlagen	BLW (2020)
Agrarbericht	BLW (2021)
Weiterentwicklung der Biodiversitätsbeiträge in der AP22+	Zurbrügg et al. (2020)
Agroforestry is paying off	Kay et al. (2019a)
Programm Labiola	Kanton Aargau (2021b)
Schweizer Christbaummarkt	WaldSchweiz (2021)
Evaluation Landschaftsqualitätsbeiträge	Steiger et al. (2016)
Whole system valuation of arable, agroforestry and tree-only systems at three case study sites in Europe	Giannitsopoulos et al. (2020)
Nature- and landscape protection	
The ValPar.CH Project	Reynard et al. (2021)
Spatial planning	
Projekt Landumlegung Region Olten (LRO)	Flurgenossenschaft LRO (2021)

Inspired by other countries, recently a series of surveys with i-Tree Eco (see also Chapter 2) was undertaken in Switzerland. These surveys are tree-specific and cover very different project designs (individual trees, project perimeters, neighbourhoods, or entire cities) (see for example Eggenberger & Bernasconi, 2021; Saluz et al., 2022).

3.7.2 Payments for Ecosystem Services

A Swiss inventory of ecosystem services was compiled and associated indicators were determined (Staub et al., 2011). This inventory is based on the CICES classification system mentioned in the previous chapters and deals with the so-called final ecosystem services, i.e., goods and services that are directly consumed by people and thus contribute directly to welfare.

There are several publications on the valorisation of forest services and ecosystem services of individual trees in the forest (see for example, FOEN, 2015; WaldSchweiz, 2018). Moreover, various case studies have dealt with the quantification of ecosystem services and their valorisation (see, among others, the studies by Kay et al. mentioned above). In the context of TOF, however, there has been little Swiss-specific work that provides a foundation for the payment of TOF services, with the exception of the economically-oriented agroforestry studies. A special case is compensation for damaged trees. Here the valuation is based on the relevant guidelines of the professional association, but it is not a valorisation of ES services in the above sense.

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Chapter 4: Recommendations

Based on the international and Swiss scoping reviews, as well as the two project workshops, a set of recommendations has been drawn up for possible next steps towards greater consideration of TOF and their values in Switzerland. Five key recommendations are provided, based on five important topics.

4.1 TOF as an important future resource

The international survey showed that TOF and their values and ecosystem services are increasingly recognised. Especially trees in urban areas, as well as the values these provide, have been given increasing attention during the past years, not in the least because of their role as 'nature-based solutions' to e.g., support climate action and public health promotion. Other TOF types are also considered important, such as fruit trees / orchards for their large economic importance. There has also been increasing attention for single, remarkable, and ancient trees in both rural, natural, and urban areas. TOF types such as hedgerows have been inventoried and studied in countries like the UK. The latter is also the only out of the give countries studied that has made efforts to comprehensively inventory the national TOF resource (and its benefits). The economic importance of TOF and their values is only partly known, but their importance in e.g., urban settings and as part of fruit tree production has been demonstrated to be very high.

For the Swiss context, the documents studied clearly show that TOF are already a very important resource supporting many areas of life. In the future, this resource will continue to gain in importance, as shown by various initiatives at local, cantonal, or national level.

Recommendation 1: *Awareness of TOF as a resource for the future is not yet fully developed. However, this is likely to change in the near future. Accordingly, there is a need for sound knowledge and adapted instruments for the sustainable promotion and further development of TOF in Switzerland. In addition, TOF and their values could be mobilized as delivery tools for global commitments, e.g., within climate change and biodiversity agendas.*

4.2 Coordinating and compilation of scattered data

Although the amount of data and body of knowledge on TOF and their values has rapidly increased during recent years, a lot of this information is still very scattered and fragmented. As mentioned, not many countries have made more comprehensive assessments of their TOF resource, let alone the ecosystem services and benefits provided. Even in cities where TOF inventories and assessments are more common, especially for municipally-owned trees, it can still be difficult to access data. Cities also often use different systems – sometimes even internally, between different departments. There are no clear standards for TOF inventory and value assessment, although the emergence of replacement cost and monetary assessment methods and programs like i-Tree (all mostly for urban trees) have started to change the situation.

