How on Earth?

Operationalizing the ecosystem service concept for sustainability

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Abstract
Production landscapes are at the center of many of the sustainability challenges that we face. The ecosystem service concept has risen in prominence over the last decades as a tool to support sustainable landscape management. Stewardship has been suggested as an approach that individuals and groups of actors can practice when striving for sustainability in complex situations. In this thesis, I explore how the ecosystem service concept can be used as a tool to support the stewardship practices of various local actors who are engaging in sustainable landscape management. The core of this thesis is a participatory resilience assessment conducted together with a diverse group of actors, all involved in different forms of landscape management in the Helgeå catchment in Southern Sweden. In Paper I, I describe the participatory ecosystem service bundles analysis that was part of the process. In Paper II, I describe the process as a whole and show how participating supported learning and articulation of complexity thinking. In Paper III, I compare this process with three other knowledge co-production processes from the Helgeå catchment, and trace how different theoretical approaches led to both similar and diverging ecosystem service knowledge outputs. Finally, in Paper IV, I use a photo elicitation exercise to articulate different narratives of how sense of home motivates private, non-industrial forest owners in the Helgeå catchment to engage in stewardship practice.

Together, these four papers show that the ecosystem service concept can support sustainability by facilitating knowledge co-production processes about complex challenges in landscape management. In such settings, it can function as a pedagogical tool and bridging concept. For participating civil servants, ecosystem service knowledge and terminology were also used strategically when communicating with actors in their own organizations, effectively influencing their situated agency to practice stewardship. Finally, the ecosystem service concept has the potential to be useful in the dialogue between private land owners and other actors. However, some pathways to stewardship, such as those rooted in a sense for history and community, would be better represented by other, more relational human-nature conceptualizations. This means that while the operationalization of the ecosystem service concept can contribute to stewardship practices in pursuit of sustainability, there are also important limitations that need to be taken into account in each context of use.

Keywords: Ecosystem services, Stewardship, Resilience thinking, Knowledge co-production, Landscape management, Learning.

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In memory of

mummo Anna-Liisa, who gave me stories

& farmor Lilian, who gave me words to tell them with
If I can stop one heart from breaking
I shall not live in vain
If I can ease one life the aching
or cool one pain

Or help one fainting robin
unto his nest again
I shall not live in vain

Emily Dickinson
SUMMARY

Production landscapes are at the center of many of the sustainability challenges that we face. Arguably, how we manage these landscapes will define whether or not we succeed in serving humanity’s needs within the means of the planet. Local communities across the globe also depend on their surrounding landscapes, directly or indirectly, for their livelihoods. The ecosystem service concept has risen in prominence over the last decades as a tool to support sustainable landscape management. Stewardship has been suggested as an approach that individuals and groups of actors can practice when striving for sustainability in complex situations. In this thesis, I therefore explore how the ecosystem service concept can be used as a tool to support the stewardship practices of various local actors who are striving to engage in sustainable landscape management.

The core of this thesis is a participatory resilience assessment conducted together with a diverse group of actors, all involved in different forms of landscape management in the Helgeå catchment in Southern Sweden. In **Paper I**, I describe the participatory ecosystem service bundles analysis that made up the first half of the process and describe how the bundles functioned as a bridging concept between the participants. In **Paper II**, I describe the process as a whole, and based on interviews with all participants, show how having participated had supported their learning, articulation of complexity thinking and has had impact on the participants’ stewardship practice. Here, the ecosystem service bundles emerged as a particularly strong communication tool.

In **Paper III**, I compare the participatory resilience assessment process with three other futures-oriented, ecosystem service-focused knowledge co-production processes that were conducted in the Helgeå catchment within the same 10-year period. Using an analytical framework for reflexive self-assessment, I, together with the other project researchers, trace how different theoretical approaches and methods to futures thinking led to both similar and diverging ecosystem service knowledge outputs.
Finally, in Paper IV, I use a photo elicitation exercise to explore how sense of home motivates private, non-industrial forest owners in the Helgeå catchment to engage in stewardship practice. I describe multiple type narratives as different pathways to forest stewardship among the forest owners. I also show how these stewardship narratives are expressed in terms of different types of instrumental, intrinsic and relational values, and discuss to what extent these values can be captured through the ecosystem service framework.

Together, these four papers show that the ecosystem service concept can support sustainability by facilitating knowledge co-production processes about complex challenges in landscape management. In such settings, it can function as a pedagogical tool and bridging concept. For civil servants who participated in the participatory resilience assessment, ecosystem service knowledge and terminology were used strategically when communicating with actors in their own organizations, effectively influencing their situated agency to practice stewardship. Finally, the ecosystem service concept has the potential to be useful in the dialogue between private landowners and other actors to highlight the benefits of specific stewardship practices. However, some pathways to stewardship, such as those rooted in a sense for history and traditions in the landscape, would be better represented by other, more relational human-nature conceptualizations. This means that while the operationalization of the ecosystem service concept can contribute to stewardship practices in pursuit of sustainability, there are also important limitations that need to be taken into account in each context of use.
SAMMANFATTNING


I Artikel III jämför jag sedan vår resiliensbedömningsprocess med tre andra framtidsblickande projekt, alla genomförda under samma tioårsperiod i Helgeåns avrinningsområde. Alla fyra projekt fokuserade på ekosystemtjänster och genomfördes som processer av samproduktion av kunskap. Genom att använda ett analytiskt ramverk för reflexiv självvärdering,
spårar jag tillsammans med forskarna från de andra projekten hur olika metoder och teoretiska angreppssätt till deltagande framtidstudier resulterade i både lika och olika utfall gällande ekosystemtjänster i studieområdet.


Tillsammans visar dessa fyra artiklar att ekosystemtjänstbegreppet kan stödja hållbarhetsarbete genom att underlätta processer av samproduktion av kunskap om komplexa utmaningar inom landskapsförvaltning. I sådana sammanhang kan begreppet spela rollen som ett pedagogiskt verktyg och en konceptuell brygga mellan olika sorts aktörer. Procesdeltagare som var anställda inom offentlig sektor, såsom kommuner, kunde även använda kunskap om ekosystemtjänster och tillhörande terminologi och figurer i strategisk kommunikation med andra aktörer i sina organisationer. Ekosystemtjänstbegreppet har även potential att användas i dialog mellan privata markägare och andra aktörer för att uppmärksamma nytan av diverse tekniker och praktiska strategier inom lokal landskapsförvaltning av bland annat produktionsskog. Dock bör det göras med försiktighet, då vissa av de privata markägarnas motivationer för hållbar förvaltning (stewardship) bland annat kommer sig ur en ansvarsälska för att upprätthålla historiska landskap och för att respektera kulturella traditioner och gynna lokalsamhället. Denna sorts motivationer är svåra att beskriva på ett tillfredsställande sätt med ekosystemtjänstbegreppet, och kan därför kräva andra, mer relationella konceptualiseringar av samspelet mellan människa och natur. Detta innebär att även om ekosystemtjänstbegreppet kan bidra till hållbar landskapsförvaltning och stewardship, så finns det också viktiga begränsningar av vad begreppet kan beskriva. Användning av ekosystemtjänstbegreppet i beslutsfattning och praktik bör därför ta hänsyn till dessa begränsningar, om det ska bidra till både ekologisk och social hållbar förvaltning av våra landskap.
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Paper I  

Paper II  

Paper III  

Paper IV  
Contribution to papers

I designed and led the participatory resilience assessment that Paper I and Paper II are based on together with Elin Enfors-Kautsky, with input from Lisen Schultz and Albert V. Norström.

Paper I: I designed the study together with Elin Enfors-Kautsky. I conducted the interviews. I completed the ecosystem service bundles analysis and wrote the paper with input from the co-authors.

Paper II: I designed the study and wrote the paper with input from the co-authors. I conducted and analyzed the interviews.

Paper III: I designed the study, developed the analytical framework and wrote the paper together with Ida Wallin, with input from the other co-authors. I analyzed reports and other publications from the four cases. Ida Wallin conducted the interviews with key participants.

Paper IV: I designed the study and wrote the paper with input from the co-authors. I conducted and analyzed the interviews.

Related publications not included in the thesis


Landscapes from across the Helgeå catchment area.
INTRODUCTION

Take a walk in a forest on a warm August afternoon, enjoy the smell of decomposing pine needles and taste of bilberries. Let a friendly cow lick your hands green with half-chewed grass in the shadow of a mighty oak. Have the cool, light brown water of a lake wash it off, soothing your skin. Watch the slow-moving waters of the Helgeå river, while the chirping of wetland birds mingle with the screeching breaks of the train arriving at Kristianstad train station. Or, by all means, move through any landscape, far beyond these examples from Southern Sweden. Take a moment to consider what you see.

Landscapes like these are where we spend our lives. We depend on them for sustenance, directly or indirectly. We enjoy them and create meaning in them. We influence them. It is not always obvious, but there are no landscapes left on Earth where human actions have not had an impact on what you see. Some things are obvious, like the cow leisurely grazing in its fenced-in pasture. Others, like the brown of the refreshingly cool water, can be traced back to processes far beyond that small forest lake. In fact, human actions in production landscapes are at the center of many of the global challenges that we face, like climate change and biodiversity loss (Nyström et al. 2019). For example, agriculture, forestry and other land uses accounted for around 23 percent of anthropogenic greenhouse gas emissions during the last decade (Masson-Delmotte et al. 2019), while these same pressures have reduced biodiversity intactness beyond safe limits on almost 60 percent of the world’s land surface (Newbold et al. 2016). Addressing these challenges, therefore, requires a transition to more sustainable landscape management. How to achieve this transition, however, is a complex task. We need to increase our understanding of the challenges. We also need

1 The river is called Helge å in Swedish. Å (pronounced like the ‘oo’ in poor) is a Swedish word for a narrow river or stream. In this thesis, for easier reading in English, I have chosen to call this river (or catchment) Helgeå.

2 Landscapes are culturally defined areas whose specific character is shaped by interactions between biophysical processes and human actions (Plieninger et al. 2015).
means to better use this knowledge so that it can contribute to a diversity of landscape management practices. Such means can be straight-forward communication, but also physical and conceptual tools, methods of translation and co-creation between different forms of knowing.

The ecosystem service concept has risen in prominence over the last decades as a tool to support sustainability transitions. In particular, it is promoted as a means to communicate how important ecological processes and healthy ecosystems are to human well-being. In this thesis, I focus on how to operationalize this popular concept for sustainability. I also use the stewardship concept, as a way to frame how different actors engage in various practices to achieve sustainability. I explore how the ecosystem service concept can be used in a set of tools to support stewardship practices in landscape management. My research focuses on the mixed landscape of forests, pastures, fields and lakes in the Helgeå catchment in Southern Sweden and different types of local actors who are engaging in landscape management there. Before presenting my research, however, I need to define and expand on the key concepts that create the foundation of this thesis: sustainability, the ecosystem service concept and stewardship.
Sustainability

Sustainability is a goal that actors, organizations, nations and other agents can commit to. A commonly applied definition of sustainability is that it requires development that “meets the needs of the present without compromising the ability of future generations to meet their own needs” (Brundtland 1987). This means that for actions or practices to be sustainable, considerations need to be both social and ecological, pertaining both to those whose needs are to be met and to the ecosystems from which the resources to meet those needs are taken. Sustainability must also be defined according to long time-frames (for “future generations”). As a definition, however, this is vague. To guide actions, it requires further operationalization.

