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REVIEW AND SYNTHESIS

Interdisciplinary insights into navigating the maze of landscape multifunctionality

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Abstract

1. Increasing demands for land to deliver multiple and sometimes conflicting services to people and nature have led to the development of an extensive body of research focussed on multifunctional landscapes. However, this has created both insight and confusion, as authors from a variety of disciplines have independently tackled the question of how to manage the trade-offs and synergies inherent in landscapes that are required to produce multiple functions and services.
2. We employed an interdisciplinary perspective to formulate some key questions that researchers of multifunctional landscapes can use to identify blind spots.
3. Our process resulted in a question-based analysis support scheme that supports reflection and recursive thinking about multifunctional landscapes, beginning with objective setting and visions for addressing it, grounded in baseline mapping, then assessing landscape functions and their single and multiple interactions; as well as the analysis of sensitivity to spatial and temporal dimensions.
4. Other key points identified are the need for clarity and examination of unstated assumptions, from aims to definitions; accounting for scale; incorporating stakeholder needs throughout the process and applying suitable methods of measurement and aggregation. The focus on asking guided questions derives from the insight that there is no universal correct approach to multifunctional landscapes; the aim should instead be to find the most appropriate methods for the given circumstances and goals.
5. *Policy implications*. Tackling current and future socio-ecological challenges is an interdisciplinary undertaking, necessitating collaborative efforts between research fields that each bring valuable and distinct insights. To effectively combat

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these challenges, multifunctional landscapes require a clear process and focused objective in their implementation. Multifunctionality should be seen as a means to an end, rather than an end in itself.

KEYWORDS
analysis support, ecosystem functions, ecosystem services, interdisciplinary research, landscape services, multifunctional landscapes, Nature's contributions to people, user-oriented functions

1 | INTRODUCTION

We live in an age of global megatrends such as climate change, biodiversity loss, space scarcity, competition for resources, environmental injustice, increased urbanisation, globalisation, densification and shifting migration patterns (EEA, 2015). These megatrends have not only global but also local implications and have thus transformed societal needs at different scales, which has increased the demands on land use to be of higher quality and to have diverse and multiple functions (Jansson et al., 2020). At the same time, anthropogenic pressures increasingly challenge ecosystem service (ES) provision (Mauri et al., 2023). More functions and user groups sharing the same space imply an increase in both the risk of trade-offs (or conflicts) and the possibility of synergies between functions and values.

In response to these megatrends and their implications, there has been a noticeable rise in research interests towards multifunctional landscapes in different research fields and regions of the world (Supporting information S1). The rise of the concept *multifunctional landscape* (MFL) indicates the need to address, and often strive for, multiple functions in a given landscape, for example, ecological, agricultural and social functions, that form the basis of a diversity of ES (MEA, 2005) such as provisioning, regulating, supporting and cultural services. Land management with an emphasis on multifunctionality is believed to benefit multiple stakeholders and the delivery of various ES, leading to increased sustainability of the landscape (O'Farrell & Anderson, 2010).

One of the many purposes of MFL research is to help unearth the varying assumptions behind multifunctionality, landscapes and landscape multifunctionality. At its simplest, multifunctionality means including multiple functions. A landscape can be considered 'an area viewed at a scale' determined by certain considerations and landscape multifunctionality thus involves 'the capacity of a landscape to simultaneously support multiple benefits' (Englund et al., 2017, p. 498). However, the literature on MFL is abundant, both within and across several disciplines (Arts et al., 2017; de Koning et al., 2023; Hansen et al., 2019; Hölting et al., 2019; O'Farrell & Anderson, 2010; Otte et al., 2007; Triviño et al., 2017). This makes MFL an ambiguous concept, with varying perspectives on which functions to include and their definitions across different research fields. Further ambiguity lies in which societal problems MFL are expected to solve and how, and its effectiveness in shaping sustainable land use. The ambiguity of the concept not only invites constant change and thus situational adaptation but also creates uncertainty about the meaning. This can lead to misunderstandings when different interpretations collide, that important functions, values or stakeholders are marginalised, or that the concept is trivialised into being only about creating several functions without a clear end goal. Moreover, the barriers and difficulties of implementing MFL are often framed as challenges for governance since current governance is adjusted to monofunctional outcomes (Selman, 2009; Solbär et al., 2019). Governance research often assumes MFL as a given, whereas natural science-based research provides results or indexes for policy use without elucidating their application or integration into the normative decision-making context for land use. This has resulted in the current situation in which, despite the need for changed governance that embraces MFL, it still remains unclear how this is going to happen in practice.

Against this context, we address the space between conceptualisation and realisation of MFL, where diverse usage of this term has led to much ambiguity and uncertainty. We suggest that different perceptions of MFL depend on the specific stakeholder groups' positions and expectations of the MFL—be it an end goal (but seemingly top-down and unreachable) or a process that entails certain tools and methods of land management. The article is based on an interdisciplinary collaboration by researchers from six different research fields and draws upon experiences spanning a broad range of landscape functions and situational contexts. This article aims to bridge the disciplinary gaps in ways to analyse MFL and to help interested scholars navigate through the various dimensions, layers and tensions in the analysis process of MFL as a preceding step for MFL realisation. Our main question is: What should be considered by researchers when they in interdisciplinary groups analyse ways to enable landscape multifunctionality?

This paper is structured as follows: First, we examine perceived purposes of multifunctionality and how they differ depending on the context (Section 2). We argue that reflecting on this is central to be able to respond to the ever-changing global megatrends in a concrete way that is relevant to different stakeholders. This section is wrapped up by presenting the first step of the so-called *MFL analysis support scheme* (henceforth the Scheme) that aims to help researchers navigate the maze of MFL while ensuring that key perspectives and aspects are considered.

We proceed to presenting three important considerations to make when working with the MFL concept (in Section 3): (i) perspectives on functions, (ii) possible ways to combine different functions and (in Section 4) (iii) structural considerations in terms of interactions between functions. In Section 5, we present the second step of the Scheme, organised as a set of key questions.

2 | PURPOSES OF MFL

Luz (2000) and other ecologists who are critical of the traditional approaches to landscape planning and managing *without people in mind* suggest that MFL brings the social aspects to landscape ecology and landscape planning. Such interlinks between the social and natural processes are addressed in the IPBES Global Assessment report, where the notion 'nature's contributions to people' (NCP) offers new ways to assess ES (Díaz et al., 2015; IPBES, 2019). While the notion of co-production of NCP is increasingly emphasised in the context of MFL, the question of how ES are co-produced by social-ecological systems remains central (Mastrángelo et al., 2019). Moreover, besides recognising the coexistence of different spheres such as ecology, economics, culture, history and aesthetics, using the concept MFL means that the interactions between these systems are fundamental and conflicts between these systems can be better managed through more integrated planning and landscape heterogeneity (ibid.).

