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Meeting Forest Futures with Payments for Ecosystem Services?

Assessing Payments for Ecosystem Services' potential for co-financing forest biodiversity preservation and climate change mitigation in Germany.

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Abstract

German forests are in a deteriorating state. The effects of climate change are increasingly showing and presenting society, and also forest owners, with the challenge of restructuring forests to become more climate resilient. At the same time there is a need to halt forest biodiversity loss and to further provide renewable resources that can be used to decarbonise its economy. At present forests' climate mitigation function and their importance as sources of biodiversity are undervalued and thus insufficiently translated into policy goals. This thesis explores how a novel economic policy instrument, Payments for Ecosystem Services, could be designed to restructure Forest Ecosystem Service governance in Germany and provide stimuli to transform forestry, forests and forest management practices to be better aligned with climate protection and biodiversity goals. With the help of an analytical framework a new policy proposal for the introduction of a Payments for Ecosystem Services scheme developed by the Thünen Institute (Elsasser et al. 2020a) is analysed and discussed. This framework builds on a recently emerged consensus of crucial design principles for PES and a Theory of Change (Wunder et al. 2020) perspective in an analytical framework to assess the policy proposal's potential to incentivise a sustainable and balanced provision of three Forest Ecosystem Services: biodiversity preservation, carbon sequestration and raw timber provision. Moreover, it compares the proposal to a well-known Finnish PES scheme for forest biodiversity preservation (METSO). The thesis demonstrates why it is essential to combine remuneration for biodiversity preservation with financial rewards for carbon sequestration in privately-owned forests to achieve the potential of the PES scheme at hand, but also to stimulate a restructuring of current forestry governance for a highly needed improved provision of biodiversity preservation. It discusses these findings in the light of the public debate around the need for preserving high-value biodiversity forest areas. It also points to the limitations of PES programmes, highlights the necessity for developing the policy proposal further and to complement its implementation with an effective policy mix to achieve its goals.

Keywords: Forest Ecosystem Services, Payments for Ecosystem Services, policy innovation, ES governance, Germany

Executive Summary

The European Union has itself ambitious targets to become the first continent to achieve climate neutrality by 2050 and transform its economies into sustainable low-carbon and resource-efficient economies. Forests and their sustainable management play a crucial role in achieving the European climate and sustainability goals. Their ability to sequester carbon in living biomass and the soil, as well as, their role in being the biggest source of biodiversity in Europe are becoming increasingly recognised. European forests are subject to a variety of socio-economic and political interests and demands. At the same time, they are currently in a precarious state. It has been reported that the overall state of the forest resource base, its resilience and biodiversity have been worsening due to a range of climate-related phenomena, but also due to unsustainable forestry practices and political mis incentives (e.g., FERN 2020). Recent research shows that Europe's forest biomass could be seriously affected by a changing climate in the future (Forziere et al. 2021). Making forests more climate resilient to maintain the present biomass and ecological state has thus become a major political concern and economic challenge.

Developing novel economic policy instruments to meet these challenges has been proposed by a variety of policymakers, scientists as well as NGOs to support Member States' efforts in achieving their biodiversity protection and climate mitigation. This thesis investigates how the development of novel Payments for Ecosystem Services (PES) schemes can be used to meet the above-mentioned challenges and sustainability goals. To do that, Germany was chosen as a case study. Germany's forests are presently in a precarious state (BMEL 2021). The effects of climate change are increasingly showing and presenting society and forest owners with the challenge of adapting to changing climatic conditions by restructuring forests. Currently climate mitigation function of German forests and their importance as sources of biodiversity are undervalued and thus insufficiently translated into policy goals and policies. This thesis explored how a Payments for Ecosystem Services scheme can help the German State to achieve its climate protection and biodiversity goals by balancing the trade-offs between three distinct Forest Ecosystem Services: carbon sequestration, biodiversity preservation and biomass provision. For that a recently published policy proposal for setting up a PES scheme in Germany (Elsasser, Köthke & Dieter 2020a) is analysed and compared to an already existing Finnish PES scheme for forest biodiversity preservation.

In order to meet this research objective three research questions have been developed:

RQ1) *What are PES design principles that support an economic and environmental effective provision of Forest Ecosystem Services?*

RQ2) *What are current policy proposals in Germany and Finland to improve the policy mix for balancing Forest Ecosystem Services provision?*

RQ3) *How can the choice of design elements, biodiversity and carbon sequestration indicators, and monetary values be implemented in a way that reconciles trade-offs between biodiversity preservation, carbon sequestration and biomass provision in the German case?*

The core of the Research Design is the analysis of the policy proposal and an anticipatory evaluation of its effectiveness and sustainability of its outcomes. For this an analytical framework based on a recently emerged consensus on PES design principles (Wunder et al. 2018) and a recently published Theory of Change for PES (Wunder et al. 2020) was developed.

To prepare the analysis and comparison, as well as embed the proposal into the current public debate, four steps were taken. In the beginning, an in-depth literature review of PES policy

evaluation studies and PES' underlying economic theory was conducted to identify elements of the policy instrument's design and implementation. Based on this the first RQ was answered. Main design principles, elements and contextual factors that have been shown to support the environmental and economic effectiveness were described in Section 2.1. A second crucial step in the Research Design was to interview researchers with expertise in the German and Finnish political and scientific context. These semi-structured interviews provided for information on recent scientific publications regarding Forest Ecosystem Services governance in Germany and Finland and were crucial in scoping the research. Thirdly, a desktop research was conducted which identified relevant documents for gathering information on the current state of EU and German forest policy. It was additionally used to find policy-briefs, scientific evaluation studies and document on the design, implementation and evaluation of the METSO programme to answer RQ2. Lastly, a content analysis of documents, online discussions, webinars and NGO reports provided for information on the public, scientific and political discourse around PES.

Based on these blocks, the policy analysis and anticipatory evaluation was conducted. The main findings of the research regard the analysis and anticipatory evaluation of the policy proposal. It was shown that Elsasser et al.'s (2020a) proposed remuneration scheme followed a comprehensive approach of targeting many forest ecosystem services. Moreover, it is based on a consistent argumentation for an outcome-based scheme on the national scale to support Germany's efforts in meeting its climate protection and biodiversity preservation targets. The proposal's main strengths can be found in its orientation towards the measurable and actual demand for forest ecosystem services, since this establishes a solid basis for calling for sufficiently high budget of the PES. This also established the basis for determining the measures for carbon sequestration and the biodiversity indicators. In showing that economic valuation studies found the contribution of forest biodiversity and carbon sequestration to be equal, the authors were able to suggest a value relation between these two services that expresses their equal financial value. Based on this they argue that it is equally important to provide sufficient economic incentives for both FES (Forest Ecosystem Services). Furthermore, by proposing to choose gross increment as a performance indicator for carbon sequestration, the proposal conceptualises the maximisation of synergies between carbon sequestration and biomass provision. On the other hand, it presented biodiversity indicators that are measurable and open to adapting to more ecologically oriented forestry management practices.

Moreover, it was found that setting the value of biodiversity and a discount factor for carbon sequestration needs further political deliberation and also democratic legitimisation, to also account for issues of permanence. It is in this choice of the indicators that a balance between the three forest ecosystem services can be incentivised by the analysed policy proposal. At the same time the indicators can be set in ways that reflect the societal demands and interest, which also allows for adaptation to changes in these demands, to newly won knowledge or changes in environmental conditions. Additionally, it was also found that the political support for financing forest carbon sequestration is high, whereas demands for remunerating biodiversity preservation is less publicly debated. This entails a threat to the biodiversity preservation overall, but also potentially for the implementation of the proposed scheme, in that either limited resources will be made available for biodiversity preservation or that the value relation between carbon sequestration and biodiversity preservation is changed in ways that remunerates the climate mitigation function of forests relatively more than their contribution to biodiversity protection.

In addition to that, some limitations of the proposal have been found. Firstly, the proposal does not discuss the case of facing a limited budget in the PES implementation. This would have substantive implications for the policy's design and implementation. Consequently, the proposed policy would presumably need to deploy spatial targeting and result in remunerating

fewer Ecosystem Services providers instead of remunerating all, which would reduce its potential and thus environmental effectiveness. On the other hand, by comparing it to the policy proposal to the METSO programme, it was shown that the proposed scheme could be adapted to a limited budget and that incentivising a balanced provision between biodiversity preservation and carbon sequestration would still be possible. Additionally, it was found that the proposal did miss out discussing enforced conditionality, a crucial design element to increase the PES schemes' effectiveness. Lastly, it was found that PES are restricted in achieving environmental conservation in that they often require complementing policies which preserve high-value conservation sites, which are not covered by PES schemes.

Based on these findings several recommendations for policymakers and environmental NGOs were developed:

Policymakers:

Designing a participative process for PES design and implementation

In the discussion, it has been shown that there are different perceptions of what problems the forest industry and forest-owners currently face, which in turn inform the calls for certain policy interventions and frame desirable solutions. One recommendation for policymakers is thus, that a participatory process should be designed in which different societal stakeholders are able to establish a common problem perception, which depicts the environmental threats, and base the aim of a potential PES scheme on this perception. This is advisable because there is a need to legitimise how a potential PES scheme configures the relation between biodiversity preservation and carbon sequestration. Moreover, this kind of process could be used to discuss the limits of the forest resource base and the uncertainty connected to this to show and debate on the limits of societal demands for forest resources.

Ensuring sufficient budget for improving the data base on biodiversity

Elsasser et al. (2020a) have shown that in order for the German state to meet its national biodiversity goals and its international commitments with a PES scheme would require the improvement of biodiversity indicators and monitoring. To make PES schemes work effectively, a sound data basis is needed, which under present conditions would need further funding.

Setting a mechanism to ensure *enforced conditionality*

Setting up a mechanism and finding an administration capable of monitoring and effectively sanctioning deviations in a PES scheme has been identified as one of the most important means to increase PES effectiveness. As the analysis has shown this should be further discussed.

NGOs:

Lobby for and ensure that biodiversity preservation and carbon sequestration are remunerated in combination

There is a threat that biodiversity preservation will not be equally valued as carbon sequestration or not be met by sufficient financial resources in the implementation of a PES scheme. It is therefore of crucial importance to communicate and demonstrate the immeasurable and measurable contribution of forest biodiversity to societal welfare. The policy proposal analysed provides a good basis for arguing scientifically for at least an equal value relation between these two forest ecosystem services.

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Abbreviations

EC – European Commission

EFI – European Forest Institute

ES – Ecosystem Services

EU – European Union

EU GD - European Green Deal

FES – Forest Ecosystem Services

MS – Member States

PES – Payment for Ecosystem Services

1 Introduction

The European Union has itself ambitious targets to become the first continent to achieve climate neutrality by 2050 and transform its economies into sustainable low-carbon and resource-efficient economies. To achieve these goals, it has developed the European Green Deal (EC 2019). This strategic framework, vision (EC 2019) and economic growth strategy aims at coordinating and updating a set of political strategies and policies to achieve a common direction towards a sustainable and "Just Transition" of Europe's economies. The governance of the European Union's natural resources receives special attention under this new framework. Strategies for agriculture (Farm to Fork Strategy, EC 2020a), biodiversity (Biodiversity Strategy, EC 2020b) and forests (EU Forest Strategy, EC 2020c; EC 2021) have been and will be updated. This reflects a growing recognition amongst politicians and scientists that preserving natural capital becomes increasingly essential in order to reach the EU's sustainability goals.

Forests and their sustainable management play a crucial role in achieving the European climate and sustainability goals. Their ability to sequester carbon in living biomass and the soil as well as their role in being the biggest source of biodiversity in Europe are becoming increasingly recognised. Forests currently receive an "unprecedented attention […] within the new (policy) tools" of the EU (Tomáš Krejzar, SINCERE 2020). The European Green Deal (hereafter EU GD) builds on and adds to this recognition by framing forests as pivotal to meeting its main priorities of climate mitigation and biodiversity preservation. In the Communication on the European Green Deal, it was stated that the European Commission "will prepare a new EU Forest Strategy covering the whole forest cycle and promoting the many services that forests provide" (EC 2020c). Hence, the strategy shall serve as an update of the already existing EU Forest Strategy (EC 2013) and will build on the updated Biodiversity Strategy (EC 2020b). Moreover, it shall be aligned with the Green Deal's priorities. The EU Forest Strategy aims to support the provision of the many Forest Ecosystem Services by also highlighting the importance of forests' economic dimensions (EC 2020c). It explicitly refers to and highlights the potentials of forests contribution to a circular bioeconomy (EC 2020c, p. 2). These newly developed policy priorities are expected to influence and change EU and Member State forest policies in the next years (Wolfslehner et al. 2020) and can be seen as a new set of political objectives, that policy development can be measured against.

European forests are subject to a variety of socio-economic, political interests and demands. They have become an even more contested resource within the newly emerging policy objectives. At the same time, they are currently in a precarious state. It has been reported that the overall state of the forest resource base, its resilience and biodiversity have been worsening due to a range of climate-related phenomena such as heat stress, droughts and pests, but also due to unsustainable forestry practices and political mis incentives (e.g., FERN 2020). Recent research shows that Europe's forest biomass could be seriously affected by a changing climate in the future, which increases the likeliness of windthrows, fires and insect outbreaks (Forziere et al. 2021). This outlook and the losses of trees in the past years are threating the economic viability of forestry. Making forest more climate resilient to maintain the present biomass and ecological state has thus become a major political concern and economic challenge.

On top of that, socio-economic and political demands for using forests' resources are increasing. A highly contested topic, which exemplifies the complexity of interests, are the EU's climate and energy laws' effects on forests. These currently incentivise the usage of wood as source of energy production and assess this as means to promote climate ambitions and stimulate economic growth. But there is a growing scientific (Camia et al. 2021) and public (Financial Times 2021) consensus that these practices are unsustainable and a major cause of biodiversity

loss and (illegal) deforestation in Europe[1], which threatens forests' climate mitigation and adaption potential, but also has severe adverse effects in other regions of the world (DUH 2021). On a broader level an imbalance between the use of forests (economic functions) and its preservation (biodiversity protection) has been widely discussed (Wolfslehner et al. 2020; D'Amato, Bartokowski & Droste 2020) and identified as a major driver of unstainable forestry practices. How to balance forestry and biodiversity is thus a pressing question for researchers, foresters and policymakers (WSL 2020).

The emerging political priorities of the EU GD can be seen as a response to the afore-mentioned crisis (climate and biodiversity, as well as the precarious state of forests) and to the perceived imbalance of Forest Ecosystem Services (FES) provision. The EU Green Deal, and the EU Forest Strategy (EC 2021) aim to reconcile the imbalance between use and preservation of forest ecosystems to ensure that forests can provide society with a broad range of Ecosystem Services (ES). This can be seen in the aim of the EU Forest Strategy Roadmap (EC 2020c) to ensure "the sustainable management of all EU forests, maximising the provision of their multiple functions while enhancing their productive capacity" (EC 2020c, p. 2) amongst other things. This aim in turn might lead to increasing trade-offs between different FES, but also requires a shift in current forest management practices. Simultaneous to the development of new political priorities a shift in forestry practices towards management for forest biodiversity conservation and carbon sequestration can be observed (Wolfslehner et al. 2020, p. 37).

This political momentum can also be perceived on the Member State level. European Member States play a central role in establishing a more balanced provision of the many services forests provide and in protecting forests' health, because the EU has no official legal competence for a supra-national forest policy (Wolfslehner et al. 2020). The main focus of this thesis thus is the question of how Member States can act to meet the precarious state of forests, to meet their international commitments in climate change mitigation and biodiversity protection, and the challenge of better balancing the provision of the many forest services.

1.1 Problem definition

At present it is difficult to predict to what degree EU forestry can remain an economically viable sector in the future given that the changing climate conditions in combination with unsustainable forestry practices have led to a precarious state of forests' health, resilience, and biomass stocks. The multiple challenges forest policy makers, foresters and forest owners are facing are to reverse these trends, to restructure forests to make them more climate resilient, and to find a more balanced approach towards providing many ecosystem services.

Developing innovative policy instruments (and novel business models) to meet these challenges has been proposed as a solution by science-policy networks across Europe. From an Ecosystem Services and political science perspective, developing novel policy instruments involves three stages: 1) assessing the trade-offs between various Forest Ecosystem Services to make these transparent and subject to processes of political deliberation, 2) developing innovative governance mechanisms and policies in order to provide the entire range of Forest Ecosystem Services (Primmer et al. 2021, p. 9) and 3) Assessing potential outcomes of these policies against the ecological boundaries and the political priorities set on Member State and EU level.

[1] Recent reports and media coverage on Estonia's forests for example show that these economic mis incentives paired with relaxation of regulations on strictly protected forests areas are having devastating effects on forests (FERN 2021).

1.1.1 Assessing the trade-offs of Forest Ecosystem Services

When developing new national policies to govern the provision of Forest Ecosystem Services (FES), it is important to assess to what degree forests can meet the growing socio-economic demands, the ecological needs of increasing their resilience and health, as well as the political objectives. Political scientists working at the science-policy intersection have identified the need to analyse the trade-offs between different FES in order to develop better governance mechanisms (and policies) that support and "take into full account the entire set of ecosystem services that forests provide, including the global dimension" (Wolfslehner et al. 2020. p. 5). Based on a growing awareness of forests' finite nature and relative scarcity these trade-offs are becoming inevitable and have to be decided on politically. Since forests provide (global) public goods like climate mitigation or biodiversity preservation, it can well be argued for that the governance of these services has to be subject to national political deliberation and democratic legitimation.

A more specific challenge in the analysis of trade-offs between various Forest Ecosystem Services exists in assessing their interdependencies and acknowledging these in the design of policies. Given forests' role in meeting the climate and biodiversity crisis, as well as the need to transform Europe's economies requires that special attention be paid to the preservation and enhancement of forest biodiversity. Forest biodiversity can be perceived as an ecosystem service in itself, but also as a precondition for a variety of other ecosystem services and life itself (also MEA 2003). It can be awarded a specific function in forests, because it is:

- a precondition to the various functions forests hold and the ecosystem services they provide society with. Findings from biodiversity-ecosystem function research show that "the extreme loss of biodiversity can reduce both ecosystem stability and a range of ecosystem functions". A loss results in a decreasing efficiency of ecological communities to produce biomass and thus sequester carbon, but also to recycle and store nutrients. On the other hand, it can be shown that biodiversity supports a number of ecosystem services, even though it is difficult to show this by establishing direct links. It can be argued that biodiversity could be an even more important precondition to the function of ecosystems and the services they provide than we know at present, which requires precautionary action to be taken. (Knapp 2019, p. 13).
- a Forest Ecosystem Service, that has not received sufficient political commitment to introduce effective conservation measurements, but also to integrate it into forestry areas outside the realm of protected landscape. This is due to a common phenomenon of lacking financial resources for biodiversity conservation, but also due to the difficulty of operationalising biodiversity into political goals (e.g., Jenkins et al. 2020; Elsasser, Köthke & Dieter 2020). As a consequence of lacking policy integration, Europe is also facing a trend in loosing (forest) biodiversity, through the loss of old-growth forests for example, but also through perverse incentives for using forest biomass for energy production (FERN 2021).

1.1.2 Developing innovative governance mechanisms and policies

Payments for Ecosystem Services (PES) schemes have become increasingly popular among policy makers in the last years. At the present an emerging consensus among policy makers, forest owner representatives and scientists alike can be observed: the above-mentioned challenges can be met with designing incentive-based policy instruments like PES. This can be observed in the formulations of the EU Forest Strategy Roadmap for example, which formulates the goal to "foster innovative financial incentives" (EC 2020c, p. 3), in research

projects[2], in statements by policymakers and forest owner organisations alike (SINCERE 2020). The consensus is that it needs financial rewards for the provision of non-market Forest Ecosystem Services for private forest owners, because there are no income opportunities that are provided by markets in which these services are traded or paid for. The question of how to develop effective economic instruments is thus receiving increasing political and scientific attention.

PES developed for the forest sector target private non-industrial forest owners, private industrial forest owners and organisations by providing financial incentives and thus income opportunities for adopting practices that enhance or provide a variety of Forest ES. In contrast to the field of agricultural policy, the forest sector is viewed as being self-sufficient in economic terms and as not depending on subsidies (Wolfslehner et al. 2020). Moreover, there is widely shared consensus that forestry and the forest sector should remain subject to the market and thus not be spoiled by subsidies[3]. The quest for policy instruments that can support a balanced approach to forest Ecosystem Service thus currently takes place within a policy setting that expresses a market-based understanding of the forestry sector. Economic instruments like Payments for Ecosystem Services (PES) are framed as politically viable solutions, because they function and operate within a market logic.

But the design and implementation of these schemes is challenging, since they have to adapt to the different contexts (political, legal, ecological, and socio-economic), and as policy instruments need to be financially effective and efficient in reaching their environmental targets. The success of these policies thus has to be measured against their financial and environmental performance. Additionally, these policies need to be designed in ways that account for the provision of the various forest services in a systematic way, i.e., either aim to minimise the trade-offs between the various ES and/ or maximise their synergies, while improving the overall resilience and health of forests.

1.1.3 Assessing the sustainability of potential outcomes

As for assessing the trade-offs and synergies of FES, it is important to evaluate and anticipate the potential outcomes of innovative policy instruments against a broad sustainability perspective. This includes assessing and anticipating their outcomes against the ecological boundaries, against the impact they have on different sectoral and political priorities, as well as the socio-economic impacts. Additionally, anticipating outcomes and impacts has to include and adapt to changes in these very systems. When looking at the current challenges forests are facing this need to account for changes in the environment and socio-economic trends becomes apparent. EU policymakers acknowledge that forest ecosystems "are under increasing pressure as a result of climate change, which aggravates other key drivers of pressures such as pests, diseases, extreme weather events and forest fires" (EC 2020c, p. 2). Socio-economic pressures arise from "rural abandonment, lack of management and fragmentation due to land use changes, increasing management intensity due to rising demand for wood, forest products and energy, infrastructure development, urbanisation and land take" (EC 2020c, p. 2). These developments have to be taken into account when designing policy instruments and assessing to what degree they have positive or negative impacts.

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[2] E.g. SINCERE – Innovating for Forest Ecosystem Services: https://sincereforests.eu/innovation/innovation-mechanisms/ or InnoForESt – Smart information, governance and business innovations for sustainable supply and payment mechanisms for forest ecosystem services: https://innoforest.eu/

[3] This consensus is shared among scientists (Wolfslehner et al. 2020), policy makers, representatives of the European State Forest Association (EUSTAFOR) and private forest owner organisations like the Confederation of the European Forest Owners (CEPF) (SINCERE 2020).

1.2 Aim and Research Question

The thesis is aiming to assess how novel Payments for Ecosystem Services schemes can support European Member States (MS) efforts in achieving their biodiversity protection and climate mitigation targets by remunerating the provision of these services through private forest owners. For the thesis a research objective of how a Payments for Ecosystem Service scheme can balance trade-offs between three distinct Forest Ecosystem Services: carbon sequestration, biodiversity preservation and biomass provision in Germany has been chosen.

In order to fulfil this objective, it was broken down into three research questions:

RQ1) *What are PES design principles that support an economic and environmental effective provision of Forest Ecosystem Services?*

RQ2) *What are current policy proposals in Germany and Finland to improve the policy mix for balancing Forest Ecosystem Services provision?*

RQ3) *How can the choice of design elements, biodiversity and carbon sequestration indicators, and monetary values be implemented in a way that reconciles trade-offs between biodiversity preservation, carbon sequestration and biomass provision in the German case?*

A recent policy proposal (Elsasser et al. 2020a) is analysed with the help of an analytical framework based on recent findings from PES evaluation studies. Based on that it is firstly discussed how trade-offs between different PES have been presented in the policy proposal. Secondly it will be analysed which design features and principles are applied, and lastly explored what potential impacts and trade-offs the policy proposal has. In a second step the proposal will be compared to a Finnish PES scheme to identify differences and commonalities, and potentials for further developing the proposal. In this way, a contribution to the ongoing political and scientific debate on how to best design incentive-based policy instruments in Germany shall be made. Subsequently, recommendations for policy makers and environmental NGOs will be developed.

1.3 Scope and Delimitations

This thesis focuses on the analysis of a recent policy proposal to find out how PES schemes can achieve a better and more sustainable balance in the provision of different ecosystem services. The thesis' scope can be differentiated by focusing on its theoretical and an empirical part.

To understand the economic policy instrument of Payments for Ecosystem Services a theoretical framework based on an in-depth literature review of PES design criteria and principles was developed. Scientific literature spanning the disciplines of environmental economics, ecological economics and Ecosystem Services research was reviewed to identify PES design criteria and principles that have been developed in these disciplines through iterative processes of assessing and comparing the theory and the implementation of PES schemes globally. For the development of the analytical framework key publications summarising PES design criteria and principles comprehensively have been focused on, while it was complemented with insights from the scholarly debate and evolution of the PES and ES concepts. Whereas the studies summarising the criteria and principles have only been published in the last 5 years, the framework has also been supplemented with studies covering the whole evolution of the ES concept (around 30 years) and the introduction of the PES concept in 2005 (Wunder 2005).

Germany was subsequently chosen as a case study because there is an ongoing public and political debate and a window of opportunity for a changing forest policy, which has developed in recent years. To further scope the thesis' approach an expert interview with Dr. Hannes Böttcher, an expert in the climate mitigation potential of German forests and the analysis of trade-offs between forest ES, was conducted. On the basis of this interview, the scope was further narrowed down to analysing a current policy proposal and comparing it to an already existing PES scheme aimed at preserving forest biodiversity in Finland.

The analysis of the trade-offs between Forest Ecosystem Services was focused on looking into two Forest Ecosystem Services with global public good character: forest carbon sequestration and biodiversity preservation, and their potential synergies and trade-offs with biomass provision. Moreover, considering biodiversity preservation in relation to carbon sequestration and biomass preservation was perceived as important, because it has received far less analytical and political attention than the relation between carbon sequestration and biomass provision so far. For the analysis and comparison only one policy proposal, the probably most relevant, for a nation-wide scheme in Germany was chosen. Additionally, the METSO programme, a "championed" (Primmer et al. 2013) PES scheme for biodiversity preservation in Finland was chosen for the comparison, due to its focus on forest biodiversity. Even though the METSO programme does not cover the whole country, it targets the southern part of Finland, where most of the privately owned forests are located. The empirical part thus includes the analysis of the policy proposal, and evaluation of METSO's effectiveness during its pilot phase (2001-2007), as well as the subsequent phase (2008-2013).

To compare the policy proposal with the METSO programme, different data was needed. Firstly, information on how national forest policies are embedded in the European sustainability, forestry and biodiversity governance structure was needed. In order to understand the political context of Germany better, the political discourse, as well as current political developments, and important legislation and strategies regarding forests had to be researched. To describe the METSO programme, information on its design and evaluation was needed. In addition to this literature and desktop research, two expert interviews with Finnish researchers were conducted to find out about current proposals and ideas to further develop the METSO programme.

Choosing to analyse a proposal for a nation-wide PES scheme implied leaving out analysing and comparing it to already existing PES schemes in Germany targeting agriculture and forestry on a regional level. Moreover, the methodological choice to analyse the proposal based on a comprehensive framework implied that single design elements could not be studied in more detail. Lastly, the comparison between the proposal and the METSO programme was restricted in that they target different scales (nation-wide versus southern part of Finland), and were distinct in their approaches. Nonetheless, the comparison proved to be fruitful.

1.4 Ethical Considerations

The research conducted for this thesis did not involve funding from an external organisation nor was anyone except the thesis supervisor in the position to influence the analysis of the thesis. The conducted interviews with researchers followed the principle of voluntariness and prior informed consent. The interviewees were informed of the purpose of the research and about how the data gathered would be used. Prior to the interviews, interviewees were asked for permission to record the interviews. The data and recordings were stored on a personal, password protected device. In individual cases interviewees were given the possibility to review the parts of the analysis they contributed to, to check for sensitive information, but also to correct any factual errors. The presentation of the respondents' names was chosen to clearly attribute the ownership of ideas. Since all of the respondents were researchers and scientists,

the data presented in the majority of cases regarded and represented their scientific work and findings, which in most cases are publicly available. There is no cause to believe that the mentioning of their names and their participation in the study will cause them any harm, disadvantage or put their reputation at risk. Participants were asked for the permission to mention their names and given the opportunity to withdraw their decision at any time before the thesis' publication. If data seemed to be politically sensitive, a considerate interpretation, contextualisation, and objective presentation has been aimed for to the best of the author's abilities and knowledge.

The research design has been reviewed against the criteria for research requiring an ethics board review at Lund University and has been found to not require a statement from the ethics committee.

1.5 Audience

This thesis is aimed at contributing to the public and scientific discourse in Germany. By comparing the analysed policy proposal (Elsasser et al. 2020a) to economic theory and policy evaluations it aims to provide background knowledge and embed the policy proposal into the scientific discourse, which could be useful for NGOs, national policymakers, but also scientists and researchers. To the author's knowledge this is the first in-depth analysis of the policy proposal, the publication of which has received attention from NGOs, policymakers and researchers alike.