Different approaches to defining ‘needs’ can be found in the literature on sustainability. In this thesis, I gravitate towards the capabilities approach. This approach, developed by Amartya Sen and Martha Nussbaum, conceives of human well-being in terms of people’s substantive freedoms (Sen 1985, 1999, Nussbaum and Sen 1993). Freedom, according to this approach, is judged by people’s capabilities to achieve outcomes that they themselves value or have reason to value. From this approach follows that needs are inherently context-dependent. Therefore, sustainability, as understood by an international audience like the research community, must be pluralistic.

In addition to this capabilities-focused understanding of needs, sustainability must encompass equity (Leach et al. 2018). This is because local communities, as well as the ecosystems that they are embedded in, are connected with each other. Actions in one place influence processes and actors in other places. In practice, this means that even though many actors engage in practices that target specific places (or landscapes), the sustainability of those practices must be judged not only based on how they influence social and ecological conditions there, but also how these actions
might influence conditions elsewhere. Practices in one place that undermine the capacity of people elsewhere to meet their needs cannot be considered sustainable. However, in practice no individual initiatives can consider all potential consequences of the actions that they encompass. Rather, it is a goal to be strived for. Underlying this goal is the recognition that because of the realities of interconnection, the pursuit of sustainability is inevitably political (no action is neutral), and so in practice there needs to be continual negotiation between interests.

Sustainability, then, is about meeting the needs of current and future generations. Achieving such a goal, however, requires knowledge about the context-specific character of those needs as well as the complex interactions that generate the resources that we depend upon, as well as tools to help us act on that knowledge. This is where the ecosystem service concept comes in.

The ecosystem service concept

Definitions & approaches

Ecosystem services as a concept was first introduced by ecologists in the 1980s as a way to highlight how ecosystem structure and functions are necessary for maintaining our societies (Ehrlich and Ehrlich 1981). It provided a lens through which to analyze the interdependencies in human-nature relationships and framed this in a language that non-ecologists could understand (Daily 1997, Daily et al. 2009). Throughout the years, ecosystem services have been defined in different ways. The most prevalent definition comes from the Millennium Ecosystem Assessment (MEA), namely: “the benefits people obtain from ecosystems” (MEA 2005). This definition has been criticized for being ambiguous and other narrower definitions have been proposed for more consistent operationalization (Boyd and Banzhaf 2007). The Economics of Ecosystems and Biodiversity report (TEEB) defines ecosystem services as “the direct or indirect contributions from ecosystems to human well-being” (TEEB 2010). This is
the definition I have used during the course of my empirical fieldwork, because I found that its emphasis on *human well-being*, rather than just *people*, more intuitively communicated the capabilities dimension in my definition of sustainability. Additionally, ecosystem services are generally divided into four categories: provisioning (for example food crops and timber), regulating (for example flood regulation and water purification), cultural (for example recreational and spiritual), and supporting (for example nutrient cycling and soil formation) (MEA 2005).

The interest in and research on ecosystem services has grown steadily over the last two decades (Costanza et al. 2017). Global reports such as the MEA (2005) and TEEB (2010), as well as intergovernmental bodies like the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) have brought the concept onto the global agenda. Today several different schools of ecosystem service studies and applications exist, and they cater to different purposes, represent different agendas and contribute to different policy debates. Hamann (2016) has identified four approaches, or centers of gravity, in the study of ecosystem services based on their disciplinary backgrounds and what stage of ecosystem service flow they tend to gravitate towards: the ecological, ecological economics, development and social-ecological systems approaches. Before describing them, I want to emphasize that these are simplified stereotypes in an interdisciplinary field where actual studies rarely fit neatly into one of these approaches (Hamann 2016). In their simplicity, however, I have found these stereotypes useful for identifying underlying, rarely explicitly stated assumptions within the broad range of studies that are produced in the ecosystem service research field. They have also helped me in navigating, or at least make sense of, some of the inconsistencies and tensions that I have come across, both in the literature and in interactions with other ecosystem service researchers.

The ecological approach tends to focus on the ecological stocks and processes generating the services (Daily et al. 2009). A common application of this approach is to increase our understanding for the role biodiversity plays in providing services that benefit human well-being (Cardinale et al. 2012). The ecological economics approach studies the benefits side, exploring monetary valuation or measurements of other values and how they contribute to society (Gómez-Baggethun et al. 2010). A seminal paper in this tradition is the study by Costanza and colleagues where they estimated the monetary value of the world’s ecosystem services and natural capital (Costanza et al. 1997). The development studies approach follows the whole ecosystem service generation chain from stocks to benefits, but with
a particular interest in differences in access, dependence and vulnerability (Daw et al. 2016), as well as the institutions mediating the relationships between people and their environments (Dawson et al. 2017). Finally, the social-ecological systems approach tends to have a systemic perspective, with a particular focus on the synergies, trade-offs and feedbacks between the social and ecological processes involved in ecosystem service generation (Bennett et al. 2009, Raudsepp-Hearne et al. 2010). Figure 1 is a conceptual visualization of the stages of ecosystem service flow, highlighting the different foci of the four approaches to ecosystem service research.

**Figure 1.** Conceptual figure of the stages of ecosystem service flow, adapted from Reyers and colleagues (2013). Social-ecological factors (ecosystem service capacity) determines ecosystem services provision, which in turn determines flow to different beneficiary groups through use and demand. Perceived effects on well-being influence the management of ecosystems, which in turn influences future capacities of ecosystems to provide services. Following this conceptualization, the ecological approach tends to focus on ecosystem service capacities and provision, while the ecological economics approach focuses on benefit flows from provision to demand. The development studies approach focuses on flows from provision to management, but with a special emphasis on differences in access, vulnerability and institutions. The social-ecological systems approach encompasses the whole cycle, but with an emphasis on system interactions such as feedbacks and trade-offs.
The distinctions between the approaches make a difference both for the type of indicators that are chosen and what analyses are useful for. An ecological approach might use high resolution landcover data to represent different ecosystem services (Burkhard et al. 2009), which is valuable for example as input data in an environmental impact assessment meant to inform spatial planning. However, landcover data is a poor proxy for the social processes involved in ecosystem service generation, making it less useful for developing strategic plans and other decision-making that requires an understanding for management and use. A development studies approach, that surveys different users of ecosystem services in a given landscape, can shed light on aspects of equity related to user rights and access to different parts of the landscape (Daw et al. 2015), but generally requires original empirical data collection, making it more costly than using landcover or other secondary data. Monetary valuation in the ecological economics tradition can be a powerful tool to motivate politicians in situations when different interests are competing for preference (Costanza et al. 2017), but this also risks commodifying nature, which can be problematic for sustainability in a wider sense (see Common criticisms below).

Finally, in a social-ecological systems approach, researchers strive for using data that illustrates the interaction between social and ecological processes, like crop yields and use of wild medicinal plants, analyze how services co-occur in space (Hamann et al. 2016, Malmborg et al. 2018), and what processes might be causing this configuration (Meacham et al. 2016). This kind of data generally does not exist with a high enough resolution to inform physical planning, but because it combines both ecological and social aspects of ecosystem service generation it is particularly useful when working strategically for long-term sustainability (Reyers et al. 2013, Queiroz et al. 2015). It recognizes that both ecological and social factors, such as management and technology, are involved in the production of ecosystem services (Palomo et al. 2016).

In this thesis, I approach the ecosystem service concept from an epistemological perspective, meaning that I do not treat ‘ecosystem services’ *per se* as existing ‘out there’. Instead, I treat the concept as a tool by which we can make sense of the world – in the case of ecosystem services, capturing how ecological processes in various ways contribute to human well-being. This epistemological perspective can be adopted using all four stylized approaches to ecosystem service research.
During the past two decades, researchers and policy-makers have made efforts, with increasing success, to establish the use of the ecosystem service concept in the policy-making arena. The concept has gained traction in international settings such as IPBES, regional settings including EU environmental policies (Diaz et al. 2018, Bouwma et al. 2018), and also at national levels. The Swedish government, for example, stipulated that the value of ecosystem services should be considered in all decision-making from local to national levels, when relevant, by 2018 (Ds 2012:23 2012). It has also been picked up in urban planning in several cities around the globe (Hansen et al. 2015).

However, how a scientific concept like ecosystem services is used in society through, for example, concrete policy-making or management actions, so-called operationalization, is not straightforward (Clark and Harley 2020). How the ecosystem service concept can be used in practice needs to be further understood (Carmen et al. 2018, Dick et al. 2018, Brunet et al. 2018). It is particularly unclear how the concept can be operationalized in a way that supports decisions and management actions that are both environmentally sound and socially equitable and fair (Beery et al. 2016, Schubert et al. 2018). In cases where the ecosystem service concept is used to translate scientific knowledge into other decision-making contexts, there is also a need to develop integrated measures, modeling methods and decision-support tools that account for ecosystem service relationships and their dynamics over time in collaboration with the users themselves (Cord et al. 2017, Costanza et al. 2017). Including the intended users in the knowledge-generation process is important, in order to ensure that the produced knowledge is not only considered credible, but also useful for the needs of policy-makers and practitioners (Clark et al. 2016, Marre and Billé 2019). In this thesis, therefore, I have focused on analyzing processes of co-production of ecosystem service knowledge.

Common criticisms

The ecosystem service concept has been questioned for commodifying nature. Political ecologists and others have pointed out that by framing ecosystems and the benefits people obtain from them in a market context, there is a risk that inequalities in access to these markets will be perpetuated (Bakker 2010, Dempsey and Robertson 2012). Beyond a concrete market context, some also argue that simply by assigning instrumental values to
ecological processes, even without measuring them in monetary terms, risks undermining ethics of care and inherent feelings of reciprocity that people feel towards their surrounding environments (McCauley 2006, Jackson and Palmer 2015). There are also other, broader, debates on how the ecosystem service concept portrays the essence of ‘nature’. ‘Ecosystem services’ as a construct is inherently anthropocentric (Barnaud and Antona 2014). This fits poorly with the worldviews in some other, non-Western scientific knowledge systems, where relationships between people and their environment are seen reciprocally and where an ethic of co-dependence and care does not translate into the narrowly defined services provided by ecosystems to people (Tengö et al. 2017). Additionally, one of the strengths of the concept, namely that it provides a means to summarize and synthesize complicated social-ecological data, can also be considered a weakness. The focus on aggregate measures means that the users of the concept risk missing important nuances (Norgaard 2010), for example relating to social justice (Dawson et al. 2017), winners and losers among ecosystem service beneficiaries (Daw et al. 2015), scale effects and off-stage burdens (Pascual et al. 2017). The concept has also been criticized by ecologists for being overly policy-oriented and for not capturing ecological complexity well enough (Johnson and Lidström 2018).