Within some research fields, the term *landscape function* refers to *ecosystem functions (EF)*, while rather indicating *ES* to other scholars, whereas yet other scholars mainly connect it to *user-oriented functions* or *landscape services* (Bastian et al., 2014; Lindholst et al., 2015; Manning et al., 2018).

The plethora of assumptions behind the MFL concept, including perceptions of problems, solutions and purposes, requires taking a step back to uncover the underlying presuppositions, visions and rationales that shape the overall agenda for MFL and influence one's stance when working with the concept.

2.1 | What MFL are expected to solve

Following Englund et al.'s (2017) logic on *capacity of a landscape*, one noticeable stream of work concerns the resource issues and argues for heterogeneity in land use to avoid unsustainable intensification of land use. To do so, MFL is seen as an exemplary model to emphasise, support and restore the diverse elements of land use that may have been lost in the process of monocultural industrialisation (Mander et al., 2007). High expectations are put on MFL. The expectations often emphasise particular functions that are to be lifted and reworked. Meanwhile, these expectations raise environmental justice questions of whom it is supposed to benefit, considering the uneven, gendered/racial/class-related access to resource, as well as the perspective of non-human actors, or the local actors versus global discourses. Fischer et al. (2017) argue that MFL means that 'a more diverse set of ES is accessible to a broader range of beneficiaries', especially benefitting local people who are more likely to be in charge of landscape management. Yet again, it is not certain local products and services from MFL benefit everyone equally. For example, MFL can empower women, but whether this happens depends on, for example, gender dynamics and power structures in local contexts (Westholm & Ostwald, 2020). Neglecting questions about who gets access to the benefits from MFL might (unintentionally) increase environmental injustice for particular groups of society (Hansen & Pauleit, 2014). Similar considerations of fairness, social equity and legitimacy have been considered in relation to NCP, where IPBES (2019) suggests that the pursuit of more equitable benefits across social groups may motivate the need to incorporate their context-specific knowledge and relational values to nature.

From a natural science perspective, MFL are expected to contribute to reduced vulnerability to, for example, floods, droughts and fires, and contribute to more resilient ecosystems providing ES (Hector & Bagchi, 2007; Seddon et al., 2020) in a context where, for example, climate change is predicted to decrease forest ES provision by an average of 15% in Europe, and up to 52% in the Mediterranean (Mauri et al., 2023).

It is also argued that MFL perspectives are needed for urban planning and landscape design to achieve sustainability goals for human health and well-being. One underlying problem definition in this field is that multifunctionality is needed because of increased urbanisation and the trend towards more dense and compact cities, which means that the benefits from urban green spaces have to be realised within limited space (Haaland & van den Bosch, 2015; Hansen et al., 2019). This literature often concerns social and health benefits from multifunctional green spaces and emphasises the need for accessibility to these areas. From that point of view, an underlying assumption is that multifunctional green spaces are needed for maximising the benefits within close distance to residents (Konijnendijk, 2023).

2.2 | Policy instruments for realising MFL

The multifunctional perspective is often implied in policy, including sector-specific ones such as the Common Agricultural Policy (Wiggering et al., 2006) or the sustainability reporting and finance regulations such as the EU taxonomy (de Oliveira Neves, 2022) with their multiple objectives in the environmental, social and governance dimensions. Yet, while explicit targets exist for single issues such as the Aichi Biodiversity targets or the Paris Agreement's 1.5 degrees global warming target, no explicit quantified target appears to exist for multifunctionality, except for the various versions of the Do No Significant Harm criteria in policies. This may be linked to the lack of clarity regarding what multifunctionality is and its desired state, which has implications for the governance of multifunctionality, where partnerships between actors, a transdisciplinary approach and an organisation committed to leading towards the goals are needed (Selman, 2009). Finally, there are many policy instruments that can promote desirable actions or outcomes. These can be classified as command and control (e.g. permits to pollute), economic instruments (e.g. taxes or agri-environmental subsidies to farmers), and information and education tools (e.g. labelling or nudging) (Ferrari et al., 2019). However, at best, these instruments are designed based on research regarding what exactly to promote, how much and for whom. As an example, there is a long history of monetary valuation studies (e.g. Bateman et al., 2013; Costanza et al., 1997, 2014) of single ES giving rise to often context and time-specific estimates of how much to compensate land users for their provision. Compliance criteria for subsidies are well-established and point-based private remuneration systems for farmers are used, for example, by Danish and Swedish dairy processors, to incentivise more and more measures rather than combinations of measures tailored to their synergetic effects or multifunctionality goals. Holistic multifunctionality and governing towards it remains complex and often context-specific. The ability of information, education tools and monetary incentives to address complex issues such as multifunctionality is further uncertain when scaling up (List, 2022) as spillover effects, diseconomies of scale and limits of the target stakeholder group emerge.

2.3 | Important to actively choose a suitable approach for MFL analysis

Important questions for those researching MFL and how to realise them include what purpose do you find relevant and what goals do you wish to achieve? Is it desirable to discuss the policy constraints and frame suggestions in terms of realistic options only and is the relevant expertise available to be able to do this? Limitation of the discussion to the realistic may be seen as the obvious and sensible choice, but consideration of ecological measures necessary to avoid suboptimal outcomes may in some cases be more realistic than a narrow focus on choices permitted by the current legislative or policy constraints. This also concerns the perception of MFL and whether it is regarded as a neutral means to consider different types of landscapes and their functions on equal terms, thus enabling possible dialogue and handling of land-use conflicts. On the other hand, how can MFL be neutral, apolitical or non-normative if interrelations between different functions are to be considered as an important criterion of MFL?

This relates to the expectations, assumptions and visions driving the conceptualisation of MFL. First, the choice of key functions to prioritise is driven by expectations linked to MFL, which vary in terms of which functions are needed in combination (e.g. carbon sequestration, water purification, recreation, etc.). Second, the choice of scale for MFL realisation or study is driven by assumptions that underlie any discussion of MFL. For instance, as human pressures on land-use increase, the provision of multiple ES from the same area becomes essential, requiring sound management or planning decisions to minimise resulting trade-offs and conflicts (e.g. Goldstein et al., 2012; van der Plas et al., 2019). An example of this view would be framing expansion in the production of biofuels as leading to a *trilemma* with food provision, biofuel provision and biodiversity goals in clear conflict (Tilman et al., 2009). Third, the choice of combination of multiple functions is driven by visions and ambitions, namely what futures do we want; more of all functions, more of some, secure a minimum of some, an optimal combination of functions, a steady state of functions or a dynamically stable (i.e. resilient) system (Holling, 1973)? Finally, stakeholders need to be considered and involved throughout analysis processes to better bridge the gaps between disciplines, problematise potential assumptions and objectives, incorporate lived experiences and take part in developing solutions.