The outcomes of the study could also be of interest for environmental NGOs working with the analysis of forest policy. The study discusses the importance of implementing economic incentives for biodiversity conservation and carbon sequestration in privately-owned forests in parallel, which has been called for by NGOs and policymakers. It also aims to embed the analysis of practical implications and of critical design elements to target a better preservation of biodiversity into the current public discourse by discussing the proposal's underlying assumptions and potentials for further development. Moreover, the thesis provides policy-makers with a comprehensive discussion of PES design principles and contextual factors that need to be accounted for when setting up new PES schemes. It also provides the basis for discussing the limitations of PES schemes. Additionally, the thesis applies recently established PES design principles and a Theory of Change perspective to analysing and anticipating the effectiveness of the policy proposal. It thus applies newly established analytical perspectives to a case, which could be of interest for researchers working with PES evaluation.

1.6 Outline

After introducing the subject and approach in *Chapter 1*, the work will proceed with presenting relevant literature on the concept of Ecosystem Services and the economic policy instrument of Payments for Ecosystem Services in the literature review in *Chapter 2*. The second part of *Chapter 2* establishes the analytical framework, which will be applied later on in the analysis and comparison of the policy proposal under consideration.

Chapter 3 presents the Research Design the thesis is following, as well as the methods used for collecting and analysing data. In *Chapter 4* background information will be provided on why choosing Germany and Finland as case countries for the analysis and comparison of PES schemes was considered to be a sound choice. It also sheds light on current political and scientific developments, which will be of relevance for embedding the analysis into these discourses later on.

In *Chapter 5* the analysis and presentation of the Elsasser et al.'s (2020a) policy proposal is unfolded (Section 5.1). Subsequently, the METSO programme is presented and analysed (Section 5.2). *Chapter 6* discussed the findings of the analyses and the comparison and evaluates the policy proposal, before the results are being reflected on in Section 6.2. The thesis concludes with *Chapter 7*, in which practical implications of the research as well as recommendations for future research are presented.

2 Literature review

This literature review is divided into two sections. Firstly, the Ecosystem Services (ES) concept will be described by tracing its origins and developments, by showing its relation to economic theory, and by depicting current research and the concept's importance for EU policymaking. Secondly Payments for Ecosystem Services will be described. After presenting its most recent definition a global overview of PES scheme implementation will be presented. Subsequently, an in-depth review of the economic theory PES schemes are based on will be conducted to show which design principles and criteria have been identified as crucial in the scientific literature. This perspective is going to be complemented by a Theory of Change perspective on PES to establish the analytical framework for the analysis conducted in Chapter 5. Moreover, policy evaluation studies assessing PES schemes' economic and environmental effectiveness will be reviewed before contested issues will be presented in the last section of this chapter.

2.1 Ecosystem Services concept

The Ecosystem Services (ES) concept or framework has been developed by conservation ecologists and ecological economists to draw political attention to the links between human society and the ecological systems (Droste, D'Amato and Goddard 2018, p. 1) and demonstrate how society benefits from the environment and nature. Following the "The Economics of Ecosystem and Biodiversity" (TEEB) definition (2010), ecosystem services shall here be defined as "the direct and indirect contributions of ecosystems to human well-being". While the idea of society benefitting from nature is hardly new, the ES concept "emphasizes the magnitude, breadth and criticality of this dependence and, broadly speaking, suggests that recognizing this dependence in economic terms and incorporating these values in decision making can substantially resolve the (environmental) crisis we are facing" (Lele 2013, p. 119). Through the acknowledgement of this fundamental dependence the concept relates to a "strong sustainability vision" (D'Amato et al. 2020, p. 1880).

A common depiction of how ecosystem contribute to human well-being can be found in Haines-Young and Potschin's cascade model (2010) (see Figure 1). The biophysical structures and processes of ecosystems (ecosystem processes) build the foundations of this model. Ecosystems are commonly described as the interaction of communities of living organisms (plants, animal species, bacteria etc.) with their non-living environment (e.g., the landscape). The structure and the processes they inhibit fulfil certain functions: they recycle nutrients, "produce" biomass, filter water etc. "Ecosystem processes and functions describe biophysical relationships that exist regardless of whether or not humans benefit" (Costanza et al. 2017, p. 3). Ecosystem services on the other hand are "those processes and function that benefit people, consciously or un-consciously" (Costanza et al. 2017, p. 3). They can only be defined in relation to the benefits they provide society with and thus from an anthropocentric viewpoint. These services are categorised as *provisioning*, *regulation and maintenance*, and *cultural services* following the Common international Classification of Ecosystem goods and Services (CICES, 2013, 2018).

Table 1: Examples of Ecosystem Services

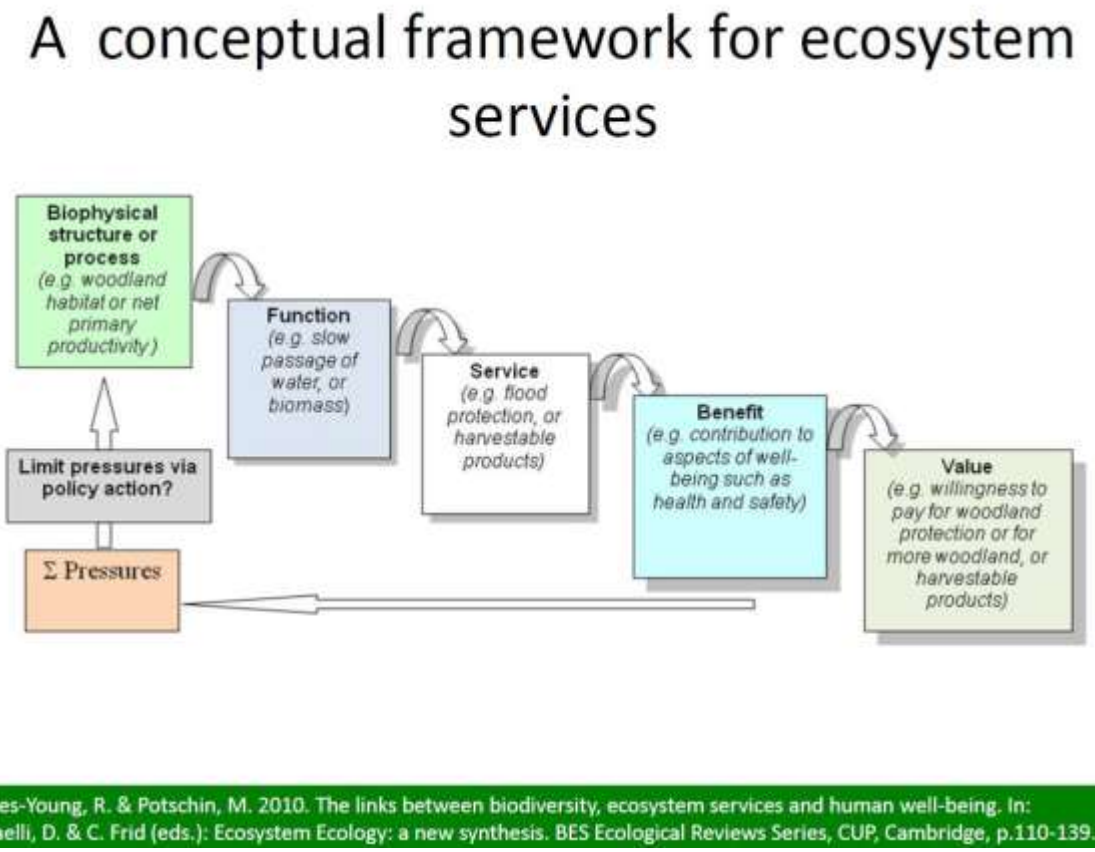
Ecosystem service	Examples:
Provisioning services:	Food, Water, Raw Materials, Genetic resources, Medicinal resources
Regulating and maintenance/ supporting services:	Air quality regulation, Waste treatment (water purification), Regulation of water flows, Moderation of extreme events, Erosion

	prevention, Climate regulation, Maintenance of soil fertility, Pollination, Biological control, Maintenance of life cycles of migrators species, Maintenance of genetic diversity
Cultural services:	Spiritual experience, Aesthetic information, Inspiration for culture, art and design, Recreation and tourism, Information for cognitive development

Source: Adapted from TEEB (2010)

These ecosystem services provide humans societies with benefits that fulfil basic material needs such as nutrition, clean air and water, physical and psychological health, safety, enjoyment (MAES 2013, p. 17; D'Amato et al. 2020, p. 1880). These benefits can be measured as values in economic terms, which can be used for policies and decision-making.

Figure 1: A conceptual framework for Ecosystem Services



Source: PowerPoint Presentation that Eeva Primmer provided the author with.

The definition of the ES concept, the categorisation of ES, and the benefits and values they provide is an ongoing development. Prior to CICES several other classification approaches to assessing ecosystem services have been developed: the Millennium Ecosystem Assessment (MEA 2003), The Economics of Ecosystem and Biodiversity (TEEB 2010), as well as the Mapping and Assessment of Ecosystems and their Services (MAES 2013, 2014) initiative of the EU. In addition to these conceptual and methodological developments and the refinement of

definitions, ES research today is concerned with the "applications and tools for ES mapping, valuation and policy implementation (…)" (Droste et al. 2018, p. 2).

To present the concept comprehensively in the following, its origins and historical developments as well as a crucial distinction between ecosystem functions, ecosystem services and ecosystem goods (Farley and Costanza 2010) will be depicted.

2.1.1 Origins and history of the concept

The term "ecosystem services" was first coined by Ehrlich and Ehrlich (1981) and bridged notions of natural and social science (Braat and De Groot 2012, p. 5). Its development followed the growing awareness of environmental pollution and the finite nature of natural resources of the 1960s and '70s, and the notions of having to manage economic development with a vision of sustainable development (Braat and De Groot 2012, p. 5). The concept was adopted as a 'boundary object' in research for "evaluating social-ecological system and as a basis for managing environmental change" (Droste et al. 2018, p. 1).

Gómez-Baggethun et al. (2010) show that the development of early notions[4] of the concept in the late 1970s was connected to a "utilitarian framing of beneficial ecosystem functions as services", which intended to increase the public's interest in biodiversity conservation (p. 1209). Subsequently, the concept was mainstreamed in the scientific literature with seminal publications like Costanza and Daly's (1992), Daily's (1997), and Costanza et al.'s (1997) on 'The value of the world's ecosystem services and natural capital' which demonstrated an increasing effort to develop methods to capture and estimate ecosystem services' economic value (Gómez-Baggethun et al. 2010, p. 1209). These publications have "kicked off an explosion of research, policy, and application of the idea, including the establishment" of the Ecosystem Services Journal (Costanza et al. 2017, p. 1). Gómez-Baggethun et al. show that the utilitarian framing was successful in attracting political attention to ecosystem services and the need to preserve them, but also point to the potential drawbacks of this framing. They claim that using market and payment schemes for conservation purposes might be counterproductive in the long run (p. 1209). This can be seen as the most pointed and sharply formulated critique towards trying to capture ES economic value as means to inform conservation policies, and as a main area of discussion in ES research (Droste et al. 2018, p. 2). Due to this critique and a discussion in the ES research the concept has evolved after "complex self-reflection processes mainly regarding the utilitarian framing" (D'Amato et al. 2020, p. 1880). Various approaches to capture indirect, intrinsic, cultural and spiritual values of ES complementing the economic valuation have been developed (e.g., IPBES 2015).

2.1.2 Ecosystem Services from an Ecological Economics perspective

This section presents a refinement of the ES concept proposed by Farley and Costanza (2010). Their crucial distinction between ecosystem services and ecosystem goods is an important analytical addition, which seems promising to the analysis of Payments for Ecosystem Services, which will be presented in section 2.2. Before describing this distinction, *The Heredia Declaration of Payments for Ecosystem Services* shall be presented, because it is the foundation on which the above-mentioned distinction builds and adds to the definition of ES in economic terms. Based

[4] Another important description of the concept's history can be found the Braat and De Groot's (2012) paper, which tracing its disciplinary backgrounds, in economics and ecology as well as in the synthesis in ecological economics (Costanza et al. 2017, p. 2).

on a number of assumptions on the nature of ecosystem services that differ significantly from a mainstream understanding of ES the declaration includes the following:

- *"Ecosystem services (the benefits humans derive from ecosystem functioning), and the natural capital assets that produce them, represent a significant contribution to sustainable human wellbeing larger than the contribution of marketed goods and services. The dominant economic paradigm does not adequately recognize these contributions and we therefore need to develop a new, more comprehensive paradigm.*
- *Ecosystem services are being threatened and degraded by human activities.*
- *Many ecosystem services cannot (or should not) be privately owned, and are therefore ignored by conventional markets.*
- *Many ecosystem services are such that providing benefits to one person does not reduce the amount of benefits available for others (they are "non-rival"), and therefore they should be provided cooperatively and not competitively.*
- *There are and will remain enormous uncertainties about how ecosystem services are provided, the magnitude of their benefits, and how human activities affect their provision. Stakes are high, the potential for irreversible outcomes are high, and a precautionary approach to decision-making should therefore be adopted.*
- *Adaptive institutions need to be developed to adequately deal with ecosystem services and tradeoffs among services so that their contributions to human well-being can be sustained and enhanced. Systems of payment for ecosystem services (PES) can be one effective element in these institutions".*

(Farley and Costanza 2010, p. 2061).

This declaration evokes a redefinition of what ecosystem services are, how they should be viewed from an economic perspective, but also what these perspectives mean for governing and managing ecosystem services. Firstly, it expresses that the ecosystem services and the natural capital assets that produce them add more to human well-being than the economic value of marketed goods and services[5]. Based on this perception it calls for the adoption of a new economic paradigm[6], since the dominant paradigm does not properly reflect this value, which is commonly seen as a reason for why natural resources are being depleted. This call has been further emphasised in 2017 by Costanza et al., who claim the "substantial contributions of ecosystem services to the sustainable wellbeing of humans and the rest of nature should be at the core of the fundamental change need in economic theory and practice to achieve" a socio-ecological transformation (p. 1). A second point of importance is that the knowledge on how ecosystems provide services through their function is and will remain highly uncertain, which restricts the potential of quantifying benefits, but also points to the limits of an active management of ecosystems to enhance and conserve the services they provide. This will be explained in more detail in the following paragraph.

On the basis of these arguments the authors introduce and propose a distinction between **'ecosystem goods'**[7] and **'ecosystem services'** (Farley and Costanza 2010). They propose to differentiate "ecosystem **goods as stock-flow resources** and ecosystem **services as fund-services**" (p. 2062) following Georgscu-Roegen's elaborations (1971) (emphasis added). They have established this distinction based on the perception of a fundamental difference in the

[5] In regard to forests a recent report by the Boston Consulting Group has estimated the economic value of global forests to be almost double the amount global stock markets with a worth of $150 trillion (BCG 2020). This demonstrates the increasing recognition of ecosystem services economic value by "dominant" economic actors and supports Farley and Costanza's argumentation from today's perspective.

[6] Interestingly enough, this call has been recently echoed by The Sustainable Market Initative, which aims to connect national and corporate leaders in an effort to create a new economic paradigm, which incorporates and depict the economic value of nature and forest better (https://www.sustainable-markets.org/10-point-action-plan/).

[7] A term coined by Daly and Farley (2010), who have called stock-flow resources ecosystem goods or ecosystem structure.

physical characteristics of two flows, that connect the economic system to the ecological system or ecosystem. The first flow, stock-flow, can be characterised as a throughput[8] of raw materials and stored energy. These are taken "out" of nature, "transformed into economic products and then returned to nature as disordered waste"[9] (p. 2062). The resources of raw materials and stored energy (e.g., in coal or oil) can be called ecosystem goods. They exhibited three properties: 1) they can be used at a rate society chooses, 2) their usage will physically transform them in the act of production and quantitatively use them up (p. 2062) (e.g., transforming wood into furniture), and 3) they can be stockpiled.

The second type of flow, **fund-services**, on the contrary is "generated by a particular configuration of stock-flow resources", i.e., it is rather the outcome and process of the interaction of resources than a single resource. These fund-services resources are like ecosystem services in that both are only available "at a given rate over time" (Farley and Costanza 2010, p. 2062), which restricts the quantity of the service that can be used. In contrast to stock-flow resources, fund-service resources are not physically transformed into the service, but rather changed in their quality. As a result, they cannot be stockpiled, nor can ecosystem services be mathematically modelled in the same ways as ecosystem goods. To better describe this distinction the authors recite the example of a car, which in a specific constellation of all the parts it is made of provides the service of individual transportation. After the car is deformed in an accident that parts on which it is built are transformed in ways that it thereafter cannot provide the service any longer, but they are only transformed and not physically used up. This proposed definition refines the provisioning services. Farley and Costanza's definition "stresses that the provisioning service is the capacity of ecosystem structure to reproduce itself, rather than the food, fibre, fuel and water provided (all ecosystem goods)" (p. 2062). It mainly adds a distinction in the provisioning services category to the existing characterisation of ecosystem services.

This distinction is crucial because it stresses the "dual nature of natural resources, and helps clarify why market economies systematically favour the conversion of ecosystem structure into stock-flow inputs into economic production over its conservation in ecosystem funds in order to provide ecosystem services" (Farley and Costanza 2010, p. 2063). The authors introduce the distinction for at least two more reasons. Firstly, they argue that thinking of ecosystems as "stocks that provide flows of benefits" can lead to seeking too "narrow, market-based solutions to ecological problems" and that this perspective cannot display the complexity of ecosystem services (p. 2062). Secondly, as mentioned above, they argue that the definition that is commonly used is, apart from its usefulness in certain areas, potentially misleading and that it is too broad and thus of "limited use in more detailed analysis of payment schemes" (p. 2062).

2.1.3 Ecosystem Services and biodiversity

There is an academic debate about whether biodiversity is a precondition for ecosystem services, an ecosystem service in itself. This section briefly summarises the main arguments for these three conceptualisations.

Biodiversity is the natural diversity of ecosystems, species, genes and landscape (UBA 2015, p. 24). It can be seen as a precondition for ecosystem services if one looks at how its loss impacts the provision of ecosystem functions and services. Knapp (2019) found that "(t)he loss of

[8] The concept of throughput is closely related to the second law of thermodynamics, which states that when energy is transformed or transferred its quality decreases, i.e. once energy is "used" it loses quality. This argumentation is here extended to economic products.

[9] This thinking, and the description of throughput was developed by the founding father of Ecological Economics: Nicholas Georgescu-Roegen in this 1971 book "The Entropy Law and the Economic Process".

biodiversity reduces the efficiency by which ecosystems provide ecosystem functions and related ecosystem services" (p. 38). This finding represents the scientific consensus of 20 years "biodiversity-ecosystem function research" (Knapp 2019, p. 38). Quantifying the exact amount of biodiversity loss, which will cause a substantial loss of ecosystem functions and services is hardly possible and thus unknown at present (Knapp 2019, p. 38). The author thus concludes that if the exact amount of biodiversity loss which will ultimately result in a loss of ecosystem services is unknown, biodiversity needs to be protected "as complete as possible – as a precautionary principle (Knapp 2019). This call for precaution has also been voiced by ecological economists before, who argue that because we "lack adequate understanding of ecosystems to know which functions are of value to humans and which are not, and often only find out after we have destroyed the ecosystem or species that provided them" (Farley and Costanza 2010, p. 2062) we need to take precaution. Whereas the link between biodiversity and ecosystem functions is well established and researched, the research on biodiversity-ecosystem service is less clear. That is mostly because ecosystem services cannot be as directly measured as ecosystem functions, and because data on ecosystems is often insufficient (Knapp 2019, p. 40). At present determining the degree to which biodiversity is a precondition for ecosystem services is not possible in ways that would allow to display how it is a precondition for them. This and the propensity of ecosystems to inhibit non-linear feedback loops makes it difficult to establish a causal link and explanation to what degree of biodiversity loss results in which degree of loss in ecosystem functions. Nonetheless, it can be assumed that a certain degree of biodiversity is a necessary precondition for ecosystems to "produce" services.

On the other hand, biodiversity can also be perceived as an ecosystem service in itself. It is distinct to other ecosystem services in that it is of indirect use and having an indirect contribution to human wellbeing. This perspective on biodiversity includes the acknowledgement that it is difficult to establish the connection between biodiversity and a direct use in the form of an ecosystem good or an impact. Measuring biodiversity is regarded as being difficult to achieve, since its value can only be determined through its intrinsic value and its benefits of enjoyment for people. (UBA 2015, p. 24).

2.1.4 Forest Ecosystem Services

The Austrian Environment Agency (UBA 2015) distinguishes 17 different forest ecosystem services:

- Biodiversity
    - Forest biodiversity
    - Pollination
    - Natural Pest Control
    - Natural Darkness
- Water quality and Availability
- Soil fertility
- Climate, Carbon storage and air quality
    - Carbon storage and climate
    - Microclimate
    - Air quality
- Protective function
    - Avalanches, debris flows and rockfall
    - Flood protection and control
- Wood, energy and by-products
    - Wood as building material, energy carriers and raw material
    - Renewable energy: hydropower
    - Wild animals

- Cultural landscape
    - Tourism
    - Recreation

2.1.5 Current Ecosystem Services research and outlook

This section is going to provide a brief overview of the research topics that are of current importance in the ES literature: 1) Analysing and accounting for trade-offs and synergies in ES management, 2) better including the complexity of ecosystems, and 3) broadening the valuation scope for better deliberation of appropriate ecosystem management practices. They have been identified on the basis of reviewing current reviews of the state of ES literature (Costanza et al. 2017, Droste et al. 2018, D'Amato et al. 2020).

One aspect that has been highly stressed in the analysis of ecosystem services management is the need to account for and analyse trade-offs between various types of ecosystem services. Since ecosystem services are commonly "jointly produced in the course of the resource management actions" trade-offs and synergies among different services result from that (Prokofieva 2016, p. 133). This is also caused by the implicit choices of different types of ecosystem management and does not only result in trade-offs between various ES, but also in trade-offs along sustainability dimensions (D'Amato et al. 2020, p. 1880). Researchers also claim that the drivers of these trade-offs are not taken into account sufficiently by scholarly analysis (Dade et al. 2019). According to Dade et al. only 19% of the assessments of ecosystem service relationships identify the "drivers and mechanism" that lead to these relationships (p. 1116). As the table below shows these drivers can be of indirect and direct nature, and include a wide array of factors:

Trade-offs are thus considered as being an inevitable result of land-management choices, but also require a transparent consideration if the choices made require a sustainability assessment against the various sustainability dimensions (economic, ecological, social, and cultural). Including the drivers, synergies and trade-offs into the analysis of ES and ecosystem management increase the complexity of the analysis, but also of the practical implication and consideration for governance. This is, as the next part shows, a necessary but also desired condition, if one wants to account for the complexities involved.

A second major issue in ES research has been identified as the need to better account for the complexity involved in assessing and analysing ecosystem services and changes in these services. To measure and map ecosystem services and the change in those services is difficult, since the "social and ecological factors, and their interactions, that create and alter ecosystem services are inherently complex" (Reyers et al. 2013, p. 268). The Cascade Model of ES (see Figure 1) has been criticised on the basis of that it focuses too much on the linearity implied by its graphical depiction, and does not properly account for the underlying complexity, which is to be found in non-linear feedback loops and of course the relative lack of knowledge about the relation and interaction of ecosystem services. What is more, is that the cyclical feedback of how changes in ecosystem services affect human-wellbeing and how this in turn feeds back and affects the generation of ecosystem services needs also to be added to the analysis (Reyers et al. 2013). Researchers thus suggest engaging more with socio-ecological systems and frameworks to account for how ecosystem services "are generated by interconnected social–ecological systems (SES), how different services interact with each other, and how changes in the total bundle of services influence human well-being (HWB)" (Reyers et al. 2013, p. 268).

Another major point of discussion can be found in the question what value dimensions should be included in assessing and determining the value of ecosystem services. While measuring the direct use and the connected economic value, which is quantifiable, is seen as effectively

informing policies, a main critique with this approach has been that including more value dimensions could lead to a better deliberation of the appropriate use and management of ES (Droste et al. 2018, p. 3). The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) has developed a framework which incorporates "various sources and concepts of values regarding nature's contribution to people and society such as anthropocentric values like instrumental, socio-ecological relational values, and ecocentric intrinsic values" (Droste et al. 2018, p. 4). Other approaches that are noteworthy are calls for an integrated valuation practice (Jacobs et al. 2016), and the insurance value of ecosystem services (e.g., Primmer & Paavola 2021).

2.1.6 The Ecosystem Services concept in EU environmental policy

The ES concept has "gained a strong political profile during the last 15 years" in EU policies (Bouwma et al. 2017, p. 213). It is mostly present in policies and strategies that address natural ecosystems and show a higher degree of policy coherence in these policy arenas (Bouwma et al. 2017, p. 213). As shown above, the concept provides a framework that allows for assessing how different policies impact the three dimensions of sustainability (economic, social and environmental) in a structured fashion and that is "sensitive to the interactions within and across different ecosystems and socio-economic systems" (Bouwma et al. 2017, p. 214). On an EU level it has been shown that "schemes fostering single ecosystem services remain dominant and as a result might lead to (unwanted) trade-offs with other services" (Bouwma et al. 2017, p. 217). This shows that whereas policy areas in which natural ecosystems are addressed already show a larger degree of considering the trade-offs between ES and thus also focus on providing ES bundles, the policy coherence across sectors is insufficient and in single cases leads to trade-offs between ES, also in natural ecosystems. A current example of this are the EU climate and energy laws which foster forest biomass provision for energy production, but do not take other ES into account.

This section has shown that the ecosystem services concept was adopted as a basis for assessing and managing environmental change and it used to inform conservation policies by estimating the economic value of ES. The concept has also been widely adopted by researchers of different disciplines and policymakers. The section provided insight into how ecological economists conceptualise the concept's use for driving ES management practices and policies and has highlighted that policy development is confronted with a degree of uncertainty about the value of ES, a need for taking precautionary action, but also to consider trade-offs for democratic deliberation. Lastly, it has been emphasised that some ES inherently provide global benefits and have to be valued on more than just the economic dimension for their appropriate use and management.

2.2 What are Payments for Ecosystem Service (PES)?

In this section Payments for Ecosystem Services, its definition, and theoretical debates regarding the conceptualisation of PES are presented. Subsequently, factors have been identified as important for a successful design and implementation of PES schemes by policy evaluation and assessment studies are reviewed. It is important to present the design principles of PES schemes in a comprehensive manner here, to use them as a basis for the analysis (chapter 5), as well as to show the complexities and resulting difficulties in designing and evaluating schemes involved. Even though comprehensive descriptions can be found in a variety of works (e.g., Wunder et al. 2018; Schomers 2019; Prokofieva 2016) bringing these findings together might help to get an ever fuller understanding of this economic instrument.

2.2.1 Definition

Payments for Ecosystem Services are an alternative economic policy instrument for environmental conservation (Prokofieva 2016, p. 130) and have been described as new "paradigm of voluntary, contractual conservation" policy instruments (Wunder et al. 2020, p. 211). They target land that is owned privately to protect or conserve it and can be seen as "counterpart to public protected areas" (Wunder et al. 2020, p. 210).

PES programmes "exchange value for land management practices" (Salzman et al. 2018, p. 136) intended to enhance or safeguard the provision of ecosystem services (Prokofieva 2016, p. 140) or other "less specified environmental benefits" (Schomers 2019, p. 4). They "redistribute wealth by making direct payments or compensations to those who produce the conservation benefit" (Raitanen et al. 2013, p. 18), but only on the condition that payments "are done conditional on the execution of certain agreed natural resource management practices" (Prokofieva 2016, p. 131). They can thus be seen as an advancement in environmental policies from the polluter-pays principle to the "provider-gets principle" (Wunder et al. 2020, p. 211).

The concept of Payments for Ecosystem Services originated from "the mainstream environmental economics understanding of market failures – namely externalities and public goods – being at the heart of environmental problems" (Prokofieva 2016, p. 131). It attempts to better "align private land- and resource-use decision with broader societal interests" (Wunder et al. 2020, p. 211), i.e., to solve environmental problems by either creating markets for ecosystem services or by rewarding the provision of non-market ecosystem services. PES schemes thus aim to better provide or conserve ecosystem services by financially incentivising landowners to adopt certain land-management practices.

The concept has been described as a "rather loose and multi-facetted term", since "many different conservation approaches (are) bundled under this "label"" (Schomers 2019, p. 4). Hence PES can be seen as an umbrella term for economic policy instruments for environmental conservation. Still, the term does not apply to as many instruments as Schomer's statement might indicate. The policy instrument has been defined as being only applicable to a narrow set of complex environmental problems. Its applicability is restricted by a set of conditions, which are important for the successful implementation of the instrument (Prokofieva 2016), but also by its definition:

The original and most commonly cited definition of PES by Sven Wunder (2005) describe it as

> *"(a) a voluntary transaction where*
>
> *(b) a well-defined environmental service (or a land use likely to secure that service)*
>
> *(c) is being 'bought' by a (minimum one) service buyer*
>
> *(d) from a (minimum one) service provider*
>
> *(e) if and only if the service provider secures service provision (conditionality)."* (Wunder 2005, p. 2).

This definition has been refined, based on scholarly debate and the development of the concept in theoretical and practical terms. In the latest definition of Wunder (2015) PES are described as:

> **"voluntary transactions between service users and service providers that are conditional on agreed rules of natural resource management for generating offsite services"** (2015, p. 241).