The international findings can be confirmed for Switzerland. There are many studies and surveys in different areas and fields of action. However, the data and databases are scattered and there is no overarching view of things nor standardisation. The knowledge on TOF is also not brought together anywhere, at least for the time being.

Recommendation 2: *In order to bring together the already existing diverse but fragmented knowledge base as a foundation for more coordinated efforts and policies, it is recommended to create an overarching framework for TOF in Switzerland. This would then make it possible to compile, systematise, and ultimately make available the data and knowledge from the different areas, disciplines, and levels in a comprehensive way.*

4.3 Methodological variety

The international survey showed that TOF and their values are currently assessed using a wide range of methods. All major IPBES assessment and valuation types have been applied, although more holistic assessments are still less widely used. Especially biophysical, sociocultural, and economic assessment and valuation have become well developed, with recent advances in sociocultural assessment also attempting to find ways for assessing relational values, perceptions, and worldviews. Economic assessment has rapidly increased during recent years, with the wider implication of the ecosystem service framework, and many countries are now applying ecosystem service accounting. Health (impact) assessments have also started to emerge but are much less developed and don't often have specific focus on TOF. Some initial work has started to look at the health impacts of urban tree canopy changes and urban greening projects.

The spectrum of methods used in Switzerland for TOF and TOF value assessment is very wide. The various disciplines approach the topic with very different instruments and methodological approaches. The policy fields and planning procedures are also very different in nature depending on the sector.

Recommendation 3: The methodological variety will remain very large in the future. A common framework and policy geared towards the sustainable development of TOF will assist with coordinating and benefitting from this methodological diversity**.** On a national level it should be discussed whether or not a national inventory of TOF should be developed. Opportunities to include TOF in the National Forest Inventory, based on e.g., the UK and US experience, should be considered. Lessons learnt from diverse ecosystem service accountings could possibly be transferred to a Swiss context. The current testing of i-Tree in Swiss cities could be further advanced.

4.4 Fostering interdisciplinary and cross-sectoral approaches

The international review, both in terms of the study of five selected countries and a wider scoping of the literature, showed that there is still a tension between natural science assessments on the one hand, and social science and humanities approaches on the other. The IPBES framework has called for a better integration of social science and humanities approaches, but very few studies to date have included a truly interdisciplinary assessment approach. Some of the recent ecosystem service assessment in countries like the UK and Spain has made some initial efforts, but especially social science approaches are often more quantitively focused which can make it difficult to truly understand cultural values, perceptions, and worldviews.

This conclusion is similar for Switzerland. Specifically for the forest sector, the project 'WaMos meets LFI' shows how the natural science methods used for the national forest inventory can be linked with the social science surveys WaMos.

In addition, there is potential for less 'silo thinking' and more cross-departmental collaboration for TOF. There is no clear 'single home' for TOF, as they are addressed partially by e.g., forestry, agriculture, urban planning, landscape planning, nature conservation, tourism, and other sectors.

Recommendation 4: *The importance of national-level consideration of TOF and their values requires interdisciplinary approaches, cross-departmental collaboration, as well as collaboration between different levels of government. The development of promising assessment and valuation tools, also for e.g., assessing cultural and possibly relational values could be enhanced. Examples of the latter include, among other, approaches that use participatory GIS, scenarios, storytelling, and community-based assessments. The findings and lessons learnt from 'WaMos meets LFI' could be extended to various questions on TOF. Appropriate new approaches could be tested within a Swiss TOF framework accompanied by a series of pilot assessment trials. In addition, from a cross-sectoral perspective, a Swiss TOF initiative would benefit from the involvement of key sectors and departments from the very start, building a partnership approach, even though it may be necessary to allocate a 'home department' for this initiative for practical reasons.*

4.5 Developing a national TOF strategy

The international survey showed that there has been a lack and often even absence of strategic frameworks and policies for TOF and their values. Some recent policies have possible started to change this ´landscape', such as the new green infrastructure law / policy in Spain and the new Dutch Forest Strategy. There is still a risk, however, that strategies and policies will be mostly sectoral rather than comprehensive and coordinating. Green / ecological infrastructure platforms can provide this interdisciplinary 'home' for TOF, potentially, as can e.g., sustainable development (goal) strategies and climate action programs.