Hence, when analysing MFL, there are many ambiguities to keep in mind. In some ways, these are similar ambiguities to those seen in attempts to understand and evaluate how different types of co-production of NCP can lead to good quality of life (Bruley et al., 2021). Indeed, there is a trend to shift from ES to NCP in order to better address human interventions in broader ecosystems. However, to assess NCP at different scales in relation to achieve MFL still requires methodological exploration (Liu et al., 2023). Therefore, rather than shifting the entire rhetoric from ES to NCP, here we follow the line of thought suggested by Fischer and Eastwood (2016) that ES are often co-produced by people together with their social and ecological environment, shaped by factors including social identities and capabilities.

2.4 | The scheme step 1

Approaching the questions above is not a one-directional task but needs to be done recursively, where previous assumptions can be revised once more insights are generated in later stages, which is outlined in Figure 1. We suggest a crucial initial step in the analysis of MFL is enabled by joint and iterative reflection within interdisciplinary groups on the five stages (i) objectives, (ii) visions for how and why MFL is the solution, (iii) baseline mapping of a broad set of human and non-human perspectives, (iv) assessment of landscape functions and interactions and (v) refined analysis of sensitivity to spatial and temporal dimensions. After the completion of the fifth stage, the objective, vision or later stages are encouraged to be revisited and revised based on the new insights gained during the process. The Scheme (Table 1) provides questions guiding each stage of the process. This process supports comprehensive exploring and identification of interdisciplinary and situational conditions and contexts, thus setting the foundation for the later stages of any MFL-related decision-making processes or research studies.

3 | PERSPECTIVES OF LANDSCAPE FUNCTIONS

While multifunctionality is often desirable, it is important to consider which functions should be present in an MFL. It is thus important to consider how a function is defined in different fields in terms of what it does, for whom and from which system. Since

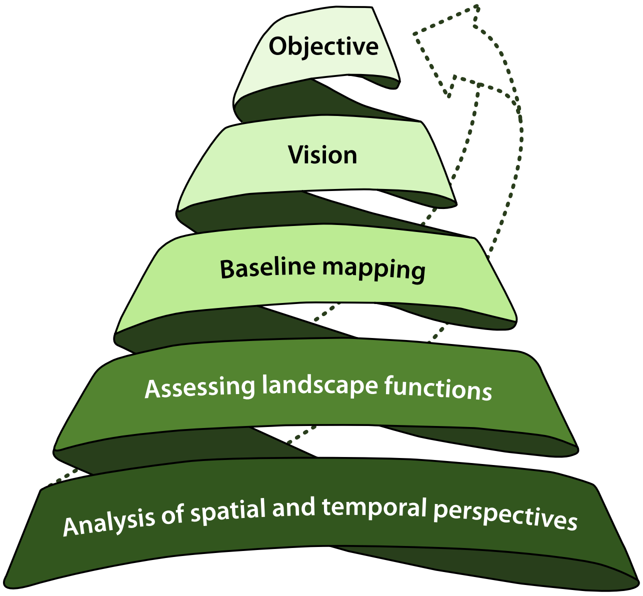

FIGURE 1 The five stages of the iterative process of exploring and setting the foundation for later stages of decision-making for multifunctional landscape realisation or research studies. After concluding the fifth stage, the objectives and/or later stages can be revisited and revised based on new insights gained during the process. This is shown here as a dotted arrow from the fifth stage back to the first one. The figure width increases for each stage of the process to indicate that the later stages are more resource-demanding than the earlier ones.

definitions vary between disciplines, which we explore below, we choose to use the term *landscape functions* to refer to the general concept when discipline-specific differences are irrelevant. Aiming to give a comprehensive and interdisciplinary interpretation of the concept, we define landscape functions as 'the capacity of natural and cultural landscapes to provide fundamental processes and services that sustain biodiversity and the health and well-being of a wide range of human user groups, thereby forming sustainable and just landscapes'.

3.1 | Defining *function*

Multifunctionality (i.e. a combination of several functions) is defined and measured in different ways across and even within research fields depending on what is understood as a function. An early attempt to describe the many functions and socio-economic values of nature to humans was made by De Groot (1992), who defined *environmental functions* as 'the capacity of natural processes and components to provide goods and services that satisfy human physiological and psychological needs (directly and/or indirectly)'. Drawing on the disciplines of ecology and economics, he presented 37 environmental functions, which could be goods or services, and divided them into *regulation functions* (e.g. climate regulation), *carrier functions* (providing space for e.g. habitation, cultivation and recreation), *production functions* (e.g. food; ornamental resources), and *information functions* (e.g. spiritual and aesthetic information; artistic inspiration) (De Groot, 1992). In a further development of the framework, De Groot et al. (2002) renamed environmental functions as *ecosystem functions* and carrier functions as *habitat functions*. Jax (2005) identified four main uses of the term function in ecology: functions as *processes* or interactions between objects such as organisms; as the *functioning of an entire system* and the sum of the processes that sustain that system; as the *roles* of different objects within the ecosystem; or as the *services* of the ecosystem to humans and other living beings. The functions of the landscape have also been divided into the ABC categories of Abiotic (e.g. groundwater interactions), Biotic (e.g. habitat) and Cultural (e.g. recreation) functions, with different parts of the landscape scoring differently on the ABC functions, suggesting that different types of environments are needed within a landscape for it to provide a full range of ABC functions and be sustainable and multifunctional (Ahern, 2007).

3.2 | Ecosystem functions and services

While this diverse array of scholarly landscape function definitions exists, there are two dominating strands within the multifunctionality research literature that to a large extent covers the perspectives and definitions described above. Biodiversity–ecosystem functioning research seeks to understand how biotic attributes of ecological communities are related to overall ecosystem functioning, that is, how to achieve *EF multifunctionality*. The land management research studies how landscapes can be managed to deliver multiple, alternative land-use objectives, that is, *ES multifunctionality* (Manning et al., 2018). EF, for example, rates of nitrification or decomposition, refers to the biological and biogeochemical processes and structures that underpin the capacity for ES provision. While applicable at landscape level, functions are often studied at smaller spatial scales (Le Provost et al., 2023). In ecosystems, the sets of species influence different EF, and the more ecosystem processes are included, the more species influence the overall function of the ecosystems (Yan et al., 2023). At the same time, a positive saturation relationship can be found between the number of ecosystem processes considered and the number of species influencing overall function (Qiu et al., 2021). Different species often influence different functions, and studies that focus on individual processes in isolation will thus underestimate the level of biodiversity required to maintain EF at the landscape level (Hector & Bagchi, 2007). There is increasing evidence that biodiversity is needed for the provision of EF/ES across a wide range of spatial scales (Le Provost et al., 2023). ES are often categorised into four types: supporting (e.g. nutrient cycling, habitat provision), provisioning (e.g. timber, food), regulating (e.g. climate regulation), and cultural (e.g. recreation) (MEA, 2005). They are reliant on the complexity of EF but are often presented at a higher level of abstraction, with a focus on how they are relevant for human well-being. As a concrete example related to climate change, a forest as an ecosystem (enabled by ecosystem processes such as the decomposition of organic matter in soils, the productivity of woody plant species, herbivory, etc.) has functions such as carbon sequestration. It can also provide intermediate ES that do not directly benefit humans, but that support other EF such as global climate regulation. This in turn can lead to the provision of ES such as climate change mitigation that benefit humans (e.g. Englund et al., 2017).