Nevertheless, despite these criticisms, the ecosystem service concept is being used extensively in various contexts in both policy and practice. Therefore, it is meaningful to try to empirically understand where and how it can be useful for reaching our sustainability goals, while at the same time acknowledging these criticisms. How is the ecosystem service concept contributing to various sustainability pursuits in practice? What are the benefits and drawbacks in different contexts of use? This is what I aim to explore in this thesis. My focus is on a specific landscape, and actors who are engaging in various management practices there. These actors are, within their respective contexts and with the mandate that their role grants them, striving to manage the landscape sustainably. One of the approaches used in the literature to describe such landscape-level sustainability practices is stewardship.
Stewardship

Definition

The Merriam-Webster dictionary defines ‘stewardship’ as “the careful and responsible management of something entrusted to one’s care” (Merriam-Webster 2021). Thus, it encompasses both care and responsibility, and is a term that has been used to describe practices in a wide range of settings. As a term in scientific literature, it is often connected to sustainability. Here, it is generally used to describe actors or groups trying to achieve some form of sustainability, with an emphasis on caring for an ecosystem, natural resources or the environment. Chapin (2020), for example, defines stewardship as “the process of shaping physical, biological, and social conditions to benefit both people and nature”. Defined this way, it is about the practices (“process of shaping”) involved in striving for sustainability (“to benefit both people and nature”). There are various ways in which people can engage with and work for sustainability (Chapin 2020). In this thesis, I focus mainly on how individual actors, embedded in various local-level decision-making contexts, strive for sustainability in a multifunctional, Southern Swedish landscape.

The scientific literature on stewardship is diverse. In their qualitative, systematic review, Enqvist and colleagues (2018) identified four different meanings to stewardship: as ethic, motivation, action and outcome. These meanings have been emphasized in different bodies of literature, where ethic is more common in arts and humanities literature (focusing on individuals and ethics as culturally shared in societies), motivation in social science (individuals), and action and outcome in problem-based and natural science (focusing on collective action, policies or other collective initiatives). Suggesting the stewardship concept as a boundary object that can enable collaboration and dialogue between these diverse fields, Enqvist and colleagues also identified three attractors that can be used to connect them: knowledge, agency and care. These are all dimensions of stewardship, but emphasized to varying degrees in the different traditions, as well as the types of stewardship practices that the traditions tend to focus on. In this thesis, I approach stewardship as a practice (a set of actions), while still acknowledging important influences from the other traditions in the stewardship literature.

When analysing my findings about the operationalization of the ecosystem service concept, I use the three attractors knowledge, agency and care (Enqvist et al. 2018), to explore the stewardship practices of the various actors that I have interacted with and studied in this thesis. Generating
knowledge, as one of the attractors of stewardship, can be supported by the use of tools. The ecosystem service concept is one such tool, specifically developed to synthesize knowledge about how ecosystems contribute to human well-being. However, the ecosystem service concept only provides means to describe this specific relationship. It cannot be used to explore other processes that are influencing sustainability, such as interactions across scales and between places, and how to deal with the inherent uncertainties in a world that is ever changing. An approach to make sense of the world that acknowledges its complexity and unpredictability is resilience thinking.

**Stewardship & resilience thinking**

Resilience thinking is a framework through which we can strive to make sense of a world that is interlinked through complex relationships and processes, and inherently changeable and uncertain. A core tenet of resilience thinking is that the social and ecological spheres are fundamentally intertwined through processes in what can be described through the notion of social-ecological systems (Folke et al. 2010). These complex social-ecological systems are characterized by non-linearity, self-organization, emergence and interactions across scales (Levin et al. 2013, Preiser et al. 2018). Social-ecological systems are dynamic and contain internal feedbacks, are affected by external drivers and change over time (Folke et al. 2016). I take an epistemological approach to social-ecological systems in this thesis, as opposed to an ontological where systems would be viewed as real-world phenomena that exist ‘out there’ (Abson et al. 2017). Following an epistemological approach, I view the lens of social-ecological systems (or complex adaptive systems) as a means to structure my understanding of the world and to provide me with some of the pre-analytic assumptions to base my analysis on. In this view, social-ecological systems are defined by the researcher, depending on the aims and focus of the research, and therefore special attention needs to be given to how the system of interest has been delineated and what implications this has for the analysis (Cumming and Collier 2005).

The notion of social-ecological systems, and the implications of them being complex adaptive systems, is a descriptive and analytic aspect of resilience thinking. Another dimension of resilience thinking focuses on change. The world is ever-changeable and uncertain. In resilience thinking, the idea is that this dynamic behaviour can be harnessed by actors, under certain
circumstances, to navigate changes onto more desirable development trajectories, referred to as sustainability transformations (Olsson et al. 2014). However, social dimensions, such as the values of actors, their agency or the governance structures that they are embedded in, can work as both barriers and bridges in the navigation process (Folke et al. 2010). Thus, there is an extensive body of literature in the resilience thinking tradition about how desirable or undesirable change has or has not occurred, for example about regime shifts (Rocha et al. 2015), transformations (Moore et al. 2014) and social-ecological traps (Boonstra et al. 2016). Harnessed from these and other types of empirical examples, insights and sets of principles have been developed about how desirable change can be promoted while undesirable change might be avoided (Biggs et al. 2012). These insights have been further operationalized into various guides of resilience practice, that is, exercises, tools and procedures for how to apply resilience thinking in practice (Sellberg et al. 2015, 2021). These guides include the Resilience Workbook (Walker et al. 2010) and Wayfinder (Enfors-Kautsky et al. 2021), and have been applied in settings ranging from strategic planning in municipalities in Sweden (Sellberg et al. 2015) and Australia (Sellberg et al. 2018), to participatory research in development projects in contexts such regreening in Senegal (Goffner et al. 2019). Important to note here is that the social-ecological systems approach to ecosystem services research has co-evolved closely with resilience thinking, meaning that these approaches are often applied together (Biggs et al. 2012).

It is particularly through these applied approaches that resilience thinking becomes relevant for stewardship. As stated previously, stewardship is a practice that various actors can engage in when striving for sustainability. Resilience thinking is a framework that can help us make sense of the inherently uncertain world we live in. It provides us with some tools and insights about how to influence the constantly changeable in a direction toward that goal of sustainability. The realization that the world is uncertain and constantly changeable, however, also means that the goal of sustainability has no end point, a state in which we have reached ‘ultimate sustainability’. Instead, it should be understood as a process and as an ideal that evolves over time. Furthermore, sustainability can, and should, be strived for through a multitude of means, ranging from international agreements and national laws, to actions and initiatives by grassroots organizations or individual actors. It is through the latter, in how individuals and organizations actively engage in these efforts, that the literature on stewardship can contribute to sustainability.
Stewardship practices, ecosystem services & sustainability

In this thesis, stewardship is understood primarily in terms of actions and practices. Stewardship needs to be intentional. A sustainable outcome, therefore, that was achieved as a positive but unintended side effect of an otherwise motivated action does not make said action part of a stewardship practice. At the same time, stewardship practices can end up having unsustainable outcomes, even if the actors did their best to reach the defined sustainability goals. Looking at the three attractors, ‘failed’ stewardship can occur for example if knowledge is poor, if agency is limited or if value judgements (which are connected to care) are assigned with a too narrow frame of reference. Stewardship can also ‘fail’ even if knowledge is good, agency substantial, and a plural value approach is adopted, because we live in a complex world that is inherently unpredictable (and there are no guarantees of anything!). Nevertheless, stewardship practice is a worthwhile endeavor in which we need to view sustainability as a process that we continually engage in and recalibrate (Chapin 2020). And sometimes, in order to engage in stewardship practices, actors may be supported by the use of tools. Ecosystem services is a conceptual tool with the potential to support stewardship practices, especially if conceptualizations and analyses using the concept are based on a framing, like resilience thinking, that acknowledges uncertainty and surprise as inherent conditions on Earth.

Research gap

To summarize, ever since its introduction in the 1980s, the ecosystem service concept has been promoted as a useful tool for capturing the interdependencies between human societies and the natural environment. Its recent entrance into the policy and practice arenas, through both IPBES, EU and in national policies, has increased its relevance. However, the research on the concept is diverse, both due to different disciplinary entrance-points and due to the type of services that are being studied. Concerns have also been raised about the concept itself – how it portrays
human-nature relationships and that it risks commodifying nature. All of these aspects are important to consider when operationalizing the ecosystem service concept in the context of sustainability, especially if it is to be used as a tool for stewardship. What role can the ecosystem service concept play for actors in various decision-making contexts when engaging in different forms of stewardship practice? How can the ecosystem service concept, and various methods to analyze ecosystem services, be combined with other approaches, such as resilience thinking, to support sustainability in local decision-making? And how well do these ways of using the ecosystem service concept address or support the three attractors of stewardship: knowledge, agency and care? It is within this space that I, through this thesis, hope to increase our understanding for the usefulness of the ecosystem service concept as a tool for sustainability. In the next section, I describe the approach and methods I have used to address this research gap.
RESEARCH APPROACH

Scope of the thesis

Context of the research

As a milestone target to reach the national environmental quality objectives, the Swedish government stipulated that the value of ecosystem services should be considered in decision-making, when relevant, from local to national levels by 2018 (Ds 2012:23 2012, Naturvårdsverket 2020). Following this, the Swedish Environmental Protection Agency (Naturvårdsverket) released a call for research on how to operationalize the value of ecosystem services in Swedish decision-making. Funded by this call, Elin Enfors-Kautsky and I, in collaboration with Kristianstad Vattenrike Biopshere Office, led a participatory resilience assessment focused on the Helgeå catchment area between 2015 and 2019. Elin also supervised me for the first half of my PhD. Together, with input from Biosphere Office staff, we designed a participatory resilience assessment process with a three-fold goal: First, to generate tangible outputs, such as strong visuals, about the state of ecosystem service provision in the Helgeå catchment (per the interest of the funder). Second, to explore methods of collaboration to address sustainability challenges in the study area (the project partner’s motivation). Third, to stimulate a complexity-based resilience perspective among the participants by combining a participatory resilience assessment with ecosystem service analyses (the research team’s focus, members of which also included Lisen Schultz, Albert Norström and Cibele Queiroz).

The case study, the Helgeå catchment area, was selected partly due to previously existing relationships between Kristianstad Vattenrike Biosphere Office and Stockholm Resilience Centre researchers. However, the catchment area also has several characteristics which makes it a particularly relevant case study when operationalizing ecosystem services for local decision-making in Sweden.
Case study: the Helgeå catchment area

The Helgeå river is 190 kilometers long and its catchment covers 4775 km² (SMHI 2002), overlapping with 13 municipalities in three counties in southern Sweden (Figure 2). It contains many of the dominant land covers and uses in Sweden, from the intense agriculture on the Kristianstad plain in the south, to the mixed small-scale agriculture, animal husbandry and forest patches in the center to the northern parts dominated by extensive production forests (Figure 3). The lower part of the catchment area also contains a system of wetlands with high biodiversity values, managed through the Kristianstad Vattenrike Biosphere Reserve (Olsson et al. 2007).

Figure 2. Overview and land cover maps of the Helgeå catchment area. Map data from © Lantmäteriet.
The Helgeå catchment is a cultural landscape with a long history of human management. There are trading communities recorded in Åhus, where the Helgeå river meets the Hanö Bay, as far back as 1300 years ago (NE 2019). However, there has been a gradual change in agricultural practices over the last 150 years, with many of the smaller fields and meadows in the upstream area being abandoned and planted with spruce, while agriculture on the downstream Kristianstad plain has intensified. This has effectively changed the landscape composition across a clear north-south gradient to become more homogenous and less multifunctional (Tuvendal and Elmqvist 2011).