Taking into account the above-mentioned findings and conclusions, it seems appropriate to develop a cross-disciplinary and cross-sectoral TOF strategy for Switzerland. The impetus from the current SDG action plan should be used to network knowledge and actors and to optimally coordinate the various action plans and sector goals that concern TOF.

Recommendation 5: *With the involvement of all relevant actors and networks, and based on the common framework introduced earlier, an umbrella strategy for TOF could be developed. This strategy would then provide overall direction and priorities within which the various sub-strategies can be implemented on a sector-specific basis. Opportunities exist within existing programs and policy arenas, such as those related to the Swiss ecological infrastructure, sustainable development strategy, and disaster / climate change preparedness programs.*

4.6 Developing a TOF value framework

As shown in Chapter 2, there are many perspectives that come together related to TOF. In many assessments, a narrowing is - inevitably - carried out for methodological reasons. The methodological challenge is thus to find a way how - systematically - the different perspectives and the associated values can be included in a survey and in planning procedures. Based on the theoretical foundations (see in particular the IPBES framework), and also realising that there are some limitations to the practical implementation of the IPBES values of nature framework, we therefore propose to create a so-called "third vessel" for the Swiss TOF initiative. The third vessel would be a supplement to the conventional natural-science or social-science based approaches and

methods, which would also serve to take a more interdisciplinary perspective that represents a wider values view.

The third vessel could be seen as a 'home' for all other perspectives and complementary approaches. This vessel would be multiform, methodologically open, explorative, experimental, but also pragmatic. It would serve as a place for reflection, where unusual and non-traditional forms and approaches also have their place. Non-organised actors or groups of actors who are insufficiently involved in conventional assessments and planning, such as children, could also find a place for inclusion here. Table 4.1 summarises the outlined idea.

Recommendation 6: *A 'third vessel' framework for recognising and assessing the multiple values of TOF in Switzerland is proposed, inspired by the more comprehensive values of nature framework by IPBES, and meeting the need for innovative, interdisciplinary, and more inclusive assessment approaches. This third vessel complements primarily nature-science and social-science based approaches.*

Table 4.1: A proposed 'third vessel' as a complementary framework for assessing and valuing TOF.

Values	**Themes**	**Vessel 1: Natural-science based approaches**	**Vessel 2: Social-science based approaches**	**The third vessel**
Non-anthropocentric	Biodiversity Nature for nature itself Intrinsic values	●	○	○
Instrumental (Nature's contribution to people NCP)	Regulating ES	●	○	○
	Provisioning ES	●	○	○
	Cultural ES	○	●	○
Relational	Good quality of life Other perspectives Living with nature	○	●	●

Legend: ● main contributions; ○ complementary contributions.

Chapter 5: Roadmap

5.1 Mission and challenges

The Forest Ecosystem Services and Silviculture Section, Forest Division, Swiss Federal Office for the Environment FOEN commissioned the present study on tree values and services (TREEVES) with focus on the values (including those related to worldviews and perceptions), services, potential, markets of trees outside forests in both Switzerland and (as a reference framework) selected European countries. This study had an exploratory character, aiming to help prepare the field for the new Measure 7 in the Swiss SDG Action Plan.

In its Sustainable Development Strategy 2030 (SDS, 2030), the Swiss Federal Council sets out its priorities for implementing the 2030 Agenda for Sustainable Development over the next ten years. The SDS 2030 and the associated Action Plan 2021-2023 were adopted by the Federal Council on 23 June 2021. Measure 7 of this action was entitled “Luring the trees out of the forest” (Feasibility study with a view to developing a systemic approach to promote the tree population and its ecosystem services) (see Textbox 5.1).

Textbox 5.1. Short description of measure 7 of the SDG action plan (in German).