This refined definition is a departure from the original definition in at least two terms[10]. Firstly, it departs from the focus on financial or market transactions, which in practice have been complemented by in-kind payments (Prokofieva 2016). Secondly, it stresses the importance of "the spatial divide between ES provision and use, by targeting PES specifically to offsite externalities" (Prokofieva 2016, p. 132). This focus points to a more restricted applicability of the concept of PES as conservation policy instrument, in that it does not focus on other ES that can be internalised otherwise (Prokofieva 2016.).

PES schemes or programmes have received increased political and scientific attention in the last 10-15 years (Schomers 2019) and are a "trending topic in environmental resource management" (Prokofieva 2016, p. 130). Regarding forests it has been found that Forest Ecosystem Services are increasingly becoming subject of PES schemes. Jenkins et al. (2020, p. 1) find that an "active and innovative development of markets and payments for the ecosystem values of forests and other ecosystems" has taken place. Before turning to a more detailed and theory-based description of PES as economic policy instruments a look at the global status of PES development is useful to better present the scope and nature of PES schemes.

2.2.2 A global overview

On a global scale PES schemes are used to finance water, forest and biodiversity preservation as well as carbon sequestration (Salzman et al. 2018, p. 136). The first and most well-known scheme was developed in Costa Rica. This nation-wide programme called *Pago por Servicios Ambientales* was introduced in 1997 and aimed at reversing deforestation (Prokofieva 2016, p. 131). Other examples of PES and PES-like schemes exist in other Central or South American countries, in China, but also in the US and the EU, where they are mostly known as agri-environmental measures (AEMs) (Schomers 2019; Prokofieva 2016).

Forests have been in the centre of attention since the introduction of the first PES schemes. Many, but not all, of their ecosystem services are targeted by PES programmes. Their preservation and function as carbon sinks have received international attention. The Reducing emissions from deforestation and forest degradation (REDD) programme of the United Nations is a prime example of a PES scheme, which targets forest preservation and carbon sequestration. But other PES schemes also point to the increasing recognition of forests' "carbon/climate value" (Jenkins et al. 2020, p. 104). Likewise, the relation of forest protection and water quality has become increasingly financed through PES initiatives (Jenkins et al. 2020) On the other hand, the forest "biodiversity PES sector remains the least developed in terms of geographical scope and is most challenging for countries to put in place" (Jenkins et al. 2020, p. 108), which hints to blind spots or political challenges in better preserving forest biodiversity on a global and national scale through PES programmes[11].

Apart from the political importance of protecting forests' functions to provide ecosystem services, there also seems to be a growing consensus that the value of forests and the services

[10] For a more detailed discussion and explanation for the change in definitions and alternative definitions see Prokofieva (2016, p. 132, 133).

[11] The limitations of implementing PES programmes to preserve forest biodiversity on a global scale have recently been critically discussed (see Bigger et al. 2021).

they provide are undervalued in economic terms (Jenkins et al.2020). A recent report by the Boston Consulting Group for instance is estimating the economic value of global forests to be $150 trillion, almost double the amount of global stock markets (BCG 2020. This debate, with special emphasis on biodiversity, has recently been complemented by the Dasgupta Review (2021), which calls for a new human-nature relation that recognises the "true" value of natural capital and incorporates this better into political and economic decision making.

Most of the globally existing PES schemes are publicly funded and were initiated by governments (Schomers 2019, p. 4; Prokofieva 2016, p. 134). But civil-society organisations also share a large part of PES schemes' financial volumes.

In sum, forest PES have been implemented all over the globe with different scopes and volumes of funding. At present, a push for better capturing the value of Forest Ecosystem Services and the natural capital to design and restructure different modes of land-governance and management practices can be observed. This is partly based on a growing global awareness of the detrimental effects of reducing habitats as a result of deforestation largely driven by an expansion of agriculture, which leads and has led to the outbreak of epidemics and the current global Covid-19 pandemic for example. One could argue that in order to work effectively PES schemes are dependent on a more extensive monetary valuation of ecosystem services, a development which currently for the reasons mentioned above gets new momentum. The potentials and limitations to the functioning of PES programmes shall be further examined in the next section, which starts from a theoretical examination of the policy instruments.

2.2.3 Economic theory

In a first step, I will analyse economics literature to identify the characteristics of the economic instruments and to show to which specific cases and problems of natural resource management PES schemes are deemed to be appropriate.

PES, as indicated above, were conceived as solving complex environmental problems. As such they have to deal with `spatial externalities`, a concept which describes the phenomenon that the costs for providing global public goods, such as carbon sequestration, biodiversity protection or watershed protection, have to be borne on the local level. These public goods are "prime examples of externality-driven ES" (Wunder et al. 2020, p. 210). PES were conceptualised for the cases in which extrinsic financial or non-financial rewards were needed for "safeguarding positive spatial externalities from landholders and resource stewards to society at large" (Wunder et al. 2020, p. 210), that is the provision of ES on the local level.

From an environmental economics perspective, the basic rational for PES lies in matching a "voluntary willingness to pay (WTP) on behalf of the ES users (or their government-financed representatives) and a corresponding willingness to accept (WTA) payments on behalf of ES providers" (Wunder et al. 2020, p. 213).

A big challenge, conceptually, but also politically, is to define and determine the "right" price, reward or level of compensations for the provision of ecosystem services in PES schemes. This can be done either by looking at the demand for the good (e.g., the price that market participants or governments are willing to pay for a sequestered tonne of CO_2) or by looking at the supply side (e.g., the costs of certain land-management practices). Another challenge lies in choosing a suitable measurement for the financial reward. This can either be the actual outcome of land-management practices (e.g., the increase in sequestered carbon) or the action taken that potentially leads to a positive change in the environment (e.g., more nature-friendly ways of harvesting wood to minimise detrimental effects on biodiversity). This can be conceptually represented as in the following Table:

Whereas there is a substantial disagreement in the scientific literature on how to determine the price to effectively conserve ecosystem services, there is a consensus that outcome-based schemes are more effective in practice. This shall be discussed in the following to explore the conceptual dimensions presented in the table above and with a focus on the three Forest Ecosystem Services that are examined more closely in this thesis.

The price and/ or value of public goods in economic theory can be derived from either looking at the demand or the supply side. Determining the ***demand side*** prices is often connected to establishing the price for goods that individuals or a society at large are willing to pay to enjoy the benefits of an ecosystem service provision. It can be argued that for the ES of biomass provision and carbon sequestration a price is rather easy to determine. For biomass (e.g., roundwood, or wood used for other purposes) a price can be determined by looking at the prices these goods are traded for in markets. The value or price of carbon sequestration on the other hand can be derived from national taxes on CO_2, the price of tonne CO_2 in the European Emissions Trading Systems (EU ETS), or from economic theory, which discusses the Social Costs of Carbon (SCC). However, the price of biodiversity conservation is far more difficult to derive from its demand, because markets for trading biodiversity as a "good" are underdeveloped or missing (Primmer et al. 2013), and because biodiversity is difficult to measure quantitatively and qualitatively. To determine the ***supply side*** price in the case of the three ES chosen can be done by either taking the opportunity costs (e.g., foregone revenues of selling wood as biodiversity protection measures decrease the total volume of wood harvested) or the costs of measures that are aimed to provide a certain service (e.g., afforestation to increase carbon sequestration).

Choosing the price is often influenced by various factors, e.g., the availability of information of the demand (CO_2 market price, economic valuation studies), the ability to actually measure outcomes, or the political legitimacy of setting a price (if e.g., a price has already been decided on to introduce a cross-sectoral carbon price). These same factors might also influence the choice of rewarding an action/measure or the actual outcome/result. If for example data for biodiversity is not available, it might be easier to fund actions that are deemed to enhance or preserver biodiversity. Still, the academic literature is expressing a consensus that focusing and rewarding results or outcomes is more effective in economic and environmental terms.

In order to distinguish PES schemes from other economic instruments for environmental conservation the distinction between "price-based" or "quantity-based mechanisms" (Ring and Schröter-Schlaak 2019, p. 321) is useful. This definition will be important to later discuss the policy proposal and compare it to other already existing PES schemes to show the degree to which systems can be compared and how that potentially restricts their analysis. "Price-based mechanisms" include PES programmes, the UN's REDD programme, and ecological fiscal transfers (Ring and Schröter-Schlaak 2019, p. 321). "Quantity-based mechanisms" on the other hand include "tradable permits and habitat banking" (p. 321). As such they are different from price-based mechanisms, in that they establish the foundations for a market-transaction, in which participants can buy biodiversity offsets, if they e.g., plan to restructure landscape in ways that is detrimental for its biodiversity.

This section has shown how the amount of payments for outcomes or measures of land-management practice can be derived from looking at the demand or the supply-side of ES provision. The next section will present elements of PES in detail.

2.2.4 Design principles and implementation of PES

In this section, economic design and implementation principles for PES programmes shall be described in depth. For that findings from various studies will be synthesised, presented in two

lists and described in more detail. Since there are scientific papers, that solely deal with design principles the aim of this section is to simplify the descriptions of these and omit some of the main discussion points, which are presented elsewhere more sophisticated and in a more detailed manner. Subsequently, a Theory of Change will be presented that depicts most of the design principles to show how they interact with other contextual factors of PES schemes.

At present sufficient knowledge has been gathered to list a set of key implementation features that have been developed through scholarly debate, but also through an iterative process of theory building and its matching with emerging evidence from practice (Wunder et al. 2018, p. 146). This has not been the case until recently, when scholars found that policy assessments studying the practical implementation of PES schemes to inform design principles were lacking considerably (e.g., Prokofieva 2016, p. 130). Even though the policy evaluation of PES schemes is lacking in "scientifically rigorous impact evaluation" still, knowledge on the design principles has been won through comparing PES case studies to cross-sectional meta-studies and other similar incentive-based mechanisms (Wunder et al. 2018, p. 146).

Context and stylised design principles

It is important to recall Wunder's PES definition here: the essence of a PES scheme is expressed in a voluntary (contractual) agreement between the users and providers of ecosystem services that prescribes transactions that are "conditional on agreed rules of natural resource management" (Wunder 2015) for generating offsite ES services. Voluntariness ensures that both parties are able to terminate the agreement if certain, conditional criteria are not being met (Prokofieva 2016, p. 132). For enabling these contractual agreements, the PES design has to take into account context specificities as the "ecological, institutional, and cultural preconditions" (Prokofieva 2016, p. 132), but should also include some generalisable and contextually customised features (cf. Wunder et al. 2018, p. 146). The following non-extensive lists present some of the contract`s key design principles, which can be distinguished into "contextually customized" (Wunder et al. 2018, p. 145) and generalisable, "specific stylized design and implementation recommendations" (Wunder et al. 2018, p. 145):

Contextually customised:

- **Duration of the contract** (Wunder et al. 2018) or
- **Duration of the programme** (Molenaar 2013)
- **Contract type** (Molenaar 2013; Börner et al. 2017) and
- **Payment modes** (Wunder et al. 2018; Börner et al. 2017; Engel, Pagiola & Wunder 2008)
- **Scale of the PES** (Wunder et al. 2018; Molenaar 2013)
- (Clearly) **defined targets** (Molenaar 2013)

The **duration** of the PES programme determines the timespan in which payments are either funding resource management practices or rewarding the actual provision of offsite ES. The duration of the contracts influences the effectiveness of the land-management or -use practices and the participation of landowners (Molenaar 2013). Designing lasting programmes is said to be more effective (e.g., Wunder et al. 2018). Since natural resource management is confronted with long timespans and uncertainties (Prokofieva 2016, p. 136), planning to finance these schemes over the long run is important. This is especially true for forests, which are faced with comparatively long planning horizons and timespans after which the effects of land-

management practices show. On the other hand, contracts that are too short in duration might entail too high transactions costs for landowners to join (Engel 2016) (e.g., administrative costs or time spent on negotiations). On a more general level the duration of the contract can be designed in ways to suit the interests of the contract parties, which can result in a variety of timespans, in flexibility of extending the contracts or even to an infinite timespan (Kay 2016).

The **contract type** characterises the contract in terms of the buyers. It can differ between public, private, or public-private types (Molenaar 2013), which depicts who the beneficiaries and thus payers of the ES provision are.

The **payment modes** can differ between financial and non-financial payments. This is well-depicted in the table below, in which Wunder et al. (2020) differentiate between *cash* and *non-cash conditional incentives* as well as *complements*. The latter include land-tenure reforms, environmental education and technical assistance (Wunder et al. 2020), as well as advice (Molenaar 2013). Whereas the first *complement* is rather a necessary precondition for landowners to be able to act, implement land-use practices, the latter *complements* help in the implementation of resource management practices. They can support landowners and conservation stewards in better understanding how to achieve certain outcomes and by which (technical) means to do so. And by this improve the effective implementation (Schomers 2019, p. 4). Other payment modes like in-kind payments or the provision of conditional land rights as payments are discussed in Wunder et al. (2020, p. 218).

Choosing the **scale of the programme** has been found to influence the level of effectiveness of the programme: certain sizes of programmes tend to be more effective in reaching environmental targets (additionality) (Molenaar 2013). The scale of programmes can vary from local to national, and even international. Its choice is influenced by the nature of the environmental problem but also on considerations on how to ensure monitoring and effectively assessing the implementation of contracts, as well as cost considerations of installing administrative structures.

Including clearly **defined targets** into a PES programme is also considered to increase its effectiveness (Molenaar 2013). This is suggested as being crucial for the successful implementation of large-scale PES schemes (Molenaar 2013). But defining targets is not feasible in all cases, which is reflected in the refined PES definition (Wunder 2015). The revision of the definition reacted to the "fiercely criticized notions of "well-defined" ES as a performance indicator" (Prokofieva 2016, p. 132) and erased it. This goes to show that where possible environmental benefits should be specified, but that it should not be constitutive for PES programmes. Taking the example of biodiversity, it will be discussed later how defining clear targets is not always possible (e.g., due to lack of data). Thus, there is a dissensus on whether PES should include defined targets from a theorical point of view and from a practical or feasibility point of view.

Stylised features:

- **Spatial targeting** (Wunder et al. 2018)
- **Payment differentiation** (Wunder et al. 2018; Börner et al. 2017; Primmer et al. 2013)
- **Enforced conditionality** (Wunder et al. 2018) enacted through **monitoring and sanctioning**

In contrast to the above-mentioned design features, that can be used to adapt the PES scheme to socio-economic, political and ecological contexts, the stylised features described here can and should be applied and implemented in all PES schemes to improve their effectiveness, with the exception of that payment differentiation is only needed when opportunity costs are considered. One major measure of environmental effectiveness is **additionality**.

The ultimate goal of the PES is to create environmental **additionality**, i.e., a positive change in the state of the environment, the protection or enhancement of an ecosystem service, which has to be measured against an assumed baseline scenario: "Additionality assessment requires an establishment of a counterfactual baseline – that is, an estimation of the expected ES provision in the absence of any PES mechanism" (Prokofieva 2016, p. 135). Comparing this to the expected or actual outcome is then used to determine the additionality. It typically entails the establishment of "a control site and the use of statistical matching techniques" (Prokofieva 2016, p. 135) to measure the evolution of the ES provided. Additionality can be improved through a variety of factors. A meta-study of 55 PES-schemes (Ezzine-de-Blas et al. 2016) showed that additionality is increased by three "theoretically recommended PES 'best design' features: **spatial targeting, payment differentiation**, and **strong conditionality** (…)" (p. 1).

To target specific areas can make economic and environmental sense. From an environmental perspective is advisable to include **spatial targeting** because the ecological characteristics of conservation sites differ in the densities of the ES they provide (e.g., high ecological values in biodiversity hotspots) and in their potential of change (e.g., expansion of forestry into areas with high carbon forest stocks) (Wunder et al. 2018, p. 145). This in turn affects the economic effectiveness as well. It is assumed and proven by already existing schemes that targeting high-value or high-ES density sites and "high-treat areas for PES enrollment" pays off (Wunder et al. 2018, p. 145). However, given that conservation financing often faces budget constraints three cost-effective strategies are advisable. Firstly, it might be good to "pre-target low-cost providers" in contexts where the provision costs differ substantially (Wunder et al. 2018, p. 145), i.e., where some landowners face lower opportunity costs and thus can provide the ES at far lower costs than others. Secondly, areas of high ecological value, biodiversity value or high carbon sequestration potential might be excluded for cost-effective reasons, if the provision costs of ES are too high in relation to a maximising approach of the provision of ES under economic criteria and under a given budget constrain (J. Kangas, personal communication, 30. March 2021). Secondly, it might be the case that not all landowners eligible for being enrolled in the scheme can participate due to budget reasons. In this case, it can become important to target areas with "expectedly highest ES gains" compared to baseline scenarios (Wunder et al. 2020, p. 216). Lastly, "thresholds and other ecological interaction effects may imply that spatial targeting needs also to enrol a minimum area size" (Wunder et al. 2018, p. 146) or should consider the vicinity of other conservation area sites to the sites being funded to improve functional biodiversity, which needs larger connected areas to strive.

Payment differentiation is an important design feature if the PES scheme is including opportunity costs of ES provision as basis for determining payment amounts. These may differ among ES suppliers, because of higher foregone revenues that are resulting from higher ecological values like more fertile soils or logistical advantages (e.g., being closer to markets) (Wunder et al. 2018, p. 145). The ES suppliers might thus face different opportunity costs, which will inform the provision costs and their payment demands. PES implementers should thus "vary payment offers according to proxies of provision costs" (Wunder et al. 2018, p. 145), to increase the programme's economic efficiency.

C**onditionality** and **enforcing sanctions** are crucial to the success of PES implementation. Wunder et al. (2018) define conditionality as the mix of compliance monitoring, which includes

"efforts to detect non-complying participants" through a combination of remote-sensing technologies and "on-site ground truthing", and sanctions (i.e., penalties for detected non-compliant participants) (p. 146). This combination is needed to hold ES providers accountable for their contractual obligations and preventing them from receiving payments without changing their land- or natural resource management practices (Wunder et al. 2018, p. 145). Apart from the difficulties of "complex biophysical monitoring or prohibitive transaction costs" Wunder et al. (2018) found that enforcing sanctions is not solely a design issue, but also has political dimensions. In comparing PES schemes globally Wunder et al. (2018) show that enforcement can be a "politically sensitive question" (p. 149). This may be due to the political costs of installing effective sanctioning systems that are connected to and influenced by the "administrative complexity of sanctions", increasing financial burdens for already poor PES-providers, and erosion of trust (p. 149). What is more is that the implementation of PES schemes might follow other political economy objectives than the stated environmental objectives: "Tolerating non-compliance may often dovetail well with recipient welfare, developmental and electoral motives for transferring PES rents to favoured beneficiaries" (p. 149).

Additionally, to the stylised design features described above, the criteria of **permanence** and **leakage** have been identified as crucial factors to the targeted additionality of PES. **Permanence** denotes that the positive change and improvement in ES condition or their protection has to remain observable for at least the duration of the contract, or above and beyond that. It is difficult to foresee if the actions that should lead to a protection or enhancement of ES or the actual outcome of this are remaining in the future, due to changes in environmental conditions or land-use practices. The issue of permanence raises some serious questions, e.g., how much forest owners should be paid for carbon sequestration when their forests become net emitters in the future due to changes induced through land-management practices or climate change. These issues will be discussed later in more detail. **Leakage** describes the phenomenon that certain actions aiming at environmental conservation might result in adverse effects elsewhere, that might even outweigh the positive benefits achieved in the PES. The design of a PES thus should aim to minimise or avoid leakage. It is obviously very difficult and complex to design policy instruments in ways that ensure minimised leakage due the complexity of contextual factors, like legal, economic, or political structures.

After having described these contextually customised and stylised design principles (Wunder et al. 2018), it shall now with the help of a chart be discussed how these principles together with other design elements influence the implementation process. For that the Theory of Change for PES developed by Wunder et al. (2020) shall be presented and analysed. An account of what constitutes a PES and how PES work is thus presented.

PES implementation: A Theory of Change

In their 2020 paper Wunder et al. present a Theory of Change for Payments for Environmental Services. This representation is an up-to-date conceptualisation of PES programmes and includes all relevant characteristics to show the functioning of PES in practice. A Theory of Change is a tool used in political science to illuminate the linkages between policy elements of inputs, treatments, outputs, outcomes, and impacts (Weiss 1997).

In the following the elements of Theory of Change are described following a graphical depiction which is taken from Wunder et al. (2020) and supplemented with the finding of previous sections adding two blocks on design principles. The **inputs** to this Theory of Change represent preconditions for a PES implementation. The **legal-administrative frame** plays a crucial role in providing the legal and political basis for setting up PES schemes and the contracts. In this regard it has been widely acknowledged that well-defined and secured property rights and the

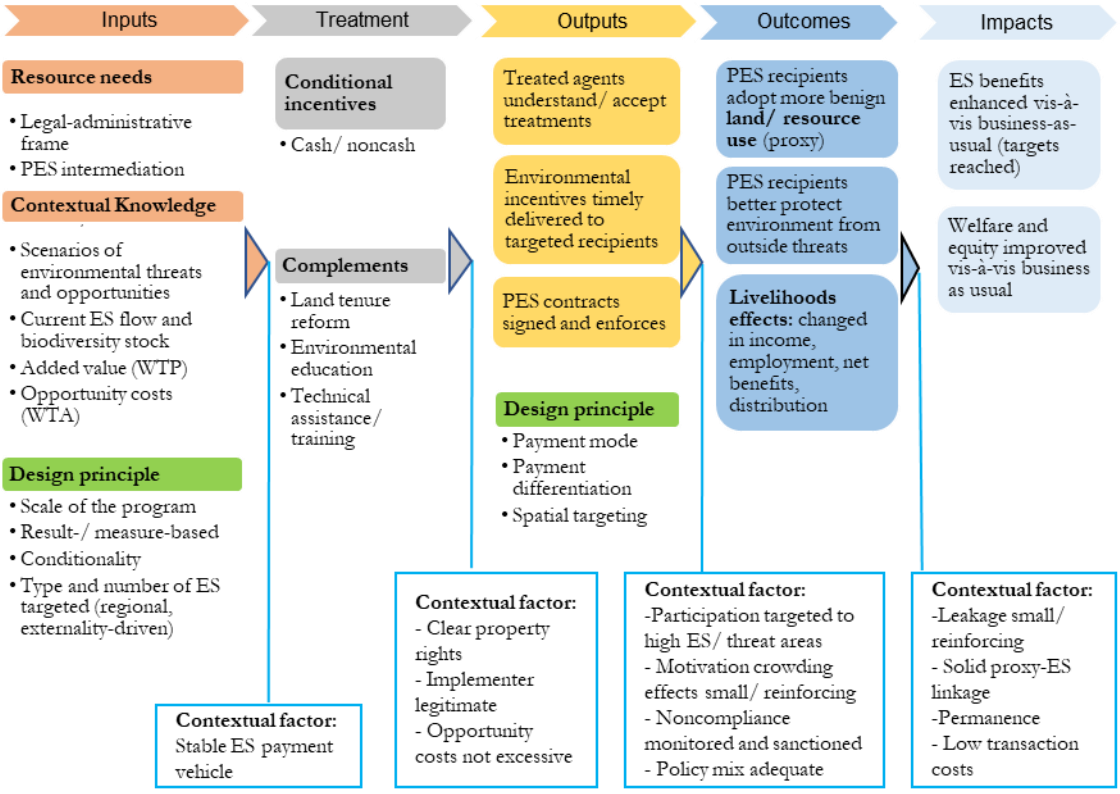
rights to alter land-use and -management practices are an important precondition that the state, or other legitimate authorities have to provide landowners with (Wunder 2005, 2013; Engel et al. 2008; Wunder et al. 2018). These rights are important for landowners to hold to be able to exclude third parties from using or benefitting from a landscape's resources, but are also a precondition for landowners to be "in charge of the decision-making processes that will come to determine ES provision" (Wunder et al. 2018, p. 145). In addition to that, *administrative* capacities in the form of institutions set up by ES users or the public are needed for introducing and managing the PES scheme (Wunder et al. 2018). But the legal-administrative frame also consists of already existing policies, that do or would interact with the PES scheme, which is commonly described as the policy-mix in which the PES is embedded in (Börner et al. 2017). The design certainly has to include an analysis of the already existing policy-mix to adapt the PES to the existing legal and political frame. The analysis and evaluation of PES should optimally also focus on its interaction with the policy-mix, as will be described later in section 2.2.5.

Additionally, **financial inputs**, i.e., the rewards and compensations, but also the administrative costs that are needed either stem from ES users that directly pay the providers (*user-financed*) (e.g., companies), or the government, which pays on behalf of the users (*government-financed*) (Engel et al. 2008).

PES intermediation[12] is another important input factor. PES design and implementation usually includes a wide range of actors (Corbera et al. 2009). Besides buyers and sellers another actor shall be pointed out here. Intermediaries, who mediate between ES providers and ES sellers, have become increasingly recognised in their importance to make PES schemes effective in environmental and economic terms (see Schomers 2019). Intermediaries can take the role of 'knowledge facilitators' and help designing and implementing schemes by giving advice and assistance (Schröter et al. 2015). A scheme that is designed on the state level has to be adapted to local contexts and decision makers often lack the knowledge of local contexts to "make the best decisions" (Farley et al. 2010, p. 2079) for the local level. "Locally embedded and committed intermediaries that hold local social and trustworthy networks" can thus play an important role here in adapting the scheme to the local level and should be included in the PES governance structures (Schomers 2019, p. 5,6).

[12] The doctoral dissertation of S.D. Schomers (2019) provides an analysis of the intermediaries' roles in the implementation of PES schemes and their effectiveness. Her publication includes many more valuable references that can be used to describe the role of intermediaries as well as novel insights and proof of their crucial role in PES implementation in Germany.

Figure 2: An analytical framework for the analysis of Payments for Ecosystem Services



Source: Adapted from Wunder et al. (2020) and Wunder et al. (2018).

The second block of the **inputs** consists of contextual knowledge of the state of ecosystems services and how they are distributed across landscapes and time. This also includes the "socio-economic and biophysical knowledge about baseline and projected scenarios" (Wunder et al. 2020, p. 214), which inform the assessment of *environmental threats* and *opportunities* the PES addresses. Defining a **baseline scenario** for the scheme is important to measure the change and success against. This might include an ecological assessment of the site that shall deliver ES and the stock or flow of ES present in that site. It is also the precondition for determining and measuring additionality, which was described in the previous section. In addition to that, Wunder et al. (2020) show that the knowledge on the economic valuation of the services and their provision costs is essential to the set-up of a PES. Determining the price that buyers, intermediaries, and beneficiaries are willing to pay (WTP), as well as the price that ES providers and sellers are willing to accept (WTA) are usually determined on the basis of economic valuation studies. These provide knowledge on how to choose the "right" price. The design principles (scale, result- or measure-based, conditionality, type and number of ES targeted) have been described previously and thus are not presented here, even though they are depicted in Figure 2.

The second element or phase of the Theory of Change concerns **Treatments**. The treatments have been discussed above under the heading of **payment types**. They are divided into conditional incentives and the complements, which also have been described previously. What is important after having described the Inputs as well as the Treatments, are conditions that have to be considered, established or given in order for a PES scheme to emerge and which build on these two blocks. Wunder et al. (2020, p. 214, 215) have described four conditions of singular importance:

Firstly, the amount ES buyers are willing to pay (WTP) ES providers should exceed or at least cover their expenses for providing the services (WTA). It is assumed that if the opportunity costs, e.g., alternative income opportunities to the PES, exceed the WTP, the benefits for the ES providers will not be sufficient for them to join the scheme. Secondly, collective efforts and action is needed to recognise the need to act, but also to organise the payments and the schemes in ways that prevent free riding (e.g., other users of ES are able to enjoy their benefits without paying for the service). Thirdly, the institutions implementing the scheme and acting as intermediaries need to be recognised as legitimate and trustworthy for sellers and buyers to enter into contractual negotiations and agreements. This is especially important to include participants into the design and increase their acceptance. Lastly, secure property rights that are guaranteed by legitimate authorities, and act as precondition for landowners to implement land-use decisions are seen as another necessary condition. (Wunder et al. 2020, p. 214, 215).

The third part, **outputs**, includes three elements. Firstly, that ES providers have received sufficient information on what entering the contract entails and as indicated above given advice and technical support to being able to realise the changes leading to the ES provision. A second output is the timely delivery of the payments. This remains difficult of course in result- and outcome-based schemes in which the actual delivery of the service might take years. A last output are the contracts. Additionally, four contextual factors for this stage have been identified by the authors. **Spatial targeting** has already been discussed as a crucial design element. It is advisable to implement this principle be targeting ES areas with high values or that are under threat to be deteriorated in their environmental quality. PES schemes that use information on the opportunity costs aim for cost-efficiency, that is incentivising ES provision for the relative lowest cost. Current research indicates that using proxies, and not solid proxies, for spatial ES data that are the precondition for spatial targeting, are more cost-efficient than not using these in the PES design (Wunder et al. 2018, p. 148). This mechanism might lead to what Wunder et al. (2018) have called adverse self-selection, which described that ES suppliers who do not face any costs for ES provision might be invited into the scheme without providing any or only low level of additionality. Targeting high value or high-threat areas has been identified as an effective means to counter this effect (Wunder et al. 2018, p. 148). The second contextual factor considers ES providers intrinsic motivation to deliver ES and how this is influenced by economic incentives. The idea behind the PES is that "external" economic incentives increase the intrinsic motivation to conserve landscapes. It has been discussed whether these economic incentives could also lead to adverse effects, in that they lower the motivation of previously highly motivated ES providers who already produced high conservation outcomes. This is regarded as crowding out. In simplifying the discussion around it, one could say that increasing the social acceptance and possibility for landowners to participate in the PES design process are factors that increase intrinsic motivation (Wunder et al. 2020, p. 220), but one could also argue that crowding-out effects are difficult to measure and have been exaggerated (Wunder et al. 2020) and are thus not as important to consider. The last two contextual factors have either been discussed, **effectively monitoring and sanctioning noncompliance,** or will be discussed in the next section, **adequate policy-mix**.