The area shows socioeconomic trends that are also playing out in many other parts of Sweden. There is an ongoing urbanization process where the large towns of Hässleholm and Kristianstad are growing (SCB 2018), both due to work and education opportunities in the towns themselves and as a consequence of being in easy commuter distance from the cities Malmö and Copenhagen. This has increased the competition for land around these urban centers through an increased demand for housing. On the other hand, small rural municipalities in the catchment are losing both inhabitants and job opportunities (SCB 2018). Two prominent and well-known Swedish export brands are also located in the catchment area: the IKEA headquarters in Älmhult and Absolut Vodka in Åhus.

This combination of biophysical, land use and socioeconomic conditions interact to produce a complex landscape where many different interests compete for natural resources and space. Their similarity with conditions and processes in other parts of the country also represent an opportunity to generalize results from research conducted here to other catchment areas in Sweden. Having Kristianstad Vattenrike Biosphere Office as a collaborator, with its long track record of adaptive co-management (Olsson et al. 2007), makes this area particularly fertile ground to conduct research that requires collaboration between researchers and other societal actors. It is within this context that I developed my research questions and conducted the studies that make up this thesis.
Figure 3. Photographs from across the Helgeå catchment area. a) Production forest with spruce close to Osby; b) Felling of timber through the use of horses in the northern parts of the Helgeå catchment area; c) Pasture and mixed forests close to Almhurst; d) Cows grazing by the Helgeå river in Kristianstad Vattenrike Biosphere Reserve; e) Beech forest close to Åhus; f) Crops in the field on the Kristianstad plain; g) The view of Helgeå river and central Kristianstad from the visitor's center Naturum in Kristianstad Vattenrike Biosphere Reserve; h) Birdwatchers observing the cranes during spring migration at lake Pulken close to Kristianstad; i) Beach by Hanö Bay in Aspet nature reserve close to Åhus.
**Research questions**

The aim of this thesis is to explore how the ecosystem service concept can be used as a tool for sustainability, specifically in support of stewardship practice.

As described previously in this section, the core findings of this thesis are based on a participatory resilience assessment that was conducted for the Helgeå catchment area. This assessment was designed with a three-fold goal, following the interests of the funder, partner organization and research team: To generate tangible outputs about the state of ecosystem service provision, to explore methods of collaboration to address sustainability challenges, and to stimulate a complexity-based resilience perspective among the participants.

Therefore, the overarching aim of operationalizing the ecosystem service concept can be broken down into the following questions:

- **RQ1.** What role can the ecosystem service concept play for local actors in various decision-making contexts when striving to engage in different forms of sustainable landscape management? (Papers I, II and III)

- **RQ2.** How can the ecosystem service concept be combined with other approaches, such as resilience thinking and futures methods, to support knowledge co-production about complex sustainability challenges in landscape management? What aspects of process design contribute to the usefulness of the co-produced ecosystem service knowledge? (Papers II and III)

- **RQ3.** In what ways do these uses of the ecosystem service concept address the three attractors of stewardship (knowledge, agency and care), thereby supporting the stewardship practices of various local actors? What are potential limitations to the use of the ecosystem service concept as a tool in support of stewardship practice? (Papers II, III and IV)

These questions are answered in four papers, briefly described below.
Focus & connection between papers

This thesis consists of four papers, in different ways connected through the participatory resilience assessment mentioned above. In Paper I, the outcomes of the included participatory ecosystem services assessment are presented, both the resulting ecosystem service bundles analysis and reflections about its uses based on interviews with process participants. In Paper II, I use a second round of interviews to analyze learning and impact of all the assessment’s constituent parts, with particular focus on articulating an understanding for complex adaptive systems. In Paper III, I pick apart and analyze the process of knowledge co-production, while comparing our participatory resilience assessment with three other ecosystem service and futures-oriented participatory processes that were conducted in the Helgeå catchment area during the same ten year period. Finally, sense of home was identified as a potential deep leverage point for change by the participants in the participatory resilience assessment. Therefore, I investigate the relationship between sense of home, stewardship practice and its potential as a deep leverage point for non-industrial private forest owners in Paper IV.

Throughout the course of this PhD project, I have realized that exploring how the ecosystem service concept can be operationalized to support sustainability requires an understanding that goes beyond only analyzing ecosystem services. The practical application of the ecosystem service concept, especially to support stewardship practices, also requires an understanding for how knowledge is used in various decision-making contexts and what motivates actors in their management practices. This is why Paper I is the only one solely focusing on analyzing ecosystem services. The focus on learning and impact (knowledge use) in Paper II, knowledge co-production in Paper III, and motivations behind stewardship practices in Paper IV complement the analyses of the ecosystem service concept to provide a more nuanced and situated understanding of the opportunities and limitations to operationalization.

Despite this broadening of research focus, ecosystem services as a concept are still present in all the papers. However, the treatment and analysis of ecosystem services in the papers gravitates towards different approaches in the ecosystem service research field (Figure 4). In Paper I, the analysis is based on a social-ecological systems approach, focusing on the ecosystem service bundles analysis which was part of the participatory resilience assessment. The focus in Paper II, in which I analyze the learnings and impacts of the assessment process in its entirety, therefore indirectly also
gravitates towards a social-ecological systems approach. **Paper III** consists of a case comparison of four futures-oriented participatory processes. One of the cases is my own, described in **Papers I** and **II**. The other cases include analyses that use land cover data to model future scenarios, suggesting an ecological approach. One project also conducted cost-benefit analyses, therefore also gravitating towards an ecological economics approach. In **Paper IV**, I shift the angle, rather focusing on different pathways to stewardship practices among one specific actor group, non-industrial forest owners. The ecosystem service concept is generally understood an utilitarian conceptualization of human-nature relationships through its focus on instrumental values (Gómez-Baggethun et al. 2010). Based in the diverse values that were expressed as motivating the forest owners in **Paper IV**, I discuss potential implication for the use of the ecosystem service concept, as mainly focusing on instrumental values, for supporting stewardship practices in various contexts.

Finally, the potential for operationalization of a concept varies, depending on the decision-making context and the actor or actors that are involved in its use. Exploring its opportunities and limitations, therefore, has to be situated in a context. In this thesis, I focus on stewardship, here understood as practices that various actors engage in when striving for sustainability in landscape management. In the scientific literature about stewardship, such actors range from farmers (Schultz et al. 2007) and urban gardeners and other civic groups (Enqvist et al. 2019) to multi-national seafood companies (Blasiak et al. 2021). In working on this thesis, I have collaborated with and studied actors who are engaged in and have responsibility for different aspects of landscape management in the Helgeå catchment area, with a special emphasis on local civil servants in **Papers I** and **II**, various actors, including researchers, in the specific context of knowledge co-production in **Papers I, II** and **III**, and private non-industrial forest owners in **Paper IV** (Figure 4).

Next, I describe the methodological approach that I have taken in conducting the research in this thesis.
Figure 4. Conceptual figure showing how the papers treat the ecosystem service concept and stewardship practice, and how they are connected to each other.
Methodologies

Epistemological plurality

As social-ecological systems perspectives make clear, the world is inherently complex and to a large extent unknowable. This means that all knowledge is provisional and partial. Inevitably, this partiality extends to social-ecological systems perspectives themselves. Therefore, this research benefits from epistemological plurality, for a richer and more nuanced picture of the issue at hand (Miller et al. 2008, 2011). This includes multiple research approaches, such as inter- and transdisciplinarity (Lang et al. 2012), and the involvement of diverse knowledge systems (Tengö et al. 2014). As researchers and other actors striving to generate knowledge about a complex world, it is therefore important with epistemological agility (Haider et al. 2018), that is, having the capacity as a researcher to engage with multiple epistemologies.

The aim of this thesis is to explore how the ecosystem service concept can be used as a tool in support of stewardship practice. This entails using a concept and connected methods that originally were developed in the sphere of science by researchers, and applying it in spheres of practice where resources, needs and logic vary from those within academia. This, in particular, requires knowledge-brokering and the application of a mix of methods (Michaels 2009). While the core, overarching findings of this thesis are largely based on the transdisciplinary, participatory resilience assessment mentioned above (and described in the next section), I have also used a variety of other, mainly qualitative-interpretive, methods to explore the ecosystem service concept in local decision-making, in order to capture various perspectives on its operationalization.

A participatory resilience assessment in the Helgeå catchment

Resilience thinking provides theoretical frameworks to make sense of the complex, uncertain and ever-changing world that we live in (Folke et al. 2010). Insights from these frameworks have been operationalized into various resilience practice guides, such as the Wayfinder (Enfors-Kautsky
et al. 2018), offering tools for practitioners and researchers to explore the complex interactions that influence a specific place (Sellberg et al. 2021). Together these tools can be used to design a resilience assessment intended to increase social actors’ understanding for the system as complex and adaptive and through that enhance their capacity to enact management that is sustainable and acknowledges complexity and surprise. The main findings of this thesis are based on one such participatory resilience assessment. This process built on a series of five workshops and two rounds of interviews carried out between 2015 and 2019 (Figure 5 and 6). Participants were selected to represent a wide range of sectors with relevance to ecosystem service provision and use in the Helgeå catchment area, including civil servants, representatives from the business sector and civil society organizations. The selection was guided by an initial actor scoping done in collaboration with Kristianstad Vattenrike Biosphere Office.

Figure 5. Photographs from the workshops in Naturum, the Kristianstad Vattenrike Biosphere Reserve visitor’s center.
Figure 6. Visualization of the sequencing of workshops and other interactions with participants, as well as the processing steps taken by the research team in-between interactions. The numbers in the margins indicate calendar year of activities. ES stand for ecosystem services and KVB for Kristianstad Vattenrike Biosphere Office.

Figure 7. Schematic of the process components and how they fed into each other. Components in boxes with the same color are considered part of the same output. Components without a box were discussed during one or several exercises and fed into consecutive exercises, but are not directly represented in any of the outputs. Solid arrows indicate that a component was directly used as a building block to develop another component, while dashed arrows indicate that a component was used as inspiration for a consecutive exercise.
The process was divided into two phases: The ecosystem service assessment phase (workshops 1-3) and the strategic planning phase (workshops 3-5). Workshops were held at the Kristianstad Vattenrike Biosphere Reserve visitors’ center. The outputs from the process include an ecosystem service assessment, conceptual system models, a future vision and a strategic action plan that focused on three key challenges by addressing leverage points for change (Figure 7). These outputs are, in various ways, present in all papers in this thesis.

**Ecosystem service bundles analysis (Paper I)**

Ecosystem service bundles analyses have been promoted for studying interactions in social-ecological systems (Bennett et al. 2009). In such analyses, multiple ecosystem services are mapped across landscapes, identifying sets of services that frequently appear together (so-called bundles). These bundles can be used to increase our understanding for interactions and trade-offs between services (Raudsepp-Hearne et al. 2010). The ecosystem service bundles are seen as the manifestations of social and ecological interactions, and therefore represent a fingerprint of the landscape under a given management regime. As such, they hold the potential to explore multifunctionality in the landscape and to support management decisions aimed at increasing sustainability (Queiroz et al. 2015, Cord et al. 2017). This is why an ecosystem service bundles analysis was selected for the ecosystem service assessment phase of our participatory resilience assessment. The ecosystem service bundles analysis, presented in Paper I, is based on 15 iteratively selected provisioning, regulating and cultural ecosystem services. In addition to the publicly available, municipality level data, the bundles analysis is based on a simple statistical clustering technique (k-means), making the whole procedure relatively simple to replicate (Raudsepp-Hearne et al. 2010, Queiroz et al. 2015).