Mit dieser Massnahme soll generell das Potenzial einer koordinierten Förderung von Bäumen in Form von *Urban Forestry* und Agroforstwirtschaft in ländlichen Gebieten evaluiert werden. Vorgeschlagen wird ein sektorenübergreifender und räumlich differenzierter Ansatz zur Nutzung von Bäumen als natürliche Ressource. Die Beurteilung des Förderungspotenzials orientiert sich an der Frage, inwiefern damit zur Bewältigung globaler Herausforderungen wie CO_2-Sequestrierung, Biodiversitätsverlust und Anpassung an den Klimawandel beigetragen werden kann. Die spezifischen Ziele der Massnahme lauten:

1. Entwicklung einer sektorenübergreifenden, koordinierten Partnerschaft
2. Dialog und Wissenstransfer zur Weiterentwicklung von Urban Forestry und Agroforstwirtschaft
3. Ausarbeitung von Leitlinien und Empfehlungen
4. Erkundung innovativer Ansätze und Perspektivenanalyse

Diese Massnahme erleichtert die Zusammenarbeit zwischen allen beteiligten Akteuren und wird von sektorenübergreifenden Fachgruppen getragen. Im Bericht über die Machbarkeitsstudie wird neben dem Potenzial der Weiterverfolgung dieses Ansatzes auch die Frage der Synergien zwischen Fachstellen und Themenbereichen erörtert. Die Studie legt das Fundament für ein Konzept zur Förderung von Bäumen und für Überlegungen zur Wald- und Landwirtschaftspolitik der Zukunft sowie zu deren Beziehung zur ökologischen Infrastruktur der Biodiversitätsstrategie.

As has been elaborated in the previous chapters, the sustainable development of TOF in Switzerland faces a range of challenges. Also based on Pütz and Bernasconi (2017), four key challenges can be outlined here:

- Developing a shared, inclusive, cross-disciplinary, and cross-sectoral vision, overcoming cultural, institutional, and definitional barriers in order to achieve a joint integrative strategy - and implement it.
- Further development of a common value-based framework to describe the values and ecosystem services of TOF and related needs and preferences.

- Coordination of planning, management and control, and assessment and monitoring of TOF in order to develop an overarching interdisciplinary knowledge basis.
- Creation of new forms and mechanisms of PES and financing of TOF management through new and strong partnerships with actors from politics, administration, society, and economy (throughout sectors and disciplines).

For the latter, past and ongoing work on PES and financing mechanisms as discussed in especially the international review chapter can provide inspiration (see e.g., SINCERE, 2021). Moreover, a recent draft White Paper by McQuaid et al. (2021), published within the framework of Network Nature, offers valuable suggestions on moving from nature-based solutions to a nature-based economy. Given the urgency of the climate and biodiversity crises the authors state the following: "(…) we advocate for sustained public sector investment in NBS in the short term, accompanied by longer term transformative change measures in systems and processes to instigate the necessary shift towards a Nature-based Economy. Investment in NBS should be accompanied by measures to ensure such investment leads to direct economic benefits in terms of increased innovation, enterprise and job creation in the private sector supplying NBS." This recommendation is also important for TOF, as markets for PES are being developed.

5.2 Draft outline for Swiss TOF roadmap

In the following, a possible procedure is outlined as to how - based on project findings - the basis for a TOF strategy for Switzerland could be set up. The information provided here should be seen primarily as 'food for thought' on the part of the authors of this study which have not been agreed upon or consolidated more widely. However, they can provide inspiration for further discussion, initiatives, and measures.

Step I: Establish a task force for Swiss TOF issues with representatives from the relevant authorities (ARE, FOEN, FOAG) and selected experts (AGROSCOPE, EMPA, WSL).

Step II: Kick-off event with all relevant partners in order to find common ground and an outline for future actions. This would also include initial steps towards building a common framework for TOF as well as a common Swiss-wide TOF-partnership (see measure 7: "Entwicklung einer sektorübergreifenden, koordinierten Partnerschaft").

Step III: Launch a pilot project to clarify specific open questions and interface issues and to derive a basic glossary and conceptual framework for TOF and their values (see measure 7: "Erkundung innovativer Ansätze und Perspektivenanalyse").

Step IV: Launch an inter-agency strategy process to develop a national strategy / action plan for TOF. The action plan should include questions of national monitoring and national impact monitoring as well as clarification of interfaces with sub-strategies at sectoral level. Although the action plan will be cross-sectoral, an agency 'home' for the plan will have to be identified – or possibly a dedicated interagency platform, potentially within one of the existing cross-sectoral programs outlined in the previous chapter. This platform should especially enhance knowledge transfer (see measure 7: "Dialog und Wissenstransfer zur Weiterentwicklung von Urban Forestry und Agroforstwirtschaft").