The fourth block described the potential **Outcomes**. These can be distinguished in the change in land- and resource use practice and thus the change in the environmental condition, and the effects on PES recipients' livelihoods. The optimal outcomes on the one hand would be that better practices that measurably, based on proxies linking the land use change and the additionality, are adopted. By this ES providers preserve and protect the environment against the threats perception of which has led to the implementation of the scheme. On the other hand, the remuneration would also imply that incomes are increased, employment added, that the PES scheme leads to better distribution of financial resources, as well as overall net benefits. Two of the five contextual factors important for this state have been previously discussed

(leakage and permanence). **Solid proxy – ES linkage** describes that it would be favourable for ES users to only pay for the actual delivery of the ES. But for different ecosystem services it can be only show to certain degrees how land management practice lead to their delivery. Whereas it is for example relatively easy to show how the service forest carbon sequestration is delivered, it is difficult to do the same for biodiversity. Thus, developing and using solid proxies is advisable, but also a challenge. Discussing **Magnet and Rebound Effects** is excluded here since in practice they appear to be small (Wunder et al. 2020, p. 222) and rather seem to be connected to relatively high increased in ES provider income, which for the German context do be discussed later, do not seem to be probable. Lastly, the contextual factor of **low transaction costs** is discussed. High transactions costs could prevent ES providers from entering the PES scheme if they face high costs of adapting to the administrative structure or of negotiating contracts of short duration. Transactions costs are thus an important contextual factor to consider if it appears to favourable to include certain groups of ES providers.

2.2.5 Policy evaluation

This section will provide a brief overview of the policy evaluation criteria that have been developed for and applied to the analysis of PES. While evaluating PES schemes has long been discussed along the criteria and trade-off between economic efficiency and equity aspects (see e.g., Wunder 2005, Pascual et al. 2010) it seems that the focus has shifted more towards also looking into the effectiveness of the schemes. It has been suggested to evaluate PES implementation's effectiveness in terms of costs and in terms of reaching environmental goals. A comprehensive evaluation of PES schemes thus would include considerations on the economic effectiveness and efficiency, the environmental effectiveness, as well as social equity aspects and the social acceptance of the scheme. It has been shown that only a handful of schemes are "thoroughly analyzed" (Prokofieva 2016, p. 138), which demonstrates the need for policy assessment studies to show how PES programmes work in practice and what limitations they face (Prokofieva 2016). Before exploring this fact in more detail, a brief description of the most important evaluation criteria and their relevance for designing and evaluating PES schemes shall be presented in the following paragraphs.

The **environmental effectiveness** of the programme seems to be the most important indicator for evaluation. It signifies the degree to which the PES schemes are able to meet their objective of conserving or enhancing ES provision, which has to be measured against at least three factors:

- additionality,
- leakage,
- and behavioural impacts "(e.g., permanence, crowding out/in, perverse incentives" (Prokofieva 2016, p. 138)

These concepts have been discussed in the previous section. For determining the effectiveness of PES programmes and evaluate them the following questions are important to answer: Does the programme constitute an improvement to the baseline scenario in buying environmental services (additionality)? Is a mechanism included that effectively ensures that the services and their benefits are provided beyond the duration of the programme (permanence)? And does the programme include a mechanism which ensures that environmental damages are not transferred to other locations (leakage) (Engel et al. 2008, p. 670). While reaching additionality and preventing leakage are often regarded as necessary conditions for a PES scheme to be rendered effective, meeting the criterion of permanence is not necessarily considered to be as important. It is of course desirable that the actions taken, and the outcomes achieved are sustained, but in assessing PES schemes the effectiveness is determined when positive outcomes (additionality) have been achieved at least for the duration of the programme.

Cost-effectiveness, the comparison of the relative costs in relation to the outcomes of different policy interventions, or the comparison of a policy intervention to the status quo, a baseline scenario, is often considered when scholars discuss whether privately- or publicly financed schemes are more effective. While there has been a tendency of rendering privately financed PES schemes more effective, which was inspired by economic thinking that considers privately-organised schemes and markets more efficient per se, evaluation studies have shown that against common perceptions, publicly financed schemes are more cost-effective than privately financed schemes (Molenaar 2013, p. 2). This finding has been underlined by Wunder et al. (2020), who are arguing that government-financed PES may also be more effective in tackling free-rider problems "by taxing multiple users (e.g., for biodiversity protection) and be more **cost-efficient** in organizing payment programmes at scale" (p. 211). A second major field of discussion concerning cost-effectiveness regards the choice of measure-based or outcome-based oriented schemes. There is a consensus of that result-based, outcome-based PES schemes are more cost-effective, but are also more difficult to realise in practice (Engel et al. 2008). Simoncini et al. (2019) for example show that the conservation of biodiversity and the delivery of ecosystem services under the Common Agricultural Policy can be best promoted by integrating result-based agri-environmental payments into the policy mix (p. 10). Measure-based and outcome-based schemes are also evaluated in their economic efficiency. Outcomes-based schemes "are preferable from the efficiency point of view, provided resulting ES provision can be verified at a reasonable cost based on reliable indicators (…) (Prokofievea 2016, p. 135). Action- or measure-based instruments on the other hand are "considered to be less effective, as the link between management actions and ES delivery is often weak and not always based on sound scientific knowledge" (Prokofieva 2016, p. 134).

In addition to these four evaluation criteria, two further aspects considering the embeddedness of PES scheme in socio-ecological systems and policy landscape are important for their evaluation. As mentioned above, several authors suggest using more elaborated **frameworks** and **impact evaluation** to analyse PES schemes. Prokofieva found that there still is a considerable lack in "empirical studies assessing the practical implementation of PES in the field" in a systematic manner and a "comprehensive framework for the thorough evaluation of existing practical experiences" is missing (2016, p. 130). Additionally, "scientifically rigorous impact evaluation" of PES' potential as conservation policies is also lacking (Börner et al. 2017, Wunder et al. 2018), even though the number of impact evaluation cases has been increasing (Wunder et al. 2018, p. 146). It has thus been suggested to use Ostrom's socio-ecological system framework to analyse and evaluate examples of PES (Prokofieva 2016, p. 138). A call for more evaluation research and advances in theory guiding these evaluations can thus be found across various publications reviewing PES evaluation and impact assessment. Börner et al. (2017) argue for example that "(a)dvances in theory and evaluation research are needed to improve our understanding of how" policy mixes interact with targeted social-ecological systems" (p. 359).

PES as other economic instruments for nature conservation can be understood as part of a **policy-mix** and not as a single policy instrument, i.e., they are usually implemented within an existing legal, economic and political framework, that governs the provision of ecosystem services and are adapted to that (Ring and Barton 2015). Ring and Schröter-Schlaak (2019) define a policy-mix in relation to nature conservation as "a combination of policy instruments that has evolved to influence the quantitative and quality of biodiversity conservation and ecosystem provision in public and private sectors" (p. 321). The evaluation and conceptualisation of PES thus has to include a perspective on the scheme's interaction with the existing policy mix. Evaluating policy-mixes has often been combined with a transdisciplinary perspective or orientation. Policy evaluation studies focusing the interaction and outlooks of policy-mixes have often connected the analysis with a normative approach to add to the sustainable transitions of energy systems (Rogge, Kern & Howlett 2017), but also for

sustainability transitions more broadly[13] (see for example Rogge & Reichhardt 2016 or Kern, Rogge & Howlett 2019). Barton et al. (2017) developed an analysis framework for PES as Policy Mix. For the aim of this thesis, it will be important to ask what design choices results from viewing PES as a policy mix rather than a single policy instruments when assessing the policy proposal.

[13] This analytical perspective has lately also been used for forest policy more broadly and to study to potential transition of the European economy to a circular bioeconomy (see Ladu et al. 2020).

3 Methods

3.1 Research Design

The core of this research is the analysis of a policy proposal for a Payments for Ecosystem Services scheme in Germany and an anticipatory evaluation of its effectiveness and sustainability of its outcomes. It consists of a theory-based analysis of its design elements and of an evaluation that aims to show how different Forest Ecosystem Services can be balanced in a sustainable manner. To inform the analysis an in-depth literature review of PES policy evaluation studies and the PES' underlying economic theory was conducted. An analytical framework was developed, which allowed for assessing what type of PES the policy proposal is. To further analyse crucial design choices the policy proposal was compared with an already existing PES scheme in Finland. On basis of the analysis, comparison, and discussion proposals to further develop the proposal will be suggested.

To scope the empirical part of the thesis webinars organised by science-policy interface organisations working to promote knowledge on sustainable forestry and forest management were attended and analysed, and an expert interview was conducted. Analysing the webinars enabled the author to perceive the public, political and scientific consensus of that developing PES schemes is needed to remunerate forest owners for the provision of FES and that analysing trade-offs should be a central part of this policy development.

3.2 Methods used for Data Collection

3.2.1 Literature Research

A literature research was conducted to identify relevant scientific literature analysing and describing PES implementation and evaluation. Google scholar was mainly used as search engine for scientific articles. Several search terms and strings was employed to find scientific publications. These included "Payments for Ecosystem Services"; "result-oriented payments schemes" AND "effectiveness" with a geographical scope on Europe, a scope for national programmes and publications no older than 10 years; "Result-oriented payment schemes" AND "design characteristics"; "result-based payment schemes"; "Agri-environmental measures" (AEMs). Moreover, scientific articles covering the evolution of the Ecosystem Services concept were researched. In both cases special attention was paid to identifying seminal publications and authors (e.g., Sven Wunder, who introduced the PES concept). Scientific literature was reviewed up until a point of saturation, which the author deemed sufficient to depict the ES concept and the evolution of Payments for Ecosystem Services. Thus, not all potential scientific research was reviewed. This research was conducted in order to build the basis for the analysis as well as for the answers for RQs 1 and 3, i.e., focusing on how PES can balance trade-offs between various ecosystem services and be implemented in ways to overcome barriers posed reconcile these trade-offs in a specific case.

3.2.2 Desktop Research

A desktop research was continuously conducted for several purposes. Firstly, to identify relevant actors, networks, webinars, and documents which provided information on the current state of EU forest policy, German forest policy, and the call for developing PES schemes. This enabled an assessment of current trade-offs between Forest Ecosystem Services, which informed the formulation of the Research Questions. But it also created the basis for showing how EU strategies, laws, and policies influence Member State governance of forests and vice versa. Secondly, it was used to identify scientific research and documentation on the design, implementation, and evaluation of the METSO programme to provide information for answering RQ2. Thirdly, it was used to monitor current public and political discourse on forest

policy related developments in Germany, but also on the EU level, and assess the environmental NGOs' perspective on Germany's current forest policies.

3.2.3 Semi-structured interviews

Semi-structured interviews were conducted for the purpose of scoping the thesis and for identifying policy proposals for analysis and comparison and developments in the German and Finnish context, i.e., to answer RQ2. A first set of interviewees was selected based on their expertise in working with PES evaluation and previous work with analysing trade-offs between forest ES. Subsequently, further researchers were contacted based on the recommendations gathered in the interviews. These expert interviews were meant to provide additional information on the METSO programme and insights into proposals for further developing it, but also to gather more information on the German public discourse around PES implementation. The interviews thus complemented the desktop and literature research to answer RQs 2 and 3 by providing specific information, which partly were not publicly available. Unfortunately, not all researchers contacted were available for interviews. After finalising the analysis, a second discussion with one of the interviewees was set up to discuss crucial assumptions and design elements of the policy proposal, as well as recent political developments.

All interviews were conducted in a semi-structured fashion. The focus and questions of individual interviews were adopted to the area of expertise and the working context of the interviewees. The interviews were recorded, and notes were taken. This method for conducting interviews allowed for having natural conversations and for new insights. To create an open and safe frame for the interview probing and establishing rapport were used. Moreover, interviewees were given the opportunity to review the parts of the findings and analysis that they contributed to in order to check for sensitive information or factual errors.

3.3 Data collected

3.3.1 Literature research

Data gathered during the literature research and review was both qualitative and quantitative date stemming from scientific publications. Additionally, research reports from NGOs, think tanks, EU agencies and bodies were identified as valuable references.

3.3.2 Desktop research

Both qualitative and quantitative data was gathered during the desktop research. For scoping the thesis aim data on the state of European forest policy and relevant laws and strategies were selected. This included scientific articles, reports from research institutions, policy briefs and ministry documents. For background data on the public and political discourse data from newspapers, radio features and online discussion (e.g., Twitter) was gathered.

3.3.3 Semi-structured interviews

Due to the methodological choice of conducting semi-structured interviews data gathered was mainly qualitative in nature. The interviews also yielded reference to further scientific articles, standards (for carbon sequestration, but also for biodiversity indicator development), reference to research projects (e.g., IBC-Carbon, SINCERE), contacts to further researchers, but also information on current political developments.

3.4 Methods for analysis

Three methods were used for the different elements of the thesis:

- A literature review for developing the analytical framework
- A content analysis for analysing the political frameworks and public discourse
- A policy analysis and anticipatory evaluation which combined elements of the two aforementioned methods

The literature review allowed for comparing and assessing the importance of the theoretical debates and design principles of PES schemes. Additionally, it established the basis for understanding the Ecosystem Services concept. By reviewing and comparing the scholarly debate around both concepts, nuances of the debates were analysed, and a comprehensive depiction of the PES design principles and elements was enabled. This also lay the foundation for assessing the limitations of PES schemes to function as policy instruments for nature conservation in privately-owned land in practice, which was relevant for the discussion and analysis of the policy proposal.

The content analysis was conducted to identify the trade-offs between Forest Ecosystem Services. Scientific articles, research institutions reports, and webinars were analysed in a qualitative manner to describe the current sustainability challenges national and supranational forest governance face. In addition, data on the ecological state of forests, current political developments, and the public discourse was analysed to embed the policy proposal analysis into the legal and economic frameworks as well as the public discourse.

Lastly, a policy analysis was conducted, that was based on an analytical framework combining the identification of how PES schemes have been described and evaluated in their effectiveness by other scholars and integrating this with a Theory of Change perspective on PES (Wunder et al. 2020). This required adapting the analytical framework and its elements and operationalising both to qualitatively describing and analysing the policy proposal. Adding the Theory of Change perspective supplemented a perspective on how PES schemes are designed to work in practice, as well as which elements and context factors have to be taken into account to designing these policy instruments. This method rather followed a heuristic approach by orienting the analysis on the policy evaluations conducted by scholars from different disciplines (environmental economics, ecological economics, political science). The analysis thus includes a certain degree of interpretation of the elements, which was clearly stated and made transparent. The analytical framework also serves as a means to categorise and present the policy proposal as a PES scheme in a structured way. In order to strengthen the analytical categories a discussion with a researcher familiar with the proposal was conducted, in which the categories and discussion of the proposal were discussed. This allowed for an external perspective on the adaptation of the analytical framework to the case.

The policy analysis and anticipatory evaluation was also employed to critically reflect upon the policy proposals' underlying assumptions and consequently developing ideas on how to further deliberate on and develop it. It also enabled to analyse its strengths and "weaknesses", as well as fundamental differences but also similarities with the METSO programme.

4 Political, socio-economic, and scientific developments

The aim of this section is twofold. Firstly, arguments for why considering Germany's and Finland's PES schemes can provide valuable insight for political development. Criteria for choosing to compare Finland's METSO programme with the policy proposal of Elsasser et al. (2020a) will be presented. Secondly, recent political and scientific developments on the EU level on in the German context shall be presented to show how the following analysis of the policy proposal and comparison to another PES scheme contribute to the research and political priorities identified for EU forest governance.

4.1.1 Case country presentation

This thesis compares novel financial policy instruments for the provision of forest-ecosystem services of two countries. Countries were selected based on the following considerations:

- The national ministries responsible for forestry were either considering installing new national policy mechanisms to finance non-market Forest Ecosystem Services or already have considerable experience in running these programmes.

- The relative weight of the country's voice in EU forest policy debates and their relative importance for European forestry overall shall be given.

- To contrast to rather distinct models of forestry and forest management.

Germany:
Germany was chosen as a case because there is an ongoing debate on how PES and result-based schemes can provide private forest owners with an economic incentive to restructure their forest management models. As Dr. Eva Müller, Director General for Forests, Sustainability and Renewable Resources of the German Federal Ministry for Food and Agriculture (BMEL), stated (WSL 2020) there is strong ongoing debate on how Ecosystem Services can be rewarded in the long term. At present Germany is focusing on financing the climate mitigation function of forests. Financing efforts of private forest owners to restructure their forests to increase the carbon sequestration potential might become possible through accessing financial means stemming from the energy and climate fund, which is based on the CO_2 tax revenues (Forstwirtschaft in Deutschland, 2020). It can be expected that forest biodiversity will also be financially appreciated (Finanztreff, 2020). Germany was also chosen as a case, because it has considerable weight in forest policy discussions. As Wolfslehner et al. (2020) found, Germany among Austria, Finland, France, and Sweden, is perceived as one of the "most active countries in forest-related discussions" (p. 30). Regarding the third criterion, Germany has been described as supporting a distinct model of forest management. Borass et al. (2017) describe the ""German model" of integrative multifunctional forest management". Similar to France, and in contrast to forest-rich countries like Sweden and Finland, Germany's landscape is defined through a mixture of agricultural land and forestry (Pülzl et al. 2017), which gives forestry and important, but varied role.

Germany: deciduous trees naturally growing, forests suffer from heat stress and drought, one of the for major wood providers in the EU. Big potential for climate mitigation and biodiversity preservation. Strong movement and political momentum supporting close-to-nature forestry.

Finland:
Finland was chosen as a case study because it has implemented an incentive-based policy programme, which supports forest biodiversity conservation efforts in 2008 called METSO.

This will be taken as an example to assess the potential and outcomes of economic policy instruments for the provision of forest biodiversity.

It was also chosen due to its considerable weight in forest-policy discussions, and due to strong forest sector. Finland's forest management model can be described as a more industrialized mode of forestry, which focuses on the economic dimension of forests and its potential for a forest-based bioeconomy. Finland: naturally occurring coniferous trees, question how much potential there is for biodiversity and climate mitigation potential enhancement in these forests.

4.2 Recent political and scientific developments

4.2.1 EU level

The discussion on forests' potential and role in meeting the European political priorities is an important contextual factor for analysing Member State approaches to financing forest biodiversity preservation and carbon sequestration. The aim of this section is to shed light on some recent political developments as well as concepts that are of importance for sustainable forest management.

There is an increasing awareness of financing needs (e.g., Kettunen et al. 2017) and forests' potential for carbon sequestration (Welle et al. 2020) and biodiversity preservation on the EU level. Research, and specifically research networks including a variety of stakeholders and experimental approaches have stimulated the debate at the science-policy interface by providing knowledge and developing solutions and approaches for better targeting integrated ES provision through policies, business models and management practices.

The **S**purring **IN**novations for forest e**C**osystem s**ER**vices in **E**urope (SINCERE) project has recently published two scientific articles. One article by Orsi et al. (2021) maps "hotspots and bundles of Forest Ecosystem Services across the European Union" and depicts where trade-offs and synergies between different FES can be found and identifies that among other countries Germany supplies "significant amounts of multiple FES" (Orsi et al. 2020, p. 1). Moreover, a second paper building on this mapping approach, which reflects an increased ability to monitor ES provision, analysis the governance of Forest Ecosystem Services provision on a European level and claims that "there is room for more use of innovation in promoting ES provision" (Primmer et al. 2021, p. 1). As already indicated in the Introduction further research projects exist that also examine how novel business models can help to finance ES provision "privately". Examples of this are the NOBEL (Novel business models and mechanisms for the sustainable supply of and payments for Forest Ecosystem Services) or the InnoForESt projects. Another recent publication depicts experimental approaches and varying forest management practices across Europe (Krumm, Schuck & Rigling 2021) that have the common goal to balance the productive uses of forests with conservation. In addition to that, different forest management approaches are currently being discussed to see how they can better balance FES provision. Some of these include close-to-nature forestry, climate-smart forestry, multifunctional forestry, Sustainable and Integrated Forest Management.

The discussion around governance innovation for Forest Ecosystem Services provision and how to better balance FES provision also includes a debate on the European competencies and capacities to influence Member States' forest governance. At the forefront of this discussion is the European Forest Institute (EFI), which regularly publishes scientific policy advise reports which are developed by leading experts on forest policy matters. In a recent report (Wolslehner et al. 2020) the question of how a post-2020 EU forest governance framework could look like is raised. Wolfslehner et al. emphasise that there is no competence for a common forest policy and that it is also not likely that one will be developed in the future. This is due to the strong

competencies that Member States currently hold, but also due to the highly diverse ecological landscapes and socio-economic contexts that characterise European forests, which makes a coordination of shared interests difficult. What is more is that forest policy is a "complex inter-sectoral policy landscape" that operates at different scales and supra-national levels (Wolfslehner et al. 2020, p. 4). The European Union still has some leverage in influencing Member States forest policies by issuing European strategies, which are communicative policy instruments, that are not-binding, like the EU biodiversity strategy, or the upcoming Forest Strategy. These are framed within the newly vision and framework of the European Green Deal. But it is questionable how far this vision can impact a more balanced and sustainable provision of forest ES: "The proof is yet to come on how integrative the Green Deal is but its potential for change seems to exist. Understanding integration as the party of different interests, the Green Deal needs to capture the full range of forests goods and services in the forest value chain. Starting from quite explicit ideas on future priorities (carbon storage, afforestation, preservation, restoration), this will require further political deliberation on how to comprehensively address forest resources in Europe" (Wolfslehner et al. 2020, p. 39). Wolfslehner et al. show that communication between Member States can play a key role. On this basis a shared vision could potentially be developed, that forms "(a) collective and collaborative forest-related response from EU Member State governments, NGOs and industry to climate change, biodiversity protection and enhancement, as well as sustainable energy and biomass provision" and which "could help to channel the long-lasting disputes between forest management, use and preservation" (Wolfslehner et al. 2020, p. 39). What the report of Wolfslehner et al. (2020) is also showing that the development of a strategy on how to use the forest resources in response to "emerging environmental and economics trends" could be valuable to deliberate on how "bioeconomy, climate change and biodiversity goals can be harmonised with respect to forest resources" (Wolfslehner et al. 2020, p. 38). This would also require a much stronger "analysis of synergies and trade-offs of forest related goals and targets" (Wolfslehner et al. 2020).

Based on these findings one could argue that a further coordination of Member States is not an easy task. The dramatic changes in the state of forests, increased public attention and demand on the forest sector, as well as new political priorities (expressed in the Green Deal), make the forest sector subject to several, partly conflicting demands, and interests. It has been shown that "forest ecosystems have become the centre of attention in global, European and national sustainability policies" (Primmer et al. 2021, p. 9). To sum up, the current research on prospects of a more harmonised and integrated approach of EU and Member States efforts to better govern Forest Ecosystem Services provision is highly debated, and elements of this debate can be applied to the political level of Member States.

4.2.2 Germany

In the German political context one recent development and concept is noteworthy in regard to the discussion presented above. In the recent years a call for a socio-ecological transition of forestry and forest management has been voiced and increasing. The concept of transitions of industrial sectors to better align or adopt more ecological driven practices has been evolved around Germany's energy transition, and in the recent years been enlarged to other economic sectors like mobility, agriculture and now to forestry. One could argue that this concept is based on a normative understanding of what a sustainable forestry should look like and is oriented towards a specific future vision of how forestry, that is strongly oriented towards more extensive forms of forestry and incorporates elements of ecological forestry management. Different actors (environmental NGOs like Greenpeace or Naturwald Akademie) drive this discourse and a variety of documents have been established depicting the concept (e.g., a current book publication Knapp, Klaus & Fähser 2021). Whereas concepts based on normative claims are rejected on ideological grounds, they also hold arguments that are important to include in processes of democratic deliberation, since they as well are based on scientific and practical

findings, which highlight the importance of preserving biodiversity, as will later be discussed. What the discourse around a redesign of forestry clearly shows is that a present a lack of knowledge exists, which makes it impossible to assess whether forestry, as it has been practiced in the past decades will be still be possible in the future, given the current climate and biodiversity crisis, which in order to be tackled might need more, if not most of the forest resources. What makes the discourse around distinct future visions so difficult to assess from an economic, political and scientific perspective, is that the costs and impacts of a potential transformation for the forest-based industries are not known at the moment (Wolfslehner et al. 2020, p. 39). They thus involve a certain degree of speculation.

5 Analysis and comparison

5.1 Policy proposal: Elsasser et al. (2020a)

In this section a policy proposal for a Payments for Forest Ecosystem Services in Germany shall be analysed. The analytical framework developed in the literature review (Chapter 2) will be applied to analyse the comprehensiveness of the proposed policy design, identify needs to further develop it according to the comparisons with scientific evaluation studies, as well as, pointing to aspects that need further discussion.

The analysis focuses on two distinct Forest Ecosystem Services, which are characterised as global public goods: climate protection and biodiversity conservation, and their relation to the provision of raw timber. The proposal also discusses and proposes to remunerate other FES/ local public goods, but these will not be included here.

5.1.1 Introduction

Before analysing the proposal in more detail, a brief categorisation of the proposal's main features as Payments for Ecosystem Services scheme will be presented in this section. The policy proposal described in Thünen Working Paper 152 by Elsasser, Köthke and Dieter (2020) ("Ein Konzept zur Honierung der Ökosystemleistungen der Wälder"/ Conceptualisation of a remuneration scheme for Forest Ecosystem Services [14]) is a Payments for Ecosystem Services scheme. It addresses the narrow (economic) problem that PES have been designed for: financially remunerating the provision of Forest Ecosystem Services, which are insufficiently provided for by the markets and that provide positive spatial externalities ("*offsite services*" (Wunder 2015)), which are global public goods. The proposal presents a rationale for why the provision of climate mitigation (as carbon sequestration) and biodiversity preservation by forest owners and business (ES providers) should financially be rewarded by the German state (ES buyer). The authors claim that there is a societal demand for a better and sustainable provision of these two FES, which is also resulting from the international political commitments of Germany's Federal Government. This has committed to taking further actions to mitigate climate change (e.g., Paris Agreement) and to better preserve biodiversity (e.g., UN CBD 1992), which creates a public and a societal demand. In addition, the proposal advises to make financial remuneration *conditional* (Wunder 2015) on the provision of Forest Ecosystem Services, i.e., a measurable positive change in the state of the environment (additionality) is conditional for the payments. The proposed PES scheme thus meets the criteria of Wunder's (2015) PES definition.

The proposal calls for a complete redesign of the political instruments governing the German forestry sector to improve the provision of FES and suggests a concrete instrument's design. As will be shown later, the proposal is highly relevant for the current state of German forests and forest policy, for the public debate, but also for Germany's international commitments and supra-national efforts (e.g., better alignment with EU strategies and policies).

The policy proposal is grounded in economic valuation studies, is designed for being cost-effective and is comprehensive in its approach. Three distinctive PES design features can be described that display this focus:

- the price for the proposed payments is directly derived from the societal demand,
- it is a result-based scheme,

[14] Since the proposal is written in German and the author of this thesis is not acquainted with all cases of technical terms regarding forests, the English translations might occur as literal but not completely adequate to the expert audience. Where possible, German terms are presented as well.

- and it aims to support the provision of the many services, while accounting for potential trade-offs and synergies.

The authors describe the problem their proposal aims to tackle in terms of environmental economics. They state that whenever a societal demand for Forest Ecosystem Services case is not met by the market, government intervention is legitimised. Moreover, it builds on the assumption that public funds should be spent on public goods and consequently the provision of Forest Ecosystem Services, if a societal demand for them exists, which is not met by the market (Elsasser et al. 2020a, p. 1, 2). Throughout the working paper the authors argue for that the societal demand for various Forest Ecosystem Services has been captured and shown in economic valuation studies, which present arguments for that there is a regional societal demand for a better provision of FES. They do so by referring to The Economics of Ecosystem and Biodiversity's (TEEB) findings for the German context (see Elsasser et al. 2020a, p. 5) or by presenting findings from an economic valuation study for FES in the German context and showing the regional demand (ReWaLe, see Elsasser et al. 2020b). By this they are able to show that there is a considerable value in the provision of non-market FES by contrasting the value of biodiversity preservation, carbon sequestration and right to access forests with the value of timber production. This comparison shows that the current marketed values, which only includes raw timber, are lower than the value of the other Forest Ecosystem Services combined. Moreover, they can show that the societal demand for biodiversity preservation is similarly high as the one for carbon sequestration[15]. In combining these economic valuation studies with the CO_2 price (price in € per tonne of CO_2) the authors are able to derive an economic figure for both ecosystem services on the basis a measurable societal demand.