**Semi-structured interviews to assess learning & impact (Papers I & II)**

As part of the participatory resilience assessment, I conducted two rounds of semi-structured interviews with the process participants. For Paper I, the first round of these interviews informed the findings about the usefulness of the ecosystem service bundles analysis according to the process participants.
Table 1. Descriptions of the six features of complex adaptive systems and the levels of impact from processes of knowledge co-production. These were used in Paper II to assess learning and impact from the participatory resilience assessment.

<table>
<thead>
<tr>
<th>Features of complex adaptive systems (Preiser et al. 2018)</th>
<th>Levels of impact from knowledge co-production (Wall et al. 2017)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relational: Constituted relationally, with interactions between system elements</td>
<td>Problem understanding: Participants have gained a better comprehension of particular problems</td>
</tr>
<tr>
<td>Adaptive: Have adaptive capacities that change over time</td>
<td>Instrumental: Participants have learned new skills and how to use certain tools</td>
</tr>
<tr>
<td>Dynamic: Generate dynamic processes</td>
<td>Personal: Individual participants have used outputs to support their professional decision-making</td>
</tr>
<tr>
<td>Open: Are radically open, with connections across scales</td>
<td>Explicit use: An output has been used in an organization’s communication, planning or management</td>
</tr>
<tr>
<td>Contextual: Contextually determined</td>
<td></td>
</tr>
<tr>
<td>Emergent: Novel qualities emerge through complex causality</td>
<td></td>
</tr>
</tbody>
</table>

Findings in Paper II are mainly based on the second round of interviews, conducted after the last workshop, during which the participants were asked to reflect on individual process components as well as the participatory resilience assessment as a whole. Through evaluation coding (Saldaña 2012), the transcripts from these interviews were used to assess learning during and impact of having participated in the process. The analysis focused on the degree to which process components supported the participants’ ability to articulate an understanding for complex adaptive systems (Table 1) (Preiser et al. 2018), as this understanding is a fundamental skill for the ability to apply other aspects of resilience thinking in various management practices (Bohensky et al. 2015). Each process component was also scored along a gradient based on their level of impact (Wall et al. 2017) (Table 1).

Case comparison through reflexive self-assessment (Paper III)
Transdisciplinarity and knowledge co-production is becoming increasingly popular, not only in research striving to apply resilience thinking, but also in projects with other approaches and among research funders (Norström et al. 2020). Between 2011 and 2020, four ecosystem service and futures-oriented research projects with an aim to co-produce knowledge about sustainable landscape management were conducted together with various local and regional actors in the Helgeå catchment area. One of these
projects was our participatory resilience assessment. The similarity in context, participating actor groups and aim of these four projects provided a unique opportunity to assess the different design-related elements that shape the knowledge co-production process. Based on two existing theoretical frameworks for inter- and transdisciplinary research (Lang et al. 2012, Defila and Di Giulio 2015) and insights from other relevant literature, we developed an analytical framework representing the knowledge co-production process, from aim and assumptions about change to knowledge outputs and intended knowledge uses. Based in this analytical framework, we explored the similarities and differences between the four projects through a reflexive self-assessment by the research teams, analysis of project reports and publications, and follow-up interviews with two to three key participating local actors from each project. The contrasts that emerged between these projects painted a nuanced picture of where and how value can be generated during a knowledge co-production process, providing insights about how to design processes to meet goals and address intended knowledge needs.

*Exploring forest owners’ stewardship practices through photo elicitation (Paper IV)*

Sense of home (*hembygdskänsla* in Swedish) was identified as a potential deep leverage point for change in the participatory resilience assessment. Important drivers behind two out of the three key challenges (increasing diversity of tree species in production forests and better water quality in lakes and rivers) are strongly influenced by how production forests are managed in the up-stream area in the Helgeå catchment. As almost 90 percent of production forests in the catchment are owned by non-industrial private forest owners (Richnau et al. 2013), I decided to explore how sense of home among this group of actors influenced their stewardship practices on their forest properties. I interviewed 16 non-industrial private forest owners who live on or close to their forest properties in a two-step virtual interview and photo elicitation exercise (Beckley et al. 2007; Beilin 2005). The exercise focused on five places on their forest properties, identified and photographed by the forest owners themselves, where they feel a sense of home. The interviews followed a flexible and reflexive structure, with prompts and follow-up questions being used to narrow down management actions and motivations (Fujii 2017).
Table 2. Types of values underlying motivations for stewardship practice. Used to analyze type narratives in Paper IV.

<table>
<thead>
<tr>
<th>Value category</th>
<th>Description</th>
<th>Types of values (and connected ecosystem service category)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instrumental</td>
<td>Value is assigned based on function or instrumental use</td>
<td>Consumptive direct use values</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Provisioning ecosystem services</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Non-consumptive direct use values</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cultural ecosystem services</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Indirect use values</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Regulating ecosystem services</td>
</tr>
<tr>
<td>Intrinsic values</td>
<td>Value inherent to the entity itself</td>
<td>Existence value</td>
</tr>
<tr>
<td>Relational values</td>
<td>Value created through the relationship between entities</td>
<td>Bequest value</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Altruistic value</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Individual relational value</td>
</tr>
</tbody>
</table>

These interviews were used to construct individual narratives of how sense of home motivated different management actions. Each narrative was coded to follow a conceptual model of stewardship practice (Bennett et al. 2018). Individual narratives were then grouped together into six type narratives based on their similarities in place character, place meanings (Masterson et al. 2017), motivations and intentions with management actions. Finally, the type of values (Richnau et al. 2013, Chan et al. 2018, Bieling et al. 2020) that motivated management actions were identified for each of the type narratives (Table 2). These expressions of values can be connected to the ecosystem services framework and other conceptualizations of human-nature interactions. This, in turn, can be used to highlight opportunities and challenges with using the ecosystem service concept when striving to promote stewardship practices among actors who attach multiple values and aspects of their identity to the land that they are managing, including private, non-industrial forest owners.

Strengths & limitations of the combination of methods

The aim of this thesis is to explore different ways in which the ecosystem service concept can be used as a tool in stewardship practice. For this purpose, the combination of a transdisciplinary process and qualitative (interpretive) methods focused on interviews are well suited. The epistemological agility I have had to practice is mostly internal, in the role
as a knowledge broker. In the participatory resilience assessment, I had to balance and negotiate claims between different kinds of scientific ecosystem service knowledge and the participants’ experiences, needs and local knowledge. In Paper III, part of the analysis consisted of assessing the usefulness of different approaches to ecosystem service analyses in the specific context of participatory processes in the Helgeå catchment. Neither of these tasks encompass combining inconsistent or incompatible epistemological claims, but rather focus on interpretations of usefulness. However, my expertise is limited with the kind of methods generally employed within the ecological and ecological economics approaches to ecosystem service research, such as those used in the three other projects in Paper III. It is therefore possible that there are opportunities and limitations of these approaches that I have not been able to fully comprehend (in the way that an expert would). Therefore, for expert-level insights into these methods, I have relied on my co-authors in Paper III.

Research ethics & reflexivity

Evolution of the PhD

As with any research, the context of this project influenced how it turned out. The initial goal to develop methods for operationalizing the ecosystem service concept was set by the funders, the Swedish Environmental Protection agency. However, beyond this overarching aim, they were not involved in how the research should be conducted and how the project eventually evolved. More influential was the academic context, Stockholm Resilience Centre, in which the research was being conducted. This influenced the choice of the ecosystem service bundles analysis, as several Stockholm Resilience Centre researchers have expertise in this approach. Additionally, the timing mattered: In parallel with my PhD project, the Wayfinder (Enfors-Kautsky et al. 2021) resilience assessment tool was being developed (work which was led by Elin Enfors-Kautsky, my supervisor at the time). This meant that trialing tools and exercises from this guide-in-development became particularly interesting for the research team. Finally, the collaboration with Kristianstad Vattenrike Biosphere Office influenced the focus on collaboration between various actors, as this is a bridging
organization with a long and successful track-record in leading such efforts in the study area. Another partner organization might have influenced the process to focus less on learning and knowledge co-production, and more on producing specific, more targeted outputs, as exemplified in some of the other projects described in Paper III.

These conditions mainly provide context for the research in Paper I and II. Papers III and IV, which were developed later in the process, were less influenced by the initial context and more by realizations and insights that I made while working on the first two papers. For Paper III, I was curious to explore other approaches than those that dominate at Stockholm Resilience Centre relating to ecosystem service analyses, knowledge co-production and futures thinking. I was fortunate enough to meet Ida Wallin at a conference, and through her, I was put in contact with the research teams from the other projects. This dialogue eventually resulted in Paper III. The effort of analyzing project reports and interacting with the other researchers broadened my perspective on ecosystem service use and approaches to co-producing knowledge. Finally, Paper IV evolved out of the interests of the process participants (through the identification of sense of home as a potential deep leverage point), and my own curiosity to explore more embodied and emotionally based types of stewardship.

**Positionality**

In the contexts where I have conducted research as part of this PhD thesis, I as a researcher represent a mix of outside and inside perspectives. I have conducted research in my native country in my mother-tongue. Most of the actors I have interacted with also have some form of higher education (including the forest owners, who often had degrees in forestry or other professions that require higher education). All of us also shared an interest in and concern for the landscape that the research focused on.

On the other hand, I am from the capital, which in the eyes of some actors makes me an outsider. There is a cultural divide between urban and rural populations in Sweden (as in many countries), and the debates revolving around this divide appears to have become more polarized recently, in both media and politics. I was aware of this potential barrier, which is why I planned my fieldwork to allow time to acquaint myself with the study area and to establish professional relationships with all process participants by visiting them at their place of work. Originally, I intended to conduct
walking interviews with the forest owners on their forest properties. Unfortunately, due to COVID-19, this became impossible. Instead, I designed a two-step interview process, where the first interview mainly was motivated by the wish to meet the participants and acquaint ourselves with each other before starting to collect data. Some participants were sceptical of me and my intentions at first, but I believe that this initial interaction established a basic level of trust. In the second interview, all participants appeared relaxed and gave both candid and reflexive responses without appearing guarded.

Of course, there are some aspects of our position that we can never remove ourselves from as researchers. However, I believe that it is possible to build bridges across cultural (as well as political and epistemological) divides, if interactions are handled with humility and given the time necessary for reflection and understanding.

This is a belief with a clear connection to my personal background. My mother is a local democracy expert who worked at the Swedish International Development Cooperation Agency for most of her career. My father is a journalist who, in addition to focusing on societal issues connected to climate change and environment, also has been active in many associations, including his workers’ union. The value of democratic processes, including the (not unproblematic) merits of Swedish association and consensus culture, were instilled in me already as a child. I grew up traveling with my parents around the world, observing them work and being exposed to environments that many of my peers at the time were not. Additionally, I grew up bilingual (my mother is Finnish), in a family where aunts, uncles and cousins have partners from all over the world. My world, therefore, was one of constant translation between languages, cultures and worldviews. The skills of translation intrigued me. This curiosity led me to pursue a bachelor’s degree in geography, a systems-oriented discipline which combines insights from various other disciplines, when relevant, for understanding phenomena in space.