3.3 | Nature's contributions to people

Adding to the complexity, there has been a movement in recent years to shift from the term ES to that of NCP, a conceptual framework advocating for both generalising and context-specific perspectives, introducing relational values, and capturing both the beneficial and harmful 'contributions' of 'living nature' to people's quality of life (Díaz et al., 2015; IPBES, 2019). These developments are perhaps best characterised as extending and advancing existing trends in ecosystem research (Kadykalo et al., 2019), in a way that weaves the natural and social science perspectives more and highlights that 'contributions' are co-produced by nature and people (Hill et al., 2021). For example, NCP's generalising perspective classifies 18 contributions into three groups overlapping in social-cultural contexts: regulating, material and non-material contributions of nature to people (IPBES, 2019), akin to the groups of ES. At the same time, NCP is argued to differ from ES as it emphasises the 'fuzziness' among the three broad groups, recognises culture as permeating all relationships with nature rather than a separate category of ES and implies that 'entities of nature providing the contributions are not confined to the ecosystem level' (Hill et al., 2021). The NCP framework is implicitly relevant for MFL analysis steps on engaging with stakeholders in identifying objectives and mapping of the current state. This is because the context-specific perspective of NCP allows to better engage with land-use groups that express their relational values, perceived and desirable benefits from multifunctionality in terms of indigenous and local knowledge.

There is a growing realisation that it is not enough to solely consider which ES are to be provided. How they are provided is also of critical importance and this is captured by the concept of nature-based solutions (NbS). These are actions that address key environmental and socio-economic challenges while benefiting human well-being, ES and biodiversity. NbS are not only a way of providing required ES/EF in a way that protects biodiversity (Eggermont et al., 2015) but also a tool to catalyse transformative change (Seddon et al., 2021). The aim here is to overcome the human/nature dichotomy often present in concepts around ES and promote NbS as partnerships between people and nature (ibid.).

3.4 | User-oriented functions

The less widely used term 'landscape services' emphasises the importance of spatial patterns, structure and character of the physical landscape for the functioning of the landscape and the provision of ES, and brings cultural aspects of the landscape to the fore (Bastian et al., 2014). The focus on landscape services in addition to ES when working with MFL is also justified by the fact that concern for the full complexity of the landscape is inherent in landscape planning, and that the landscape—not the ecosystem—is the arena for public participation and decision-making related to local landscapes (Bastian et al., 2014).

Understanding different users' preferences is important for developing socially inclusive MFL that reflect the different needs and uses of local stakeholders of different ages, something that requires a user-oriented management approach (Sundevall & Jansson, 2020). To foster environmentally just landscapes, it is important to recognise the range of existing user (and non-user) groups, including traditionally marginalised ones, and to identify the functions that different user groups require from the landscape. Functions desired by different user groups are referred to here as *user-oriented functions*. They could be seen as a way of further specifying some ecosystem and landscape services, but the fact that the focus on different user groups is not inherent in the concepts of ES and landscape services justifies a separate term.

Studies of this consider how *user-oriented multifunctionality* can be obtained at local urban green space scale or city scale. Here, *functions* rather refer to the function of the green space, where different societal user groups have different needs; for example, children may seek the function *a place for playing sport* of a green space, while elderly persons may want *recreation in a serene place* and physically disabled persons may wish to have *a place for picnics that is wheelchair accessible*. Urban green spaces with high user-oriented multifunctionality are also often described as of high quality, a terminology based in a general reorientation towards quality in public urban green space management, embedded in the larger new public management reform movement in the public sector since the 1980s (Lindholst et al., 2015). The importance of not only occurrence but also quality of functions is also mentioned in landscape ecology, where *functional landscapes* are said to be crucial for the maintenance of biodiversity and the provision of ES, referring to a landscape that contains a network of ecologically functional habitats of sufficient extent, distribution and quality for the long-term survival, reproduction and dispersal of the species occurring in the landscape (Von Post et al., 2022).

3.5 | Relations between concepts in MFL

There is no single conceptualisation of landscape functions that covers all key aspects of the term, as individuals from a particular discipline will have blind spots in their knowledge of MFL that may be core aspects of MFL according to another discipline. Figure 2 shows in a simplified manner how different conceptualisations of landscape functions relate to each other. There is some overlap between different types of landscape functions, where many EF are potential ES that may be realised, some ES can be expressed as landscape services when the

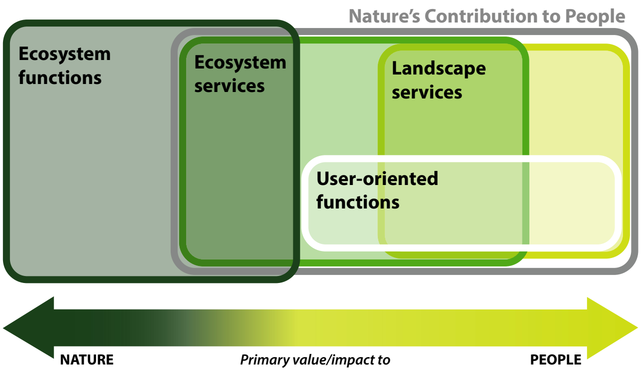

FIGURE 2 Overview of the relation between different conceptualisations of landscape functions along a nature–people gradient. Ecosystem functions are of primary value to nature, while ecosystem services, landscape services, Nature's Contribution to People and user-oriented functions are of primary value to people.

service is delivered by other landscape elements than ecosystems or when landscape issues play a considerable role (Bastian et al., 2014). Some ecosystem and landscape services can be classified as user-oriented functions as well, where for example, the ES *recreation* could be further specified as the user-oriented function *recreation for the elderly*. NCP covers ES, landscape services and user-oriented functions.

3.6 | Measuring landscape functions

There is an obvious interest in measuring and quantifying multifunctionality, as we often wish to compare areas, assess whether an area is improving or deteriorating or analyse the relationship between multifunctionality and other quantitative variable(s) that may be considered important (e.g. Cusens et al., 2023).

EF multifunctionality is quantified through either *averaging*, that is, by taking the average of the standardised values of each function, or by using the *threshold approach*, which involves counting the number of functions that have passed a threshold, usually expressed as a percentage of the highest observed level of functioning in a study (Manning et al., 2018; Neyret et al., 2023).