A second major design feature is the result-based and outcome-oriented design the proposal describes. Elsasser et al. argue that only results or actual outcomes should be rewarded based on cost-effectiveness considerations for using public funds. This reflects scientific and evaluation studies of PES, which as show in Section 2.2.5 regard result-based schemes as more cost-effective. Moreover, the authors view result-based schemes as being better able to preserve already existing beneficial conditions (Elsasser et al. 2020a, p. 4). The proposal seems to follow a dictum that can be summed up as that outcome- or result-based schemes "are preferable from the efficiency point of view, provided resulting ES provision can be verified at a reasonable cost based on reliable indicators" (Prokofievea 2016, p. 135). As will be shown in greater detail later the authors discuss the choice of "reliable" and pragmatic indicators, which provide the basis for their proposal

The third substantial approach to this policy proposal is that it focuses on and discusses Forest Ecosystem Services in a comprehensive manner by looking at their synergies and trade-offs (Elsasser et al. 2020a, p. 2). This reflects a consensus of scientists and policy-makers working at the science-policy interface who view the analysis of potential trade-offs and synergies between ES as an essential aspect in the development of policies that should be included to prevent perverse incentives, to better account for the complexities of the socio-ecological systems involved in the governance of forest ES, but also to make trade-offs in different sustainable dimensions more transparent and thus subject to political or scholarly deliberation (as shown in Chapter 2). By proposing a comprehensive forest PES, the proposal aligns with priorities set by the upcoming EU Forest Strategy. This aims at the provision of the many Forest Ecosystem Services (EC 2020c).

[15] The authors argue here that despite of methodological restrictions of the ReWaLe study (Elsasser et al. 2020a, p. 25) German forests contribute to climate mitigation and biodiversity preservation equally.

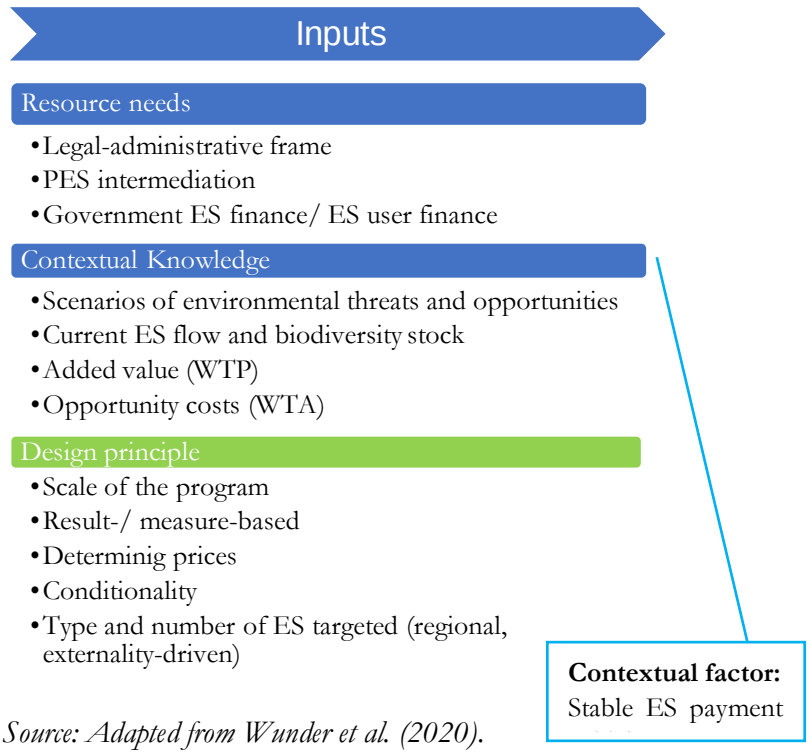
By reviewing and analysing these substantial design features, it has been shown that the suggested PES scheme combines an orientation on actual societal demand with determining a price for FES (see Section 2.2.3). It aims at aligning private and public land- and resource-use decisions with broader societal interests and demands, which according to Wunder et al. (2020, p. 211) is a main criterion for a PES scheme. Moreover, the proposal is comprehensive in its approach by suggesting a scheme that includes various Forest Ecosystem Services and outlines two steps to provide for global public goods (carbon sequestration and biodiversity conservation) and other ES with a regional character, which here due to the scope of this study are excluded.

In the next section a more detailed presentation and analysis of the proposal will be conducted following a Theory of Change structure (Wunder et al. 2020) and include a presentation and analysis of context factors and stylised design features, all of which have been presented in Section 2.2. Since the policy proposal is not yet implemented and does not have outputs, outcomes nor impacts, these categories are only discussed in so far as the authors discuss anticipated effects in each of these stages. Contextual factors, that influence these phases, are discussed though, since they can be already accounted for in the design stage of the proposal.

5.1.2 Inputs

The Theory of Change developed by Wunder et al. (2020) shall be used here in a similar manner that the authors used it to provide an analytical framework to analyse which "contextual preconditions, preparatory steps, and implementation arrangements" need to be developed to achieve ecosystem services output and impacts (p. 212) for the case of the policy proposal. In this, as in the following sections, it will be presented how the elements of the Theory of Change, and the design principles, that have been included and discussed in the Elsasser et al.'s (2020a) policy proposal. Combining these, also graphically, establishes the analytical framework for this analysis. This first section will be considerably longer than the analysis of the other parts, since the proposal sets out a design of a PES scheme and is not yet implemented.

Figure 3: Inputs



Source: Adapted from Wunder et al. (2020).

Resource needs

The **Resource needs** include the *legal-administrative frame*, *PES intermediation*, as well as the source of financing (*user finance* or *government finance*). Elsasser et al. (2020a) discuss the legal, political, and administrative frame in several dimensions. They present the current governance of FES in Germany, point to the international commitments for biodiversity preservation and climate mitigation, and the necessity to implement further policies. They also present how the current legal and political framework has to be changed for the suggested proposal to be implementable.

The proposal's authors present the current legal basis, which sets preconditions for the State's ability to finance forest ES. At present Germany's constitution prescribes that Federal States are the political entity responsible for *governing* the forestry sector (Elsasser et al. 2020a, p. 29). State intervention and action, which targets forestry and forest policies, thus has to have a legal basis and justification (Elsasser et al. 2020a, p. 29). Only one political instrument is allowing the German state to influence FES provision at the moment: the joint task for the improvement of agricultural structures and coastal protection (Gemeinschaftsaufgabe "Verbesserung der Agrarstruktur und des Küstenschutzes" (GAK)). A join task describes the collaboration of the State government and the Federal State governments. More specifically it describes tasks of the federal states, the achievement of which is supported through the State government with planning and financial capacities, if these tasks are of importance for the whole nation and lead to an improvement of living conditions (Article 91a of the constitution; Gesetze im Internet, n.d.). This joint task is the main economic policy instrument for the state to support forests and the forestry sector (Elsasser et al. 2020a, p. 29). Its main aim is to improve the performance and economic competitiveness of agricultural and the forestry sector as well as, ensuring the continuous economic development of rural areas (Elsasser et al. 2020a, p. 29). They argue that the current focus on the forestry sector's economic competitiveness and the measure-based orientation of the GAK is insufficient to meet the demand for providing many FES. It is on this basis that they argue for reforming the current legal frame, which would be needed to provide room for developing policies focusing on more that the economic competitiveness of the sector, i.e., also on its contribution to climate and biodiversity protection.

The German State has *internationally committed* to take action on climate change (UNFCCC 1992, 1997, 2015) and to preserve biodiversity and nature (UN CBD 1992). These commitments on the international, but also supranational (EU) political level frame and have an impact on national legislation (like the newly adopted climate law), strategies (Germany's Biodiversity Strategy (BMU 2007)) and administrations. The authors underline to that these commitments create a global demand for the climate mitigation functions and biodiversity preservation and enhancement functions of German forests. They argue that it is in the state's and public's interest to include the forestry sectors' climate mitigation function for achieving the national GHG emission reduction goals, and thus provide the forestry sector with economic incentives for fulfilling its potential (Elsasser et al. 2020a, p. 7). Showing that the demand for biodiversity and nature protection is also international, but also of public interest, the authors conclude that a nation-wide supporting scheme should be set up to incentivise the provision of both services (Elsasser et al. 2020a, p. 9). This would justify government funding (*Government ES finance*) as well as choosing the *scale of the programme* to be nation-wide, the former representing an input factor (Wunder et al. 2020), the latter being a design element of importance.

The authors also discuss the *administrative frame,* especially with a view on how the choice over the policy's design influence its economic and environmental effectiveness. One of the most important claims of this proposal is that the administrative structure is to be kept as lean as possible to design a practicable system and by this prevent the loss and waste of public resources (Elsasser et al. 2020a, p. 4). This call for a practical and pragmatic system has been taken up by

policymakers[16]. Additionally, the authors recommend not to target all potential Forest Ecosystem Services that exist, but rather focus on the most important ones (Elsasser et al. 2020a, p. 4), also as means to keep the administrative burdens low. What is not discussed or proposed here is the entity to administer the contracts, the payments, the monitoring, and sanctioning, as well as the *PES intermediation*. Whereas this could be considered to be an important input factor, it seems that at this stage of the proposal and its intention, suggesting administrative entities and organisations potentially acting as intermediaries seem to lie beyond its focus. But presenting the resource needs for setting up administrative structures for monitoring and sanctioning is missing.

Contextual knowledge

The elements of **Contextual knowledge** include *scenarios of environmental threats and opportunities*, knowledge on *current ES flow and biodiversity stock*, as well as information on the *opportunity costs (WTA)*, and *added ES value (WTP)*.

5.1.2.1.1 Environmental threats

The policy proposal discusses the *environmental threats* in different parts. In relation to carbon sequestration, it shows that the effects of climate change already take toll on the state of German forests and their ability to mitigate the effects of a warming climate in the future (Elsasser et al. 2020a, p. 7). It also points to the intensity and reoccurrence of damages (Elsasser et al. 2020a, p. 7) as a result of droughts, heat stress and pests, which have been recorded by the National Forest Inventory (Bundeswaldinventur (BWI). Although the potential threats are not described in much detail, they are a fundamental point of reference for the proposal. The authors point to the threat of forests becoming instable and to the economic threats connected to this. They mention for example that it is unclear whether the kind of forestry practised at the moment will remain economically viable in the future (Elsasser et al. 2020a, p. 17) and show that the costs related to afforesting damaged forests, which are usually covered by revenues from selling timber and raw wood, might not be covered any longer in the future, especially with regards to the fall in value of timber, which results from damages[17] (Elsasser et al. 2020a, p. 27). Additionally, the authors articulate that there is a substantive need for afforestation, due to its potential to mitigate climate change, but also due to the societal demand for increasing the forest areas (Elsasser et al. 2020a, p. 13). They argue that at present the economic prospects of transforming land into forests are restricted by the subsidised agricultural land-use forms, that make an initial afforestation ("Erstaufforstung") financially unattractive (Elsasser et al. 2020a, p. 13). On the other hand, they also point to *environmental opportunities* in arguing that since "carbon sequestration can be and is used as part of the emission reduction commitment, the demand for this service has an economic dimension, which poses further incentives for sequestering carbon in forests" (Elsasser et al. 2020a, p. 6) and thus might act as an economic stimulus. It is on this basis that the authors argue that a continuous funding by the German State to support forests' climate mitigation function becomes necessary to maintain it, but also to provide forest owners and businesses with the resources to adapt, afforest and restructure their forests to become more climate resilient (Elsasser et al. 2020a, p. 27).

In relation to biodiversity the *environmental threats* are not discussed in as much detail in the proposal. Elsasser et al. refer indirectly to the threats by pointing to national biodiversity targets

[16] For example, by Dr. Eva Müller, Director General for Forests, Sustainability and Renewable Resources of the German Federal Ministry for Food and Agriculture (BMEL), who in a webinar expressed that designing a pragmatic system to remunerate FES is needed (WSL 2020).

[17] The damages have apart from decreasing the wood's quality also led to higher harvesting rates, which in turn have caused a fall in prices, due to a temporal over-supply in raw timber.

that have not been met yet. The German state has aimed for increasing the protected forest area to 5% of the total area by 2020 (Elsasser et al. 2020a, p. 21). These goals reflect priorities to secure and halt biodiversity loss. But apart from this reference biodiversity loss is not discussed prominently. *Environmental opportunities* regarding forest biodiversity are discussed in relation to carbon sequestration. The authors show that forests that are more diverse in species, and include native species are likely better adaptable to a changing climate (Elsasser et al. 2020a).

5.1.2.1.2 Current ES flow and biodiversity stock

The next element of the **Contextual knowledge** concerns the *current ES flow* and *biodiversity stock*. It is important to describe the **Ecosystem Service definition** the authors deploy in a first step here before turning to the assessment of the current ES flow and biodiversity stock. The proposal does not define biodiversity as an ecosystem service in itself, but rather as a precondition for other ES (Elsasser et al. 2020a, p. 8), based on the Millennium Ecosystem Assessment definition of biodiversity. The authors use the definition of nature protection and landscape protection as being cultural ecosystem services, to operationalise biodiversity (Elsasser et al. 2020a, p. 8). Moreover, they define the climate mitigation service as carbon sequestration in aboveground forest biomass, and the sequestration of carbon in timber (Elsasser et al. 2020a, p. 6). But, as they argue, since the usage and further processing of the timber and raw wood cannot be influenced be the forestry sector it is excluded from the ecosystem service scope here. The authors also discuss the provision of biomass as raw wood and timber as an ecosystem service, which differs fundamentally from biodiversity and carbon sequestration in that it is a private good and being fully traded in markets (Elsasser et al. 2020a, p. 3). They describe the relation of the latter ES as important to the overall conceptualisation of the policy proposal in that this ES is the most important economic income factor for forestry and thus special attention needs to be paid to the potential trade-offs with the remuneration of other FES.

The authors discuss the *current ES flow* of carbon sequestration and *biodiversity stock* in relation to their approach to **quantifying** these two services. For the ES of forest carbon sequestration, they show that its annual increase, the current flow, or rate of change, amounted to 117 million cubic meter solid timber per annum in 2017, which the carbon inventory showed (Elsasser et al. 2020a, p. 20). This can be converted into an annual carbon sequestration in aboveground forest biomass of 150 million tonnes CO_2 per annum, which quantifies the service provision (Elsasser et al. 2020a, p. 20). The *stock of biodiversity* on the other hand is far more difficult to measure and depict, since it encompasses many elements and cannot be easily converted into a single and comparable unit of measurement (Elsasser et al. 2020a, p. 20). Where measures and goals currently exist, they are either not specific enough or the monitoring is only insufficiently implemented. The forest areas protected and included in the Natura2000 network for example are not monitored and assessed in detail enough nor on the basis of formulated nature protection goals (Elsasser et al. 2020a, p. 20, 21). Quantifying performance indicators for biodiversity based on the national biodiversity strategy on the other hand is not recommended since the goals are too broadly formulated and do not allow for an operationalisation on a local and business level (Elsasser et al. 2020a, p. 21). This reflects a broader issue of that goals for nature protection are not sufficiently operationalised on the societal and political level (Elsasser et al. 2020a, p. 20, 21), which restricts a detailed assessment of the biodiversity stock on the reginal level. As will be discussed in the next paragraph, this also has implications for determining a price based on the ES flow and stock.

A third element of the **contextual knowledge** includes the knowledge on the potential *added ES value*, the Willingness to Pay (*WTP*). As already indicated, one of the great strengths of this policy proposal is its stringent reference to an actually measurable societal demand for the

provision of ES. The general rationale behind PES is to provide incentives for changing land-use decisions to meet this social demand. As already shown in the Introduction to this section, the authors refer to economic valuation studies to show that there is a societal demand for forest carbon sequestration and biodiversity preservation that can be expressed in economic values. In order to translate this into a proposal for the amount of the funding, choosing a measurement for the provision of the service, which is based on the indicators of *ES flow* and *biodiversity stock* is needed. The choice of these measurements is the core of the proposal. Therefore the next sub-chapter will describe the authors' argumentation and approach to quantifying the value of carbon sequestration and biodiversity at length.

5.1.2.1.3 Determining the value of forest carbon sequestration and biodiversity

For the **carbon sequestration** of the forests, the authors discuss different potential measures. There are two main considerations for the choice of the measure: to what degree the supporting scheme enables forest owners and businesses to adapt to calamities; and how the trade-offs between carbon sequestration and biomass provision can be minimised. On this basis the authors recommend the adoption of the annual gross increment, the positive and relative change in the CO_2 as measure of quantifying the ES.

Choosing the relative annual growth rate of CO_2 stocks as measure for carbon sequestration is discussed as the best option for incentivising a continuous and maximised growth of carbon sequestration. It is favoured overusing the actual and present stock of CO_2 in forests or the change in stock, which are two alternative measures discussed. The discussion can be simplified by summarising the arguments on the basis of the two considerations mentioned above. Apart from incentivising the biggest increase in carbon sequestration, this measure would be best suited to provide forest owners and businesses with financial means to meet calamities, but also discriminates the fewest against the usage and further processing of timber. Basing the valuation of carbon sequestration and thus the remuneration provided on the gross increment would incentivise the orientation of forestry practices on the biggest increase in carbon sequestration and on afforesting, since young trees sequester high amounts of CO_2 in their growth phase. In cases of calamities (windthrows, droughts, pests) the financial rewards would rather remain constant if areas affected by damages are afforested and re-established, due to the characteristics of young trees mentioned above. This incentive would be different from the current situation, but also from making financial rewards conditional on the changes in the CO_2 forest stock, in that forest owners experiencing damages would not have the huge economic losses they presently face, or financial sanctions that would have to be implemented in a PES scheme to ensure conditionality. Basing the payments on the gross increment would thus not only provide sufficient means for afforesting damages areas but might act as insurance against risks and natural catastrophes (Elsasser et al. 2020a, p. 17, 18). As a second argument, the authors point to the sequestration of carbon in timber. The proposed measure is preferable because it would incentivise an increase the carbon sequestration in timber which increases the absolute contribution to climate change mitigation (Elsasser et al. 2020a, p. 18). Whereas the other two options would incentivise the preservation of the current forest cover and stock, the sequestration of carbon in wood and the subsequent usage of timber would be discriminated against (Elsasser et al. 2020a, p. 17, 18). The authors discuss the potential impacts choosing gross increment as a measure would have. Firstly, it would lead to a permanent forest cover, since freshly afforested or continuously managed forest allow for constant payments. Secondly, choosing tree species that are the most resilient to climate change, but also best adapted to local environments, native, would be incentivised, since these promise the highest growth rates over the long run. The authors argue here that coniferous trees, which so far have been often used for economic reasons, might not be the optimal choice in the future since they take up less carbon and are more prone to climate related and naturally occurring stresses (Elsasser et al. 2020a, p. 18). Lastly, turn-over rates would be oriented towards the increase in carbon, which

would prevent over aging of the forest cover (Elsasser et al. 2020a, p. 18, 19). This is solely looking on the climate impacts preferable, because turn-over rates would be chosen according to maximising carbon uptake and thus also lead to an increased provision of timber, which could further store CO_2 while being used in different economic processes. Before discussing the *biodiversity stock* it shall be briefly mentioned how the authors derive at valuing carbon sequestration based on the measure suggested.

Elsasser et al. propose to remunerate forest carbon sequestration based on the CO_2 price by either taking the CO_2 certificate price traded in the EU-ETS or the carbon price that has been set by Germany's climate protection law (BEHG 2019). Whereas the former has on average been 24.83€/t CO_2 in 2019, the latter was set to be implemented at a price level of 10€/ t CO_2 in 2021 and slowly increase to 35€/t CO_2 in 2025 and onwards (Elsasser et al. 2020a, p. 20). They argue for taking these prices as orientation, since they are democratically legitimised on the national and supra-national level. On the same basis they argue that setting a higher price, as suggested by various studies on the Social Cost of Carbon, or a lower price would face difficulties in being democratically legitimised[18]. Based on the discussion presented above, in which the authors show that their approach to quantifying carbon sequestration does not account for permanence of the carbon sequestered, i.e., the time that the carbon remains stored in raw timber used after the harvest, Elsasser et al. propose to introduce a discount factor, which accounts for the oxidisation of CO_2 at the end of the timber's life cycle (e.g. when it is burned or rotting). The choice of the discount factor would necessarily influence the amount of rewards substantially. It is important to consider here how the discount factor should be determined to account for permanence, but also how it can be designed in ways that make it adaptable to new insights (e.g., how rising temperatures influence trees abilities to store carbon), but also to set it in a manner that provides investment security of forest owners and businesses. Additionally, it has to be considered that the discount factor is also influenced by the usage of the timber. If more wood is used to produce energy the factor should probably be set higher to account for the short permanence of the sequestered carbon. But it should also reflect changes in the economic and political framework that influences the usage of the wood to account for the actual usage and thus the average permanence. What is more is that the discount factor could be determined by looking into how carbon accounting standards for forestry globally assess and compare the permanence of sequestered carbon (UBA, to be published). To sum up, the authors indicate choices for setting the CO_2 price, but do not discuss the size of the discount factor, which would account for the permanence of the CO_2.

As depicted above the authors state that **biodiversity** is more difficult to measure and to operationalise into goals than carbon sequestration. This has implication for the choice of indicators that are meant to measure and prove the improvement in the provision of this service, as well as the monetary evaluation of the services that fall into the biodiversity category. Elsasser et al. claim that on this basis and the current practice of monitoring biodiversity proofing additionality is restricted or made impossible (2020a, p. 20). They show that neither the goals and indicators formulated in Germany's national biodiversity strategy nor in the ones used in the Nature2000 sites can be used as a 'practicable set of indicators' (p. 22). Subsequently they propose to use a simplified set of indicators, which can either be determined by adapting the indicators used in the biodiversity strategy or the annual National Forest Inventory (Bundeswaldinventur (BWI)). They argue that even though the indicators assessed in the forest

[18] With a recent ruling by Germany's Constitutional Court, which assessed that the Climate protection law is insufficient to meet the goals of the Paris Agreement, and with the reactions of Germany's major parties and promises to adapt the existing legislation to the ruling, it is at least to expect that the price per tonne CO_2 will be further discussed in this year and after the elections, since it is one of the most important political instruments governing climate ambitions and actions on the national scale. This should optimally be reflected in further discussing the proposal's implementation.

inventory do not present a comprehensive measure for forest biodiversity, they are useful in providing approximate information on the stock and change in biodiversity (Elsasser et al. 2020a, p. 22). The authors propose to use the following forest biodiversity characteristics based on the Forest Inventory to translate them into indicators measuring the additionality, i.e., the improvement of the provision:

- Age and diameter of forest stock
- Structure and height profile of the tree stock
- Tree species composition
- Degree to which native species are chosen
- Dead wood and biotope trees
- Percentage of conserved area

Elsasser et al. recommend using these indicators transitionally until indicators are developed, that are in line with the biodiversity strategy and the conditions of the Habitat Directive (Elsasser et al. 2020a, p. 22). In order to attain measurable outcomes, it is firstly proposed to define a threshold level of these indicators, which determines that the remuneration in relation to the area of the forest is meeting this threshold level (e.g., the number of species that have to be presented for receiving payments in the "tree species composition" category). Secondly, a weighting factor is proposed, which establishes and expresses the relative importance of some services over others (they for example ascribe categories of "age and diameter of the forest stock" and close-to-nature areas with the highest factors). Both, threshold level and weighting factors are suggestions, which need further elaboration. Based on this system forest businesses and owners would be remunerated according to the sum of points resulting from the weighted indicators per year and hectare (Elsasser et al. 2020a, p. 23). To determine the contribution of the forest business or owner to biodiversity and nature conservation and the resulting remuneration one would have to multiple the sum with the area size under their management (Elsasser et al. 2020a, p. 23). The authors stress the importance of critically discussing and politically legitimising the choice of these indicators and their weighting. Even if they propose an approach which is aimed to reflect the international commitment and goals expressed in the national biodiversity strategy, and which is based on the available data, the proposal is missing democratic legitimation in this regard (Elsasser et al. 2020a, p. 24).

The authors find that no independent basis exists that indicates or implies an appropriate price for the remuneration of forest biodiversity preservation (Elsasser et al. 2020a, p. 24). Neither do international agreements, nor supra-national or national legal frameworks provide guidance and legitimation for this, nor do national or international markets for biodiversity preservation goods exist, from which a price for biodiversity preservation could be derived (Elsasser et al. 2020a, p. 24). The authors suggest that the payments for biodiversity should be related to climate protection remuneration in a sensible way, if they are to have an impact (Elsasser et al. 2020a, p. 24). To practically implement this, it would either need a constant relation between the CO_2 price and the performance indicators for biodiversity protection, or prescribing a 1:1 relation is needed, which would imply to modify the performance indicators in such a way that this relation would be depicted (Elsasser et al. 2020a, p. 24). Relating the rewards for the two services at an equal relation is justified on the basis of scientific findings that the societal demand for the two services based on preferences is equal (Elsasser et al. 2020a, p. 24, 25). Thus, the added ES value of both services is assumed to be equal. The authors also include a supply side perspective into their considerations, arguing that if one of the two services is rewarded substantially higher than the other, only one of the two would be provided, while producing administrative costs for the other, which in the end nihilates the rewards on the providers site (Elsasser et al. 2020a, p. 25). They argue for that designing the relation between the services and thus the level of payments for biodiversity preservation is a political decision in the end (Elsasser et al. 2020a, p. 25).

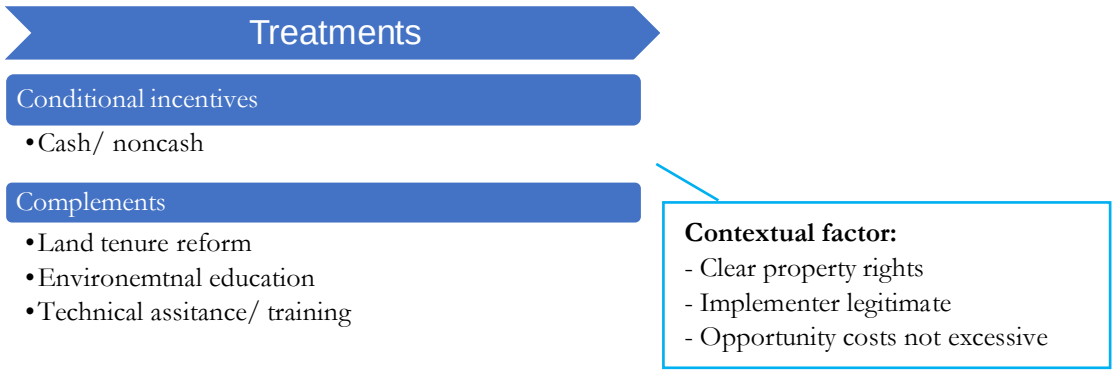
Wunder et al. (2020) distinguish between three scenarios of conditionality: 1) the actual service is measured and paid for, 2) the input level (e.g., adoption of land-use plans) is paid for, 3) intermediate level of outcomes/ resource-use proxies are paid for (e.g., protecting a certain area) (p. 212). Following this distinction, it can be argued that due to the data basis, carbon sequestration is fully outcome-based conditional, whereas biodiversity preservation has to be based on an intermediate level of providing proxy-services.

Summing up the elements of the contextual knowledge are the very core of the proposal for the scope of this thesis. The authors clearly depict the environmental threats and opportunities connected to forest carbon sequestration, but do not discuss forest biodiversity loss in as much detail. They argue for choosing sets of indicators that measure the annual change in sequestered carbon (gross increment) and using a pragmatically chosen set of indicators for biodiversity preservation to remunerate the area size that meets one or more of the six characteristics presented. The authors consistently argue on the basis of studies depicting a measurable demand for biodiversity preservation and carbon sequestration, which are assumed to have an equal monetary value. The proposal is thus grounded in economic valuation studies that indicate the WTP for specific FES across regions, but also in the availability of data and subsequent potential of monitoring additionality.

The last step of analysing this first block of the Theory of Change is to discuss the *influential contextual factor:* Wunder et al. (2020) do not further specify what a *stable ES payment vehicle* includes. Taking an educated guess based on the literature review, it shall be assumed here that it includes the security provided by establishing clear legal- and administrative structures, that are transparent in how the payments are to be organised and on what they are based on (indicators/ clearly described goals). It is here argued that the policy proposal is designed in ways that if implemented would lead to a stable payment vehicle. It is designed as an outcome-based scheme, which implies that only the actual provision of services is remunerated; it establishes a transparent data basis for further discussing the proposal and ties it back to democratic institutions and decisions. It also does not explicitly address the duration of the programme, which could indicate that it is supposed to remain in place for a longer period. All of these aspects and points of discussion feed into creating a basis for establishing a stable ES payment vehicle.

5.1.3 Treatments

Figure 4: Treatments



Source: Adapted from Wunder et al. (2020).

The **Treatments** are the payments for ES provision, as well as, the *Complements* that enable implementation of practices that lead to the ES provision. Elsasser et al. only discuss *conditional incentives* in monetary terms. As shown above the proposal includes the quantification of the

economic carbon sequestration value that the authors propose they remunerate financially (*cash*). The same is discussed for remuneration of forest biodiversity preservation. In-kind payments (*noncash*) are not discussed.

None of the *complements* are discussed in the proposal. Still, it is valuable to discuss here why thinking about these in the design process has been identified as valuable by the scientific literature. Tentative explanations for why the complements have not been discussed in the proposal will also be presented in the next paragraphs.

Land tenure reform is discussed by the scientific literature as being an important precondition for establishing clear property rights and to provide landowners with the opportunity to make independent land-use decisions, where this has not been the case previously. This is a precondition for them to participate and profit from the PES scheme by providing services. This complement is more often discussed in PES contexts where no clear property rights are established (Wunder 2020). Elsasser et al. discuss the need for legal reforms, where they see them needed, but do not discuss land tenure reforms. It could be argued that since the German legal system provides land tenure clarity, this complement has not been included in the proposal's discussion.