Step V: Elaborate guidelines, adopt, publish, widely communicate, and implement the Swiss TOF Action Plan (see measure 7: "Ausarbeitung von Leitlinien und Empfehlungen").

The road map described above is designed to develop a framework for a national Swiss TOF strategy. Experience shows that such processes take a long time and can be rather cumbersome. Therefore, it is recommended to complement the strategy development process with the launch of some easily implementable actions. These are deliberately smaller, low-threshold measures that can be readily implemented even with limited resources. These actions can be implemented in parallel and independently of the above-mentioned process. Moreover, they can be used at different planning levels (local, regional, cantonal, national).

TOF Platform
Initiated by a partnership with representatives of several institutions, a website "TOF Switzerland" could be established. This platform would aim to collect good examples in dealing with TOF as well as knowledge about TOF in Switzerland as well as abroad and make this available to an interested audience. The website could be very low-threshold, in the sense of a starting vessel, and could - with increasing interest - develop as a national platform for TOF.

Afterwork TOF-walks
A short guide for small walks after work could be developed and disseminated in professional circles. Using a 3-3-30 formula, the idea would be to visit three trees within a short time (e.g., 30 to 60 minutes duration) and to exchange at least three different perspectives (with experts from different disciplines or representatives of different value systems) on the example of these trees. The trees and could be photographed and key findings and reflections recorded in a few words. These TOF walks could be understood in terms of a campaign to promote knowledge around TOF. All interested parties such as neighbourhood associations or the like could develop such offers in the sense of guidance.

Tiny TOF pilots
As a rule, pilot projects are conceived as larger projects, which also take longer and require considerable funds to realise. However, the idea of pilots could be broken down to small and very small projects, so-called "tiny pilots". These micro-projects would have a common label ("Tiny TOF Projects", or TTF in brief) and would ensure minimum standards such as the exchange of different values. These TTPs could also have an experimental character. All TTPs would be collected nationally. It would also be conceivable to establish a funding mechanism to support such TTPs.

5.3 Concluding remarks

The Swiss and international experts involved in this review all showed great interest and openness towards the topic of TOF. Moreover, they were supportive of future-oriented cooperation among all actors and sectors. Based on this as well, as on our assessment of the general context on the one hand, and the specific framework conditions and sub-policies on the other, we believe that the time is right for a cross-sectoral TOF strategy in Switzerland. The roadmap outlined in the previous section provides possible guidance, as do the five recommendations listed in Chapter 4: 1) TOF are an important resource and we are started to learn more about their value, also economically; 2) much can be gained from better compilation and coordination of existing (and new) data and knowledge; 3) the emerging methodological variety for assessing and monitoring TOF and their values and services should be cherished and used; 4) more cross- and interdisciplinary work will be needed to recognize and incorporate TOF and their values to their full extent; and 5) there is a real need and opportunity for a national, cross-sectoral TOF strategy in Switzerland.

As the Swiss initiative for TOF rolls out, maintaining close links with developments elsewhere in Europe and beyond will be important. Several countries have already gone further down the road of

assessing TOF, TOF values (including their economic ones), and integrating TOF into national policies and programs. There have been many relevant initiatives, but often mostly for individual TOF components or settings, which calls for a more comprehensive framework and approach.

We would also like to take this opportunity to express our sincere thanks to all the people who generously contributed their time and expertise in interviews, discussions, and during the two project workshops. Their contributions were essential for obtaining a more in-depth understanding of TOF and their values, as well as possible next steps, both internationally and in Switzerland in particular.

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Appendix 1: Guide for the expert interviews

Part I: Values

What type of values/perceptions do exist/are evaluated (in relation to nature, social-ecological systems)?

What kind of studies/results exist?

Part II: Valuation methodologies and approaches

What methodologies and approaches are in place for the values and services of trees outside forests in your country?

Part III: Data and knowledge

What data and knowledge are known? What are the gaps and knowledge gaps?

What are the most important studies and assessments being realized by now?