ES multifunctionality is measured by comparing the demand for ES (the level of service provision desired by people and estimated through stated or revealed preference methods) and their supply (the capacity of an ecosystem to provide a given ES) or by making maps showing different ES supplied as different layers to assess trade-offs and synergies between them and to find hotspots of multiple ES that can be prioritised for conservation (Manning et al., 2018). ES may also be combined into an index of ES multifunctionality using similar methods to those outlined above to create indices of EF multifunctionality (Cusens et al., 2023). Methods for assessing ES and landscape services are partly similar or identical, but while landscape ecology provides methods for assessing the supply side of landscape services, methods for assessing the demand side or the combination of supply and demand of landscape services are lacking (Bastian et al., 2014).

User-oriented multifunctionality is needed in landscapes used by the public, for example, urban green spaces and rural recreation forests, to meet the needs of a wide range of user groups and could be measured using one of the many existing green space quality assessment schemes. In them, *quality* is often measured by noting the occurrence of central green space quality aspects, and in the next step, by assessing the level of quality aspects on a rating scale (Lindholst et al., 2016). To achieve a user-oriented multifunctional urban green space, there are specific functions that need to be in place; it will not do with just any multiple functions. In addition, the quality level of these central functions is important; a part of the urban green space that is large enough for the function *play* will still not be a good place to play if it is situated next to a large road without a fence in between. Quality of a space can thus be considered to echo the notion of *service level*, albeit more categorical or ordinal rather than continuous. Terms such as quality can thus give a different way of evaluating certain functions.

3.7 | Frameworks for landscape assessment

Future frameworks for landscape service assessment should incorporate knowledge from both relevant scientific and practical disciplines and include considerations of the relationship between demanded services and the spatial and temporal structure of the landscape (e.g. service-providing areas, service-benefiting areas and service-connecting areas), the identification of potential services regardless of actual use, and the involvement of stakeholders in service valuation within the landscape planning and governance context (Bastian et al., 2014; Syrbe & Walz, 2012).

In addition, when discussing landscape multifunctionality either in interdisciplinary collaboration or with practitioners it is worth considering what the units underlying multifunctionality are assumed to imply in your context, and subject to your identified purposes behind multifunctionality. This is important since the representatives of various disciplines bring with them the assumptions-laden terms of that discipline. Moreover, the varying ways of understanding the units behind multifunctionality can also elicit the available and lacking competencies of those working towards multifunctionality. It may be useful here to begin with an analogy. Biodiversity is usually seen as desirable, and much research and many practical efforts are devoted to protecting or increasing it. However, this does not mean that increasing biodiversity per se is always and everywhere a suitable goal. The introduction of a new malaria-carrying mosquito species into to a European city is an increase in the biodiversity of the area (Chen et al., 2021), but certainly not a desirable outcome. The spread of boreal species into the arctic with climate change is also an increase in biodiversity (at least temporarily) but neither is that a cause for celebration. Similarly, it could also be argued that promoting multifunctionality does not imply supporting just any functions as long as they are plural; some functions are crucial in certain contexts and places, while others are central to resilient landscapes in other places. Solely aiming to enhance multifunctionality might disregard the weakening or depletion of single ES that are fundamental to ecosystem well-being but have little effect on multifunctionality scores (Hansen & Pauleit, 2014). Selman (2009) argues that it is not enough with only the co-location and coexistence of functions, but that there is also a need for their interactivity to create synergistic effects. It is important for anyone working with MFL to know what one is trying to create or conserve such as co-location of functions, synergistic effects, resilience or sustainability.

4 | STRUCTURAL CONSIDERATIONS BEHIND LANDSCAPE MULTIFUNCTIONALITY

So far, we suggested considerations of which functions and purpose a study on MFL departs from. From these, a key guiding question naturally emerges: How should these multiple functions be combined? Structural considerations behind the combination of functions are central to the measurement assumptions of MFL. They are also highly relevant for the practical challenges to implementing MFL. Let us consider the structural considerations in terms of interactions between functions (trade-offs and synergies), scale considerations (spatial and temporal dimensions) and aggregation rules for MFL measure(s).

4.1 | Interactions between functions: Trade-offs and synergies

Studies (e.g. Allan et al., 2015) are increasingly raising the need to incorporate the effects of functions on one another. Causal relationships between functions have been described as positive, neutral and negative (ibid.). Trade-offs are relationships between ES, where an increase in the provision of one is negatively associated with the level of another. This contrasts with the notion of synergies, where the relationship has a positive impact. Trade-offs have been included in many studies reviewed within the topic of MFL, and methodologies for considering them have been proposed, for example, a multivariate diversity–interactions framework (Dooley et al., 2015). Natural and semi-natural ecosystems may produce not only services but also disservices, which have been defined as 'ecosystem generated functions, processes and attributes that result in perceived or actual negative impacts on human wellbeing' (Shackleton et al., 2016) and include, for example, branches falling from trees causing injuries to people and buildings, or urban trees reducing air quality by generating ground-level ozone via BVOC emissions and producing allergenic pollen (Roman et al., 2021). Since ES and disservices are related, they often co-vary, making it important to study the synergies and trade-offs between them (Ulrich et al., 2023). Roman et al. (2021) expand on the synergies and trade-off concepts, defining *positive synergies* as win–win scenarios in which multiple services are increased while disservices are reduced, *trade-offs* as scenarios where services and disservices are of similar magnitude and *negative synergies* as lose–lose scenarios with worsened disservices and reduced ES. The evaluation of such trade-offs and synergies can lead to better integration of ES and disservices into the analysis and in the next step reduce unintended negative consequences for local communities and sustainability (Roman et al., 2021). Yet, while trade-offs are often outlined following one methodology or the other, they and the resulting net effects are not always quantified, which may hamper the ability to integrate them into multifunctionality metrics. Given the multiplicity of functions, the interactions are also likely not unidimensional, that is, one function might affect two other functions differently than only one other function. However, so far, trade-offs are commonly depicted for function pairs, for example, in axis graphs (e.g. Sandell, 2016). In such visualisations, the number of functions considered in terms of trade-offs or synergies is typically two or three (e.g. van der Plas et al., 2019). Beyond the number of functions interacting, the nature of their effects on each other is also suggested to vary, for example, in terms of the local–distant, immediate–delayed and reversible–irreversible nature of the impact (Rodríguez et al., 2006). Here, we wish to highlight that effectively capturing the complexity of trade-offs is important for resulting land-use prioritisations. Since visualising is a powerful aid for communication, it may thus be relevant to explore comprehensive depictions of function relationships in the analysis. A *correlation matrix* (e.g. Dooley et al., 2015) could be used as a starting point for this and developed further towards one of the methods proposed by Ulrich et al. (2023), such as a *matrix model* for the analysis of various relationships and data needs.