Environmental education is presented as an important complement to the financial treatments, where knowledge on how to manage forests for providing certain FES is lacking with landowners, businesses, and administrations (Wunder et al. 2020). It can be argued that if the policy proposal was implemented as suggested by Elsasser et al. providing *environmental education* to forest owners and administrations is needed to spread knowledge on management practices, like close-to-nature forestry or multifunctional forest management. Since these are not applied in most privately-owned forests in Germany, and because especially close-to-nature forestry management and other forms of ecological forest management practices are rather a niche practice, financial incentives supporting these management practices would have to be complemented with *environmental education* for them to be effectively implemented by forest owners, promoted by intermediaries, and monitored by forest administration.

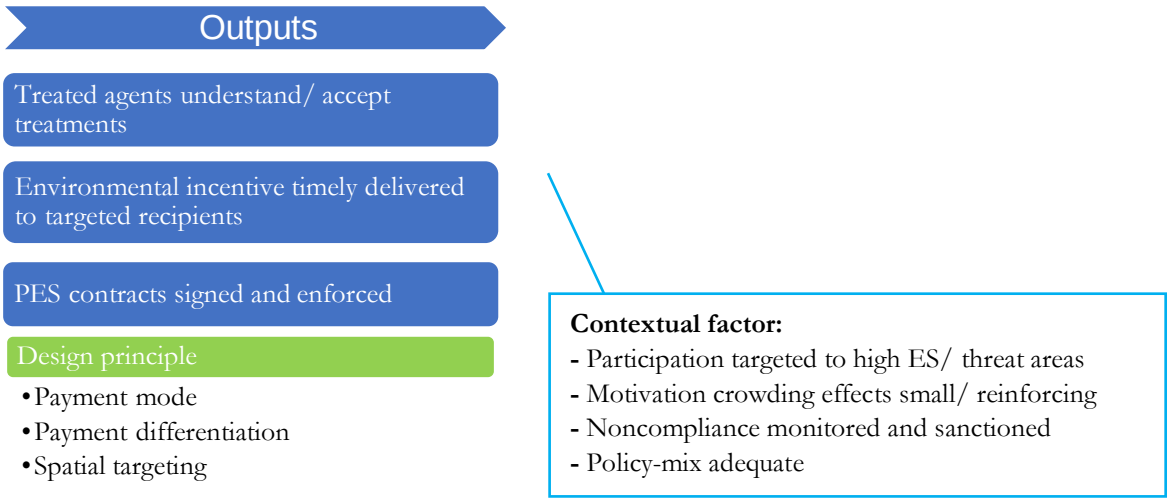
For similar reasons providing *technical assistance* and *training* can be advised. The policy proposal does not discuss these *complements, as* means for better assessing and monitoring biodiversity for example. It has been shown that the effectiveness of PES schemes increases if for example intermediaries provide advice to forest owners and authorities (Schomers 2019).

When it comes to the contextual factors at this stage, the authors describe the state to be *legitimate implementer* of the scheme, by its legal obligations. They argue that state intervention can firstly be legitimised if the market does not provide socially desirable outcomes (Elsasser et al. 2020a, p. 1). Secondly, the German State is by the international commitments it has made and as representing the societal interest responsible for implementing measures to ensure the provision of forest ES. Additionally, the call for a state financed or supported provision of FES is growing. Thus, the state is identified as being a legitimate implementer. Apart from the state, intermediaries also need to be seen as "legitimate actors" (Wunder et al. 2020, p. 214, 215). Elsasser et al. do not discuss the role that intermediaries could play in the implementation, nor do they suggest administrative entities that seem fit to occupy this position. In further discussion and implementing the scheme, suitable administrations, organisations and actors should be looked-for and identified, which are fit to take the role of building trust in local communities, supporting the negotiations of the contracts, but also in giving advice for implementing the necessary measures, as indicated above.

The authors define a second contextual factor, *opportunity costs not excessive*, in showing that the attractiveness of the financial rewards is necessary precondition for forest owners and business (Elsasser et al. 2020a, p. 4). The aim of the *Treatments* should be that businesses are enabled to make profits over the long run. This includes that the payments should not only cover the costs for providing the ES, and the administrative costs or risks connected to this system, but rather should provide support to enable profits (Elsasser et al. 2020a). This is also relevant for competing land-use options. The authors show that at present transforming land into agriculture is more financially attractive, than establishing forests. In order to meet the social demand for afforestation, financial incentives should thus be designed in ways that make it more and equally attractive to afforest land. On the other hand, their proposal does not analyse the opportunity costs since the amounts of payments are derived from the societal demand.

5.1.4 Outputs

Figure 5: Outputs



Source: Adapted from Wunder et al. (2020)

Since the working paper proposes the design of a policy, it cannot be evaluated or discussed against actual outcomes. Still, the proposal discusses desirable outputs, design principles and contextual factors, which are valuable to discuss here.

Result-based schemes, especially related to forest conservation, are faced with long time spans of measures leading to an actual and measurable provision of FES. A crucial output for PES has been identified in the timely delivery of the environmental incentive to targeted recipients. This is interpreted here as a timely payment of FES provided. The policy proposal has a great strength in suggesting the gross increment as measure for CO_2 sequestration. If implemented ES providers would receive payments after the period of one year, since the outcomes of increased carbon sequestration are proposed to be measured on a yearly basis. Even if the same can be assumed for the remuneration of biodiversity, it is not specified clearly on what timely basis payments shall be delivered. In order to avoid misguided incentives, it would be necessary to also provide payments on a yearly basis, so that ES providers can choose freely between which FES to provide, without being overly influenced by economic considerations. Adopting an interval of yearly payments would also provide incentives for changing forest management practices soon, as well as providing a stable payment rhythm.

The proposal does of course not discuss the treated agents and the contracts (points 1 and 3 of the outputs in more detail. From a design perspective it is advisable to further discuss how a social acceptance of the scheme, and thus an acceptance of the treatment could be created via participatory or stakeholder processes, since it has been showed that this is an important influencing factor for the scheme's effectiveness.

Regarding the design principles, none of them are discussed in the proposal. Whereas the *Payment mode* does not play an important role for the scheme's effectiveness at this stage, *payment differentiation* and *spatial targeting* could in the future discussion of the proposal play a central part. The latter two are not discussed, since the payments are based on the actual societal demand, and thus do not have to consider the relative costs for ES provision, as opportunity costs of ES providers, which would inform payment differentiation nor a budget constraint, under which spatial targeting should be considered, since the proposal suggests that the actual demand is met by funds that remunerate all providers. Wunder et al. (2020) have found that these two contextual factors are most crucial to increase environmental additionality when a PES scheme faces budget constraints. Due to the economic mechanism and rationale behind PES schemes, a budget constraint would imply that the sites for nature preservation contraction would be chosen according to the ecological value they hold provided at the lowest cost. A payment differentiation would increase the cost-effectiveness by negotiating contracts based on the opportunity costs of ES providers and on their intrinsic motivation. If the opportunity costs for providing a service are low, then the payment amount should be decreased, and if the intrinsic motivation of the ES provider to provide society with ES is high, this might lead them to accept contracts with lower payments. This has of course ethical implications in that the payment amount would solely be based on cost efficiency consideration and would utilise intrinsic motivation. On the other hand, this approach would also imply that areas with high ecological values or that are highly threatened to be devaluated in their quality are targeted to achieve the best conservation results. The proposal does not discuss spatial targeting either, because it suggests offering each and every ES provider remuneration.

Three contextual factors have been identified as important for this stage of PES implementation. *Motivation crowding effects small/ reinforcing* is not discussed by the proposal, since this also only regards schemes that are based on including opportunity costs to determine the amount of payments. The idea behind this factor is, that if ES providers hold intrinsic motivation to perform certain land-use practice that led to the ES provision without being paid for, then payments should be designed in ways that do not crowd out their intrinsic motivation, but rather reinforce it. Crowding out in this context describes the phenomenon that ES providers remunerated for a certain provision of an ecosystem service lose their intrinsic motivation to provide it for free through the financial incentive (Wunder et al. 2020). Consequently, payments cause them to stop their beneficial practice and result in fewer ES provided. These effects shall be minimised according to PES theory.

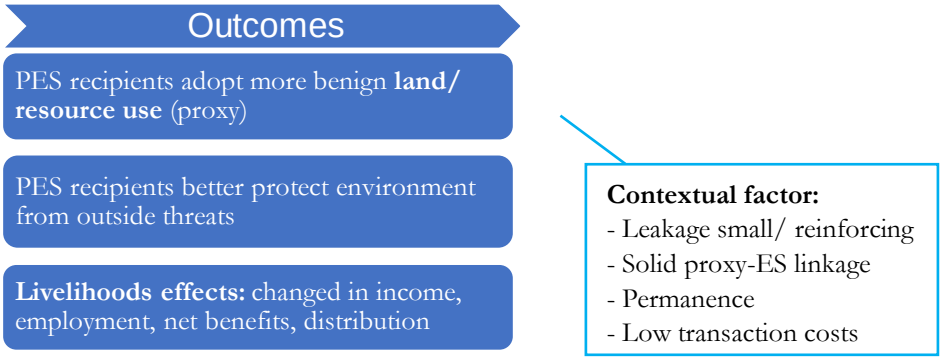
A second contextual factor is in fact discussed by Elsasser et al. They discuss what other policies might be needed to ensure a comprehensive and effective nature preservation. Hence, by discussing, for example that restructuring the legal- and economic framework is needed to also enable private-finance ES provision (Elsasser et al. 2020a) or showing that there is also the need for financing of National Parks to fulfil national biodiversity goals, the authors discuss the adequate *policy mix* needed for supplementing the suggested PES scheme and making it more effective in its implementation. Proposal also calls for including financing of National Parks but leaves open for what reasons.

Lastly, *enforced conditionality*, which can be reached through monitoring noncompliance and sanctioning is not discussed. Whereas it could be argued that based on the nature of their policy

proposal, Elsasser et al. did not need to consider the missing outputs, design principles and contextual factors described above, leaving out describing the need for enforced conditionality can be seen as a need for further development. It has been shown how enforcing conditionality can be looked at in Section 2 (e.g., Prokofieva 2016) and that it is a design principle that is usually left out on the global scale (Wunder et al. 2018). Even though Elsasser et al. argue that remuneration should take place on the condition that ES are measurably provided, they do not discuss the mechanism needed to ensure and enforce this. It has been shown that including such a mechanism considerably increases the scheme's effectiveness (Wunder et al. 2020). Since Elsasser et al. discuss the data needs for measuring the FES provision, it could be argued that on this basis, on an established monitoring mechanism, also a mechanism for sanctioning noncompliance could be developed. This has to be included in further discussing the potential implementation of PES schemes in Germany.

5.1.5 Outcomes

Figure 6: Outcomes



Source: Adapted from Wunder et al. (2020).

As for the previous sections the **Outcomes** can only be discussed to the degree of anticipation and expected steering effects. Thus, it seems helpful to assume what outcomes the PES scheme has, if it was already implemented. This section thus asks whether the **Outcomes** will probably be met and to what degree.

Two of the three Outcomes are discussed in the proposal. Firstly, the authors base the proposal on rather solid proxies showing that certain ecosystem services have been provided (*contextual factor)* by basing the suggested performance indicators on existing and reliable data. Additionally, as a result of the outcome-based orientation one could assume that forest owners and businesses would adapt more environmentally beneficial *land and resource use decisions*. Moreover, by integrating biodiversity preservation measures (like diversifying tree species composition and including close-to-nature forestry practices) forest could become more climate-resilient, which could be reinforced by the afforestation and the increase of the permanent forest cover incentivised by the carbon sequestration performance indicators, and thus better protect forest from *outside threats*. The proposal does discuss the *livelihood effects* to a certain degree. It argues that by providing financial incentives payment recipients are provided with income opportunities, which meet the current precarious situation of forest owners that are faced with calamities, but which also adds and might even exceed their current income by providing additional payments. It does not discuss issues of distributional justice, nor net benefits, which would require a more detailed assessment of ES providers, which at this stage is not feasible and not the scope of the proposal.

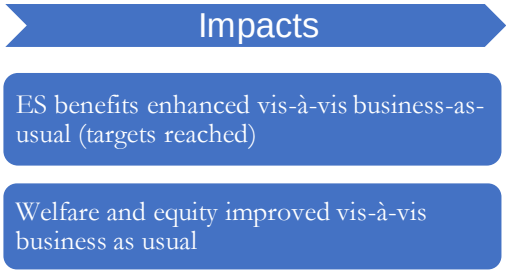
One could speculate in assuming that if the proposal was to be complemented by policies providing training and environmental education for implementing the scheme, it could well be that jobs are created for this. New jobs for training forest owners and businesses to adopt more climate and biodiversity friendly practice, for giving advice on how to restructure forests could emerge. While the proposal suggests strengthening the synergies between timber provision and carbon sequestration, potential effects on employment in the timber processing and manufacturing industries can hardly be foreseen.

Two of the contextual factors have been identified to be of utmost importance by the scientific literature. The *permanence* of the environmental benefits and the potential *leakage* effects describe the time and spatial dimension of PES schemes. Whereas the policy proposal discusses permanence, it does not discuss leakage effects in depth. The permanence of the CO_2 sequestration is discussed in relation to the performance indicators. The authors claim that the discount factor should incorporate considerations on how permanent the carbon is stored in living biomass, but also in timber products. It does not discuss the permanence of biodiversity though. But here it could be assumed that due to the suggested annual payments a sufficient incentive for providing biodiversity preservation over a long time is given. What can be added to the permanence considerations is that PES evaluation studies have shown that, once landowners provide certain services, they are likely going to continue providing at least a certain degree of the same provision even if the payments are stopped.

Leakage on the other hand is not at all discussed by the authors. As the Introduction has shown and as the discussion later will show, is that discussing leakage effects is crucial to account for the economic, political, and ecological contexts of PES implementation. There is a growing scientific consensus that using wood for energy production, which is supported by the EU's climate and energy laws, is having large leakage effects in that timber is being harvested in other parts of the world (e.g., the U.S., African countries, but also within the EU) to be burned. This produces higher CO_2 emissions and is detrimental to the biodiversity and presents an insensible usage of high-quality wood. If the PES was to be implemented, it would have to be considered how it impacts current forestry practices and trade-flows in order to not increase the detrimental effects. Whereas it can be argued that the introduction of PES schemes on a global scale cannot counteract the global loss in biodiversity that is driven by trade, investment, and financial regulation practices (Bigger et al. 2021) and thus divesting or abolishing legal and economic structures that drive this should be primarily targeted, the national introduction of PES schemes should be complemented by an anticipatory analysis of how it effects environmental conservation in other parts of the world.

5.1.6 Impacts

Figure 7: Impacts



Source: Adapted from Wunder et al. (2020).

As for the two sections above, the actual impacts can only be discussed on the basis of how the proposal is designed to create impacts. Wunder et al. (2020) show that even though many PES programmes focus environmental effectiveness mainly, they also have social targets. Whereas it has already been shown that the proposal by Elsasser et al. (2020a) includes many factors shaping the impacts, social welfare and equity concerns are not discussed prominently. It could be argued that including social welfare and equity concerns is important for assessing how the introduction of a PES scheme could support rural development and achieve a higher societal appreciation for the provision of FES.

5.2 The METSO programme

This section will include findings from the literature review, desk research as well as expert interviews. It will follow a similar structure in describing the METSO programme as a PES like in the previous section but will not go in as much detail and rather focus on the aspect of how it was effective and successful in preserving forest biodiversity. The analytical elements are highlighted in italics, to guide the reader.

5.2.1 Introduction

The METSO programme is a championed voluntary PES scheme and the "most important policy tool for forest biodiversity conservation in Finland" (J. Kangas, private conversation, 30. March 2021) which was implemented in Finland's southern region and is one of the most well-known schemes to target private non-industrial forest owners. Its main aims are to "halt the ongoing decline in the biodiversity of forest habitats and species" and to "ensure that favourable trend in forest biodiversity is established by 2025" (Metsonpolku, n.d. a). Private forest owners are given the opportunity to preserve "ecologically valuable forests habitats" for "temporary conservation or for permanent protection" (Metsonpolku, n.d. a). It is considered as furthering "many EU directives and long-term strategies for enhancing and promoting forest biodiversity and connects the needs of forest owners with those aiming to provide forest ecosystem services" (EFI Resilience Blog 2019). METSO's aim reflects what Wunder et al. (2020) called the *contextual knowledge* on the scenarios of environmental threats and opportunities (biodiversity loss vs. ensure favourable trends) and as well as the *biodiversity stock*.

Historical and political background: In their 2013 publication Primmer et al. track "the historical evolution of forest biodiversity conservation policies culminating in the development of a PES scheme", the METSO programme, in Finland. They distinguish between three phases: the traditional conservation approach that existed before the PES; a piloting phase, in which the PES was competitive; as well as a phase of institutionalised practice of an administrative PES (Primmer et al. 2013, p. 1141). The description of these phases is represented in the following to highlight the main PES design elements of the pilot and the administrative PES.

To describe the traditional approach of biodiversity conservation it is important to look at the forest ownership structures first. The structure of Finnish forest ownership is very diverse, but one can say that most privately owned forests, which often consisted of small holdings, are in the southern part, whereas most of the forests in the northern part are state-owned (CBD 2013, p. 1). The conservation of forests was implemented by the state in the northern part, where 28.6% of the land were protected (CBD 2013, p. 1), but faced difficulties and political resistance in the southern part in which the land purchase of the State sometimes even resulted in "law-enforced takings" (Primmer et al. 2013, p. 1141). Even though biodiversity conservation was also integrated with "conventional management of forests" (Primmer et al. 2013, p. 1141) only 2% of forests in the South were under protection (Primmer et al. 2013, CBD 2013), which implied political action.

The pilot, which was set out to run from 2001 to 2007 and was called "payments for nature values" (Primmer et al. 2013, p. 1142), aimed to increase the protected area size of just 2% in the southern part of Finland. It introduced an unprecedented and innovative policy instrument that was drafted to address the political resistance and was thus based on the voluntary participation of forest owners (Primmer et al. 2013, p. 1142), which is a key feature of PES schemes. Besides increasing forest biodiversity safeguards it also aimed at enhancing the network of protected areas (CBD 2013, p. 1). The scheme was government financed and ES providers received payments as a combination for "timber income loss and ecological characteristics" (Primmer et al. 2013, p. 1142). The price for the payments was determined based on the wood supply. i.e., from a supply side perspective, but also of ecological characteristics, i.e., the supply with ecological values. Thus, this phase oriented the payments on the Willingness to Accept (WTA), that is, the opportunity costs of forest-owners.

The PES scheme in its pilot phase followed a competitive bidding process in which sites that met certain ecological and prioritised characteristics would be chosen "by comparing sites and landowner offers, after which the payment was negotiated between the landowner and the administration (…)" (Primmer et al. 2013, p. 1142). This allowed for an economic efficient allocation of restricted funds (Primmer et al. 2013, p. 1142). The conservation budget that was provided, determined the price of the payments on the basis of the most attractive offers, which reflected the supply of certain ES. By this it shifted the payments from being bound to "hectares of a certain habitat type" to sites that "would meet some of the prioritized characteristics" (Primmer et al. 2013, p. 1142). Sites were chosen according to the lowest supply costs for certain ecological values. The scheme thus oriented towards preserving already existing favourable ecological conditions. Through this the PES scheme was including *spatial targeting*, one of three contextual factors identified to be most important to increase additionality (Wunder et al. 2020). Complementary to these financial incentives, the METSO programme intends to "enhance the communication, education and training of professional foresters" (Metsonpolku, n.d. a), two of the *complements* identified by Wunder et al. (2020).

The contract duration was mostly set at ten years, with fixed-term contracts (Primmer et al. 1142), but as mentioned above forest owners could also chose to temporarily establish nature reserves for periods of twenty years (Metsonpolku, n.d. a). The scheme was evaluated as a success, because it integrated and acknowledged land-owners' perspectives, but also had some "small positive ecological effects" (Primmer et al. 2013, p. 1142), which was proof for its *additionality*, even though the "newly acquired sites were considered to remain too fragmented" to be counted as meaningful entities (Primmer et al. 2013, p. 1141). In comparison to traditional regulatory conservation policies, the cost effectiveness was not as high as expected (Primmer et al. 2013, p. 1143). But the pilot achieved to attract forest owners that were intrinsically motivated to achieve ecological goals, which lowered the payment amount (Primmer et al. 2013, p. 1143). Hence, the *motivation crowding effects* (Wunder et al. 2020) could be said to be reinforcing.

The following PES scheme, which ran from 2008 to 2016, expanded its *scope* from a regional pilot to a programme that covers the entire southern Finland. But it was also considered to be discontinuation of the competitive PES scheme since it was "amalgamated into pre-existing governance mechanisms for forestry and nature conservation" (Primmer et al. 2013, p. 1138). The programme focused on financing two action points. Firstly, the programme in this phase financially rewarded conservation measures (*measure-based*), the amount of which was derived from compensating the opportunity costs (*WTA*), i.e., the economic loss. By this, the price was not determined based on the existing ecological values, but solely on the opportunity costs. The programme also merged already existing payments for environmental support for forestry with the payments for ecosystem service and was thus targeting already "protected Forest Act habitats and the new habitat types defined under the program". Moreover, its aim was to target

areas around already protected sites. This could be said to be *spatial targeting*, but one which is not necessarily targeted on the highest ecological values, but rather to expand the network, to also increase functional biodiversity. Sites were subsequently chosen on a "first-come, first-served basis". In addition to that hectare targets were included to improve the network of protected areas. Secondly, a further way of received financial rewards was incorporated: "nature values trading". Landowners would initiate offers of sites, which would fulfil certain habitat criteria. These offers would be integrated into permanent protection, whereas the offers would solely be negotiated on the basis of the ecological values and not on a comparison any longer. The implementers of the scheme were the forestry and environmental administration, which both had distinct responsibilities (*administrative frame*). This combination of administrations was potentially intended to overcome traditional conflicts between proponents of conservation and of utilisation of forests (Primmer et al. 2013, p. 1142 ff).

Before discussing this PES scheme further against the background of the analytical framework and comparing it to the policy proposal, three features shall be discussed in more detail: Intermediaries, biodiversity criteria, recent developments. These are of interest to the discussion of the proposal, because they provide a basis for comparison of crucial design features, but also highlight what policy makers would have to consider when further developing a PES scheme for the German context: the preconditions for radical institutional change, which can be influenced by intermediaries and "normative and cultural-cognitive institutions" (Primmer et al. 2013); the choice of biodiversity indicators (section 5.3.3.); and considerations of budget constraints as well as FES trade-offs (section 5.3.4.).

5.2.2 The role of intermediaries in shaping institutional change

Besides tracking the historical background and evolution of the METSO programme Primmer et al. (2013) also examined how institutional constraints could present barriers to a more radical change in policies governing PES provision by analysing the METSO programme. They were able to show that the effectiveness of PES programmes could be better explained by examining different institutions: regulative, normative, and cultural-cognitive institutions. This institutional analysis also proofs valuable in adding to the "realism of both the assumptions and the expectations" (Primmer et al. 2013, p. 1138) of PES' potential. As the authors have shown it is important to add this institutional perspective to the evaluation of PES schemes, to show how policy instruments, which seem to come into effect through change in regulative institutions only, are also affected by normative and cultural-cognitive institutions (Primmer et al. (2013, p. 1137), but also to keep these barriers in mind if PES schemes are designed.

The study's findings are important for designing the PES implementation process, but also for understanding what other elements or contextual factors, other than the ones in the Theory of Change, need attention in the designing process if the PES is to be effective. Primmer et al. show that landowners and members of administrations act as intermediaries, who influence the behaviour of other ES providers, resource managers and administration by carrying normative institutions (Primmer et a. 2013, p. 1140). These normative institutions include "communication and management practices among landowners and between landowners and authorities" (Primmer et al. 2013, p. 1140). They rest on "local social and professionals' expectations and standards, and guide behaviour on logic of appropriateness" (Primmer et al. 2013, p. 1140). Moreover, these intermediaries also hold cultural-cognitive institutions which include "motivation structure and local community commitment" (Primmer et al. 2013, p. 1140). Especially the later has been shown to influence the PES implementation in that "locally embedded and committed intermediaries that hold local social and trustworthy networks" are able to increase the effectiveness by providing advice and assistance to landowners and "should be considered as an active component within PES implementing governance structure" (Schomers 2019, p. 3,4).

Primmer et al. argue that "(a)dministrative and professional practices are often undervalued as an institutional constraint for introducing new policies" (2013, p. 1147) and for example show that the implementation of the PES scheme in Finland was influenced and likely continuously permeated by "standardized silviculture driven practices" of forest management in nonindustrial private forests which „are closely tied to these professional norms" (2013 p. 1148) and the administrative management practices. This goes to show that the implementation of new policy instruments is influenced by already existing administrative practices, by normative institutions that favour certain practices over others, and by intermediaries holding these normative and cultural-cognitive institutions. Any implementation of a PES scheme has to take these into consideration.

5.2.3 The programme to date

As in its beginnings the political and administrative responsibility for implementing, evaluating, and further developing the programme lie with the Finnish Ministry of the Environment and the Ministry of Agriculture and Forestry. The programme today is aiming to enhance "habitat management in commercially managed forests" as well as in privately owned non-industrial forests. In addition to the stated aims above it also serves to "improve the knowledge base on forest biodiversity and promote collaboration between forest and environmental organizations". The programme also enables "active nature management" to take place in both "temporary conservation agreements and in permanent ones". It is focused on "restoring and preserving valuable habitats in private forests". (Metsonpolku, n.d. a)

There are considerations and suggestions to expand the scheme's scope to carbon sequestration at present. Researchers from the Finnish Environmental Institute SYKE and associates from different ministries, forestry and agricultural organisations, and other research organisations are working in the Integrated Biodiversity Conservation and Carbon Sequestration in Changing Environment (IBC-Carbon) project, which aims to provide decision-supporting tools to manage forests, also for balancing ecosystem service (IBC-Carbon, n.d.). To date only research outputs, but no policy proposals exist, suggesting integrating the remuneration of different Forest Ecosystem Services. During the research phase Johanna Kangas from the University of Helsinki was interviewed, since she has co-authored a research paper with Markku Ollikainen, which still is in the process of being reviewed and not published (Kangas & Ollikainen 2021). Hence the intention of discussing the findings from the interview is not to present the findings of the actual paper that Johanna Kangas and Markku Ollikainen worked on, due to the limits of citing an unpublished work, but also not to unrightly anticipate and publish findings of the work of others. The intention of the following paragraphs is rather to use the interview for a more general argument by simplifying the argumentation line of Kangas' and Ollikainen' work. The author of this thesis is aware of the restricted validity of this procedure that comes with the inability to cite the methodology chosen to validate the findings, but it is convinced that the main economic argument can be used as a thought experiment and is of high value for the general argumentation of this thesis.

The paper's main intention was to find out how forest biodiversity conservation would be impacted if a carbon premium, that is a payment for carbon sequestration which does not fully cover the price of a tonne of CO_2, would be added to the METSO programme. Kangas and Ollikainen's work can be seen as a first step to explore how paying for carbon sequestration could be implemented into the METSO programme. The idea behind the carbon premium is that it would provide additional economic incentives to private forest owners, complementing the already existing incentives for biodiversity conservation.

Johanna Kangas argued that given a budget constraint PES schemes might exclude forest areas with high potentials for biodiversity preservation and carbon sequestration due to two reasons.

Firstly, maximising the provision of several ES under one budget constraint might lead to a cost-efficient outcome, which does not necessarily work to protect high ecological value areas. It has been shown that even if the indicators used in the METSO programme led to an identification of habitats with high value for biodiversity, not all have been covered and it might be potentially difficult to do that through this policy instrument (CBD 2013, p. 5). Secondly, one could argue that if PES' funds are restricted in budget and are not funded in ways that reflect the total value of forest biodiversity, some areas are left out of the PES' scope due to budget constraints, but also due to the nature of the instrument, which by aiming to maximise ES provision under a given budget constraint might exclude high-value areas for cost-efficiency reasons.

5.2.4 Analysis against Theory of Change background

Whereas the analysis based on the Theory of Change (Wunder et al. 2020) and the design features was not required for the purpose of this thesis, the main elements were described above. To be able to compare this scheme to the policy proposal the contextual factors (Wunder et al. 2020) as well as the main characteristics shall be summarised here to better explain how the scheme was successful in incentivising and achieving better biodiversity conservation. Over its history and evolution, the METSO programme has achieved to provide a *stable ES payment vehicle*. As shown by Primmer et al. (2013) the state was perceived as *legitimate implementer* and could overcome barriers to conservation by developing a PES scheme, which in its nature to be based on voluntariness was highly accepted by private forest owners and did prevent further enforced land-takings, i.e., secured existing *property rights*. It provided sufficient incentives to balance opportunity costs (*opportunity costs not excessive*), but in some instances the opportunity costs were overestimated, which resulted in a marginal decrease in economic effectiveness (Primmer et al. 2013, p. 1143). *Spatial targeting* was applied, based on site selection criteria (see Section 5.3.3), which resulted in small environmental additionality in the pilot phase, and was likely increased by targeting sites close to already protected areas and thus establishing larger connected areas, which likely also increased functional biodiversity. It has also been shown that the *motivation crowding effects* have been reinforced. Payment requests were lowered due to the intrinsic motivation of forest-owners (Primmer et al. 2013, p. 1143) and thus cost-efficiency was increased. As of 2013 sanctions targeting noncompliance were not reported (CBD 2013, p. 6), but in order to judge whether *enforced conditionality* was implemented more current evaluation studies would have to be assessed. The analysis and research were restricted in their comprehensiveness and thus statements on other contextual factors cannot be provided in a conclusive manner. What was found though is that the discussion around leakage effects is discussed around the possibility of biodiversity offsets (e.g., Primmer et al. 2019). The METSO programme was based on determining the amounts of payment by compensating the forgone revenues and the "conservation value as represented by surrogate indicators (e.g., decayed wood, large aspen trees)" (Raitanen et al. 2013, p. 20). Hence, the willingness to accept (WTA) payments was used to provide *contextual knowledge*. It increased the preservation of biodiversity in forests by allocating funds through a voluntary contractual and competitive PES scheme, which determined the most attractive sites based on the relation of provision of costs and ecological characteristics under a given budget constraint.