I am therefore a person prone to looking for connections and system interactions, means to translate between ways of knowing and communicating, and doing this through democratic dialogue. Being rooted in Swedish consensus culture, a position even further engrained in me by my upbringing, makes me more likely to focus on opportunities for collaboration and shared interests, rather than points of tension or conflict. This inevitably influences the way I conduct research. It is particularly relevant for how the participatory resilience assessment evolved. As
discussed in Paper II, the outputs from this process revealed surprisingly few conflicts or points of contention. It is likely that I, together with the rest of the (predominantly) Swedish research team, designed a process that would be conductive for reaching consensus, that is, identifying shared interests and opportunities for collaboration. In doing so, we probably steered the process away from areas of conflict. Depending on the situation and purpose of a process, this can be problematic.

Not surprisingly, however (considering my background), I also believe that starting with identifying shared interests to initiate collaboration makes it easier to address areas of conflict later, once a level of trust between actors has been established. We just need to make sure not to forget to identify those potential conflicts, once trust has been established. This is a bias in my background and training which it is essential that I account for in my research, especially when using transdisciplinary approaches. For me, and others with my kind of consensus-oriented background, it is also important to be cautious when using the ecosystem service concept. Its instrumental framing can make ecosystem service analyses appear neutral, while in actuality, it can hide inequalities in access, taboo trade-offs (Daw et al. 2015) and underlying value-based prioritizations that we are not being transparent about.

Research ethics procedures

All participants who contributed to this PhD thesis provided informed consent before being interviewed. All data were handled and stored securely and to maintain anonymity. Once the papers in this thesis have been published, the anonymized interview transcripts and photographs will be archived through Stockholm University. Data will not be made accessible for any uses except for reviewing the original research, as its qualitative nature makes analyses beyond the original purpose problematic. My work on this thesis began before an official ethics review process had been set up at Stockholm Resilience Centre. Therefore, ethical considerations for the participatory resilience assessment were only assessed post-hoc by the Stockholm Resilience Centre Research Ethics Sub-Committee, while the research in Paper IV was assessed and formally approved by said committee before data collection started.
RESULTS & FINDINGS

A participatory ecosystem service bundles analysis (Paper I)

The iterative, participatory ecosystem service bundles analysis resulted in a selection of six provisioning, five regulating and four cultural ecosystem services. Through the three iterations, this list changed extensively, both with regards to the services to include and how these services should be represented through indicators based on publicly available, municipality-level data. The cluster analysis of the 15 ecosystem services resulted in three distinct ecosystem service bundles (Figure 8). In general terms, these can be described as a northern cluster of municipalities dominated by forest production and relatively high values for regulating services (bundle 1), a southern cluster with high values for the cultivated crop services (bundle 3), and a central cluster with a relatively diverse bundle, including high values for milk and meat production as well as for cultural services (bundle 2). For the stability of the statistical analysis, the sample size was extended beyond the 13 municipalities that overlap with the Helgeå catchment, to also include all other municipalities in Skåne and Kronoberg counties. Only one municipality in bundle 3 overlaps with a small part of the Helgeå catchment. Therefore, in the rest of the participatory resilience assessment, exercises focused on exploring the dynamics behind bundles 1 and 2, while bundle 3 was only included as a point of reference.

Similar ecosystem service bundles analyses have been conducted before, both in Sweden (Queiroz et al. 2015), Denmark (Turner et al. 2014) and elsewhere (Raudsepp-Hearne et al. 2010, Hamann et al. 2015). My contribution to this literature, through Paper I, is to conduct the ecosystem service selection and indicator development in collaboration with a diverse group of local actors through an iterative, participatory process. This strengthened our analysis and created a shared understanding and overview of the multifunctional landscape around the Helgeå river among the process participants.
Learning & impact from a participatory resilience assessment (Paper II)

In addition to the ecosystem service bundles analysis, the participatory resilience assessment resulted in three concrete knowledge outputs:

Figure 8. Three clusters of municipalities with their type bundle of ecosystem services. Cluster (1) is forestry-dominated, with high production of regulating services. Cluster (2) has a mixed landscape with high milk and meat production and comparatively high levels of cultural services. Cluster (3) has high production of cultivated food and fodder crops, but generally low levels of all other provisioning and regulating services, and average levels of cultural services. The photographs show characteristic landscapes from the respective clusters.
conceptual system models, a future vision and a strategic action plan (see Figure 7 in Methodologies). Based on follow-up interviews with the participants, certain aspects of the process design and content emerged as particularly beneficial for the participants’ learning. These aspects include the process being iterative and having lasted for a long time period, with five workshops spread over the course of three years. That the process included the same group of participants also contributed to building trust, between participants and towards the researcher team. Additionally, the type of exercises that were included contributed to learning. In particular, the iterative selection of ecosystem services for the ecosystem service bundles analysis and the conceptual system model building encouraged all participants to be active in the discussion, supported social learning and helped the participants to situate their knowledge in relation to each other.

The knowledge outputs also supported the participants in articulating an understanding of complex adaptive systems, a skill which is fundamental for being able to apply other aspects of resilience thinking. Through the interviews, the outputs and connected exercises emerged as complementary in supporting an articulation of complexity. While the ecosystem service bundles helped express the relational and contextual features of complex adaptive systems and the conceptual system models further articulated the relational feature, the future vision helped the participants to explore the dynamic and radically open characteristics of their system. Finally, the strategic action plan, and in particular learning the leverage points concept, articulated an understanding for the adaptability of the system.

The usefulness, or level of impact, of the knowledge outputs varied (Figure 9). All outputs had increased most interviewed participants’ problem understanding in relation to current sustainability challenges in the landscape. Many also felt that they could have instrumental use of them, in the sense of there being a value in repeating the same exercises, for example within their own organizations. Some participants had personally been able to use the leverage points concept, through it having influenced the way they think when planning projects or looking for collaborators. The strongest impact was found for the ecosystem service bundles, as these had been explicitly used in some municipalities, mainly for communication but also as supporting material for developing strategic sustainability plans.
Knowledge co-production about future landscapes (Paper III)

Based in the analytical framework, our comparison of the four futures-oriented participatory processes revealed important insights, tensions and opportunities for knowledge co-production. The participatory resilience assessment I contributed to is hereafter called SRC-KVB in this description of our case comparison results. The usefulness of the knowledge outputs seems to have been strongly influenced by how the process had been set up and how its purpose had been communicated to its participants. Important for initial design includes a consistency in theoretical approach, assumptions about change, the key challenges or goals and how the participants are expected to contribute. The two projects with partner organizations (one of which was SRC-KVB) seemed to have produced the

**Figure 9.** Impact level of the process outputs. Impact gradient based on the evaluation indicators developed by Wall et al. (2017). The numbers indicate how many of the participants that expressed a specific level of impact for an output and how many of the participants that made a connection between a process output and a specific feature of complex adaptive systems (Preiser et al. 2018).
most useful outputs for the participating local actors. On the other hand, for actors operating at national and EU levels or a broader research community, the projects that belonged to larger research consortia produced valuable insights through more generalizable results. However, belonging to a research consortium also decreased the flexibility of the research team to adjust aims and exercises to the needs of the local participants.

The use of the ecosystem service concept in the projects varied. All projects conducted some form of ecosystem service analysis, with the number of services that were analyzed ranging from two to 15 (in SRC-KVB). All projects, except SRC-KVB (which only analyzed current provision), produced model outputs of both current and future provision of ecosystem services following the climate and management scenarios that were developed in the co-production processes. In these models, the ecosystem service framework functioned as a means to synthesize and organize data, to then create outputs about the current and future landscape. Contrast also emerged in how participants perceived the concept, with it being appreciated in SRC-KVB (as described in the sections about Paper I and II), but experienced as too complicated and therefore excluded in most interactions with local actors in the other projects. A difference between the process designs was that SRC-KVB explicitly included time for learning about and discussing the ecosystem service concept during several workshops, while the other projects did not. This suggests that the concept can be complicated and participating local actors might need to be given time to properly explore its uses for it to be picked up.

These insights and tensions between the projects suggest that it is very important with the feedback mechanism between what the hoped-for uses of the process and knowledge outputs are, and how the process is set up and designed. It is also important that these goals are communicated to the participants, so that the right expectations are set. In projects where a goal is to produce generalizable knowledge for higher level actors or a broader research community, the decreased flexibility might lead to knowledge outputs losing some of their usefulness for the participating local actors. However, benefits for participants goes beyond the use of outputs. Benefits also include networking, being inspired and the potential for instigating future collaborations, as exemplified in various ways in all four projects.
Narratives of forest stewardship from sense of home (Paper IV)

The analysis of interviews and photographs from the non-industrial private forest owners resulted in 90 individual place narratives. These were grouped into six type narratives, based on shared place meanings, motivations and intentions for management actions (Figure 10 and Table 3). Four of these describe narratives of stewardship practice (based on the definition that stewardship practices need to be motivated by both ecological and social considerations for long-term sustainability), while two represent indirect stewardship.

Figure 10. Example photographs of places belonging to the six type narratives (narrative in brackets). a) Pine forest (Managing forests for sustainability); b) Restored meadow with historical cottage ruin (Inter-generational connectedness); c) Hay being harvested using traditional techniques (Upholding landscape aesthetics and diversity); d) Island with protected deciduous forest (Conservation and recreation); e) Small dam where the participant built a shed as part of convalescing from an illness (Places with special personal attachment); f) Middle-aged spruce forest planted by the participant (Dormant forest stewardship).
Table 3. Descriptions of the six type narratives, including number of participants who described places belonging to each of the narratives.

<table>
<thead>
<tr>
<th>Type narrative</th>
<th>Brief description</th>
<th>Number of participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Managing forests for sustainability</td>
<td>Production forests where motivations for management decisions include longevity and resilience of the forest in terms of multiple values, both monetary and non-monetary. Appreciated for their beauty, recreational opportunities and as forests where time and energy has been spent in management. Often described as stands that are managed differently from conventional production forests. There are four sub-categories, distinguished through the dominant tree species and what initially motivated potential changes in management practices.</td>
<td>16</td>
</tr>
<tr>
<td>Inter-generational connectedness</td>
<td>Historical landmarks, ranging from cottage ruins to glacial erratics and old, peculiar-looking trees. Remind of historical heritage that participants feel responsible to maintain. Symbolize the long time-periods involved in forestry. Often relate to a feeling of responsibility towards neighbors and others. There are two sub-categories: (1) The landmark motivates management of the immediately surrounding landscape to maintain historical practices, and (2) The landmark is a symbolic representation and is protected, but does not otherwise directly motivate management of the surrounding forest.</td>
<td>12</td>
</tr>
<tr>
<td>Conservation and recreation</td>
<td>Protected areas and large water bodies appreciated for their beauty and biodiversity. Positive memories often attached to them due to being frequented for outdoor recreation with friends and family.</td>
<td>10</td>
</tr>
<tr>
<td>Upholding landscape aesthetics and diversity</td>
<td>Grazed pastures or harvested hay meadows that are appreciated because of their beauty, contribution to biodiversity and the importance of maintaining a historical practice.</td>
<td>9</td>
</tr>
<tr>
<td>Places with special personal attachment (indirect stewardship)</td>
<td>Places vary greatly in character, but are grouped based on their connection to particularly strong positive or negative memories. Generally managed to maintain the function that the place had at a specific point in time (connected to the memory).</td>
<td>5</td>
</tr>
<tr>
<td>Dormant forest stewardship (indirect stewardship)</td>
<td>Places with conventional production forests (spruce). Included because spruce production forests are the most common forest types on the properties and because they generate income for the participant. The specific places that were included have all been planted by the participant or by a family member.</td>
<td>4</td>
</tr>
</tbody>
</table>
Based on the analysis of the type narratives, the forest owners generally expressed a diverse set of values motivating their stewardship practices, ranging from direct use consumptive values (like timber production as part of their livelihood) to bequest and existence values (responsibility to maintain a historical heritage and biodiversity, respectively). They also expressed relational values, for example connected to a responsibility towards neighbors and other members of society at large (Figure 11).