Part IV: Assessments

What is the primary focus of these methodologies/approaches, and how do trees outside forests feature in a wider nature and ecosystem perspective?

What are some of the findings of these assessments, and what values and services are highlighted?

Part V: Implementation

According to existing schemes for nature/biodiversity/tree promotion, what are or have been the levers or blockers of a wide application?

Have different social groups (i.e. with specific values and worldviews) been distinguished as having an influence on the effectiveness of promotion schemes, or the evolution of policies?

Part V: Policy

How are valuation and assessment methods informing policy and decision making?

What gaps are there currently in terms of assessment and valuation of TREEVES?

Part VI: Further Comments

Do you have any other comments concerning the topic "Trees outside the forest"?

Part VII: Remarks by the interviewer

Appendix 2: Overview of selected relevant international studies, projects, and approaches

Tabel A1: Selected sources related to values of trees and their assessment (international)

Study/ Assessment	Domain and setting	Source	ES				Scale			
			P	R	C	H	I	N	R	L
Ancient Tree Inventory (UK)	Woodland Trust inventory of the UK's ancient trees	Woodland Trust (2021)			X	X		X		
Assessing, mapping, and quantifying cultural ecosystem services at community level (Germany, international)	Innovative and comprehensive assessment cultural ecosystem services of a landscape (included tree and woodland elements), using combination of mapping exercises and structured interviews with 93 persons that were analysed with statistical and GIS-based techniques.	Plieninger et al. (2013)			X					X
CAVAT (economic) assessments of tree values, multiple trees and sites (UK)	United Kingdom, mostly urban. Does not make direct assessment of ES, but estimates amenity value	The London Tree Officers Association (2017)			X					X
Changing the urban design of cities for health: The superblock model (Spain)	Health impact assessment of an urban transformation project in Barcelona, Spain that includes greening	Mueller et al. (2020)		X						X
Colourful Green: Immigrants' and non-immigrants' recreational use of greenspace and their perceptions of nature (The Netherlands)	Dutch study on perceptions and worldviews in relation to green space, outdoor recreation	Kloek (2015)			X			X		X

Study/ Assessment	Domain and setting	Source	ES				Scale			
			P	R	C	H	I	N	R	L
Cultural ecosystem services as revealed through short stories from residents of the Swabian Alb (Germany)	Using storytelling by residents of a regional German landscape to assess cultural values	Bieling (2014)			X				X	
De Baten van Bomen – Resultaten van i-Tree Eco in Nederland	i-Tree assessment of 1 full city and neighbourhoods in 13 additional municipalities in The Netherlands	Platform i-Tree Nederland (s.a.)		X				(X)		X
Defra's Payments for Ecosystem Services Pilot Projects 2012-15 (UK)	Pilot study for selected number of areas and services in the UK	Defra (2016)	X	X	X	X				X
Do European agroforestry systems enhance biodiversity and ecosystem services (international)	International meta-analysis	Torralba et al. (2016)	X	X	X	X	X			
Estimating hedgerow length and pattern characteristics in Great Britain using Countryside Survey data (UK)	National assessment in the UK	Barr and Gillespie (2000)				X		X		
Experimental monetary valuation of ecosystem services and assets in the Netherlands (The Netherlands)	Monetary valuation of a range of ecosystems and ecosystem services, using different methods	Horlings et al. (2020)	X	X	X	X		X		
German national Nature awareness study (German)	Representative population survey on perceptions of nature and biodiversity. Done every few years.	BfN (2019)			X			X		
Green space and mortality in European cities: a health impact assessment study (international)	Pan-European study of over 1000 cities; health impact study	Pereira Barboza et al. (2021)		X	X		X			X