4.2 | Accounting for scales

Diagrams with axes that illustrate the level of the function being affected by another function are essentially ways of presenting the relationship between two gradients. Besides being a gradient of a certain function, a gradient can apply to different types of land use within a landscape. Typically, there are no strict borders between different types of land use in terms of economy and functions. Rather, several different gradients exist within the landscape, for example, from the rural forested to the rural agricultural part of the landscape, where land use focused on both forestry and agriculture leads to areas of agro-forestry or silvopasture. Similarly, agricultural practices within an urban area can be described as urban agriculture and the management of trees and forest resources in and around urban areas is called urban forestry (see Figure 3). Gradients are often more useful than a binary denomination. For example, we can frequently see a gradient in the degree of urban development rather than a clear boundary between the urban and rural landscapes. Importantly, a gradient changes with the scale considered. An advantage of using a gradient approach on a landscape level is that it better fits reality where different types of land use are blended, and where stakeholders cross boundaries between different parts of the landscape.

4.3 | Accommodating the needs of different stakeholders

Different stakeholder groups have different needs from the landscape and thus perceive MFL and landscape gradients in different

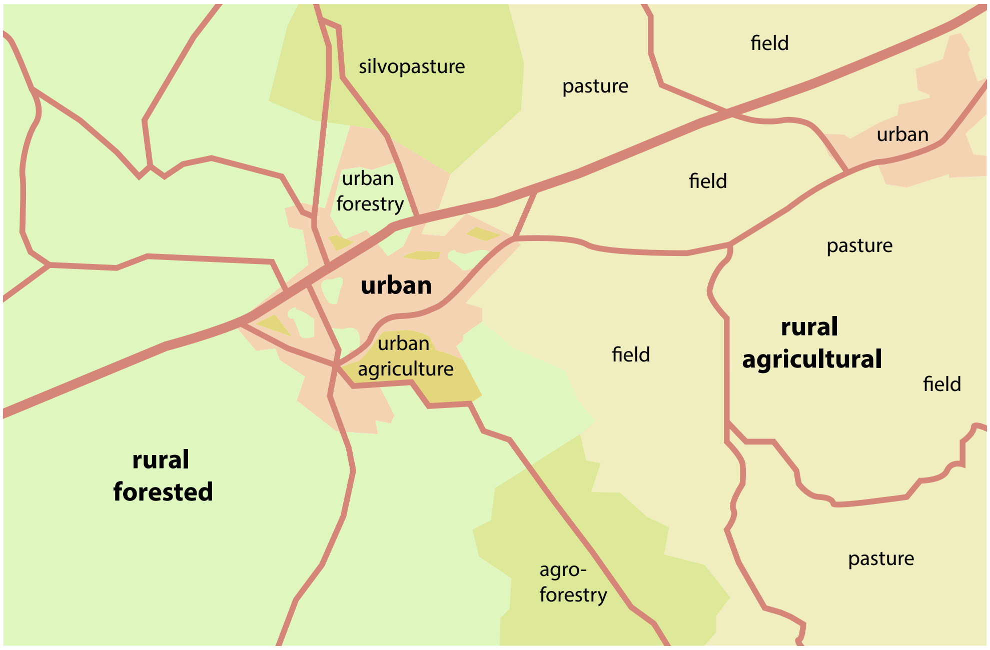

FIGURE 3 Land-use gradients within the landscape. Different colours represent different land uses. Red lines represent roads.

ways. Taking the Swedish context as example, forest landscape stakeholders include a diverse group of forest owners (Statistics Sweden, 2023), nature conservation organisations, hunters, the Swedish Forest Agency, the Swedish Environmental Protection Agency, county administrative boards, recreation forest users, the Sami people (who are both right holders and stakeholders) and the non-human actors. At the same time, a needs-based perspective may show how forestry, through landscape gradients, is overlapping with urban and agricultural land use, indicating that the needs of stakeholders are not impacted by governance related to one type of land use only. For instance, forest stakeholders are often also concerned with governance connected to agricultural and urban parts of the landscape, since forests can be used for, for example, husbandry or recreation.

Given this broad range of types of land use and the multiplicity of stakeholders using the land, it is not immediately clear who should, can or is best suited to take action to promote landscape multifunctionality. Further unclear is to what extent this should be a mutual undertaking of several stakeholders, how many is enough and even more crucially through which forms of governance. In contrast to landowners, it is also relevant to consider the role of regulators of land use such as local, regional and national authority representatives. Whether the stakeholders are public or private, as well as the size of the organisation, may be relevant to the motivation and the need to act because of the expectations and obligations faced. Larger organisations are increasingly faced with greater sustainability reporting obligations, for example, to provide sustainability disclosures on environmental, social and governance issues. Related to this, they need to disclose certain indicators related to the EU taxonomy (de Oliveira Neves, 2022). Beyond regulations, there is also a plethora of voluntary and compulsory sustainability reporting standards with diverging and contested implications for how to select relevant from their operations and land use, viewed as *materiality* assessment (e.g. Adams & Abhayawansa, 2022). Voluntary reporting frameworks such as Global Reporting Initiative and Science-Based Targets initiative for carbon emission reduction (and emerging science-based targets for nature), as well as the new European Sustainability Reporting Standards and IFRS Sustainability Disclosures, are all relevant for multifunctionality. Such voluntary and increasingly compulsory private sector-oriented policies also primarily focus on the larger private land users but become pushed down their supply chains all the way to the smaller landowners.

4.4 | Spatial perspectives

The extent of multifunctionality depends heavily on the spatial scale. In a sense, it is easy to find multifunctionality by zooming out on a spatial level. However, many functions must be present more locally if they are to be relevant. The provision of clean air needs to be available to everyone and cannot be compensated for by an overabundance of clean air at a distant location. Another aspect motivating local provision is resilience through redundancy; key services replicated across the landscape ensure that a disturbance at one location will not destroy the only source of a key service or function.

The spatial perspective captures a lot of contextual and harder-to-observe issues that affect the provision of a function and the relationships between functions. For example, the magnitude of trade-offs appears to increase with land-use intensity (Qiu et al., 2021). In addition, the relationship between different ES depends on the response to, for example, management, climate or nutrient availability and the interactions between the ecosystem drivers (ibid.). Increased spatial scale inevitably adds noise to the relationships between multiple functions. Mastrangelo et al. (2014) differentiate between spatial scales along a continuum from *local*, to *landscape*, to *regional scale* and describe differences in spatial multifunctionality between these scales, where the spatial arrangement of functions depends on which ES that are included and how they interact at specific scales. Within remote sensing studies, *landscape scale* has been defined as areas smaller than 100 km^2 (Ayanu et al., 2012). Considering these different landscape scale definitions, it is likely that the magnitude of uncertainty or error introduced by scaling up is substantial at landscape level. A too narrow spatial focus, on the other hand, may fail to take into consideration important yet more distant trade-offs between different services (Rodríguez-Loinaz et al., 2015). Spatial scale is not only important in one dimension, from smaller to larger, but in addition, different patterns of how functions are spatially connected may be important at each area size. For example, the recreational service from a playground would be different if it were adjacent to a forest or a motorway, even if both were within the same 1 km^2 area.