The diverse set of values that were attached to the selected places mattered for how the forest owners chose to manage their forest properties. The diversity of values poses a challenge for policy-makers and other higher-level forest sector actors that seek to influence this particular group. Policies that focus on different forms of instrumental values, for example those that are defined by ecosystem services, or intrinsic values, for example focusing on protection of endangered species, risk missing the relational values that this study reveals as strong motivating factors for forest owners' stewardship practice. This does not have to be a problem, however, if policy instruments are constructed in ways that target instrumental or intrinsic values, while not creating barriers for the individual's agency to enact management based on the relational values that personally motivate them.
Uses of the ecosystem service concept

Bringing it all together

I have now presented the four papers that make up this PhD thesis. The findings in these have provided insights into opportunities and challenges in operationalizing the ecosystem service concept for sustainability in landscape management. I will now elaborate on these insights, in relation to the three research questions. First, I discuss the role the ecosystem service concept can play for local actors (RQ1) and how the ecosystem service concept can be combined with other approaches to support knowledge co-production (RQ2), focusing on the three uses that I have identified: As a communication tool, a pedagogic tool and a bridging concept. Then, I reflect on what these uses imply for the application of the ecosystem service concept in support of stewardship practices (RQ3), focusing on the three attractors of stewardship: Knowledge, agency and care (Enqvist et al. 2018).

As a communication tool

Through the research presented in Paper I and II, the ecosystem service concept emerged as an effective communication tool. This is a common finding in research from other contexts as well, and one of the main reasons for why it was introduced in the first place: to communicate the contributions of well-functioning ecosystems to society (Daily 1997). The analysis in Paper II indicates that the ecosystem service bundles could be used to articulate several features of complex adaptive systems (Preiser et al. 2018). This confirms that concepts, analytical frameworks and terminology can play an important supporting role in complex decision-making contexts such as landscape management (Carmen et al. 2018, Preiser et al. 2018). In our case, the participants perceived that the bundles
facilitated communication and provided a structured way to simplify the complexity of social-ecological system interactions. The resulting diagrams functioned as stronger arguments in negotiations with other actors, precisely because they were based on empirical data from the study area (McKenzie et al. 2014).

However, Paper III nuanced findings about these communicative strengths. In the other three projects, the ecosystem service concept was introduced, but then deemed too complicated to include in interactions with participants. This was likely due to a combination of factors, one of which was that these projects were not designed to generate learning about ecosystem services specifically, but rather included it as one academic concept among others. This meant that less time was spent on teaching, suggesting that the ecosystem service concept still (at the time of these projects, 2011-2020) is a complicated framework that needs to be properly introduced, before its usefulness can be realised (Beery et al. 2016).

It is also possible there is a difference between the approaches to ecosystem service research. Methods falling within the ecological and ecological economics approaches, like those used in the other three projects in Paper III, tend to have a high level of detail and be methodologically sophisticated, for example through computational modeling of future scenarios based on landcover data (Nordström et al. 2019, Lodin et al. 2020). The kind of information that can be gained from such methods is valuable for informing decisions that require high accuracy and reliability, like instrument design (Barton et al. 2018). However, the sophistication of these methods can also make them difficult to understand for actors who have limited experience with the underlying conceptual framework, in this case, ecosystem services. The ecosystem service bundles analysis that was used in Paper I, on the other hand, is comparatively simple. It cannot be used to inform decisions that require high detail, but its simplicity and visual appeal makes it easier to comprehend and engage with (Queiroz et al. 2015). Therefore, such methods are suitable for awareness-raising (Gómez-Baggethun and Barton 2013) and strategic communication (McKenzie et al. 2014) in a policy context when an issue is not yet on the agenda (Tomich et al. 2004). In later stages of the policy cycle, when actors generally agree that an issue is important, but need to negotiate the kind of policies needed to address them, more sophisticated methods become relevant (Barton et al. 2018, Marre and Billé 2019). These include both the kinds of analyses used in ecological and ecological economics approaches, but also insights, essential for priority-setting (Gómez-Baggethun and Barton 2013), that can be gained from
analyses of vulnerabilities, inequalities and environmental justice (development studies approach) (Daw et al. 2015, Dawson et al. 2017).

Therefore, the larger political and societal context matters for the communicative strength of the ecosystem service concept as such, as well as for the different approaches that are used to analyse them (Tomich et al. 2004, Clark et al. 2016). During the years that the four projects in Paper III lasted, there was a concerted political push to start using the ecosystem service concept in all levels of administration in Sweden (Beery et al. 2016). The last interactions in our participatory resilience assessment occurred later than in the other projects, meaning that participants had had more time to be exposed to material about ecosystem services beyond the context of our research project. Thus, the usefulness of the ecosystem service concept, as with any concept or other material stemming from research and academic discourse, cannot be separated from the larger societal context into which it is being introduced (Bohensky et al. 2015, Clark et al. 2016).

As a pedagogic tool

The ecosystem service concept also emerged as a pedagogical tool in the actual design of our participatory resilience assessment. As a concept that could be used to represent various elements in the landscape, it focused the exercises, giving the participants a shared vocabulary and definition of what was meant by multifunctionality (Abson et al. 2014). By always returning to the ecosystem services from the initial assessment, we could add layers of complexity through the conceptual system model building and strategy development, without losing sight of what the participants recognized and valued in their landscape. It functioned as an anchor for the exercises and gave a narrative arch to the resilience assessment.

The datasets that were used for the ecosystem service bundles analysis are generally well-known by many Swedish local actors, especially those involved in environmental monitoring. This allowed many of our process participants to partake in insightful discussions about the indicators, as well as suggesting changes when maps misrepresented the participants’ understanding of the local landscape. This process of iteratively both selecting services and developing the indicators contributed to the participants’ uptake of the concept, as the active engagement took them beyond merely being taught, to being involved in making important decisions about the analysis (Boeraeve et al. 2018). They gained valuable
insights about how to interpret not only our analysis, but other ecosystem service products that they encounter in their professional roles as civil servants and managers. Examples of such insights include the challenges with data availability and the simplifications that need to be made in order to consistently represent complex ecosystem processes in maps and models. It suggests that efforts to operationalize ecosystem services, and other academic concepts, is facilitated by practitioners taking part in not only framing studies, but also actively engaging in the practical aspects of the knowledge production process (Lang et al. 2012).

However, the usefulness of the ecosystem service concept for process design and learning depends on context and how it is engaged with. As already mentioned, the researchers in the other projects included in Paper III felt that it acted as a barrier in their interactions with practitioners. Being aware of the participants’ areas of expertise and knowledge levels is therefore important to account for when designing knowledge co-production processes, for example when choosing which concepts and tools to use, and how these should be introduced and incorporated into the process design.

As a bridging concept

Finally, ecosystem services emerged as a bridging concept in our participatory resilience assessment. Bridging concepts actively link disciplinary and practice fields and stimulate dialogue (Baggio et al. 2015). In our case, the ecosystem service bundles created a conceptual platform that the participants could meet around (Abson et al. 2014), where their diverse expertise could be discussed through the representation of fifteen different ecosystem services in the same figure.

Findings in Paper III, however, points at some limitations of this use. The focus on multiple ecosystem services, through the ecosystem service bundles, allowed the participatory resilience assessment to be flexible in terms of key challenges, as opposed to the other projects that focused on fewer services. When some participants objected to the initially discussed sustainability challenge, which happened in most projects, we (SRC-KVB) could be flexible and complement the first challenge with two additional ones. It was made possible because the variety of ecosystem services in the bundle could be used to represent the other challenges also. This suggests that the value of ecosystem services as a bridging concept in knowledge co-production is increased if the type of analysis includes a diversity of services.
This is because such representations have the potential to connect actors with diverging interests into the discussion about synergies and trade-offs (Queiroz et al. 2015). However, such representations increase requirements on data availability. Covering multiple services with indicators that are analytically consistent is challenging. For analyses involving ecological or economic modeling, where requirements on data consistency is high (Barton et al. 2018), it might not be possible to find indicators to represent multiple services. The scenario modeling exercises in the other projects in Paper III were more restricted in terms of number of services analysed, but their capacity to articulate future trade-offs in terms of, for example, management options and climate change have other benefits (as discussed in previous sections). Therefore, the choice of method has to be guided by who the participants or intended users are, and what the desired outcome of the chosen ecosystem service analysis is (Marre and Billé 2019).

**Limitations**

The uses described in the previous sections are based on interactions with actors in public administration, the business sector, civil society organizations and researchers. These are contexts where the internal logic generally fits well with the instrumental framing of the ecosystem service concept. In other contexts, practices might be motivated by a much more diverse set of values (Chan et al. 2016). The narratives in Paper IV show that non-industrial private forest owners, as local private landscape managers, are motivated by diverse instrumental, intrinsic and relational values in their stewardship practices. Here, the focus on instrumental values in the ecosystem service framework can potentially create a tension, if policy and various incentives are solely focused on ecosystem services, while not giving space for local landscape managers to practice management that is motivated by intrinsic and relational values (Bieling et al. 2020). Therefore, decision-makers need to be careful when using the ecosystem service concept to design policy instruments with the intention to incentivize sustainable practices (Jackson and Palmer 2015). It is important that such policies do not create barriers for management motivated by other values (West et al. 2018). Next, I reflect on this balancing act through the opportunities and challenges in using the ecosystem service concept to support stewardship practices.
Operationalization for stewardship practice

Knowledge to inform actions in landscape management

The ecosystem service concept is a tool to structure knowledge through systematically synthesizing, exploring and monitoring ecosystem functions and how human well-being is influenced by these (as exemplified in the various ecosystem service analyses described in Paper I and Paper III). This partially represents the use as a communication tool described above. Monitoring, in turn, is important for following long-term developments of environmental conditions and is important for accountability (Wilkinson et al. 2013), which is a cornerstone in democratic governance (Garmestani et al. 2019). This is particularly relevant for actors in public administration. However, as is described in Paper IV, the ecosystem service concept cannot efficiently be used to capture the full range of values that motivate local actors when engaging in stewardship practices. It is therefore important to not overstate the concept’s strengths, and only use it to guide decisions for which it is appropriate.

By being a bridging concept and pedagogic tool, the ecosystem service concept also supported knowledge co-production. Knowledge co-production has the potential to contribute significantly to addressing many complex sustainability challenges, both to generate more credible, salient and legitimate knowledge (Cash et al. 2003, Clark et al. 2016), but also as a potential means for deliberation and dialogue about contested issues where interests and values diverge (Tengö et al. 2017, Norström et al. 2020). The analysis in Paper II also found that the ecosystem service concept, combined with other tools from resilience practice, contributed to the participants’ ability to articulate various features of complex adaptive systems. Such skills are important when striving to address complex sustainability challenges (Preiser et al. 2018, Sellberg et al. 2021).