Study/ Assessment	Domain and setting	Source	ES				Scale			
			P	R	C	H	I	N	R	L
Health impact assessment of Superblock implementation in Barcelona (Spain)	Ongoing implementation of closing off streets for cars and greening in Barcelona are assessed for their health impacts.	Mueller et al. (2020)		X	X					X
High public appreciation for the cultural ecosystem services of urban and peri-urban forests during the COVID-19 pandemic (Germany)	Two cities in Germany, survey and participatory mapping	Beckmann-Wübbelt et al. (2021)			X					X
i-Tree assessments of multiple UK cities (e.g., Bristol, Glasgow, London) (UK)	Multiple cities, and some non-urban cases. Mostly regulatory services assessed, also in monetary terms.	Bristol i-Tree (2019); Rumble et al. (2015); Treeconomics (2015)		X						X
i-Tree Sverige (i-Tree Sweden)	Assessment of urban forests, ecosystem services, and their economic value for 26 Swedish municipalities	Deak Sjöman and Östberg (2020)		X				X		X
LillNILS landscape habitat assessment (Sweden)	Sweden, at county board level	Länsstyrelsen, 2021				X			X	
Multimethod approach to engaging different groups in governance and management of urban green spaces (Sweden)	Work by the VIVA-PLAN project in urban neighbourhoods in Denmark and Sweden, with focus on vulnerable groups	Raymond et al. (2021)			X					X
No wilderness for immigrants: Cultural differences in images of nature and landscape preferences (The Netherlands)	Study in the Netherlands, national-level survey	Buijs et al. (2013)			X			X		

Study/ Assessment	Domain and setting	Source	ES				Scale			
			P	R	C	H	I	N	R	L
National Inventory of Landscapes in Sweden (NILS) (Sweden)	National study of selected landscapes in Sweden (including rural areas), monitoring change	SLU (2021)				X		X		
Norma Granada – Spanish method for tree valuation (Spain)	Widely used, also in court, in Spain. Includes an estimate of ecosystem service values	AEPJP (2020)		X	X	X				X
Outstanding heritage trees (Spain)	Overview of different registers at regional and local scales prepared by the Landscape Observatory of Catalonia	Observatorio de Paisatge (2021)			X	X			X	X
Study 'Public Perceptions of Urban Trees' (UK)	UK-wide, representative study, including different societal groups. Done by Forest Research	Forest Research (2021)			X			X		X
Spanish National Ecosystem Service Assessment (Spain)	First nation-wide assessment of ecosystems, biodiversity, and ecosystem services in Spain	Gobierno de España (2014)	X	X	X	X		X		
The Green Space Factor and the Green Point System (Sweden, international)	Assessment and scoring system for green space and green elements (including trees), used in cities such as Malmo	Kruuse (2017)				X				X
The importance of scattered trees for biodiversity conservation (international)	Global meta-study, involving 62 quantitative studies.	Prevedello et al. (2017)				X	X			
Tree cover outside woodland in Great Britain (UK)	National assessment, as part of the National Forest Inventory	Forest Research (2017)				X		X		

Study/ Assessment	Domain and setting	Source	ES				Scale			
			P	R	C	H	I	N	R	L
UK National Ecosystem Assessment	National assessment of ecosystems and their services in the UK, including economic assessment.	UK National Ecosystem Assessment (2021), UNEP (2014)	X	X	X	X		X	(X)	
Urban heat island mitigation by green infrastructure in European Functional Urban Areas (international)	European-wide study of cooling effects of green infrastructure	Marando et al. (2021)		X			X			X
Using a participatory GIS tool to compare the appreciation and use of green spaces inside and outside urban areas by urban residents (Germany)	Assessment of people's connection to special places at different scales	Bijker and Sijtsma (2017)			X		X	X	X	X
Valuing the social and environmental contribution of woodlands and trees in England, Scotland and Wales (UK)	Overview of current valuation of various ecosystem services provided by woodlands and trees, including in urban and farming areas.	Binner et al. (2017)	X	X	X	X		X		
Wood-pastures of Europe: Geographic coverage, social–ecological values, conservation management, and policy implications (international)	Study of the importance and values of wood-pastured in Europe (various countries)	Plieninger et al. (2015)	X	X	X	X	X			
Spatial quantification and valuation of cultural ecosystem services in an agricultural landscape (The Netherlands)	Survey among tourists and residents of a local/regional landscape in The Netherlands, also involving Willingness to Pay and travel cost method estimates	Van Berkel and Verburg (2014)			X				X	X

Scale: *I: International; N: National; R: Provincial/Regional; L: Local.*

ES Ecosystem Services: *R: Regulating Services; P: Provisioning Services; C: Cultural Services; H: Habitat Services (including biophysical and ecological characteristics)*