Important considerations in relation to stakeholders are to decide who is relevant to invite to the MFL realisation process and to what extent various actors, such as users, landowners and regulators, may influence the end result. Who to regard as main stakeholders may shift with change in choice of spatial scale from, for example, a smaller to a larger one for the MFL study at hand. Considering thoroughly the choice of spatial scale may allow one to engage more deliberately with the normative potential of MFL research, namely addressing at what spatial scale multifunctionality of a landscape would be not only possible but also desirable. This implies bridging the gap between the biogeophysical characteristics of which and how many functions can be accommodated in a given area on the supply side, and the socio-economic circumstances of where, and which service is more needed, preferred, cost-effective, etc. on the demand side. Selected scale is relevant also for the land sharing–sparing debate (e.g. Fischer et al., 2017), where the upper bound for *land sparing* is delimited by land availability at the largest spatial scale and the lower bound for *land sharing* being contingent on the socio-cultural belief systems prevailing in the smallest governable area. On the demand side, differentiating between the needs of several user groups is a challenge. Sundevall and Jansson (2020) stress the importance of socially inclusive urban green spaces adapted to the needs of several different user groups, whose needs vary due to, for example, age and preferred green space use. They concluded that *social multifunction*, where different age groups use the same urban green space, was more easily achieved in *non-programmed* places (e.g. an open lawn; a shrubbery) that simultaneously accommodate the needs of several different user groups, whereas *programmed* elements (e.g. a playground; a bridge; a fence) make the targeted user group feel welcome, while other groups may feel excluded from the place (ibid.).

4.5 | Temporal perspectives

Just as multifunctionality can be spatial (Rode, 2016), it can also be time-based, combining several functions in the same area, but at different times (Ahern, 2011; Sundevall & Jansson, 2020). Some functions develop slowly over time, making the time span relevant to consider for time-based multifunctionality very long. Cross-effects among functions also vary over time, with some impacts being distant. Discounting thus becomes important for the conceptualising of MFL, including the possibility for heterogeneity in discount rates spatially and across functions. Similarly, factoring in the time aspects in sensitivity analysis, simulations of landscape multifunctionality and effects visualisation over time (e.g. Biber et al., 2020) is highly relevant. Frei et al. (2020) explored changes in multifunctionality in an agricultural landscape over a 20-year period and found that areas increasing in multifunctionality of ES had also become more diverse in terms of avian biodiversity and agricultural products produced, without large losses in overall food production. This further highlights the importance of longitudinal studies of MFL for understanding interactions between functions and how they change over time.

Yet temporal scale is not only underexplored towards the longer intervals; shorter periods like seasons, rotation periods, days and time of day are interesting avenues to explore for many functions, but also in which part along existing gradients within the landscape they are most relevant. As an example, time-based multifunctionality may vary with time of day in an urban green space where the elderly use the place in the morning and the youth in the evening, whereas seasonal differences become a more relevant temporal scale for a forest that is used for silvopasture in the summer and cross country skiing during winter. It is thus interesting to consider which multifunctionality niches can be identified and prioritised when explicitly accounting for the temporal scale, akin to ecological niches established by certain animals hunting at different times of day.

Developing the way MFL accounts for temporal scale has the potential to better capture uncertainty, as the time interval required for measurable effect sizes of positive or negative cross-effects is often unknown (Ulrich et al., 2023). A historical perspective can be relevant for studying the unfolding of changes in functions and presence as well as constellations of trade-offs contingent on prior bio-geochemical factors of the same landscape. The availability of detailed and long time series of landscape maps, as is the case in Sweden, facilitates such analysis. Moreover, exploring the ways in which institutional and stakeholder beliefs and biases emerged and were addressed in the past around multifunctionality can also be of behavioural relevance for present and future scenarios. For some functions and trade-offs, it is important to study the historical development, disappearance, strengthening or weakening of functions (cf. Foley et al., 2017). For example, one cannot fully account for services stemming from reindeer herding without taking note of its historical context and the role of factors such as loss of land, fragmentation and other obstructions of reindeer migration routes

(Skarin & Åhman, 2014). Similarly, some natural and anthropogenic disturbances, for example, forest fires, that are generally controllable now and disregarded from the relationships between functions, may no longer be controllable under future climatic conditions and must be accommodated into landscape multifunctionality rather than eliminated.

4.6 | Aggregation approaches

Effects and scale considerations are in turn important when approaching an aggregate measure of MFL for explorative or normative purposes. Analysis decisions are involved in the choice of aggregation method. In terms of the aggregation, various studies, especially in biodiversity and ecosystem-oriented research, have compared approaches such as adding, averaging, overlapping, or using single or multiple threshold methods (e.g. Dooley et al., 2015; Manning et al., 2018). Thresholds are particularly important here. For some functions, the gradient may have a cut-off due to the biophysical processes, all other things constant. The provision of a function may thus be non-linear. Thresholds can be upper or lower bounds. These bounds may also depend on other functions or ecosystem properties. For example, you also need a certain level of water for biomass to grow (lower bound) or if too many people are in a green space, its recreation service may start to diminish (upper bound). Finally, thresholds may be irreversible and are then sometimes referred to as tipping points (Hughes et al., 2013). This is where a function may be altered or lost altogether rather than just diminish.

To determine the usefulness of an MFL measure in land management, one must consider the problem formulation behind the MFL metric. This includes evaluating whether a maximisation or minimisation objective function is relevant or if other heuristic rules are more appropriate. Additionally, it is necessary to assess which constraints to integrate and whether to aim for a single or bundle-like MFL measure(s). For instance, suppose the purpose (i.e. the objective function) of MFL is to maximise the overall level of all functions. This objective function is restricted by constraints, such as that trade-offs should remain below defined thresholds and the level of certain functions should exceed thresholds set for a particular area size and specific groups. Optimisation models can be used for such analysis (Bateman et al., 2013). In the first step, functions and cross-impacts can be optimised as stable for a selected area, uniform stakeholders and without time considerations. This can subsequently be varied by integrating additional variations due to single or multiple scale adjustments. In this way, an MFL measure may also have a threshold when varied in relation to spatial and temporal perspectives (see Table 1). The sensitivity of the MFL measure (whether increasing or decreasing) to the number of functions, impacts and scale adjustments may illustrate the specific factors leading to multi-dysfunctionality, that is, a marginal decrease in multifunctionality for a unit of size, an additional function or an additional impact considered or a so-called shadow or accounting price in optimisation (Dasgupta, 2021). Ultimately, reflecting on these structural issues of impacts, scales and aggregation of functions may help the researcher to be aware of the robustness of the analysis when some key assumptions are relaxed.

5 | THE SCHEME STEP 2

Very few are experts in multifunctionality per se, and engaging in analysing and realising MFL is a multi-actor and interdisciplinary work. Researchers wanting to address questions where multifunctionality is a suitable approach are almost by definition unfamiliar with at least some aspects, and a guide to key questions to consider is therefore needed. Furthermore, an interdisciplinary approach can be challenging, with the risk of regular misunderstandings and conflicts leading to missed opportunities, degraded environments, less functions and environmental injustice. Therefore, it is also important to possess a tool that facilitates communication and reflection across disciplines, offering opportunities to share and jointly engage in diverse perspectives and to identify and analyse difficulties and alternative solutions.