The ecosystem service concept and the methods for their analysis that have been developed within various research fields, therefore, can contribute to stewardship practices both by supporting learning and by providing information that actions can be based on. The processes described in Paper I, II and III, however, occurred in a specific context (local and regional governance in Sweden), with specific types of actors as participants (mainly engaged in various forms of landscape management). As discussed in
previous sections, the ecosystem service concept needs to be introduced in
ways that are conducive to the participants’ professional contexts and
expertise. Beyond the specific context of these studies, there are situations
where the ecosystem service concept is likely to be equally facilitating, or to
hinder both knowledge co-production and some forms of stewardship
practice. In the next section, I discuss some such potential contexts.

Agency to influence various decision-making contexts

The ecosystem service concept does not automatically influence actors’
agency, that is, their ability and opportunity to act in a given context (Brown
and Westaway 2011). However, as a knowledge product, it can be used
strategically by actors to motivate or convince other actors to engage in
various practices (McKenzie et al. 2014), including stewardship. For
example, as described in Paper II, participants had been able to use the
ecosystem service bundles to communicate knowledge which they
themselves already had (about social-ecological system interactions) to
other actors with less expertise in ecological processes but with decision-
making power over how resources are dedicated to landscape management.
This is an example of strategic knowledge use (Rich 1997, McKenzie et al.
2014), which can influence an actor’s situated agency, that is, the ability to
influence decisions, practices and the actual constraining structures of a
specific situation that an actor is embedded in (Koene 2006, Järnberg et al.
2018). Through strategic use of the ecosystem service concept, actors in
contexts such as public administration have been able to introduce
previously ignored environmental considerations onto the agenda
(McKenzie et al. 2014). The instrumental logic of the ecosystem service
framework allows these environmental considerations to be discussed in
parallel with other interests and responsibilities that organizations such as
municipalities have (Beery et al. 2016, Schubert et al. 2018), because it aligns
with the logic in these decision-making contexts.

Similarly, private non-industrial forest owners and other local managers of
the landscape could use the ecosystem service concept strategically in their
communication, if they wish to convince other actors that their stewardship
practices are beneficial for long-term sustainability (Jackson and Palmer
2015). Here, a focus on multiple ecosystem services might be beneficial, as
this would take the conversation beyond conventional dichotomies of, on
the one hand, solely focusing on production of timber or crops, and, on the
other hand, the protection of specific habitats for the sake of biodiversity
As the use of the ecosystem service concept is currently being promoted in Swedish policy, framing the benefits from various stewardship practices through their influence on multiple ecosystem services has the potential to be favorably received by policy-makers and actors in public administration (Clark et al. 2016). At the same time, there is a risk that such strategic use might lead to local landscape managers, such as private forest owners, being made accountable to society in terms of the ecosystem services that they, through their management, are generating. This, in turn, risks excluding or crowding out other rationales of their practices in the long-term – rationales that play an important and positive role for many local landscape managers in creating meaning and identity, as evidenced in Paper IV and elsewhere (West et al. 2018, Bieling et al. 2020). This argument is sometimes brought up against payments for ecosystem service schemes (Gómez-Baggethun et al. 2010), and the risk of such commodification needs to be taken seriously if the ecosystem service concept is used strategically or in the design of policy instruments.

Additionally, participating in processes of knowledge co-production, about any issue, has the potential to be empowering, and thus influence participants’ agency (Norström et al. 2020). In this context, the ecosystem service concept emerged as a bridging concept and a pedagogic tool. However, it is important that the ecosystem service framing is not used to co-opt a process for the benefit of powerful actors. The instrumental framing of ecosystem services easily lends itself to actors in decision-making contexts with a similar logic, like the private sector and, at least partially, public administration. If a knowledge co-production process is conducted in a place where important actor groups base their motivations on a diversity of values, beyond the instrumental, this needs to be acknowledged in the process (Bennett et al. 2018). Interactions between actors need to be designed to give space to other types of valuation, in order for important perspectives not being missed (Arias-Arévalo et al. 2017).

In a Southern Swedish context like the Helgeå catchment area, this is important to be aware of but not necessarily deeply problematic. However, in contexts like Northern Sweden, where Sami (indigenous) interests compete with forestry and mining and where historic legacies have created structures of marginalization in landscape management (Moen and Keskitalo 2010), the use of the ecosystem service concept in a co-production process, without also acknowledging other values, risks increasing tensions, rather than facilitating dialogue. In order not to perpetuate old patterns of marginalization, ecosystem service analyses likely need to be complemented by analyses based on other conceptualizations of human-
nature interactions. On the other hand, if done with intention and care, the ecosystem service concept has the potential to be used as a tool for translation between different epistemologies, and thus highlight the value of previously ignored local or indigenous practices (Jackson and Palmer 2015). The function of the ecosystem service concept in knowledge co-production processes is therefore neither inherently facilitating or excluding, but depends on how it is used and who gets to design the process.

This connects the ecosystem service concept to discussions about deep leverage points (Abson et al. 2017). The deeper leverage points are generally connected to values and worldviews. Findings in Paper IV suggest that sense of home (*hembygdskänsla*) can be a deep leverage point for sustainability by motivating local landscape managers to engage in stewardship practices. However, I also found that the ecosystem service concept poorly captures the diversity of values that motivate these local actors in engaging in their stewardship practices. This seems to suggest that this deep leverage point cannot be targeted through the use of the ecosystem service concept. Meanwhile, findings in Paper II point in another direction. In certain policy contexts and, for instance, in some private sector situations, ecosystem services might be revolutionary. Using this framework can lead to acknowledging values in the landscape that previously had not been accounted for, due to the internal logic of those decision-making contexts (Wilkinson et al. 2013, McKenzie et al. 2014). That most of the participants interviewed in Paper II are embedded in such contexts is a likely explanation for why the majority of these actors were so positively inclined towards the ecosystem service concept. On the other hand, in other contexts, such as among local, private managers of the landscape or in indigenous practices, the introduction of the ecosystem service framework as part of inciting actions might actually be a step backwards. This highlights the importance of perspective and context in assessing leverage points related to the ecosystem service framework, as well as other concepts and knowledge products that are used to promote sustainable landscape practices.

Thus, the use of the ecosystem service concept has the potential to influence the situated agency of people striving to practice various forms of stewardship. However, its transformative capacity depends on the context, meaning that the analysis method that is used (or, indeed, if the concept is used at all) needs to be adapted to the situation.
Care as a motivation in landscape management

Care, arguably, is the aspect that puts stewardship apart from other forms of decision-making for sustainability (Worrell and Appleby 2000). The emphasis on ethics, or responsibility, ultimately makes stewardship practice a deeply situated endeavor that is embodied and practiced (West et al. 2018). This stands in contrast with ecosystem services as instrumental, or utilitarian, which is a logic that removes the services from a situated and embodied interaction, to becoming generalized and substitutable (Gómez-Baggethun et al. 2010, Chan et al. 2018). This is one of the criticisms of the ecosystem service concept, namely, that the representation of nature as a stock that provides services removes people from the fundamental interdependence in which we are encompassed as humans living on Earth (Norgaard 2010). As found in Paper IV, such instrumental values also do not capture all of the meanings private non-industrial forest owners, and other similar local actors (Arias-Arévalo et al. 2017), assign to the landscape and that contribute to their motivations for engaging in stewardship practices. Instead, the meanings connected to care, generally those motivated by personal ethics and emotions, are described in terms of relational and intrinsic values (West et al. 2018).

Yet, as previously discussed, this disconnect does not necessarily have to undermine stewardship practices (Bieling et al. 2020). Policy-makers and others who use ecosystem services when designing policy instruments and other tools for landscape management, however, need to consider if a specific use risks undermining or counteracting existing care-motivated practices that local actors are already engaging in (Chan et al. 2016, Bennett et al. 2018). Findings in Paper IV, and elsewhere (Jakobsson et al. 2021), suggest that poorly designed forestry policies in the past undermined this actor groups’ trust and willingness to comply with rules. This also led to feelings of resentment due to other actors ignoring land owners’ care by solely focusing on simple measures of productivity or narrowly defined biodiversity metrics.

Recently, proposals for how to analyze ecosystem services in terms of relational values have been suggested (Klain et al. 2017, Himes and Muraca 2018). These are interesting and could potentially help to better articulate care through the use of the ecosystem service framework. Through IPBES, the concept Nature’s Contributions to People has also been proposed, as an umbrella term for several conceptualizations of human-nature interactions of which ecosystem services is one (Díaz et al. 2018). Additionally, there are other concepts and approaches that are already being used in various
scientific fields to articulate such interactions, for example sense of place (Masterson et al. 2017) (which was used in Paper IV), dwelling (Ingold 2000, Cooke et al. 2016), and biocultural diversity (Sterling et al. 2017). These are all approaches that are embodied and situated, and therefore, arguably, better able to articulate an understanding for how care contributes to stewardship practices (West et al. 2018).

After thoroughly engaging with the ecosystem service concept through the research in this thesis, I am inclined towards the opinion that the ecosystem service concept does not need to encompass all forms of human-nature interactions. Therefore, efforts to extend the ecosystem service framework to also encompass relational and intrinsic values might be pushing research in a direction where it does not need to go. Instead, we could focus the use of the ecosystem service concept on the types of valuations (mainly instrumental) that it was originally framed around and for the decision-making contexts where this makes sense (as discussed in the previous sections of this Discussion), while (and this is essential) acknowledging where its limitations lie. In parallel, we can expand on the concepts and tools that are better at encompassing other, more relational forms of human-nature interactions, exploring ways to make these frameworks and connected methods adapted to produce knowledge that will meet the needs of relevant decision-making contexts (Clark et al. 2016), complementing ecosystem service analyses.

I also believe that it is important to maintain an epistemological perspective on the ecosystem service concept, if it is to be used to produce usable knowledge, support situated agency and not undermine care in stewardship practice. An epistemological approach at least partially helps us avoid the issue of viewing nature as a stock, metaphorically removing us from our embeddedness in the ecosystems that we live in (Norgaard 2010). Through an epistemological approach, while still ontologically maintaining that we are embedded through interacting and complex relationships, we can use the ecosystem service concept as a tool to simplify complexity in situations where it is necessary for informing relevant actors in their decision-making for sustainable landscape management (Jackson and Palmer 2015, Ainscough et al. 2018).
CONCLUSION & WAYS FORWARD

In this thesis, I have explored some ways in which the ecosystem service concept may be used as a tool in various local stewardship practices and in support of sustainable landscape management. As an instrumental conceptualization of human-nature interactions, I found it to be useful for certain contexts, but not for others. For example, ecosystem service analyses could produce knowledge that simplified complexity, while still articulating important social-ecological interactions, allowing certain actors to strategically influence their situated agency to practice stewardship. However, the ecosystem service framework poorly captured care, which is at the core of many local actors’ motivations for why to engage in stewardship practices in the first place. The ecosystem service concept should therefore be used with caution, acknowledging its limitations, so as not to neglect or undermine important motivations for stewardship and other actions aimed at increasing sustainability.

As a conceptual tool with the capacity to bridge and translate between both scientific disciplines and between different ways of knowing, however, it presents a valuable contribution to both sustainability science and to practical sustainability work. Bridging though concepts and frameworks is particularly important in a field like sustainability science, where methods and theories stem from a diversity of disciplines, some of which are based in diverging epistemologies. Therefore, researchers in sustainability science can make an important contribution both to their own field and to sustainable landscape management by further developing concepts and tools that will help bridge the gap between disciplines and between science and practice. Ecosystem services can function as one such concept.
REFERENCES