6 Discussion

6.1 Discussing your results against that which was already known

The analysis has shown that the policy proposal presented is a highly interesting case and suggestion for a Payments for Ecosystem Services scheme and can be called an innovative governance mechanism. It presents a consistent design of an outcome-based scheme, which if implemented in its comprehensiveness would create sufficient incentives for a balanced provision of forest biodiversity conservation, carbon sequestration and timber provision. The proposal has two strengths: its demand-side orientation and how it relates biodiversity conservation to carbon sequestration. The first major strength can be found in its orientation towards the measurable and actual demand for Forest Ecosystem Services since this establishes a solid basis for calling for sufficiently high budget of the PES. It is consistently argued why the remuneration scheme should aim at supporting the full extent to which Germany's forests can sequester carbon and provide biodiversity, i.e., all potential providers willing to join the scheme should be remunerated. If this call would be met, a substantive improvement in the environmental conditions could be achieved. A second major strength can be found in the proposal's suggestion on how to determine the measures for carbon sequestration and the biodiversity indicators. Incentivising the gross increment of carbon sequestered annually is a promising approach, because it could in fact lead to a quantitative increase of the forest cover by incentivising the transformation of land into forests, but also to a qualitative improvement of the forest's stock in incentivising a permanent forest cover and mixed tree stands. If, and only if, additionally, the remuneration of biodiversity services would be incentivised in a similar form as suggested and by setting the value relation to the provision of carbon sequestration equal, this would also lead to an improvement in the environmental conditions. The proposal can thus be evaluated as analysing the potential trade-offs between the three Forest Ecosystem Services focused on and aiming to maximise the synergies between carbon sequestration and timber provision, while minimising the trade-offs with biodiversity provision through suggesting biodiversity performance criteria, which act as a minimum standard in six categories.

6.1.1 Trade-offs

In order to discuss how the proposal considers trade-offs between FES different categories of trade-off analysis will be discussed in the next sections. Firstly, it will be shown how the proposal deals with incorporating ecological boundaries. Secondly, it will be asked if it ascribes biodiversity a prominent position. Thirdly, the choice of the carbon discount factors is discussed.

As shown in the Introduction, PES scheme development optimally includes an analysis of trade-offs between different FES that also incorporates considerations of ecological boundaries. It is argued here that whereas the proposal does include references to the finite nature of forest resources by emphasising the worsening state of forests' health and the resulting insecure economic outlook, it does not include and cannot account for the high uncertainty connected to the future of forestry. Since Elsasser et al. base their proposal on the current scientific consensus and aim for providing a basis for political discussion rather than providing inherently political views, they probably do not include this. But to further adapt the PES scheme a political discussion addressing these uncertainties will be needed, since they influence the choice of the proposal's indicators and thus its ability to react to environmental or economic threats. It can be speculated that the continuance of drought and pest damages will make the economic use of wood in products that do not store CO_2 long an unsustainable option in the future. Based on these environmental trends it might moreover become even more important to preserve the forest cover for securing its resilience and climate-mitigation functions in the near future. This implies that the policy's incentive for maximising timber growth, that has benefits for

afforestation and carbon sequestration, might have to account even stronger for not using as much timber in the near future.

One of the main assumptions this thesis builds on is that forest biodiversity protection is not sufficiently targeted by forest policies. Thus, the question whether the proposal accounts for this fact and what implications that has for its design is raised here. Elsasser et al. demonstrate that their suggestion for choosing biodiversity performance indicators is dependent on further political deliberation and legitimation which reflects the societal and political consensus on the priority of biodiversity preservation. By this they provide suggestions for and point to the needs of further political deliberation in aspects of trade-offs (e.g., carbon sequestration vs. biodiversity preservation). They provide strong arguments for biodiversity preservation on a factual basis: e.g., that the demand for it is to be roughly equal as the one for carbon sequestration and point to the needs to extend the network of conservation sites in addition to introducing biodiversity conservation through their proposal in private industrial and non-industrial as well as state industrial used forests[19]. What seems to be missing from their proposal though is a clear "political" statement on the need for awarding biodiversity preservation a special position in a potential PES scheme. But given that their proposal is adaptable to a higher or lower societal and political valuation of biodiversity conservation, they provide a proposal that can be designed to strongly protect biodiversity. For the reasons presented in Chapter 2, and the author's statement that further biodiversity protection is needed, the further political discussion should ensure that biodiversity is evaluated at least as equally important as carbon sequestration.

The proposal prescribes the synergy of carbon sequestration and timber provision by choosing gross increment to be the performance measures, which aims to incentivise the maximisation of both ES. The relation to biodiversity is on the other hand determined by the relative weight that the biodiversity performance indicators are given, and by choosing the discount rate. Setting the discount rate at a certain level thus influences the incentives for all three ES. In the following paragraphs it will be presented what further considerations have to be taken into account for setting the discount rate.

Determining the "right" discount rate is influenced by various factors and data availability, but also changes in economic and political systems and in climatic conditions. The discount rate is suggested for accounting for the issue of permanence, the duration the CO_2 is sequestered in living biomass, but also in timber, which depends on how it is used in economic process (e.g., as wood for energy or as construction material). In a first step it shall be discussed why making the discount rate adaptable to changes in economic, political, and environmental systems is crucial. Subsequently, arguments for why choosing a high discount rate based on the uncertainties connected with forest carbon sequestration potential are presented. The discount rate should be made adaptable for at least two reasons. Firstly, one could argue that because it is unknown to present how the effects of global warming will affect the sequestration potential of German forests, the discount factors should take these changes into account, by being based on the available data of the German carbon inventory (private communication with Hanner Böttcher). On a more theoretical basis it should also be made adaptable to the change in the legal and economic framework. If for example the EU's legislation on climate and energy, which currently incentivises burning wood for energy purpose, is changing more sustainable forms of using timber and wood could be enabled, that would store CO_2 longer. Apart from reflecting and better reacting to the changes in the economic and natural systems, an adaptive discount factor might also imply a certain insecurity for investments. But this insecurity is to be assessed

[19] They exclude municipality (and Federal State owned) forests from this list, due to the differentiation in responsibilities and the subsidiarity principle, which give the State a scope of action only in state owned and private forests.

as rather small regarding the prospects of an increasing CO_2 price in Germany. The same arguments also do account for setting the discount factor. Here, it is argued that choosing a rather high discount factors is politically advisable given the certain lack of knowledge of how climate change is further going to affect forests and the permanence of CO_2 sequestration, as well as to ensure that biodiversity is sufficiently preserved as well.

6.1.2 Adapting the scheme to a budget constraint?

There is a second assumption that is of crucial importance for the anticipatory evaluation of the proposal's effectiveness, which is that the proposal is met with the financial means to meet the actual and measurable societal demand for biodiversity preservation and carbon sequestration and thus implemented in its comprehensiveness. As argued above, the proposal's strength is to base its outcome-orientation on the actual demand. But how would the proposal's effectiveness be influenced if it was not met with the financial resources that can be derived from the societal demand, the CO_2 price and from setting the values for biodiversity conservation and carbon sequestration equal? This question is important to raise, since it seems that the idea of remuneration of the forest climate mitigation function attracts substantial political support across a wide political spectrum while (combining it with) biodiversity preservation is discussed far less. There clearly is a threat that any proposal, also the one that is currently prepared by a Federal and State Commission ("Bund-Länder Arbeitsgruppe"), faces difficulties in combining the remuneration of these two services for various reasons. While it is difficult to assess how likely it is that remunerating both services will attract political support in the future some thoughts on this shall be presented here briefly, before discussing the prospects of adapting the proposed scheme to a budget constraint. While it is rather likely that the economic incentives for using forests climate mitigation function resulting from Germany's international commitments area are sufficient to mobilise political support and capital for a PES, the outlook for funding biodiversity preservation is more insecure. Concrete proposals and opportunities for funding forest carbon sequestration already exist. The most important facility to mention here is the energy- and climate-fund, which receives financial resources from taxing CO_2 and has been discussed as a feasible option (WSL 2020; Forstwirtschaft in Deutschland 2020). For biodiversity this is not yet the case. Still, political incentives are also given in that Germany aims to implement nature preservation areas in privately-owned forests on a size of 10% (BMU 2019).

Because it cannot be anticipated at the moment how likely it is that biodiversity preservation receives the same political commitment as carbon sequestration, or how likely it is that a PES scheme will be equipped with sufficient financial resources, it is valuable to discuss what would happen if a proposal supporting the two FES was facing a budget constraint in its implementation. To discuss this the comparison between the proposal and the METSO programme proved valuable. The next paragraphs will discuss the questions of A) How would the proposed scheme need to be adapted? B) How would a budget constraint impact the provision of both FES? And C) What are potential advantages and disadvantages of this?

It is to assume that if the policy proposal was facing a budget constraint it would need adaptation, because not all potential ES providers could be remunerated. The theory and evaluations of PES have shown that given a budget constraint environmental additionality and cost-effectiveness can be best achieved by *spatial targeting* (Wunder et al. 2020, p. 215). Spatial targeting includes that high-threat or high-value (ecological, biodiversity or carbon sequestration) are specifically targeted. Due to the nature and economic mechanism the PES is based on a budget constraint would also imply that it is most cost-effective to orient the payments to the opportunity costs of ES provision in relation to the relative environmental benefits. The rationale behind the scheme would thus potentially have to change to one where instead of providing financial rewards to all potential ES providers only those would get rewarded which in sum could offer a maximised ES provision under a given budget constraint.

Other needs for adapting the scheme's design would probably also occur. Basing a scheme's payment amount on the opportunity costs would in the optimal case include regional or even individual assessments of ES providers' opportunity costs to identify the most cost-efficient offers and sites, which would come at higher input costs for these studies and assessments.

To show how the implementation of the proposal under a budget constraint would lead to different outcomes in the ES provision, and compare the proposed scheme to its adapted form, the findings from analysing the METSO programme are helpful. By the comparison to the METSO programme[20] it can be shown that implementing the proposed policy with a limited budget could have disadvantages. Firstly, based on the findings from the interviews it could be speculated that this would lead to an exclusion of areas with high biodiversity values and high carbon sequestration potential from the programme, due to their relative cost-inefficient provision. Secondly, areas with lower biodiversity values might be included since the opportunity costs for preservation are lower (H. Böttcher, private conversation 12. May 2021), especially if the performance indicators for biodiversity preservation are not sufficiently ambitious. This would have the impact that the potential for forest carbon sequestration and biodiversity preservation would partially be realised. The incentives for afforestation would probably be lower in proportion to the budget. Another outcome could be that forest with high biodiversity values would not be protected, which might result in further losses. This could potentially have an economic disadvantage in that even higher funds for regulatory forest conservation policies would be needed to preserve high-value areas that were excluded from the PES scheme, if a certain quality of biodiversity was to be preserved.

On the other hand, adapting the scheme to the budget constraint could also have benefits. It could provide a cost-efficient option to reach the nature protection target of 10% in privately owned forests (BMU 2019). Similar to METSO's pilot phase, a competitive bidding process could be the basis for choosing conservation sites and the targeted area goals could be increased yearly on the basis of the most cost-efficient offers (H. Böttcher, private conversation 12. May 2021). For this to process to achieve environmental additionality, sites should preferably be chosen in ways that connect already existing conservation areas. This discussion has shown that whereas it is preferable to implement the proposal with sufficient budget, it could also function well under a budget constraint, but would have to be fundamentally changed.

6.1.3 Discussing missing design elements, limitations, and policy mix

This section discusses the limitations of the analysed proposal and of the policy instrument as such. It also discusses Elsasser et al.'s recognition of PES limitations and the potentials of improving or designing an adequate policy mix to meet these limitations.

Whereas it has been shown that Elsasser et al. did not discuss certain design principles as spatial targeting due to the design of their proposal that did not require to account for opportunity costs, one design principle is apparently missing regardless of their choices: ***enforced conditionality***. Elsasser et al. do not discuss how a mechanism and the administrative capacity responsible for monitoring ES provision, detecting deviations and effectively sanctioning them, could be set up and determined. Wunder et al. (2018) found that PES schemes globally often leave this design principle out and identified it to be one of three measures to increase environmental additionality the most (Wunder et al. 2020). A further discussion on the

[20] The METSO programme was an outcome-based scheme in its pilot-phase. It targeted already existing high-value ecological areas and determined payments from the supply side (forgone revenues from selling timber, but also the cost of providing high-value ecological sites). It faced a budget constraint, and maximised ES provision under this.

implementation of the policy proposal would need to consider how an effective mechanism enforcing conditionality could be designed.

Apart from this the policy instrument class of PES schemes faces substantive limitations that have not been addressed in the proposal but need to be reiterated especially in the face of the public discourse surrounding PES schemes. PES schemes are faced with an increasing interest by policymakers and an associated hope and have been mistaken as a "silver bullet" to tackling environmental policies in the past. In reviewing their potential to tackle the current climate and biodiversity crisis against the scientific literature and the analysis of this paper, certain limitations become apparent. Outcome-based PES, and PES schemes in general are limited in their potential in that they can only steer the provision of ES for which performance indicators, based on available data, can be developed. After a long-standing critical debate on PES' ability to work as an effective conservation policy instrument (e.g., Gómez-Baggethun et al. 2010), and on its ability to account for different value dimensions, a consensus on their limited applicability has developed. It has been shown that PES can be an effective policy instrument in preserving certain natural values, but that they are limited to our knowledge and ability to measure and evaluate FES' and biodiversity's contribution to societal welfare. It has been argued that they cannot depict nature's full value due to this lack of knowledge, but also due to the inability of quantification and economic valuation methods to capture the various value dimensions that ecosystem services hold. One could argue that their potential for enabling environmental conservation, that is also based on a precautionary approach, which accounts for value dimensions outside the market-based logic, depends on whether these policy instruments and the economisation of nature they utilise are based on an approach to "promote the acceptance of a politics of sustainability by using supportive economic arguments" (R. Loske in Green House think tank 2021). The question of how they are framed and how they are complemented by other policies is thus of high relevance.

This leads to the question of how an ***adequate policy mix*** can look like, and which aims it should follow to complement the PES scheme. It has been shown that for a successful preservation of forest biodiversity further policy instruments might be needed to complement the PES scheme. Past and current evaluations of the METSO programme, and the policy proposal analysed suggest that in order to preserve high-value ecological sites more traditional policy approaches might be needed to complement the PES scheme. Elsasser et al. (2020a) for example call for integrating the financing of further environmental and nature protection measures into the proposed PES scheme. They highlight the need for financing of national parks (2020, p. 31) in order to meet international nature and environment protection goals. But since the German State does not have the competence to implement them, a need for financing them is identified. In doing so the authors consider the limits of their proposal and call for complementing policies to reach the mentioned goals.

6.1.4 Critical reflections

In this section, critical and normative perspectives observable in the public discourse, but also perspectives regarding the interconnection of forestry with other sectors shall be discussed to constructively criticise the PES approach to better environmental and climate protection.

A main critique to the proposal can be formulated in that it does not point to forest policy's responsibility of the precarious state forests are presently in. This critique has been voiced by different environmental NGOs and researchers, who remark that the state of forests in the public discourse is often explained by climate change related stresses, but not by forest policy omissions to better provide guidance and support to organise forest and forestry to become more climate resilient. This critique is also connected with a call for a sustainable transition of forestry ("Waldwende"), which aims amongst other things at enhancing close-to-nature forestry

practices and views the economic prospects of forestry as potentially more conflicting with the need to preserve biodiversity and strengthening carbon sequestration than the policy proposal does. The critical voices of past forest policy also point to the detrimental effects that using heavy machinery at the current turn-over and harvesting rates for forest ecosystems, argue that using wood with short life cycles does not account for its value and has adverse effects for forest biodiversity and its climate mitigation function. They thus have a different problem perception than the one expressed in the policy proposal, which is partly overlapping, but also more critical of the current forestry practices. The policy proposal can be evaluated as being cautious in taking positions that are too normative or political in nature. It proposes that crucial design elements should be further deliberated on to be democratically legitimised and reflecting a societal consensus. It opens a window for deliberation in stating that determining the relation between carbon sequestration and biodiversity preservation performance indicators, which is critical for providing economic incentives and balancing the three ecosystem services, has to take place in the political arena. From analysing the proposal, it can be shown that the performance indicators and the discount factor can theoretically be set in ways that reflect a high valuation and appreciation of biodiversity. Hence, incentivising forest-owners to adopt close-to nature forestry practices, increase the number and composition of tree species, and to leave dead wood in the forest to increase biodiversity, all elements that are highly emphasised by proponents of a more fundamental restructuring of current forestry practices, could be decided on.

Still, the proposal does not call for a broader societal discussion on the future of German forestry and forest policy, which seems to be needed to include diverse perspectives, account for the value of the public goods forest provide, and to make it more sustainable. Whereas it can be argued that the proposal aimed to provide a balanced view of different societal, political, and economic interests in the forest resources and thus also bridge the ideological divide between proponents of conservation and the use of forests, one could also argue that for a better representation of societal interests in forest politics and governance a stronger participation and democratisation of the policy field could be beneficial. This would not only account for the increasing interest of the public, but also for the potentials of the forest sector to better demonstrate its valuable contribution to society. To break this down to a more concrete level, to foster the proposed PES acceptance and effectiveness, participation processes for co-designing the instrument are needed as next steps.

In addition to that it can be criticised in setting the gross increment as measure to maximise the synergies between carbon sequestration and timber provision. Whereas it is argued that this would be a sensible solution to not discriminate against the usage of wood, and thus against the current most important income opportunity for foresters, it can also be well argued that this perception misses the synergies between carbon sequestration and biodiversity in that it designs the proposal in ways that maximises the synergies between carbon sequestration and timber provision through using a "shared" performance indicator. A study conducted by Oeko-Institut for Greenpeace Germany (Böttcher, Hennenberg & Winger, 2018) has found that there are considerable synergies between managing forests in more extensive forms, e.g., close-to-nature, and carbon sequestration. Connecting to this study are findings that suggest that forests grow to become more resilient and better able to sequester carbon if they are naturally rejuvenating. One could criticise the proposal for not connecting carbon sequestration better with biodiversity preservation but would also have to provide a "better" way for doing so, which is difficult to find. Alternatively, one could argue and call for that the proposal, or adaptations of the proposal must include strong biodiversity performance indicators that are implemented in relation to the carbon sequestration, if the synergies that have been identified are to be realised.

Additionally, to prevent trade-offs between carbon sequestration and biomass provision on the one hand, and forest biodiversity on the other hand, minimum criteria for biodiversity (H.

Böttcher, private conversation 4. March 2021) or for 'good forestry practices' (Winkel & Volz 2003)[21] could be integrated into the PES scheme. Whereas the former might be easy to adapt to the proposed scheme's logic, the later might be rejected based on arguments that it restricts or would prescribe certain forest management practices in a policy instrument that is voluntary in nature. It could be argued that the proposal should provide forest-owners with a maximum of freedom in choosing which ES to provide and which incentives to choose among. On the contrary, it could also be well argued that in order for the proposal to have the envisioned effects of not only restructuring forest policy, but also forestry practices, it should adopt minimum standards for supporting a more fundamental change. The very nature of PES schemes lies within "voluntary transactions between service users and service providers that are conditional on agreed rules of natural resource management for generating offsite services" (Wunder 2015, p. 241). It could thus be argued that in principle the State could set minimum requirements as the rules of natural resource management practices without harming the voluntary nature of the PES, if ES providers are free to join or to agree to these practices. Introducing standards for 'good forestry practices' or minimum requirements for biodiversity preservation could serve the purpose of changing the focus of forestry from providing biomass as its primary goal to ensuring forests' ability to provide biomass, alongside other FES that are to be remunerated. This appears to be valuable against the background of the following section.

Following Farley and Constanza's (2010) distinction of ecosystem goods and ecosystem services, an additional analytical perspective could be added to Elsasser et al.'s ES definition. Farley and Costanza proposed to define timber as an ecosystem good and the productive capacity of forests to sustainable supply the timber as an ecosystem service. Whereas both Farley and Constanza, and Elsasser et al. (2020a) come to the same conclusion of that governments should act to ensure and preserve the productive capacity of forests to secure timber supply, this distinction implies taking a different perspective on FES. It can be well argued that if preserving the productive capacity of forests would be defined as an ES to remunerate slightly or even more fundamental changes in developing performance indicators and measures taken to provide this ecosystem service would be incentivised. This could for example include a perspective on preserving soil health, strengthening nutrient exchange between trees by letting forest naturally regrow and emphasising biodiversity preservation even more since its loss results in less efficient nutrient uptake of ecosystems. Introducing this perspective and distinction into the political discourse and debate around the design of PES is important to show that from a theoretical, as well as, practical perspective changing the focus of forestry would be valuable to achieve the nature protection and climate targets.

6.2 Reflecting on the results of your study

This section will discuss the strengths and weaknesses of the methodological choices, the legitimacy of the research questions, and the generalisability of the obtained results.

The chosen methodology mainly enabled three analytical perspectives. Firstly, the analytical framework proved useful for analysing, presenting, and comparing the policy proposal in a comprehensive manner. Secondly, the in-depth literature review and analysis of the current public and political debate allowed for including some of the more fundamental critique from an ecological economics perspective regarding the usefulness of PES in general, but also for reflecting about the different purposes a PES scheme could serve. Lastly, by reviewing literature from different disciplines a more nuanced discussion of the policy proposal was enabled. This allowed for better differentiating between justified criticism regarding the economic instrument

[21] The proposed idea was found in an article written by László Maráz (Forum Umwelt & Entwicklung, 2020).

and the proposal's design choices, and criticism that rather concerned the elements that the proposal could not address, like politically advocating for more biodiversity conservation.

The research questions were legitimised. Over the course of the research the public, political and scientific debate around forest policy, its goals and the finiteness of forest resources intensified within the German context, but also on the EU level. This reaffirmed the topicality of the questions. The methodological and analytical choices also implied some limitations. Further research would have been needed to answer RQ3 more comprehensively. The findings from the interviews with researchers showed that the analysis and comparison of biodiversity indicators and carbon standards would be needed to better discuss the policy proposal's crucial design elements. Moreover, to better anticipate the potential impacts of setting the discount factor for carbon sequestration at different values analysing how this choice would impact balancing of incentives for carbon sequestration and biodiversity preservation would have been interesting.

Two findings seem to be of a broader relevance for countries that also have a comparably high share of forests like France, Poland, but also the Nordic countries of Sweden and Finland. It can be assumed that balancing biodiversity preservation and carbon sequestration better in these countries would also lead to an increase in societal welfare. This is especially true for countries which have large forestry industries and in which biodiversity loss has become a pressing issue (like Sweden). The second finding of importance is that to better overcome the ideological divide between forest preservation and forest use (Wolfslehner et al. 2020) participatory stakeholder processes are needed to complement the design and implementation of PES schemes in order to better include and reflect different stakeholder perspectives and societal interests. It has been shown that where similar processes have been tried, these processes were in some instances dominated by specific interest groups. Fischer et al. (2020), for example, show that in a Swedish stakeholder process dominant industry perspectives were excluding interests from marginalised groups. This gives reason to assume that further participatory and stakeholder processes are needed for forest policy development.

7 Conclusions

This thesis analysed and compared a recent policy proposal for introducing a remuneration scheme for Forest Ecosystem Services in Germany against an analytical framework and an already existing PES scheme for forest biodiversity preservation in Finland. It highlighted the need for developing new policy instruments and governance mechanism for better balancing the provision of different Forest Ecosystem Services. Based on the observations that the current changes in global climate connected to unsustainable forestry practices have led to an increasingly deteriorating state health and resilience of forests, and the resulting insecure economic prospects for forestry, the need to restructure Forest Ecosystem Services policy and governance has been identified. The research objective was thus to find out how Payments for Ecosystem Services schemes can balance the trade-offs between three distinct Forest Ecosystem Services (carbon sequestration, biodiversity preservation and biomass provision) in German forests.

The following research questions were raised and answered:

***RQ1**) What are PES design principles that support an economic and environmental effective provision of ES?*

By reviewing scientific articles describing the theory behind Payments for Ecosystem Services schemes and policy evaluation studies analysing the implementation of PES a set of design principles and elements, as well as, policy evaluation criteria was identified (see Section 2.2). This informed the development of an analytical framework, which combined a Theory of Change for PES (Wunder et al. 2020) with design principles found in the scientific literature. Figure 2 graphically depicts the design principles and contextual factors that support an economic and environmental effective provision of Forest Ecosystem Services.

Firstly, it was found that result- and outcome-based schemes, as well as government financed schemes were most cost effective in reaching their environmental goals. A crucial precondition for this was identified to be *conditionality*, and the enforcing of conditionality by effectively monitoring and sanctioning deviations. Secondly, it was shown that schemes in which the implementer (e.g., the State) or intermediaries were perceived to be legitimate gained higher social acceptance, which positively influenced their overall effectiveness (economic and environmental). Thirdly, developing and finding the adequate policy mix to complement the implementation and goals of PES was found to be substantive to reach its goals. For example, policies to protect high-value ecological sites were regarded as decisive for supplementing PES implementation, to add to the overall environmental effectiveness by conserving valuable sites. Fourthly, developing and using solid ES proxies was shown to increase the environmental effectiveness of the schemes, since these proxies enabled incentivising better informed land-use decisions and monitoring. Lastly, considering and accounting for the permanence of the ES benefits and the leakage effects was described as being crucial for the PES schemes' environmental effectiveness.

***RQ2**) What are current policy proposals in Germany and Finland to improve the policy mix for balancing Forest Ecosystem Services provision?*

In a first step a recent policy proposal suggesting a remuneration scheme for Forest Ecosystem Services in Germany (Elsasser et al. 2020a) has been described and analysed (see Section 5.1). It was shown that the proposal is an outcome-based PES scheme, that not only targets the three Forest Ecosystem Services of relevance for this thesis, but also others, which makes it comprehensive in its approach. By structuring its analysis and presentation with the help of the analytical framework it was shown that the proposal is also comprehensive in discussing various input factors, like the legal basis needed for implementing a PES scheme, or the contextual

knowledge of ecosystems and the relevant economic actors. It was found that it provides a strong basis for discussing the potentials of PES schemes in Germany, by being based on economic valuation studies, current available data, but also by tying the proposal back to the international commitments for climate protection and biodiversity preservation the German State has committed to.

In a second step, the METSO programme, a Finnish PES for forest biodiversity conservation, was analysed (Section 5.2). It was found that no current policy proposal exists that proposes to further develop this programme for balancing Forest Ecosystem Services provision. Nonetheless, it was found that based on yet to be published research, an idea of supplementing the METSO programme with a carbon premium is being developed. To be able to compare the policy proposal by Elsasser et al. to METSO's design and to the newly developed idea, the METSO programme was described based on evaluation studies. It was shown that it followed a competitive bidding approach in its pilot phase, in which sites for forest biodiversity preservation were chosen by combining cost efficiency and ecological criteria. The programme was evaluated as successful in reaching its preservation and area targets. Reviewing the idea to integrate a carbon premium into the programme showed that the programme could be further developed to also finance the provision of forest carbon sequestration through private forest owners.

RQ3*) How can the choice of design elements, biodiversity and carbon sequestration indicators, and monetary values be implemented in a way that reconciles trade-offs between biodiversity preservation, carbon sequestration and biomass provision in the German case?*

It has been found that in order to develop a PES scheme, that is able to balance the provision of the three forest ES, a policy instrument development has to include at least three elements: 1) The analysis of current and potential trade-offs between forest ES, 2) Accounting for current political and economic framework conditions, and 3) Making choices and trade-offs between different FES transparent and subject to political deliberation.

The policy proposal analysed includes these three elements. It, for example, analyses the trade-offs between using timber and carbon sequestration in discussing a suitable performance indicator for carbon sequestration, points to potential trade-offs between these two ES and biodiversity preservation, as well as proposes to meet these trade-offs with setting sufficient biodiversity performance indicators. The authors also include current economic and political conditions by discussing how for example the forestry sector is unable to influence the usage of wood, which is why they do not include sequestration of carbon in timber in the performance indicator for carbon sequestration. Lastly, the authors show that relating the societal and economic value of carbon sequestration and biodiversity preservation in a way they propose needs further political deliberation. They thus point to the choices they have made by proposing a certain value relation, make this choice transparent and moreover call for further political deliberation on their suggestions.