The Scheme (Table 1) can provide such guidance and help interested readers to navigate through various dimensions, layers and tensions as a crucial first step towards realising the concept. When discussed by an interdisciplinary group, the questions in the Scheme ensure that key perspectives and aspects are taken into account, reduce individuals' blind spots related to MFL and allow a more comprehensive understanding of problems and potentials. By centering discussion around the Scheme, opportunities and difficulties are made visible and the group's ability to view the many important aspects of a MFL from a joint overall perspective is strengthened. Furthermore, the strand of literature on bringing multifunctionality, its metrics and tools closer to practitioners is underdeveloped (see e.g. Duarte et al., 2020; Rodríguez-Loinaz et al., 2015; Tran et al., 2023 for attempts). The Scheme aims to prepare researchers to engage in transdisciplinary discussions with practitioners.

6 | CONCLUSION

Pursuing MFL requires the integration of various aims and perspectives. Yet multifunctionality research is rife with divergent assumptions, definitions and resulting choices influenced by different scholarly fields. Landscape multifunctionality requires effective communication that breaches the boundaries between scholarly fields on the one hand and between research and practice on the other hand. An interdisciplinary approach is therefore particularly warranted to account for a wide range of functions. Although the definition of function and the choice of which of these to include is critical to the outcome, there is no universal answer to the question of which functions to include when developing future MFL. Furthermore, it is essential to reflect on the meaning of functions in a landscape, determine which ones are necessary and can be

TABLE 1 The MFL analysis support scheme provides questions to discuss and reflect on within-interdisciplinary groups studying MFL.

	Nature	People
Objective, vision and baseline		
Objective	What is/are the problem(s) assumed to be solved or objective(s) to be achieved?	
	Does your landscape involve problematic trade-offs?	
	Are there land availability or locality constraints?	
Vision	In what way is landscape multifunctionality expected to solve the(se) problem(s) or contribute towards achieving the objective?	
Benefits	Which non-human actors, such as animals and plants, will benefit from the MFL?	Which are the main stakeholders that the MFL is aimed to benefit?
Context	Which relevant bio-geochemical factors are there in the landscape?	What is the current governance (incl. remuneration) context you are in? Who/which groups are currently involved?
Condition	What is the current state of affected ecosystems?	Are any competencies or stakeholders missing for you to tackle the envisaged problem or fulfil the objective?
Landscape functions		
Single	What are the key landscape functions (A, B, C …) resulting from the previous steps? Are there further fundamental functions that you have taken for granted?	
	What is affected positively or negatively by these functions?	Who is affected positively or negatively by these functions? How are the needs of all affected stakeholders considered?
Bilateral interactions	What are the negative or positive interactions (trade-off or synergy) between functions A and B?	
Multivariable interactions	How are the function interactions (e.g. A–B) affected by the presence of other functions and/or interactions (e.g. B–C)?	
Spatial and temporal perspectives		
Spatial scale	How do the landscape functions respond to change in spatial scale and part of the land-use gradients within the landscape?	At which spatial scale and in which part of the land-use gradients within the landscape must the landscape function be safeguarded and then governed?
	How do interactions (trade-offs or synergies) depend on the spatial scale?	Who are considered the main stakeholders if you change the spatial scale of the landscape?
Spatial distribution and connectivity	How do interactions between functions (trade-offs or synergies) depend on the spatial distribution and connectivity?	How can interactions between functions be addressed when considering equity (environmental justice) and institutional interdependencies?
Temporal scale	How do the landscape functions respond to a change in temporal scale?	Looking at stakeholders from a temporal dimension, are there stakeholders missing and/or that need to be further prioritised, e.g., future generations?
	What are the time scales for the interactions between landscape functions (e.g. trade-offs appear or worsen with time)?	
Temporal distribution	Do some functions have time niches, i.e., occur in certain time periods?	How does the relevant stakeholder composition vary with certain time periods? (e.g. day/night, season)
Historical influences	Are there some alternative ways to envision landscape multifunctionality if we consider historical influence and past landscape management?	Are there persisting institutional trends or biases to account for?
Revisting the problem formulation		
Identify gaps	Are there any essential factors that have been missed?	
Reconsider	Has your understanding of the problem and envisioned solutions changed? Are there better ways to formulate the problem and its solutions?	

Note: The subsections correspond to the stages in Figure 1. The questions are organised by key parameters provided in the first column. The Nature column focuses on the situation-specific non-human perspectives on MFL, while the People column focuses on human perspectives, including the stakeholder, institutional and governance context, thereby providing opportunities to integrate interdisciplinary insights.

Abbreviation: MFL, multifunctional landscape(s).

maximised, why, and for whom. It should be made clear why, how and on what basis these decisions are made, acknowledging that there are advantages and disadvantages inherent in any such choice.

To aid in this endeavour, this paper aims to lift new perspectives for researchers engaging with MFL across disciplines. Our process resulted in a question-based Scheme that supports reflection and recursive thinking about MFL and includes statement of the objectives and visions for achieving them, based on baseline mapping; assessment of landscape functions and their single and multiple interactions; as well as analysis of sensitivity to spatial and temporal dimensions. The interdisciplinary approach behind the Scheme implies that consideration of stakeholders' needs should form an integral part of the entire analysis process and not be relegated to scoping the functions; the latter choice would only delay the assessment of feasibility of implementation and its scaling to subsequent research. While researchers are the primary target group for the Scheme, it could also be relevant and feasible for practitioners to use. The study contributes by guiding interested readers in their navigation through the maze of various dimensions, stages and tensions arising in the pursuit of a MFL. This enables them to pose questions that are relevant to their specific circumstances and make and review their analysis steps accordingly.

AUTHOR CONTRIBUTIONS

Striving to conduct truly interdisciplinary research, all authors contributed equally to all parts and stages of this article, from conceiving the ideas and designing the methodology to literature searches, analyses and the writing of the manuscript. All authors contributed critically to the drafts and gave final approval for publication.

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The authors have no conflicts of interest to declare.

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This article does not include any data.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

Supporting information S1: Upper chart: The line chart of scientific documents by the year they were published is generated from a search ('multifunctional landscape*' OR 'landscape multifunctionality') made within article title-abstract-keywords in the Scopus database (www.scopus.com), which yielded 474 documents published between 1996 and 2022. It shows a clear increase in research studies on MFL over the two latest decades. To some extent, this exponential growth is evident in many academic fields, as there are increased incentives for publication. Lower chart: The treemap chart, based on the same search, shows that scientific studies on MFL, although mainly carried out within Environmental science (41%), Social science (20%) and Agricultural and biological sciences (18%), cover a wide range of research fields.

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