Moreover, it has been found that balancing the provision of different FES crucially depends on how performance indicators measuring and quantifying ES contribution to societal welfare and awarding these contributions an economic value are determined. The policy proposal develops the performance indicators based on findings from economic valuation studies and on data available for the ES provision. By choosing gross increment as performance indicator for carbon sequestration, the proposal aims to maximise the synergy between carbon sequestration and biomass provision. It relates forest biodiversity conservation to forests contribution to carbon sequestration by deriving an equal value relation from economic valuation studies. By setting the contribution of these two services to societal welfare equal a balance of economic incentives

is reached, which if the PES scheme was to be implemented could also practically lead to a balanced provision of forest ES. But this would only be achieved if the proposal was either being met by sufficient funds to incentivise the provision of ES that meets the actual demand for both services, or if the value relation of 1:1 would be implemented, regardless of the financial resources the proposal receives.

7.1 Practical implications and recommendations for non-academic audiences

It has been shown that the analysed policy proposal is promising in that if it was implemented with sufficient financial resources and an equally high valuation of forests' biodiversity and carbon sequestration it would likely incentivise a balanced provision of Forest Ecosystem Services. It has also been shown that even if it faces a budget constraint in its implementation it could be adapted in ways to make it environmental and economically effective.

However, from a politics of sustainability point of view the implementation of the proposal has to be further debated on in order to determine if further precautionary measures are needed to better reflect the lack of knowledge regarding the value of biodiversity or how climate change will further affect forests' health and the economic prospects of forestry. Determining the discount factor has been identified as a crucial design element to account for this lack of knowledge, which also concerns the permanence of the carbon sequestration. It could be argued that setting the discount factor for carbon sequestration high would be advisable to account for the uncertainties of permanence and for precautionary measures to preserve biodiversity, given that the incentive to sequester carbon remains sufficiently high.

Based on these considerations, recommendations for policymakers and NGOs can be established.

Policymakers:

Designing a participative process for PES design and implementation

In the discussion, it has been shown that there are different perceptions of what problems the forest industry and forest-owners currently face, which informs the call for certain policy interventions and frame desirable solutions. One recommendation for policymakers is thus, that a participatory process should be designed in which different societal stakeholders are able to establish a common problem perception, which depicts the environmental threats, and base the aim of a potential PES scheme on this perception. This is advisable because there is a need to legitimise how a potential PES scheme configures the relation between biodiversity preservation and carbon sequestration. Moreover, this kind of process could be used to debate on the limits of the forest resource and the uncertainty connected to this to show and discuss the limits of societal demands for forest resources.

Ensuring sufficient budget for improving the data base on biodiversity

Elsasser et al. (2020a) have shown that in order to meet the National biodiversity goals and meet the international commitments with a PES scheme would require the improvement of biodiversity indicators and monitoring. To make PES schemes effectively work, a sound data basis is needed, which under present conditions would need further funding.

Setting a mechanism to ensure *enforced conditionality*

Setting up a mechanism and finding an administration capable of monitoring and effectively sanctioning deviations in a PES scheme has been identified as one of the most important means to increase PES effectiveness. As the analysis has shown this should be further discussed.

NGOs:

Lobby for and ensure that biodiversity preservation and carbon sequestration are remunerated in combination:

There is a threat that biodiversity preservation will not be equally valued as carbon sequestration or not be met by sufficient financial resources in the implementation of a PES scheme. It is therefore of crucial importance to communicate and demonstrate the immeasurable and measurable contribution of forest biodiversity to societal welfare. The policy proposal analysed provides a good basis for arguing on a scientifically for at least an equal value relation between these two Forest Ecosystem Services.

7.2 Recommendations for future research

The recommendations for future research can be distinguished into research that suits the scope of this work and research that goes beyond it.

The results of this research indicate that further research on already developed biodiversity indicators and standards assessing carbon sequestration and its permanence is needed to better assess the potential of the analysed, but also other, PES scheme(s) to account for the uncertainties connected to climate change and to further the knowledge on biodiversity.

Connected to this, it would certainly be valuable to assess and further research on how setting the discount factor for carbon sequestration in the suggested scheme would influence the degree of a balanced ES provision. It would be particularly interesting to discuss and find out how setting a high discount factors influences the steering effects for forest biodiversity preservation, how it would affect incentivising carbon sequestration and biomass provision. This could be useful for further political deliberation on setting the value relation between carbon sequestration and biodiversity preservation.

In cases where a PES scheme for the German context would be based on considering the opportunity costs for setting the price, recently developed models and frameworks that assess and map areas for integrated carbon sequestration and biodiversity conservation could be utilised (Forsius et al. 2021). It has been shown that using data to monitor and assess ecosystem service provision and hotspots is becoming increasingly important (see Primmer et al. 2021). An improvement in this will be needed to map ES in Germany and potentially target regions or habitats, as well as tailor the implementation of the PES scheme to local and regional needs, which is administered by PES intermediaries (e.g. Primmer et al. 2013). Future research could help to target high-value areas, that maximise both services under given opportunity costs, in order to gain a better understanding of the PES potential, given that data is available.

The research conducted for this thesis also pointed to fields of interest for future research that lay beyond the scope to the thesis.

Firstly, reviewing already existing evaluation studies that analyse regional PES and AEM implementation in Germany might show what enablers and barriers for a successful implementation in local and regional contexts have been identified. This could certainly be used as valuable input for setting up a national scheme that also has to consider local and regional adaptation of the scheme.

Secondly, reviewing findings from different contexts in which solutions for balancing forestry and biodiversity conservation have been developed (Krumm et al. 2021), could be valuable for policy learning, but also for enriching the public discourse around forest policy and FES governance.

Lastly, the research has shown that it could be valuable to further consider and investigate how alternative performance indicators for relating forest biodiversity preservation, carbon sequestration and biomass provision could better display the synergies between carbon sequestration and biodiversity. Whereas the policy proposal analysed chooses to maximise the synergy between carbon sequestration and biomass provision, an alternative performance indicator for carbon sequestration could be developed, that couples carbon sequestration stronger to biodiversity preservation.

Bibliography

Barton, D. N., Benavides, K., Chacon-Cascante, A., Le Coq, J. F., Quiros, M. M., Porras, I., ... & Ring, I. (2017). Payments for Ecosystem Services as a Policy Mix: Demonstrating the institutional analysis and development framework on conservation policy instruments. Environmental Policy and Governance, 27(5), 404-421.

BCG (2020). The Staggering Value of Forests – and How to Save Them. Accessed 07.05.2020 https://www.bcg.com/publications/2020/the-staggering-value-of-forests-and-how-to-save-them

Bigger, P., & Shapiro-Garza, E. (2021). Beyond The Gap: Placing Biodiversity Finance in the Global Economy. 10.13140/RG.2.2.10618.21449.

BMEL (2021). *Ergebnisse der Waldzustandserhebung 2020*. Accessed 06.04.2021 from https://www.bmel.de/SharedDocs/Downloads/DE/Broschueren/ergebnisse-waldzustandserhebung-2020.pdf?__blob=publicationFile&v=8

BMU (2007). Nationale Strategie zur biologischen Vielfalt. Accessed 21.05.2021from https://www.bmu.de/fileadmin/Daten_BMU/Pools/Broschueren/nationale_strategie_biologische_vielfalt_2015_bf.pdf

BMU (2019). Relevante national Strategien im Bereich Waldschutz. Accessed 14.05.2021 https://www.bmu.de/themen/natur-biologische-vielfalt-arten/naturschutz-biologische-vielfalt/waelder/relevante-nationale-strategien-im-bereich-waldschutz/

Borrass, L., Kleinschmit, D., & Winkel, G. (2017). The "German model" of integrative multifunctional forest management—Analysing the emergence and political evolution of a forest management concept. *Forest Policy and Economics*, *77*, 16-23.

Börner, J., Baylis, K., Corbera, E., Ezzine-de-Blas, D., Honey-Rosés, J., Persson, U. M., & Wunder, S. (2017). The effectiveness of payments for environmental services. *World development*, *96*, 359-374.

Böttcher, H., Hennenberg, K., & Winger, C. (2018). Forest Vision Germany. *Description of methodology, assumptions and results. Report from the Öko-Institut eV, January.*

Braat, L. C., & De Groot, R. (2012). The ecosystem services agenda: bridging the worlds of natural science and economics, conservation and development, and public and private policy. *Ecosystem services*, *1*(1), 4-15.

Bouwma, I., Schleyer, C., Primmer, E., Winkler, K. J., Berry, P., Young, J., ... & Vadineanu, A. (2018). Adoption of the ecosystem services concept in EU policies. *Ecosystem Services*, *29*, 213-222.

Camia A., Giuntoli, J., Jonsson, R., Robert, N., Cazzaniga, N.E., Jasinevičius, G., Avitabile, V., Grassi, G., Barredo, J.I., Mubareka, S., The use of woody biomass for energy purposes in the EU, EUR 30548 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-27867-2, doi:10.2760/831621, JRC122719

CBD (2013). Payment for Ecosystem Services - Forest Diversity Programme METSO - in Finland. Resource Mobilization Information Digest No 245 September 2013. Accessed 21.05.2021 from https://www.cbd.int/financial/doc/id245-finland-pes-en.pdf

Corbera, E., Soberanis, C. G., & Brown, K. (2009). Institutional dimensions of Payments for Ecosystem Services: An analysis of Mexico's carbon forestry programme. *Ecological economics*, *68*(3), 743-761.

Costanza, R., & Daly, H. E. (1992). Natural capital and sustainable development. *Conservation biology*, *6*(1), 37-46.

Costanza, R., d'Arge, R., De Groot, R., Farber, S., Grasso, M., Hannon, B., ... & Van Den Belt, M. (1997). The

value of the world's ecosystem services and natural capital. *nature*, *387*(6630), 253-260.

Costanza, R., De Groot, R., Braat, L., Kubiszewski, I., Fioramonti, L., Sutton, P., ... & Grasso, M. (2017). Twenty years of ecosystem services: how far have we come and how far do we still need to go?. *Ecosystem services*, *28*, 1-16.

Dade, M. C., Mitchell, M. G., McAlpine, C. A., & Rhodes, J. R. (2019). Assessing ecosystem service trade-offs and synergies: The need for a more mechanistic approach. *Ambio*, *48*(10), 1116-1128.

Daly, H., Farley, J., 2010. Ecological Economics: Principles and Applications: 2nd edition. Island Press, Washington, DC.

Daily, G.C. (1997). Nature's Services: Societal Dependence on Natural Ecosystems. Island Press, Washington D.C..

D'Amato, D., Bartkowski, B., & Droste, N. (2020). Reviewing the interface of bioeconomy and ecosystem service research. Ambio, 49(12), 1878–1896. https://doi.org/10.1007/s13280-020-01374-0

Dasgupta, P. (2021). The Economics of Biodiversity: the Dasgupta Review.

DUH (2021). Gutachten im Auftrag der Deutschen Umwelthilfe zeigt: Verheizung von namibischem Buschholz in Hamburger Kohlekraftwerk ist nicht nachhaltig. Press release. Accessed 03.05.2021 https://www.duh.de/presse/pressemitteilungen/pressemitteilung/gutachten-im-auftrag-der-deutschen-umwelthilfe-zeigt-verheizung-von-namibischem-buschholz-in-hambur/

Droste, N., D'Amato, D., & Goddard, J. J. (2018). Where communities intermingle, diversity grows–The evolution of topics in ecosystem service research. PLoS One, 13(9), e0204749.

EC (2013). COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS. A new EU Forest Strategy: for forests and the forest-based sector. Brussels 20.09.2013. Accessed 18.05.2021 from https://eur-lex.europa.eu/resource.html?uri=cellar:21b27c38-21fb-11e3-8d1c-01aa75ed71a1.0022.01/DOC_1&format=PDF

EC (2019). COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE EUROPEAN COUNCIL, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS. The European Green Deal. Brussels, 11.12.2019. Accessed 17.05.2021 from https://eur-lex.europa.eu/resource.html?uri=cellar:b828d165-1c22-11ea-8c1f-01aa75ed71a1.0002.02/DOC_1&format=PDF

EC (2020a). COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS. A Farm to Fork Strategy for a fair, healthy and environmentally-friendly food system. Accessed 18.05.2021 from https://eur-lex.europa.eu/resource.html?uri=cellar:ea0f9f73-9ab2-11ea-9d2d-01aa75ed71a1.0001.02/DOC_1&format=PDF

EC (2020b). COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONSEU. Biodiversity Strategy for 2030- Bringing nature back into our Lives. Brussels, 20.05.2020. Accessed 17.05.2021 from https://eur-lex.europa.eu/resource.html?uri=cellar:a3c806a6-9ab3-11ea-9d2d-01aa75ed71a1.0001.02/DOC_1&format=PDF

EC (2020c). EU Forest Strategy. Roadmap. Brussels 30.10.2020. Accessed 18.05.2021 from https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12674-Forests-new-EU-strategy_en

EC (2021). COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONSEU. New EU Forest Strategy for 2030. Brussels 16.7.2021. Accessed 30.07.2021 from https://ec.europa.eu/info/sites/default/files/communication-new-eu-forest-strategy-2030_with-annex_en.pdf

EFI Resilience Blog (2019). The Forest Biodiversity Programme METSO – voluntary forest conservation and management in private forests. Accessed 02.05.2021 https://resilience-blog.com/2019/06/03/the-forest-biodiversity-programme-metso/

Ehrlich, P., & Ehrlich, A. (1981). Extinction: the causes and consequences of the disappearance of species.

Elsasser P, Köthke M, Dieter M (2020a) Ein Konzept zur Honorierung der Ökosystemleistungen der Wälder. Braunschweig: Johann Heinrich von Thünen-Institut, 42 p, Thünen Working Paper 152, DOI:10.3220/WP1598533026000

Elsasser, P., Altenbrunn, K., Köthke, M., Lorenz, M., & Meyerhoff, J. (2020b). *Regionalisierte Bewertung der Waldleistungen in Deutschland* (No. 79). Thünen Report.

Engel, S. (2016). The devil in the detail: a practical guide on designing payments for environmental services. *International Review of Environmental and Resource Economics*, *9*(1-2), 131-177.

Engel, S., Pagiola, S., & Wunder, S. (2008). Designing payments for environmental services in theory and practice: An overview of the issues. *Ecological economics*, *65*(4), 663-674.

Ezzine-de-Blas, D., Wunder, S., Ruiz-Pérez, M., & Moreno-Sanchez, R. D. P. (2016). Global patterns in the implementation of payments for environmental services. *PloS one*, *11*(3), e0149847.

Farley, J., Aquino, A., Daniels, A., Moulaert, A., Lee, D., & Krause, A. (2010). Global mechanisms for sustaining and enhancing PES schemes. *Ecological economics*, *69*(11), 2075-2084.

Farley, J., & Costanza, R. (2010). Payments for ecosystem services: from local to global. *Ecological economics*, *69*(11), 2060-2068.

FERN (2020). Biodiversity strategy: the European Commission lays the path for a greener future in the wake of COVID-19. Brussles, 20.05.2020. Accessed 20.05.2021 from https://www.fern.org/publications-insight/biodiversity-strategy-the-european-commission-lays-the-path-for-a-greener-future-in-the-wake-of-covid-19-2144/

FERN (2021). Logging surges in Estonia's protected habitats, study reveals. Press release. Accessed 03.05.2021 https://www.fern.org/publications-insight/logging-surges-in-estonias-protected-habitats-study-reveals-2317/

Financial Times (2021). Letter: EU rules on burning biomass for energy must be tightened. Accessed 07.05.021 https://www.ft.com/content/453e5335-a26b-4e96-bcb9-222e6aa323f1

Finanztreff (2020). ROUNDUP/Minister: Klimafreundliche Wälder fördern, Schweinepest bekämpfen. Accessed 05.05.2021 http://www.finanztreff.de/news/roundup-minister-klimafreundliche-waelder-foerdern-schweinepest-bekaempfen/21881461)

Fischer, K., Stenius, T., & Holmgren, S. (2020). Swedish Forests in the Bioeconomy Stories from the National

Forest Program. *Society & Natural Resources*, 1-18.

Forsius, M., Kujala, H., Minunno, F., Holmberg, M., Leikola, N., Mikkonen, N., ... & Heikkinen, R. K. (2021). Developing a spatially explicit modelling and evaluation framework for integrated carbon sequestration and biodiversity conservation: Application in southern Finland. *Science of The Total Environment*, *775*, 145847.

Forstwirtschaft in Deutschland (2020). *Prämie für Klimaschutzleistung bewirtschafteter Wälder gefordert!* News released 01.10.2020. Accessed 06.04.2021 from https://www.forstwirtschaft-in-deutschland.de/aktuelles/news-detailansicht/news/praemie-fuer-klimaschutzleistung-bewirtschafteter-waelder-gefordert/?contrast=1&cHash=f75ddb26a876fa73321d9a064efbd1f3

Forum Umwelt & Entwicklung (2020). GELD FÜR KOHLENSTOFF? Klimaschutz als neues Geschäftsmodell in der Forstwirtschaft. Rundbrief 2/2020. Accessed 21.05.2021 from https://www.forumue.de/wp-content/uploads/2020/06/17-Geld-f%C3%BCr-Kohlenstoff-Maraz.pdf

Forzieri, G., Girardello, M., Ceccherini, G., Spinoni, J., Feyen, L., Hartmann, H., ... & Cescatti, A. (2021). Emergent vulnerability to climate-driven disturbances in European forests. *Nature communications*, *12*(1), 1-12.

Georgescu-Roegen, N. (1971). The Entropy Law and the Economic Process. Harvard University Press, Cambridge, MA.

Gesetze im Internet (n.d.). Grundgesetz für die Bunderrepublik Deutschland Art 91a. Accessed 04.05.2021 https://www.gesetze-im-internet.de/gg/art_91a.html

Gómez-Baggethun, E., De Groot, R., Lomas, P. L., & Montes, C. (2010). The history of ecosystem services in economic theory and practice: from early notions to markets and payment schemes. *Ecological economics*, *69*(6), 1209-1218.

Green House think tank (2021). The Economisation of Nature and its Services. The path to salvation or the wrong track? A Green House Gas by Reinhard Loske. March 2021. Accessed 21.05.2021 from https://www.greenhousethinktank.org/uploads/4/8/3/2/48324387/economisation_of_nature_gas.pdf

Haines-Young, R., & Potschin, M. (2010). The links between biodiversity, ecosystem services and human well-being. *Ecosystem Ecology: a new synthesis*, *1*, 110-139.

Haines-Young, R.; Potschin, M. (2013): Common International Classification of Ecosystem Services (CICES): Consultation on Version 4, August-December 2012. EEA Framework Contract No EEA/IEA/09/003.

Haines-Young R, Potschin MB. (2018): Common International Classification of Ecosystem Services (CICES) V5.1 and Guidance on the Application of the Revised Structure. 2018. Available from www.cices.eu (accessed at 20.04.2021).

IBC-Carbon (n.d.). Integradted Biodiversity Conservation and Carbon Sequestration in the Changing Environment. Accessed 02.05.2021 https://www.ibccarbon.fi/en-US

IPBES (2015). Preliminary Guide Regarding Diverse Conceptualization of Multiple Values of Nature and Its Benefits, Including Biodiversity and Ecosystem Functions and Services (Deliverable 3 (D)). Available from: https://www.ipbes.net/sites/default/files/downloads/IPBES-4-INF-13_EN.pdf

Jacobs, S., Dendoncker, N., Martín-López, B., Barton, D. N., Gomez-Baggethun, E., Boeraeve, F., ... & Washbourne, C. L. (2016). A new valuation school: Integrating diverse values of nature in resource and

land use decisions. *Ecosystem Services*, *22*, 213-220.

Jenkins, M., Salzman, J., Bennett, G., & Granfors, J. (2020). Making the priceless valuable: Forests and ecosystem services. *International Forestry Review*, *22*(1), 104-112.

Kangas, J. & Ollikainen, M. 2021. A PES scheme promoting forest biodiversity and carbon sequestration. Submitted manuscript.

Kay, K. (2016). Breaking the bundle of rights: Conservation easements and the legal geographies of individuating nature. *Environment and Planning A: Economy and Space*, *48*(3), 504-522.

Kern, F., Rogge, K. S., & Howlett, M. (2019). Policy mixes for sustainability transitions: New approaches and insights through bridging innovation and policy studies. *Research Policy*, *48*(10), 103832.

Kettunen et al. (2017). Integration approach to EU biodiversity financing: Evaluation of results and analysis of option for the future. Final report for the European Commission (DG ENV)(Project ENV. B. 3/ETU/2015/0014). Institute for European Policy (IEEP). Brussel/London.

Knapp, S. (2019). The Link Between Diversity, Ecosystem Functions, and Ecosystem Services. In *Atlas of Ecosystem Services* (pp. 13-15). Springer, Cham.

Knapp, H.D., Klaus, S., Fähser, L. (2021). Der Holzweg. Wald im Widerstreit der Interessen. Oekom.

Krumm, F., Schuck, A., & Rigling, A. (2021). How to balance forestry and biodiversity conservation?-A view across Europe.

Ladu, L., Imbert, E., Quitzow, R., & Morone, P. (2020). The role of the policy mix in the transition toward a circular forest bioeconomy. Forest policy and economics, 110, 101937.

Lele, S. (2013). Environmentalisms, justices and the limits of ecosystem services frameworks. *The justices and injustices of ecosystem services. Earthscan, London*, 119-39

MEA (2003): Ecosystems and Human Well-being: A Framework for Assessment. Washington D.C.: Island Press. The Millennium Ecosystem Assessment Series 212 pages.

MAES (2013): Mapping and Assessment of Ecosystems and their Services – An analytical framework for ecosystem assessments under Action 5 of the EU Biodiversity Strategy to 2020. Luxembourg: Publications office of the European Union.

MAES (2014): Mapping and Assessment of Ecosystems and their Services – Indicators for ecosystem assessments under Action 5 of the EU Biodiversity Strategy to 2020. Luxembourg: Publications office of the European Union.

Metsonpolku (n.d. a). METSO – The Forest Biodiversity Programme for Southern Finland. Accessed 02.05.2021 https://www.metsonpolku.fi/en-US/METSO_Programme

Molenaar, K. (2013). Payments for Ecosystem Services (PES) design characteristics. Netherlands Deltares publications.

Orsi, F., Ciolli, M., Primmer, E., Varumo, L., & Geneletti, D. (2020). Mapping hotspots and bundles of forest ecosystem services across the European Union. *Land Use Policy*, *99*, 104840.

Pascual, U., Muradian, R., Rodríguez, L. C., & Duraiappah, A. (2010). Exploring the links between equity and efficiency in payments for environmental services: A conceptual approach. *Ecological economics*, *69*(6), 1237-1244.

Primmer, E., Paloniemi, R., Similä, J., & Barton, D. N. (2013). Evolution in Finland's forest biodiversity

conservation payments and the institutional constraints on establishing new policy. Society & Natural Resources, 26(10), 1137-1

Primmer, E., Varumo, L., Kotilainen, J. M., Raitanen, E., Kattainen, M., Pekkonen, M., ... & Ollikainen, M. (2019). Institutions for governing biodiversity offsetting: An analysis of rights and responsibilities. *Land Use Policy*, *81*, 776-784.

Primmer, E., & Paavola, J. (2021). Insurance Value of Ecosystems: An Introduction. *Ecological Economics*, *184*, 107001.

Primmer, E., Varumo, L., Krause, T., Orsi, F., Geneletti, D., Brogaard, S., ... & Mann, C. (2021). Mapping Europe's institutional landscape for forest ecosystem service provision, innovations and governance. *Ecosystem Services*, *47*, 101225

Pülzl, H., Giurca, A., Kleinschmit, D., Arts, B., Mustalahti, I., Sergent, A., ... & Brukas, V. (2017). The role of forests in bioeconomy strategies at the domestic and EU level. In *Towards a sustainable European forest-based bioeconomy* (No. 8, pp. 36-53). European Forest Institute.

Raitanen, E., Similä, J., Siikavirta, K., & Primmer, E. (2013). Economic instruments for biodiversity and ecosystem service conservation & the EU state aid regulation. *Journal for European Environmental & Planning Law*, *10*(1), 6-28.

Reyers, B., Biggs, R., Cumming, G. S., Elmqvist, T., Hejnowicz, A. P., & Polasky, S. (2013). Getting the measure of ecosystem services: a social–ecological approach. *Frontiers in Ecology and the Environment*, *11*(5), 268-273.

Ring, I., & Barton, D. N. (2015). Economic instruments in policy mixes for biodiversity conservation and ecosystem governance. In *Handbook of ecological economics*. Edward Elgar Publishing.

Ring, I., & Schröter-Schlaack, C. (2019). Policy Mixes for Sustained Ecosystem Service Provision. In *Atlas of Ecosystem Services* (pp. 321-326). Springer, Cham.

Rogge, K. S., & Reichardt, K. (2016). Policy mixes for sustainability transitions: An extended concept and framework for analysis. *Research Policy*, *45*(8), 1620-1635.

Rogge, K. S., Kern, F., & Howlett, M. (2017). Conceptual and empirical advances in analysing policy mixes for energy transitions. *Energy Research & Social Science*, *33*, 1-10.

Salzman, J., Bennett, G., Carroll, N., Goldstein, A., & Jenkins, M. (2018). The global status and trends of Payments for Ecosystem Services. *Nature Sustainability*, *1*(3), 136-144.

Schomers, S. D. (2019). *Intermediaries within the governance structures of payments for ecosystem services: cost-effectiveness and environmental effectiveness from an institutional economic perspective* (Doctoral dissertation, Hannover: Institutionelles Repositorium der Leibniz Universität Hannover).

Schröter, B., Matzdorf, B., Sattler, C., & Alarcon, G. G. (2015). Intermediaries to foster the implementation of innovative land management practice for ecosystem service provision–A new role for researchers. *Ecosystem Services*, *16*, 192-200.

Simoncini, R., Ring, I., Sandström, C., Albert, C., Kasymov, U., & Arlettaz, R. (2019). Constraints and opportunities for mainstreaming biodiversity and ecosystem services in the EU's Common Agricultural Policy: Insights from the IPBES assessment for Europe and Central Asia. *Land use policy*, *88*, 104099.

SINCERE (2020). Towards an EU policy framework for forest ecosystem services. Reflecting on 2020, exploring

2021! Webinar 7 December 2020. Accessed 08.12.2020 file:///D:/Downloads/SINCERE-Talks_2_policy%20for%20FES.pdf

TEEB (2010) The Economics of Ecosystems and Biodiversity: Ecological and economic foundation. Earthscan, Cambridge.

UBA (2015). Ökosystemleistungen des Waldes. Erstellung eines Inventars für Österreich. Wien.

UN CBD (1992). United Nations Convention on Biological Diversity.

UNFCCC (1992): Rahmenübereinkommen der Vereinten Nationen über Klimaänderungen. Accessed 21.05.2021 from http://unfccc.int/resource/docs/convkp/convger.pdf

UNFCCC (1997): Kyoto Protocol to the United Nations Framework Convention on Climate Change. Accessed 21.05.2021 from http://unfccc.int/resource/docs/convkp/kpeng.pdf

UNFCCC (2015): Paris Agreement (FCCC/CP/2015/10/Add.1). Accessed 21.05.2021 from http://unfccc.int/sites/default/files/english_paris_agreement.pdf

Vatn, A. (2010). An institutional analysis of payments for environmental services. *Ecological economics*, *69*(6), 1245-1252.

Winkel, G., & Volz, K.R. (2003): Naturschutz und Forstwirtschaft: Kriterienkatalog zur „Guten fachlichen Praxis". Angewandte Landschaftsökologie, Heft 52. Bonn, Bundesamt für Naturschutz

Weiss, C. H. (1997). How can theory-based evaluation make greater headway?. *Evaluation review*, *21*(4), 501-524.

Welle et al. (2020). Waldvision für die Europäische Union. Naturwald Akademie. Accessed 16.05.2021 from https://naturwald-akademie.org/wp-content/uploads/2020/11/Waldvision-fuer-die-Europaeische-Union.pdf

Wunder, S. (2005). Payments for environmental services: some nuts and bolts.

Wunder, S. (2013). When payments for environmental services will work for conservation. *Conservation letters*, *6*(4), 230-237.

Wunder, S. (2015). Revisiting the concept of payments for environmental services. *Ecological economics*, *117*, 234-243.

Wunder, S., Brouwer, R., Engel, S., Ezzine-de-Blas, D., Muradian, R., Pascual, U., & Pinto, R. (2018). From principles to practice in paying for nature's services. *Nature Sustainability*, *1*(3), 145-150.

Wunder, S., Börner, J., Ezzine-de-Blas, D., Feder, S., & Pagiola, S. (2020). Payments for environmental services: Past performance and pending potentials. *Annual Review of Resource Economics*, *12*, 209-234.

WSL (2020). "How to balance forestry and biodiversity – a view across Europe". Panel discussion. 9 November 2020. Accessed 08.12.2020 https://www.wsl.ch/en/about-wsl/events/details/how-to-balance-forestry-and-biodiversity-a-view-across-europe.html. Full video available under: https://www.youtube.com/watch?reload=9&v=j_AbCHJbjBU

Wolfslehner, B., Pülzl, H., Kleinschmit, D., Aggestam, F., Winkel, G., Candel, J., ... & Sotirov, M. (2020). European forest governance post-2020